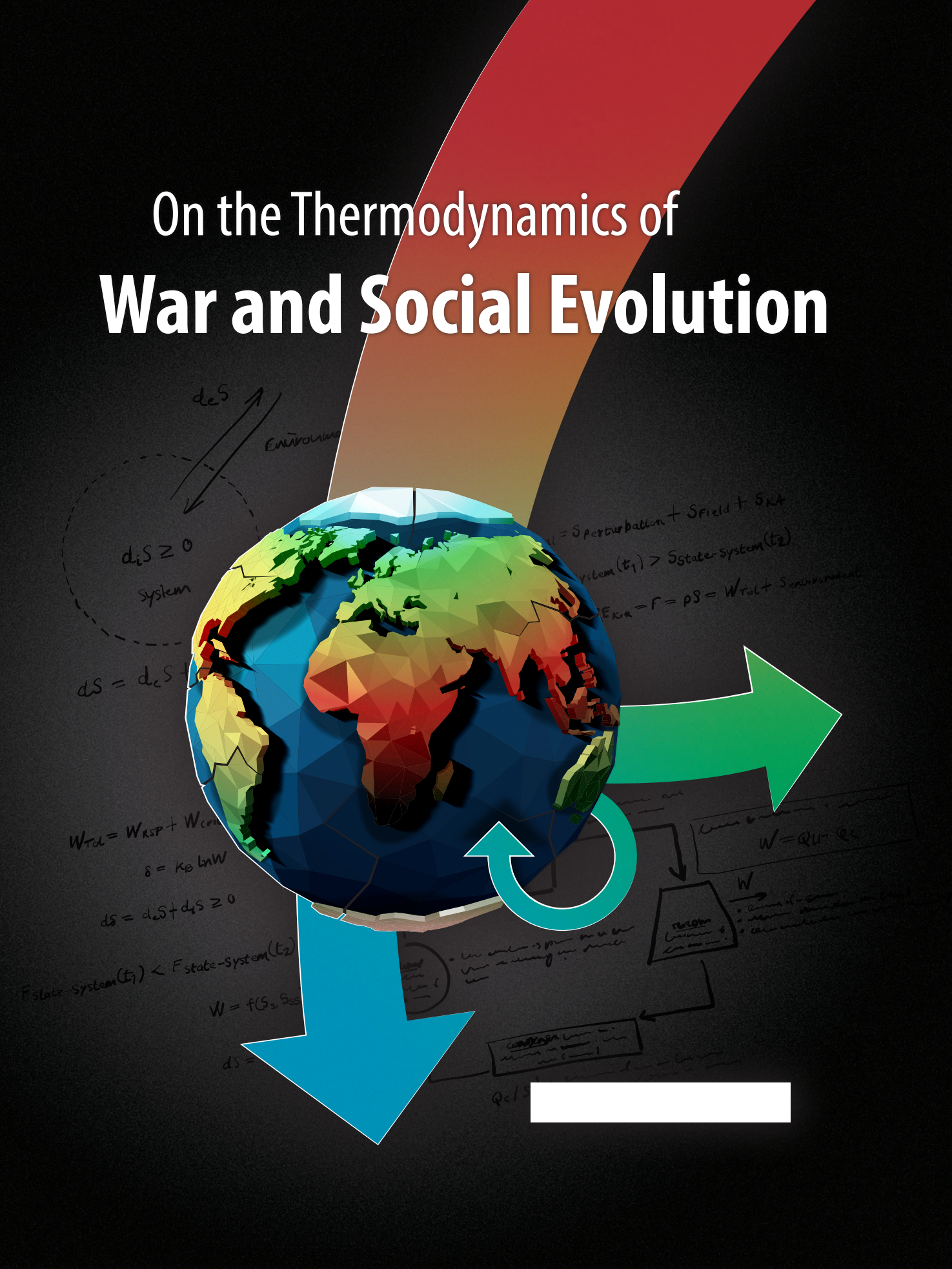
On the Thermodynamics of
War and Social Evolution



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Colophon

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On the Thermodynamics of

War and Social Evolution

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Abbreviations & variables

Abbreviations

BCD	Battle Casualty Death
BR	Basic Requirement
CL	Correlation Length
CLD	Causal Loop Diagram
CSD	Critical Slowing Down
D	Measure of disorder
DoF	Degrees of Freedom
DySA	Dynamic Self-Assembly
EMIS	Energy, Matter, Information and Entropy (= S)
EP	Exceptional Period
EU	European Union
EWS	Early Warning Signal
+ FB	Positive Feedback
- FB	Negative Feedback
FFE	Far From Equilibrium
FSI	Fragile State Index
FTS	Finite-Time Singularity dynamic.
GTD	Global Terrorism Database
GTI	Global Terrorism Index
HCR	High Connectivity Regime
H-imperative	Homeostatic imperative
ISFP's	Interacting Self-Fulfilling Prophesies
KA	Kinetic Activity (= war)
LCR	Low Connectivity Regime
LS or L	Life-Span

MEP- Principle, MEPP	Minimum Entropy Production Principle
PBMP(-mechanism)	Powerful-Become-More-Powerful(-mechanism)
PDLI	Path-Dependence and Lock-In
PoL	Pace of Life
RR	Release-Rate
RSP	Relatively Stable Period
SA	Self-Assembly
SIE	Social Integration and Expansion
START	Study of Terrorism and Responses to Terrorism
S/T-field	Entropy/Tension-field
S-imperative	Entropic (or entropy) imperative
TP	Tipping Point
U	Internal energy
VC	Vulnerable Cluster
VIXS	Volatility Index of the System

Variables

a	Acceleration
B	The number of possible structural arrangements
dS, ΔS	The total change in entropy
d_eS	The change of the system's entropy due to a reversible exchange of energy and matter with the environment/exterior.
d_iS	The change in entropy due to irreversible processes within the system
E	Energy
F	Free energy (Also, Helmholtz energy (in physics); chemists use the term Gibbs free energy (G), conceptually their meaning is similar).
F	Force
F_R	Resulting force (concerns the process of aggregation vs fragmentation).

f	Acceleration factor of successive cycles (PoL)
G	Enthalpy
H	Helmholtz energy
I	Information
k_B	Boltzmann constant
k	Degree; number of connections of a node in a network
ln	Natural logarithm
m	Mass
M	Matter
N	Number
Ω	Multiplicity (the number of microstates that compose a macrostate).
p	Probability or total pressure
p	Momentum
S	Entropy
s	Distance
T	Temperature
U	Internal energy
μ	Chemical potential
v	Velocity/speed
V	Volume
W	Work or the number of microstates corresponding to the macrostate
Q	Heat
>	Greater-than sign
≥	Greater than or equal to sign
<	Less-than sign
≤	Less than or equal to

On the Thermodynamics of
War and Social Evolution

Knowledge of the Second Law of thermodynamics - the statistical law favoring disorder over order - reminds us that life is always balanced like a tight-rope walker over an abyss of chaos and destruction. Living organisms distill their order and complexity from the flood of thermodynamic information which reaches the earth from the sun. In this way, they create local order; but life remains a fugitive from the Second Law of thermodynamics. Disorder, chaos and destruction remain statistically favored over order, construction, and complexity.

— **John Scales Avery**

The fantastic ordering of atoms and molecules necessary to produce and maintain a living system is accompanied by a more than compensating disorder created in the surroundings. Thus, the ever-increasing order represented by increasing numbers of the human species is more than matched by the trail of disorder left in our surroundings, of which the increasing pollution of our atmosphere, rivers, and oceans is but an example.

— **H.C. van Ness**

It is easier to burn down a house than to build one, easier to kill a human than to raise and educate one, easier to force a species into extinction than to replace it once it is gone, easier to burn down the Great Library of Alexandria than to accumulate the knowledge that once filled it, and easier to destroy a civilization in a thermonuclear war than to rebuild it from the radioactive ashes.

— **John Scales Avery**

... war is the violent clash of energies...

— **Herman Wouk**

... when a social scientist speaks of irrational behavior, he generally refers to normative criterion.

— **Nicholas Georgescu-Roegen**

Scientific modes of thought cannot be developed and become generally accepted unless people renounce their primary, unreflecting, and spontaneous attempt to understand all their experience in terms of its purpose and meaning for themselves.

— **Norbert Elias**

Preface

War has always been inextricably linked to human affairs. War - the organized application of violence - has developed into a political instrument, and the suffering and destruction that accompanies war are mostly taken for granted; a price we are prepared to pay.

We accept war as an activity that is necessary or unavoidable. And because we are not able to fathom the phenomenon of war, and we can always justify our side of the "story", as participants in war-activity, we accept war as it is. But we created a war-trap that will force us to increase our war-activity over time, as this study shows.

Contrary to the physical, medical and biological sciences for example, we never made any progress in our understanding of historical processes. Although, the scientific revolution has been extensively studied by historians, its lessons were never applied to historical science itself, and we stopped trying, it seems.

In an effort to break this stalemate and our lethargy, I studied war from a completely different, but on the other hand, a very obvious perspective: The physical sciences.

Socials systems and their dynamics are also grounded in the physical sciences, and the laws of thermodynamics obviously also apply to social systems.

In my study, I have made extensive use of research by Ilya Prigogine et al. who defined dissipative structures and their role in thermodynamic systems far from equilibrium.

In this study, I argue that around 1480, the System - which consists of interacting communities and societies, and of their interactions with the respective environments on which they depend - produced a dissipative structure through a bifurcation, and that this dissipative structure was instrumental in the accomplishment of a phase transition, during the period 1480-1945.

The phase transition resulted in thermodynamic equilibrium of the European State-System and in the globalization of the System. The dissipative structure - I also refer to as the 1st finite-time singularity dynamic (1st FTS) - was accompanied by four accelerating war-cycles. This behavior is consistent with the laws of thermodynamics and related principles that apply: War is kinetic activity generated by the System in response to entropy and entropy-production.

The research also shows that currently, the (globalized) System produces a 2nd (global) FTS, that drives the *global* State-System to thermodynamic equilibrium. Presently, we are in the 1st cycle (1945-....) of a 2nd FTS, data-analysis shows.

Other observations this study produced, include the observation that: entropy - tensions, uncertainty, possibilities, etc. - serves as a source of order in the System; social structures can be understood as "institutionalized" manifestations of thermodynamic potentials; non-systemic wars the System produced - and still produces - are normally chaotic in nature; technology does *not* impact on the war dynamics of the System; and that the System resembles a primitive organism in its basic responses.

These - and other remarkable findings - are discussed in this study.

Furthermore, a disturbing finding of this study is that a FTS not only necessarily accelerates, but that the State-System "self-destructs", during the last stage of the phase transition the FTS is instrumental in; as was the case with the European State-System in 1939-1945. The System develops and grows through "kinetic destruction.

As I mentioned, presently, the System is in the 1st cycle of the 2nd FTS; to be more precise, in the last stage of the 1st cycle, data-analysis shows.

Although, *non-systemic* wars are intrinsically unpredictable (a property that can be attributed to the chaotic nature of these dynamics), *systemic* wars, on the other hand, are highly predictable.

As I explained in a previous publication (59), analysis suggests that the System becomes critical at a global scale - and consequently produces a systemic war - in 2020 (plus or minus two years, assuming the data is correct). This study confirms - explains - this prediction from a thermodynamic perspective.

The outcome of a (next) systemic war - as was the case with the four systemic wars the 1st FTS produced, during the period (1480-1945) - is an "upgrade" of the State-System to a next level of organization, that allows for a next relatively stable period.

The social and political volatility and radicalization tendencies we now experience, are a consequence of the accumulation of entropy in the System, caused by a combination of accelerating entropy-production and decreasing effectiveness of non-systemic wars to neutralize and redistribute the entropy that is produced. Eventually, the System is driven into a critical state, and produces a systemic kinetic response (systemic war).

This study also shows that our free will is much more limited than we assume: We obey the laws of thermodynamics and related principles blindly, when the FTS demands increasing kinetic activity (war) to maintain its coherence and accomplish its purpose: Thermodynamic equilibrium in the State-System.

Social systems are manifestations of the laws of thermodynamics and related principles: Social systems - and their "parts" - are shaped and conditioned by these laws.

Through various ingenious mechanisms - including through "interacting self-fulfilling prophecies" of actors in the System, socialization processes and conditioning - social systems shape our behavior and responses and ensure our compliance with the demands of the Second Law of thermodynamics and related principles.

Various social mechanisms ensure that we can (always) justify our behavior, within the social context we (interactively) create. Through the accumulation of entropy (tensions) in the System, we are psychologically prepared for war.

The regularities in the war dynamics generated by the System are "proof" of our obedience to physical laws.

This study can contribute to a better understanding of the functioning of the System and its dynamics: This study shows that a 2nd global FTS - if not stopped or "tamed" - causes collective destruction at a global scale, even without taking the effects of climate change into consideration.

To escape the war-trap we collectively create through our interactions, we must understand the workings of the System, and realize that our free will is much more limited than we think. We must escape the destructive "behavior" the Second Law and related principles imposes on us.

I urge the reader to challenge my study and observations, to participate in this discussion and to take war - and the war-trap we collectively create - not for granted.

This study describes my thinking process - the journey - that resulted in a series of remarkable observations.

This study consists 45 chapters divided into eight parts. In part I, I present an overview of some of the main observations and conclusions, however without a (detailed) explanation. The purpose of part I - *observations and conclusions* - is, to give the reader an overview of the main results and a reference for the remainder of the study.
In Part II (*Basic concepts*), I present several basic concepts, e.g. the Second Law of thermodynamics and its relationship with information.
In part III (*The homeostatic-imperative*), I discuss "living systems" and their properties, including their need for regulation (homeostasis); I also discuss the relation between homeostasis and the Second Law of thermodynamics.
In part IV (*Nonequilibrium thermodynamics*), different thermodynamic states that can be distinguished, so-called bifurcations, phase transitions, and chaotic dynamics are discussed.
In the next part - part V (*The first dissipative structure / 1st FTS* (*1480-1945*)) - I "confront" the various concepts discussed in the preceding parts with empirical observations (war-data), test various (working) hypothesis, and discuss the results of these (iterative) confrontations. Part V concerns the 1st FTS (1480-1945).
In part VI (*The second dissipative structure / 2nd FTS* (*1945-....*)), the same approach is applied to the 2nd FTS, which is currently unfolding (1945-....).
In part VII (*Some general features of the* (*State-*)*System*), I discuss some general features of a FTS and a State-System. For example, I show that a FTS resembles a kinetic engine, to which the Carnot theorem applies.
In part VIII (*Applications and implications*), I try to determine the relationship between the Second Law of thermodynamics and war - kinetic activity of the System - and social development and evolution of and in the System. I also discuss the relationship between the FTS, the State-System and (the effects of) climate change.
Appendix A contains several terms and their definitions that are introduced in this study.

Ingo Piepers

Amsterdam, The Netherlands
January 2019

Part I

Introduction

In this part, I discuss some results - observations and conclusions - of the research presented in this study. This part also serves as a reference for the reader.

Contents

1. Observations and (some) conclusions

1. Observations and (some) conclusions

1.1. Introduction

In this study, I show that the System - which includes the State-System, states and societies - is the product of the interplay between highly deterministic - physical - processes, regulated by the laws of thermodynamics and related principles, and probabilistic factors.
Over time, the System has evolved into a "living system" that resembles a primitive organism in its basic structure and behavior.
Furthermore, this study shows that a process of growth and development of the (State-)System, provides a context for social evolution for societies and their subsystems.
Tensions in the System are the (by)product of (inter)actions and exchanges (between parts) in the System and can be considered entropy: In systems far from equilibrium, entropy is a (potential) source for order (44).
War is kinetic activity (KA) of the (State-)System. From a thermodynamic perspective, the purpose of KA is to "neutralize" entropic perturbations (during relatively stable periods, RSP's), and to upgrade the order of the (State-)System during critical periods.
Social and political dynamics take place within the latitude - the contingent latitude - that is allowed by the laws of thermodynamics and related principles.
This study shows that in 1480 - following a period of increasing instability, with population growth as the main driver - the System in Europe produced a dissipative structure (I refer to as the 1st finite time singularity dynamic, 1st FTS); the 1st FTS was accompanied by four accelerating KA/war-cycles.
During a transient period from 1480 until 1945, the 1st FTS accomplished a phase transition, with two complementary effects: Thermodynamic equilibrium in/of the European State-System (core), and the simultaneous merging of the core (Europe) and non-core, resulting in a global State-System. During the transient period, the System consisted of a core - Europe - and a non-core; the "rest of the world".
Following the phase transition (1480-1945), the (globalized) (State-)System produced a 2nd FTS (1945-....). Data-analysis reveals that the 2nd FTS is now producing a first KA/war-cycle (1945-....) and driving the (State-)System into a critical state.
As I explain in this study, the purpose of the 1st FTS was - and of the 2nd FTS is - to accomplish thermodynamic equilibrium of respectively the European State-System and the global State-System, via the moth efficient path, in accordance with the Second Law and related principles.

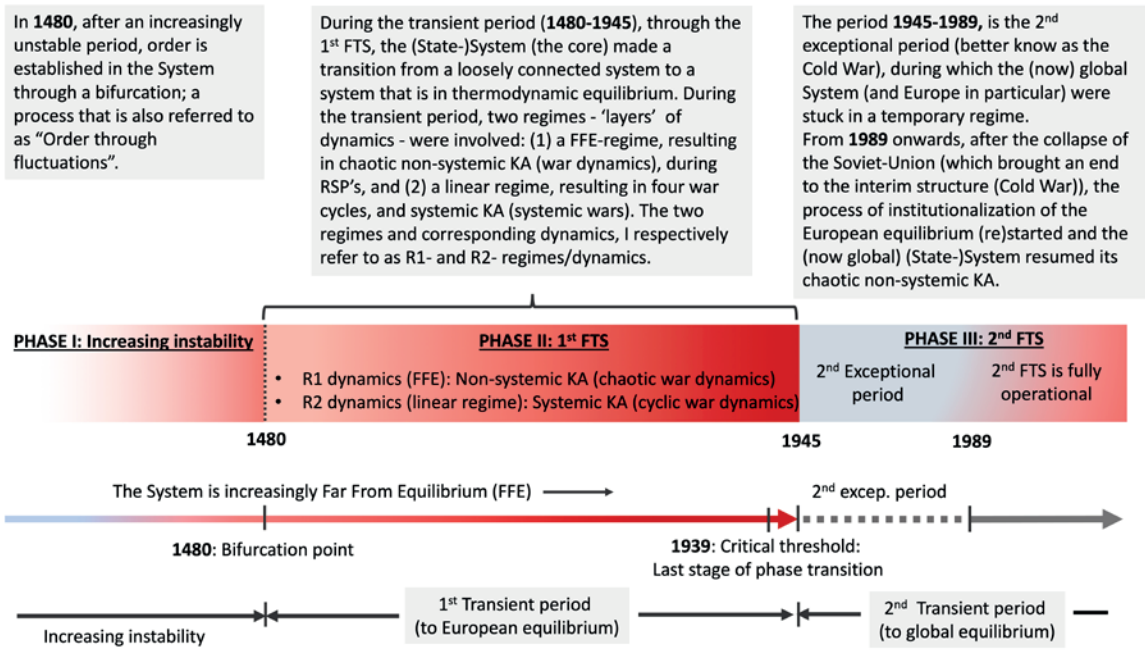


FIGURE 1.1: Three phases in the development of the (State-)System.

In this chapter, I discuss some of the main observations and conclusions from this research; this chapter can be considered a preview to the study itself. The following subjects will be discussed: The scientific method; dissipative structures and the emergence of the 1st FTS in 1480; entropy-regulation in the (State-)System; the phase transition the 1st FTS accomplished during the transient period (1480-1945), resulting in thermodynamic equilibrium of/in the European State-System (although with a delay until 1989) and the merging of the core and non-core (the establishment of a global State-System); two types of dynamics and KA/war that can be distinguished; the thermodynamics of KA/war; the interplay between probabilistic and deterministic factors and the intrinsic (un)predictability of KA/war dynamics; the interplay between competing thermodynamic potentials and between the entropic (S-) and homeostatic (H-) imperatives; the institutionalization of thermodynamic principles in social structures; the - what I name - "FTS-engine"; kinetic growth; a second infinity KA/war that is unavoidable if the 2nd FTS is maintained; the (current) accumulation of entropy and, development and evolution in/of the (State-)System.

1.2. The scientific method

For this study, I have applied the scientific method. The problem I investigate in this study, concerns our very limited and (at best) only superficial understanding of the phenomenon of war, and of social development and evolution. Despite the (increasing) destruction and suffering war caused and is still causing, we seem to take war for granted and simply accept war as a fact of life.

In an effort to break this lethargy, I applied concepts and ideas that originate in the physical sciences - i.e. the laws of thermodynamics and related principles - to the study of the (war) dynamics of the System. I assume that the laws of thermodynamics also apply to social systems; that seems an obvious assumption to me.
The results of this study are very promising and provide numerous clues for further research. The fact that we are on a path to a second "infinity war" and also increasingly damaging and depleting the Earth system, add to the urgency to better understand the functioning of the (State-)System, and to take appropriate actions.
In this paragraph, I describe the scientific method, and how it is applied in this research. Below figure describes the scientific method.

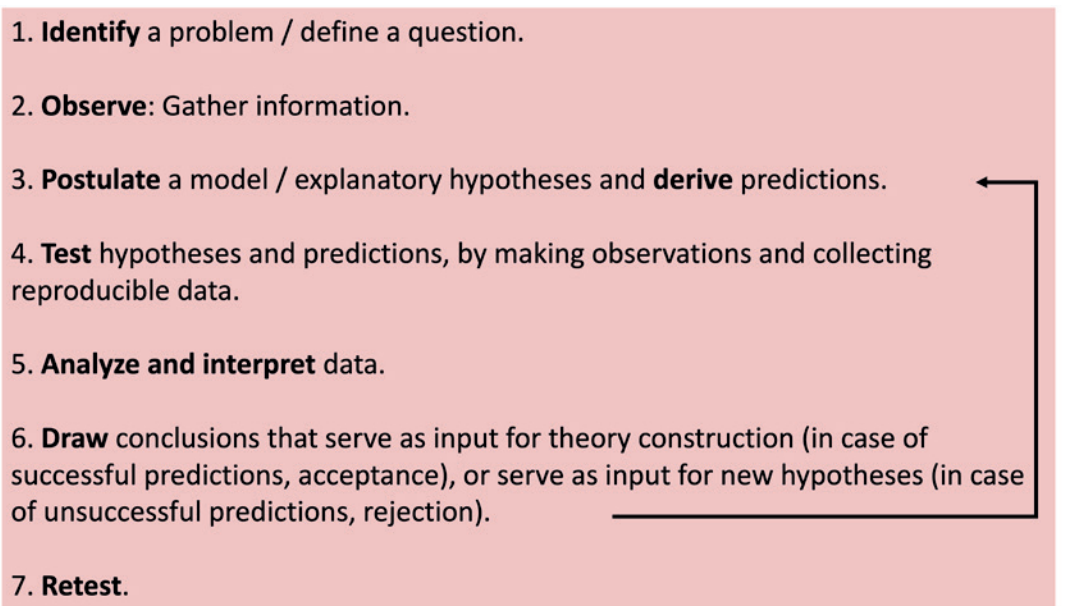


FIGURE 1.2: The scientific method. The data I use to study the (war)dynamics of the System, can be considered "observations".

The scientific method is used in this study to better understand the workings of the System; the focus is on the war dynamics – kinetic activity (KA) - and on the social development and evolution of the System (*Step 1*). The impact of KA/war - causing massive destruction and suffering - is evident, while we still lack a basic understanding of this phenomenon.
The primary source of observation I use (*Step 2*), is a database compiled by Levy, which is considered the most complete dataset covering the period 1495-1975 (48) (see also appendix B). The dataset is supplemented with data from other sources, covering the period 1975-2018; by making use of the same definitions etc. as Levy did, the integrity of the data should be ensured.

My assumption is that to understand the KA/war dynamics and social development and evolution of the System, a long-term perspective is required. By using 'hard' data, I aim to 'transcend' the level of (separate) issues (specific wars), and to avoid the descriptive and (mostly) normative research methods historians and political scientists typically use.

I assume that the System and its dynamics must obey the laws of physics: KA/war (dynamics) and social development and evolution involve energy and entropy, and work must be accomplished to accomplish change.

The laws of thermodynamics - especially the Second Law of thermodynamics (also referred to as the 'entropy law") and related principles - occupy an important place in the model and hypotheses I have formulated (*Step 3*). I have used various theories and perspectives that originate in the physical sciences - e.g. nonequilibrium thermodynamics - and sciences where these concepts - already found credible application (like ecology) - to construct the model and hypotheses concerning the workings of the System.

Step 4, testing, is problematic: The System is unique - at least as far as the unique (historical) events the System produces are concerned - and the system is also not particularly suitable for experiments.

However, as I show (*Step 5*), the System and its dynamics, is not so unique from a thermodynamic perspective (as developed by Prigogine et al. (44, 62, 63, 64, 65, 66): The System - I show through logical inference - can be considered an example (case) of a so-called dissipative system, and functions consistently accordingly. I also demonstrate that the dissipative structure the (State-)System constituted, was instrumental in a phase transition, during the period 1480-1945; war dynamics - KA of the (State-) System - accompany the phase transition.

Despite these limitations, certain consistencies and system behavior can be predicted (*Step 6*), e.g. that following the phase transition (1480-1945), the global System that was established also should produce chaotic non-systemic KA, given the fact that the conditions that produced chaotic non-systemic KA during RSP's of the first dissipative structure (1480-1945), are in place, albeit at a global scale. As this study shows, this is indeed the case.

The "theory" (in fact, it is more realistic to speak of "building blocks" for a theory that must still be constructed) that is developed in this study, also 'predicts', that at a certain point - the tipping point of the current (first global) RSP (1945-....) - the average size of chaotic non-systemic wars (KA) should decrease and result in the accumulation of tensions and issues (entropy). Data-analysis shows that the current RSP, reached the tipping point in 2011: From that point onwards, the average size of chaotic non-systemic KA started decreasing and tensions and issues started accumulating: The current political and social volatility - the fragmentation of the global order, Brexit, religious and political radicalization, the increasing connectedness of issues, etc. - are manifestations of entropy-accumulation.

The development of the 1st FTS shows that it is a matter of time before the current entropy-accumulation causes the System to become critical and to produce a systemic kinetic response; the accumulated entropy and energy that is released, will be used to upgrade the order of the (State-)System.

The observations and insights that are presented and discussed in this study are the outcome of the application of the scientific method: The method constitutes a cycle that was applied multiple times; theory formulation is an iterative process.

One of the main insights of this study is that around 1480, the System produced a dissipative structure, I also refer to as the 1st finite-time singularity dynamic (1st FTS). During a period from 1480-1945, the 1st

FTS accomplished a phase transition, with two complementary effects: Thermodynamic equilibrium of the European State-System, and the simultaneous "upscaling" to a global State-System; the period 1480-1945, is also referred to as the transient period.

This new insight has been obtained by applying the scientific method. Prigogine has demonstrated that "dissipative systems give rise to transition phenomena, long-range order, and symmetry breaking far from equilibrium and can serve as an archetype for understanding other types of systems" (66). By applying the scientific method, I show that the European State-System (1480-1945) and the present global State-System (1945-....), can be considered the structural components of respectively a 1st and 2nd FTS (dissipative structure).

During the (scientific) process, I identified analogies between dissipative systems in general as observed/defined by Prigogine et al. (44), and the System and its dynamics. By "zooming-in" on certain aspects of the "model", the confrontation of the model with data, etc. and identification of typical dynamics and regularities that characterize dissipative structures (66), the model of the FTS could be adjusted and refined.

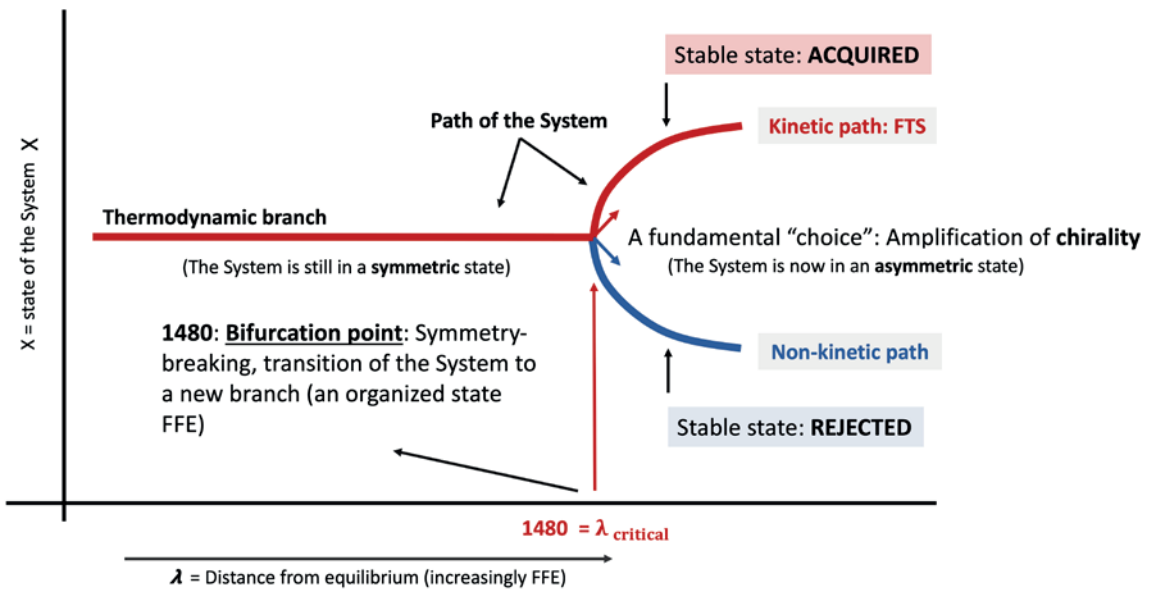


FIGURE 1.3: Bifurcation in 1480: The System acquires an organized state FFE. According to Kondepudi et al. "one of the most remarkable aspects of nonequilibrium systems that came to light in the twentieth century is the phenomenon of self-organization. Under certain nonequilibrium conditions, systems can spontaneously undergo transitions to organized states, which, in general, are states with lower entropy" (44). According to Kondepudi et al. this is in contrast to equilibrium situations where the range of correlations is determined by short-range intermolecular forces (44). "As is well known today, far-from-equilibrium situations lead to new space-time structures" and "for this reason the restriction to equilibrium situations hides, in our opinion, some essential features of the behavior of matter and energy. An example is the role of fluctuations" (44). "The type of dissipative structure depends critically on the conditions in which the structure is formed" (65). In FFE conditions we may have transformation from disorder into order: New dynamic states of matter may originate, states that reflect the interaction of a given system with its surroundings (environment) (65). These emergent structures, called dissipative structures, are distinct from machines and are a good thermodynamic basis on which we may begin to build a theory of biological organisms (44, 65), and of social systems.

1.3. Dissipative structures: Emergence of the 1st FTS in 1480

After a period of increasing instability in Europe - when the System was pushed increasingly far from equilibrium (FFE) - the System produced in 1480 a dissipative structure - the 1st FTS - through a bifurcation, see above figure. A dissipative structure involves "organized' flows of energy and entropy, also with its environment: By exchanging - exporting - entropy to an environment, a state of lower entropy - of order - can be sustained.

In case of the dissipative structure the System produced - the 1st FTS - the flows of energy (***E***), matter (***M***), information (***I***) and entropy (***S***) (EMIS-flows) - generated processes of kinetic activity (KA, war), aggregation of the core of the System (the European State-System), expansion to the non-core of the System ("the rest of the world"), and empowerment.

The emergence of a dissipative structure - of order - is an example of "order through fluctuations" (44, 62). The dissipative structure ensures that the excess entropy that was produced during the preceding phase (when the system became increasingly unstable) is "put to use" by the emergence of order.

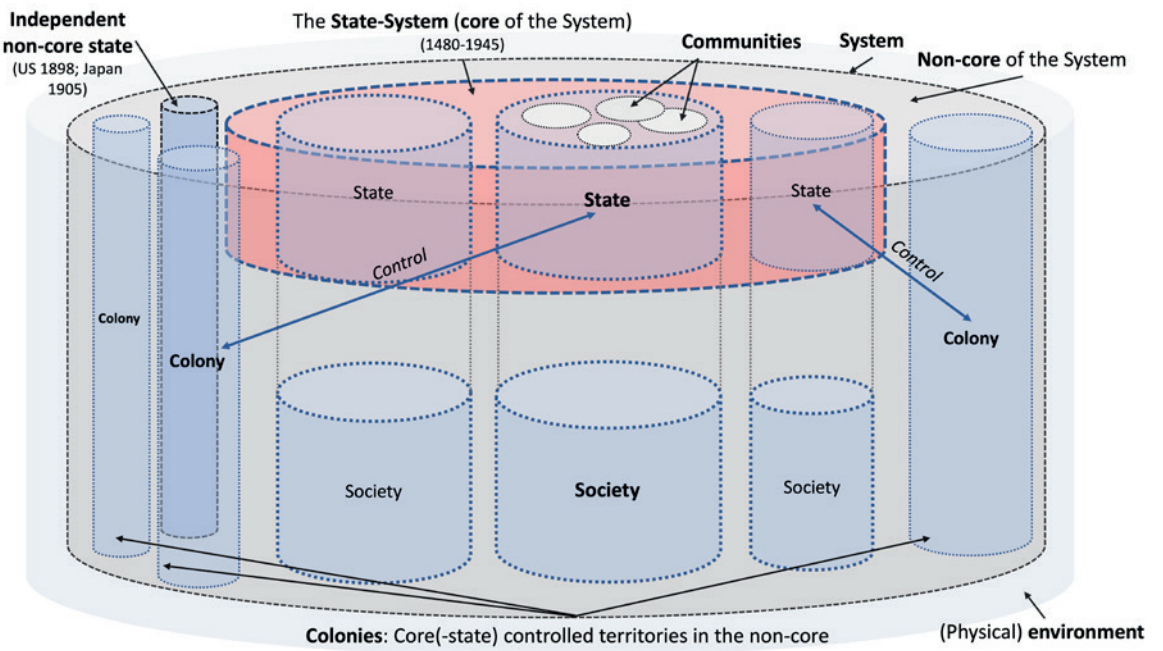


FIGURE 1.4: Structure and components of the System (1). This figure shows the structure and components of the System. During the transient period (1480-1945), a distinction can be made between a core - the European State-System - and a non-core; "the rest of the world". During the transient period (1480-1945), the process of aggregation ("unification") in the core, was accompanied by a simultaneous and complementary process of expansion - entropy-exchange - to the non-core. The process of expansion concerns the colonization of the rest of the world (the non-core) by European states (the core). Not coincidentally the process of colonization and eventual decolonization were synchronized with the operation of the 1st FTS (1480-1945).

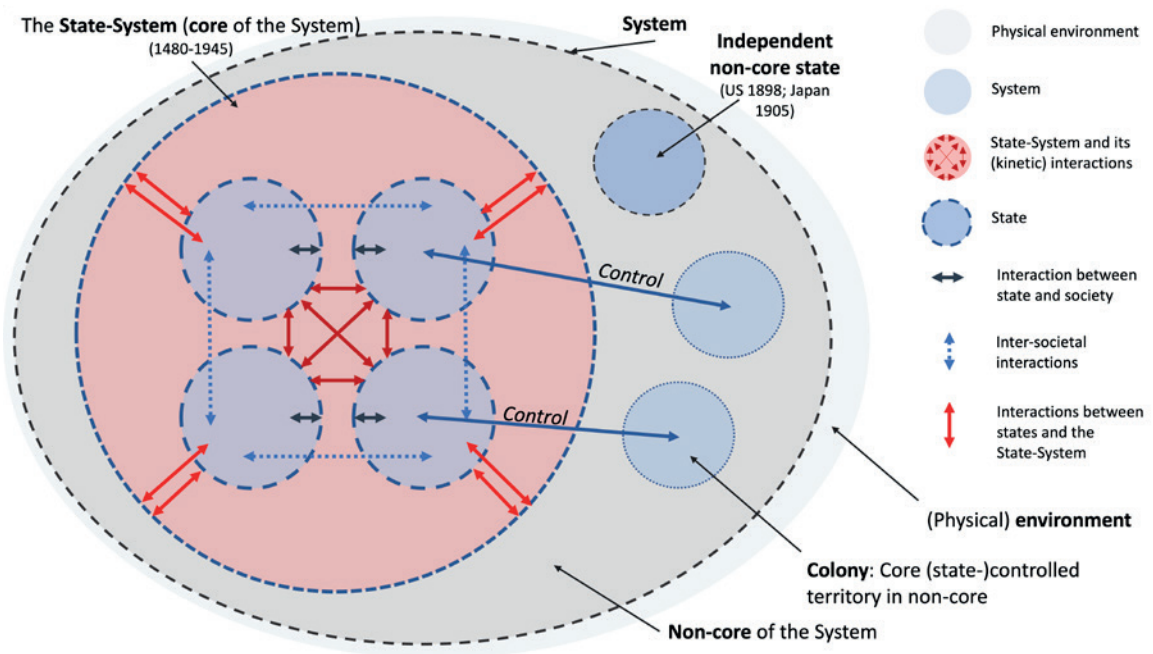


FIGURE 1.5: Structure and components of the System (2).

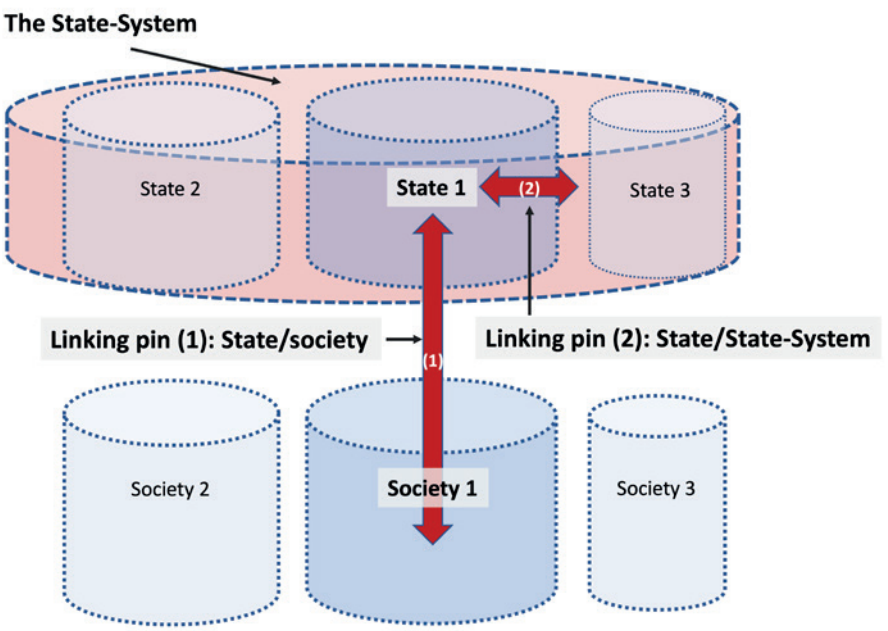


FIGURE 1.6: The regulatory function of the state. The state fulfilled - and still fulfills - a two-fold regulatory role: To (1) maintain homeostasis in the society it regulates/represents (the internal environment of the state), and (2) to regulate the external environment of the society; the (State-)System. Societies and the State-System constitute the environment of state-structures, while societies/states and the non-core can be considered the main components of the environment of the European State-System, during the transient period (1480-1945).

Entropy - also referred to as "degraded energy" and disorder - is produced in case of irreversible processes: All natural processes - including social (inter)actions and processes - are irreversible, and consequently produce entropy. "Entropy encompasses all aspects of transformations of matter: changes in energy, volume and composition. Thus, every system in Nature, be it a gas, an aqueous solution, a living cell or a neutron star, is associated with a certain entropy, just as we associate an energy" (44). "There is no real system in nature that can go through a cycle of operations and return to its initial state without increasing the entropy of the exterior, or more generally the 'universe'. Because of the irreversibility of actual processes, "every process in Nature increases the entropy, thus establishing a distinction between the past and future. The Second Law establishes an arrow of time: the increase of entropy distinguishes the future from the past" (20). Because entropy can also be considered a probabilistic concept, as Boltzmann showed (47), entropy can also be equated with randomness; "the greater the randomness or disorder, the greater the entropy" (20).

Although, "entropy and entropy-producing irreversible processes are generally thought of as agents of disorder, (...) under far-from-equilibrium conditions, irreversible processes are, in fact, the drivers of self-organization and order we see all around us in Nature" (44); as is - this study shows - also the case for the State-System that is sustained in an organized state FFE, by the 1st FTS. Kondepudi et al. observe in reference to these phenomena that "one of the most profound lessons of nonequilibrium thermodynamics is the dual role of irreversible processes: as destroyers of order near equilibrium and as creators of order far from equilibrium" (44): Although the destruction of order always prevails in a system in or near thermodynamic equilibrium, the construction of order may occur in a system far from equilibrium.

In case the entropy in (of) a system in which irreversible processes take place (like societies and the System) is stabilized at a lower entropy 'level', the 'local' entropy level comes at the expense of an increase of entropy of the environment: "According to the Second Law of thermodynamics, such an entropic decrease can occur only if there were an equivalent or larger increase in entropy elsewhere in the Universe" (20)

From a thermodynamic perspective, the function of a dissipative structure is to 'eradicate' a gradient as efficient as possible, and by doing so, to restore (thermodynamic) equilibrium. In case of the 1st FTS, the dissipative structure was able to power itself (through self-reinforcement), during the transient period (1480-1945), and by intensifying and accelerating its operation, it could eventually establish thermodynamic equilibrium in the core.

As I mentioned in the introduction of this chapter, tensions in the System - including in and between societies - can be considered entropy: A (by)product of social (inter)actions and exchanges. "Social" entropy provides new possibilities - that can manifest themselves as opportunities or threats - to the System and its components. An intermediate level/amount of entropy - like energy - and the ability to utilize (new) possibilities, are preconditions for life, development and evolution, and also survival.

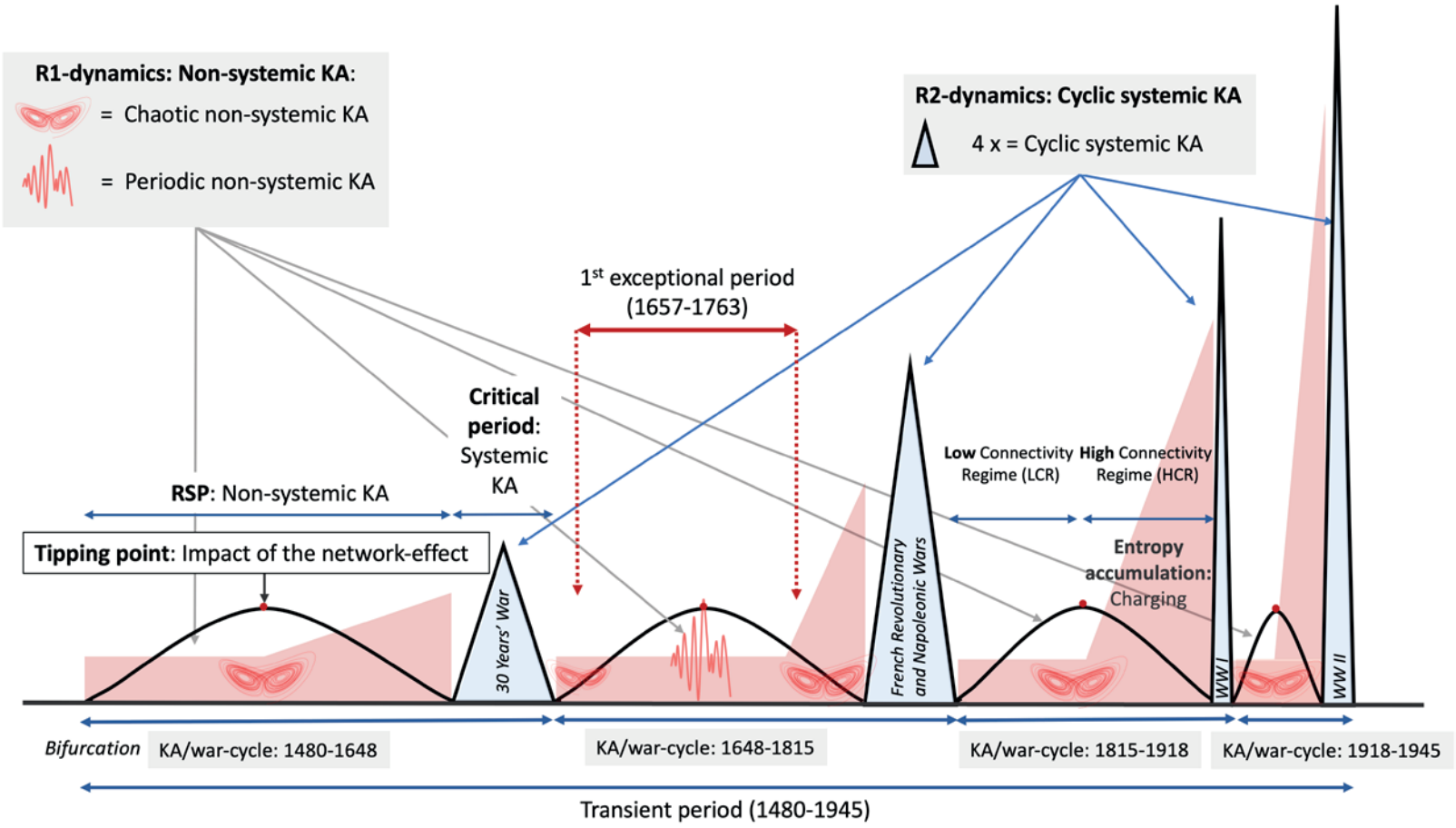


FIGURE 1.7: The 1st FTS (1480-1945). The 1st FTS - the dissipative structure the System produced FFE in 1480 - was accompanied by four accelerating KA/war-cycles, and instrumental in a phase transition, during the transient period (1480-1945). The formation of a dissipative structure "requires a thermodynamic threshold corresponding to a minimum level of dissipation" (62). A dissipative structure can be considered a "a giant fluctuation" that is stabilized by the flow of energy and matter from the outside world (the system's environment) (62). This has "a lower entropy compared to the uniform steady-state entropy" and the "entropy decrease is translated by the emergence of space order". The FTS - the 1st FTS, during the transient period (1480-1945) - can be considered a "giant fluctuation" that was stabilized and sustained by four accelerating EMIS-flows (KA/war-cycles), involving exchanges with the environment of the State-System (consisting of societies/states and the non-core). Through the flows and exchanges, the lower entropy state of the (State-)System could be sustained.

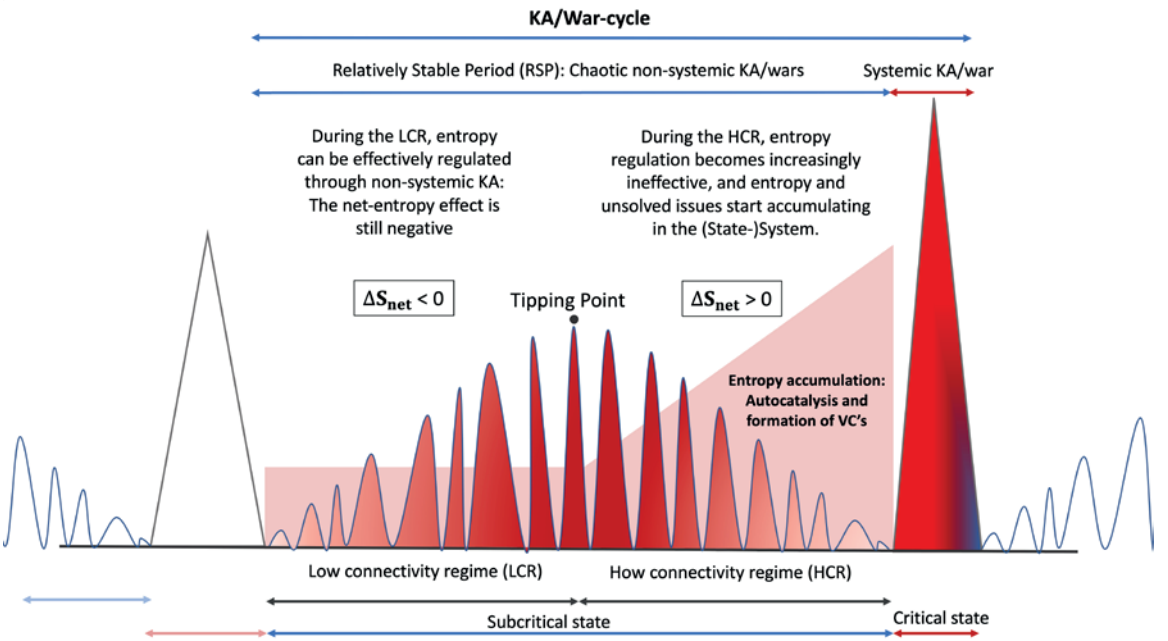


FIGURE 1.8: Schematic representation of a KA/war-cycle. During the transient period (1480-1945), the 1st FTS was accompanied by four accelerating KA/war-cycles, each cycle consisting of a RSP and a critical period, when (regulated by the 1st FTS) the (State- System produced respectively non-systemic KA/wars (to ensure continuity) and systemic KA/war (to ensure change). Once the tipping point of a cycle was reached, non-systemic KA/wars decreased, and entropy (issues and tensions) started accumulating in the System.

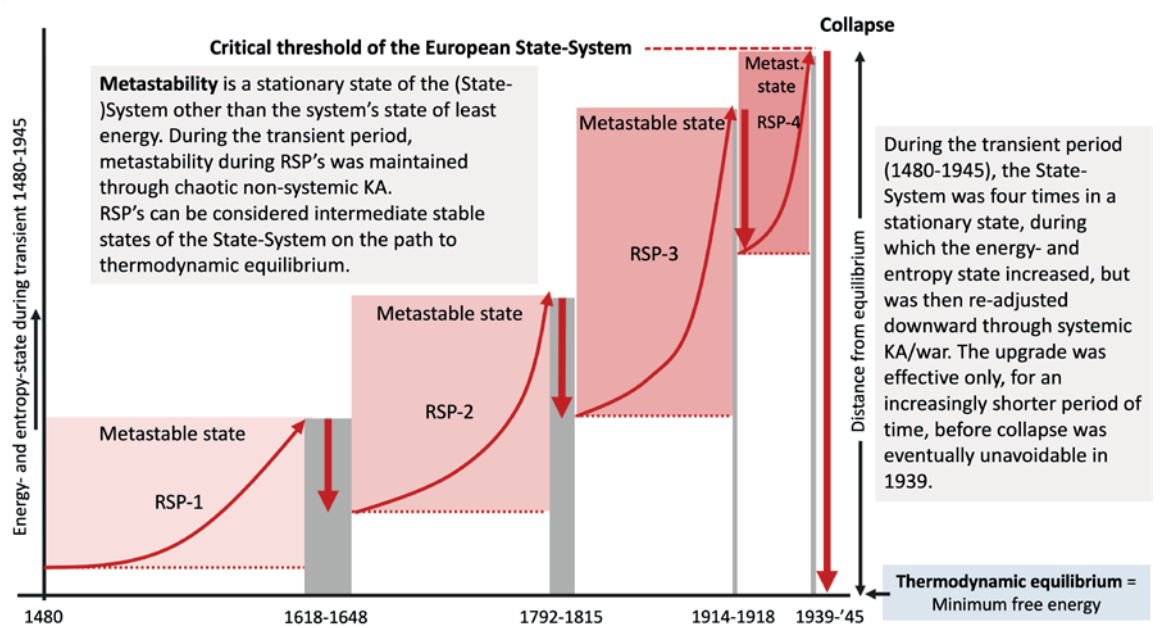


FIGURE 1.9: The transient period (1480-1945), depicted as a series of metasTABLE states. The purpose - from a thermodynamic perspective - of periodic upgrades of the order of the (State-)System during critical periods, through cyclic systemic KA, R2-dynamics - in response to accumulated entropy (excess entropy, that could not me neutralized or redistributed) - was (and still is) to decrease the entropy(-production) and energy state of the System, and to optimize - update - the regulatory-capabilities of the State-System/FTS.

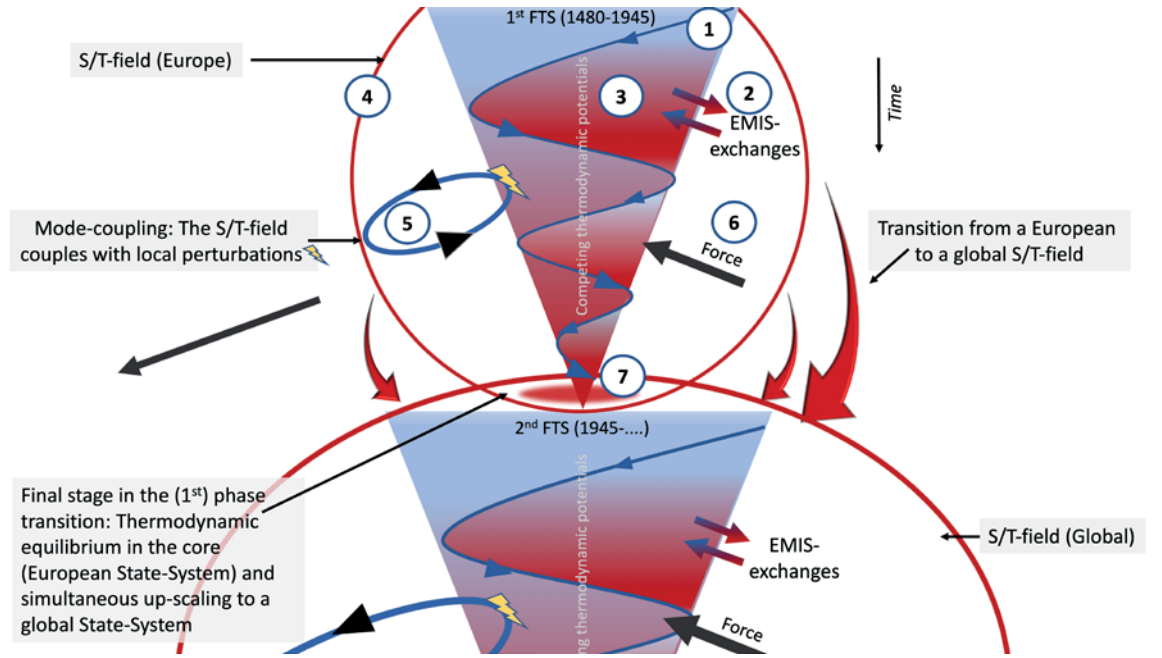


FIGURE 1.10: Components of the FTS. In this figure, a schematic representation of the 1st FTS and the transition to the 2nd FTS is shown. The components/mechanisms are numbered: (1) Refers to the bifurcation that resulted in the emergence of the 1st FTS in 1480; (2) refers to EMIS-exchanges of the 1st FTS with its environment (societies/states and the non-core); (3) refers to the KA the FTS generated and the four KA/war-cycles that were produced during the transient period (1480-1945); (4) refers to the presence of a S/T-field; (5) refers to mode-coupling; (6) to the force the FTS applies to the (State-)System and (7) to the final stage of the phase transition (the 4th systemic KA/war, the Second World War, 1939-1945), and the actual transition.

The 1st FTS followed a very regular and predictable - the most efficient - path to thermodynamic equilibrium in the core. This path provided a 'template' for social and political dynamics in the contingent domain. Through the FTS - and through the interplay between domains - dynamics and developments in the physical and contingent domains became 'locked' and synchronized. The 1st FTS set the pace and direction for social and political dynamics and developments in the contingent domain. Societies/states had to respond to the accelerating frequency of systemic KA, that was imposed by the 1st FTS: All four systemic KA/wars were accurately timed, and their magnitudes (in terms of BCD) were predetermined; social and political dynamics had to 'fit' - to match - the dynamic template the FTS imposed.

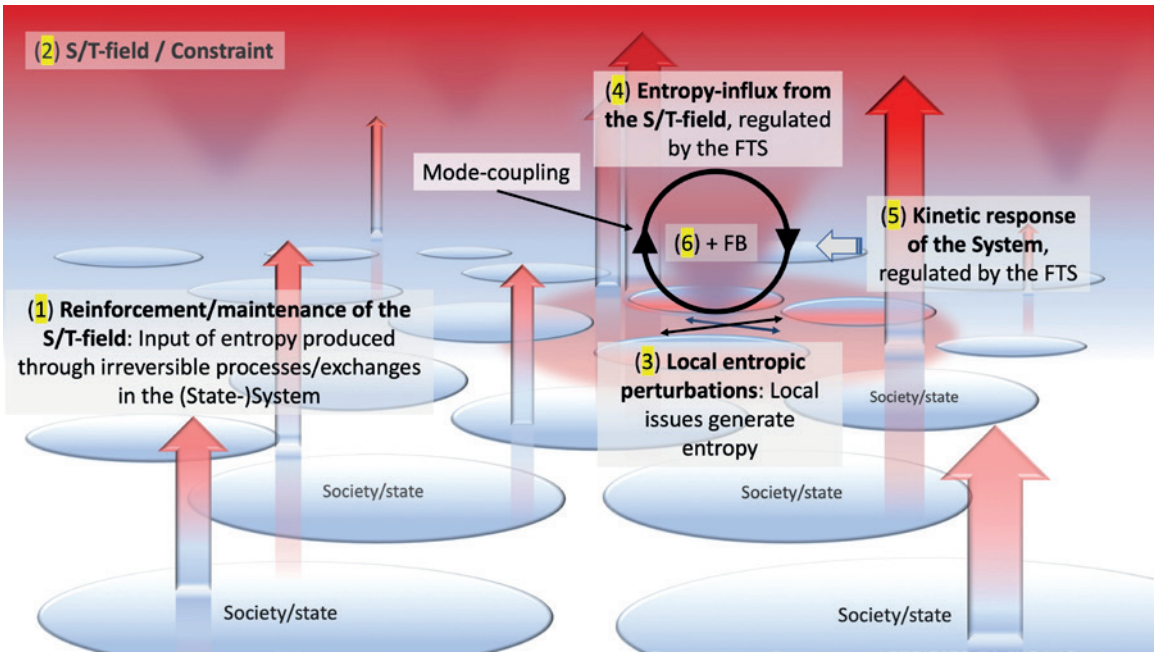


FIGURE 1.11: Interactions between issues and the S/T-field. The S/T-field is an integral component of the FTS. Although many - most - entropic perturbations in the (State-)System (issues in the contingent domain) stay isolated, are not amplified and just fade away, some entropic perturbations - selected through a combination of probabilistic and deterministic factors (a combination of chance and constraint) - are amplified and start interacting with the S/T-field. Consequently, these perturbations/issues are amplified (escalate) and become subject to further FTS-regulation; the FTS ensures compliance with the Second Law and related principles that apply FFE. These issues are part of the process of KA and are 'selected' with the help of the FTS. Through this process and the KA that is generated, the (State-)System - and the FTS - are able to maintain their coherence and operation. Although, the issue - the war that follows - does not (always) have the intended effect/ result in the contingent domain of the (State-)System - the Vietnam War is a good example - the KA always serves a 'constructive' role in the (State-)System, from a thermodynamic perspective.

Above figure, is a schematic depiction of the S/T-field and its interactions with entropic perturbations: (1) Through regular (irreversible) interactions between components/parts entropy is continuously produced in the System; (2) This entropy feeds the S/T-field; (3) Entropic perturbations - inhomogeneities - always occur, and local perturbations contribute to (further) entropy-production; (4) Through a combination of probabilistic and deterministic factors, certain perturbations (issues) are selected, and an interplay - through the mechanism of mode-coupling - starts between the (initially) local perturbation/ issue and the S/T-field; (5) Through the S/T-field, an influx of entropy (4) and kinetic energy/KA is generated, causing further amplification (escalation). The process is regulated by the FTS, although the entropic perturbation and KA are (and stay) localized (in case of non-systemic KA/wars), the response qualifies as a system-response, that serves the FTS and the coherence of the (State-)System. The deterministic domain - the laws of physics - is indifferent what results the issue produces in the contingent domain (from a social and political point of view). For a certain time, the 'local perturbation (issue) and the S/T-field reinforce each other (6), when a solution is found, KA dies out, and the solution is embedded in the network of VC's.

1.4. Entropy-regulation in the System

According to Kondepudi et al. (44), the stability of equilibrium and nonequilibrium systems are closely related to entropy and entropy-production in the system. Living systems - including social systems like the System - require a certain order - an intermediate level of entropy - to ensure their 'operation' (and survival). To that end, entropy needs to be regulated - e.g. redistributed - and free energy must be made available and put to work to accomplish this. The System consists of various subsystems (like societies, states and the State-System) that continuously interact; the System - and these subsystems - are in a dynamic steady state.

In chapter 2, the Second Law and the equation $\boldsymbol{dS = d_eS + d_iS \geq 0}$, are discussed.

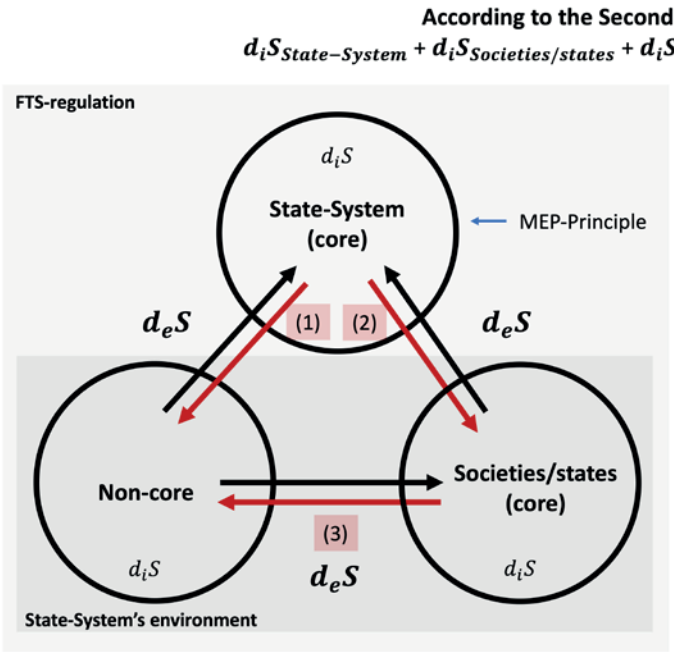
For open systems, including the State-System - systems which exchange energy and matter with the outside world - a distinction must be made between two terms in the entropy chance $\boldsymbol{dS}$, $\boldsymbol{dS = d_eS + d_iS}$ (44). During the period 1480-1939, the State-System was a European State-System (not a global State-System); the System consisted of a core (The European State-System) and a non-core ('the rest of the world'). Societies in the core (Europe) and the non-core can be considered the environment of the (European) State-System, during the period 1480-1939.

The term $\boldsymbol{d_iS - d_{State\text{-}System}S}$ in this context - is the change of entropy due to irreversible processes within the European State-System. Here, in this context, $\boldsymbol{d_eS}$ is the change of the State-System's entropy due to exchanges of energy, matter and entropy with the State-Systems environment, consisting of societies (in the core) and the non-core. Thus, $\boldsymbol{d_eS = d_{societies\ core}S + d_{non\text{-}core}S}$.

Three processes play a central role in the redistribution of entropy in the System; the process of (1) aggregation, the merging ('mixing') of societies (states), that a allows for (results in) an entropy increase; the process (2) of expansion to the non-core that allows for an increase in the exchange of entropy to the expanding non-core; and the process (3) of empowerment of 'parts' (individual humans and communities) in societies. These three processes allow for the redistribution - the 'dumping' - of increasing amounts of entropy that were produced by the European State-System, during the period 1480-1939.

KA - kinetic activity, war (as we know it) - also played (and still plays) an important regulatory role in the redistribution of entropy, apart from the fact that KA itself also contributed to entropy-production (through wars tensions are 'neutralized' but also are new tensions - depending on the conditions of the State-System - introduced).

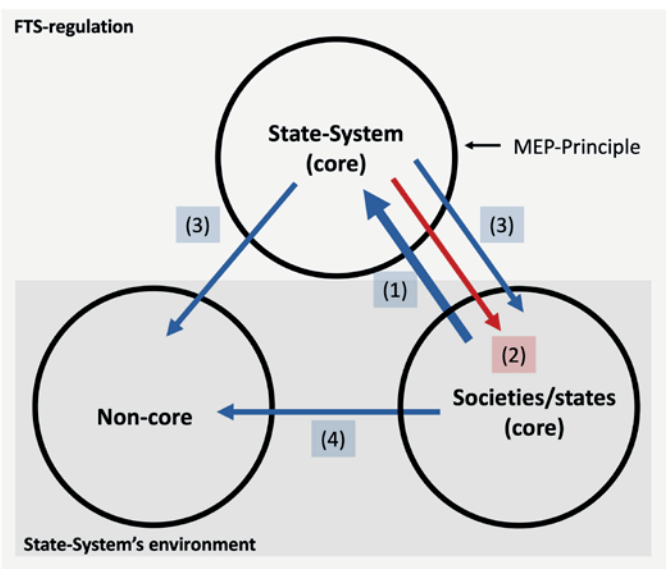
With the term "order through KA", I refer to the phenomenon that during the transient period (1480-1945), order was maintained through chaotic non-systemic KA/war, during RSP's of cycles, and order was upgraded through systemic KA/war, during critical periods. Without KA, the FTS and the European State-System could not have maintained macroscopic coherence. Because KA (war) was (and still is) instrumental for maintaining order, KA/war is institutionalized in the contingent domain of the (State-) System.



Schematic and simplified depiction of **entropy-flows** regulated by the 1st FTS, during the transient period (1480-1945):

- Entropy-flows (1) and (3) are the main drivers of the process of expansion of the core to the non-core.
- Entropy-flow (2) contributes to the process of empowerment in societies/states.
- The MEP-Principle applies to the State-System and drives the process of aggregation (core).

FIGURE 1.12: Schematic depiction of entropy-flows in the System, involving the core (European State-System), non-core and societies/states.



Schematic and simplified depiction of **(kinetic) energy-flows** regulated by the 1st FTS, during the transient period (1480-1945):

- (1): The State-System extracts kinetic energy from societies; entropy influx (2) serves as a catalysator in the transformation process of "societal-energies" into kinetic energy (military capabilities). The FTS (State-System) utilizes the energy.
- (3): Kinetic energy is applied by the FTS/State-System through KA/war, a process that involves the S/T-field. The kinetic energy that is applied in the non-core concerns expansion wars.
- (4): A limited amount of kinetic energy is applied by core-states in the non-core, but does not involve the S/T-field

FIGURE 1.13: Schematic depiction of (kinetic) energy-flows in the System, involving the core (European State-System), non-core and societies/states.

The State-System - with population growth and rivalries between states as the main drivers - produced accelerating amounts of entropy, during the period 1480-1939, that had to be redistributed - mainly through aggregation, expansion, empowerment and KA - at an accelerating rate, to ensure that the State-System could maintain a certain order. Not only were accelerating amounts of entropy produced, but the European State-System at the same time (that is during the period 1480-1939) was driven to near zero entropy by the Minimum Entropy Production (MEP) - principle, that (also) applied to the (State-) System's dynamics. The MEP-principle impacted on the (need for) redistribution of entropy in the System. The drive of the State-System to near zero entropy - a state reached in 1939 - resulted in an increase in available free energy ($\boldsymbol{F}$) in the State-System, during the period 1480-1939:

$$\boldsymbol{E}_{State\text{-}System} = \boldsymbol{F}_{State\text{-}System} + \boldsymbol{S}_{State\text{-}System}$$

The energy in the State-System is equivalent with the sum of the free energy ($\boldsymbol{F}$) and degraded energy (entropy S) of the State-System.

$\boldsymbol{E}_{State\text{-}System}$ continuously increased (and still increases) through population growth, etc.;

$\boldsymbol{S}_{State\text{-}System} \rightarrow \boldsymbol{0}$ (through the effect of the MEP-principle), and consequently $\boldsymbol{F} \rightarrow \boldsymbol{E}$.

The increasing amounts of free energy in the State-System were required and used to regulate the accelerating entropy(-production) in the System. During the period 1480-1945, the KA of the System also accelerated.

In case of the System, the following equation applies to the production and redistribution of entropy:

$$\boldsymbol{dS} = \boldsymbol{d}_{societies\ core}\boldsymbol{S} + \boldsymbol{d}_{non\text{-}core}\boldsymbol{S} + \boldsymbol{d}_{State\text{-}System}\boldsymbol{S} = \boldsymbol{d}_{aggregation}\boldsymbol{S} + \boldsymbol{d}_{expansion}\boldsymbol{S} + \boldsymbol{d}_{empowerment}\boldsymbol{S} + \boldsymbol{d}_{KA}\boldsymbol{S}$$

This is a somewhat simplified explanation of matters; but these processes - a combination of entropy-production (new possibilities) and free energy use - shape(d) the System. These processes - aggregation of societies (states) in Europe, expansion of Europe to the non-core (colonization), empowerment, and KA (war dynamics) - are closely related. These processes were regulated by - integral components of - a dissipative structure (the 1st FTS) that emerged through a bifurcation in 1480, when the System was pushed sufficiently far from equilibrium (FFE). These processes reinforced each other and were responsible for the acceleration the System - and its evolution and development - experienced (and still experiences) since 1480. I show in this study, that the processes and rates of aggregation (the decrease of the number of states in Europe, during the period 1480-1945) and Europe's expansion (to the non-core) were synchronized, and that the KA - war dynamics - of the System (not surprisingly) obeyed the Second Law.

1.5. Phase transitions

During the transient period (1480-1945), the 1st FTS accomplished a phase transition, with two complementary effects: Thermodynamic equilibrium in/of the European State-System (core), and the simultaneous merging of the core (Europe) and non-core, resulting in a global State-System.

Thermodynamic equilibrium of the European State-System was accomplished through self-destruction, during the last stage of the phase transition: The 4th systemic war (the Second World War, 1939-1945).

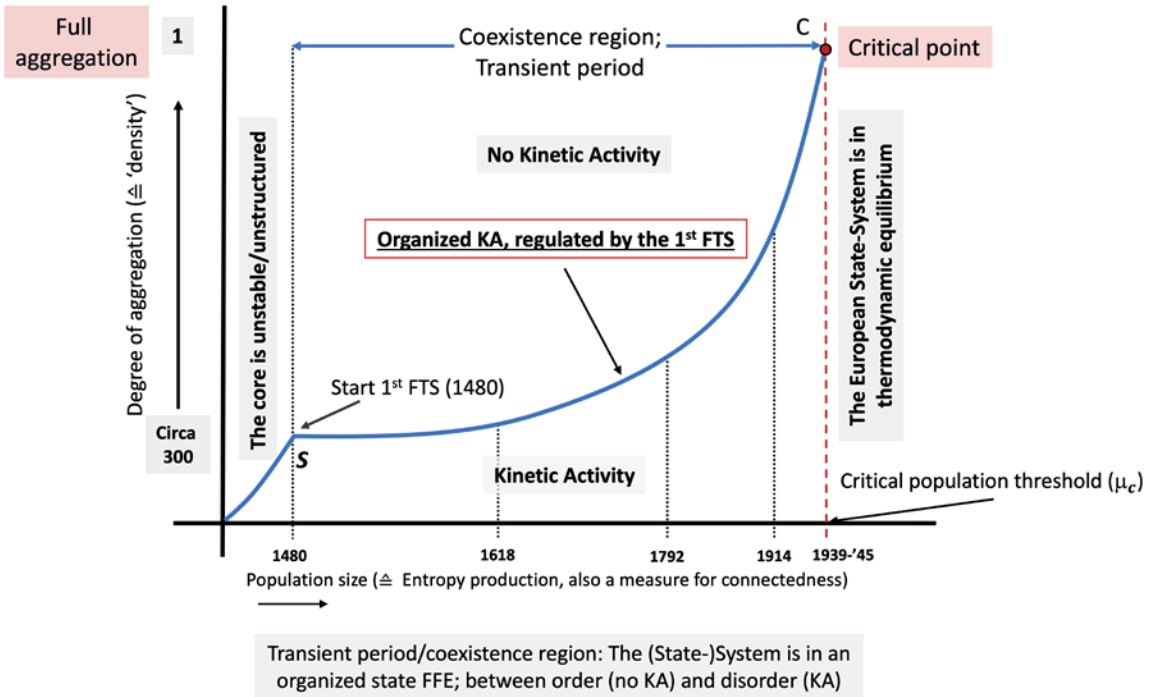


FIGURE 1.14: Phase diagram of the European State-System, 1480-1945.

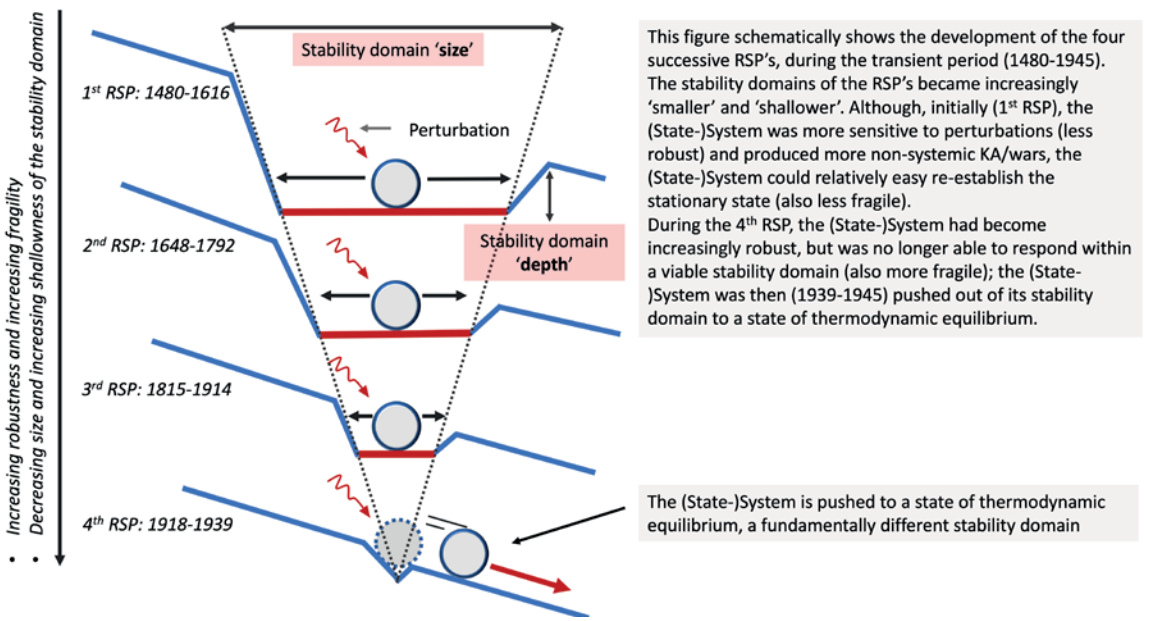


FIGURE 1.15: Increasing robustness and increasing fragility, during the transient period (1480-1945). Through the 1st FTS, the (State-)System was forced into another stability domain.

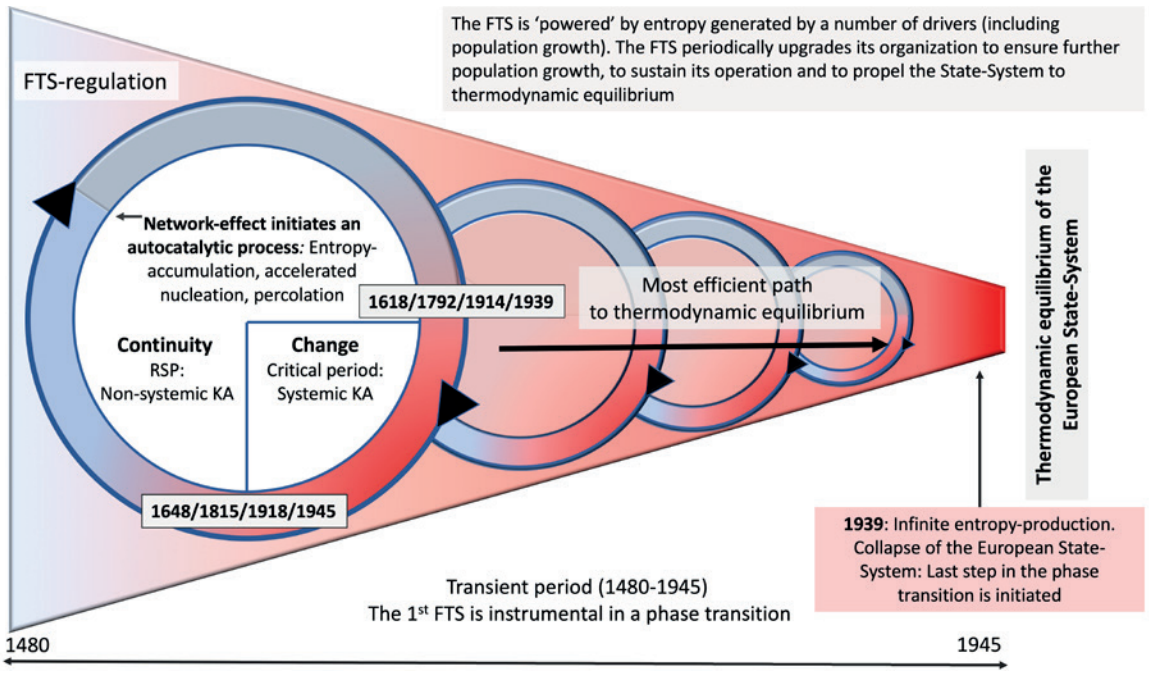


FIGURE 1.16: Continuity and change constitute a positive feedback loop in the State-System, regulated by the FTS. The 1st FTS not only accomplished a phase transition (1480-1945), but also ensured that continuity and change were balanced.

As I show in this study, the 1st FTS consisted of two types of closely related and complementary dynamics, referred to as R1-dynamics - consisting of non-systemic KA/wars during relatively stable periods (RSP's) of KA/war-cycles, subject to FFE thermodynamics - and as R2-dynamics, consisting of (four) accelerating cyclic dynamics, subject to near equilibrium thermodynamics (the MEP-Principle), and the main driver of the phase transition. The main component of the R-dynamics is systemic KA/war, during critical periods. The development of the properties of these two types of dynamics point to the singularity in finite-time that was reached in 1939; also referred to as the critical connectivity or population threshold of the State-System.

The moment the singularity was reached in 1939, the (State-)System produced "infinite" amounts of entropy and KA, and the European State-System consequently collapsed. The critical threshold triggered the last stage in the phase transition (1480-1945): The 4th systemic KA/war, better known as the Second World War (1939-1945).

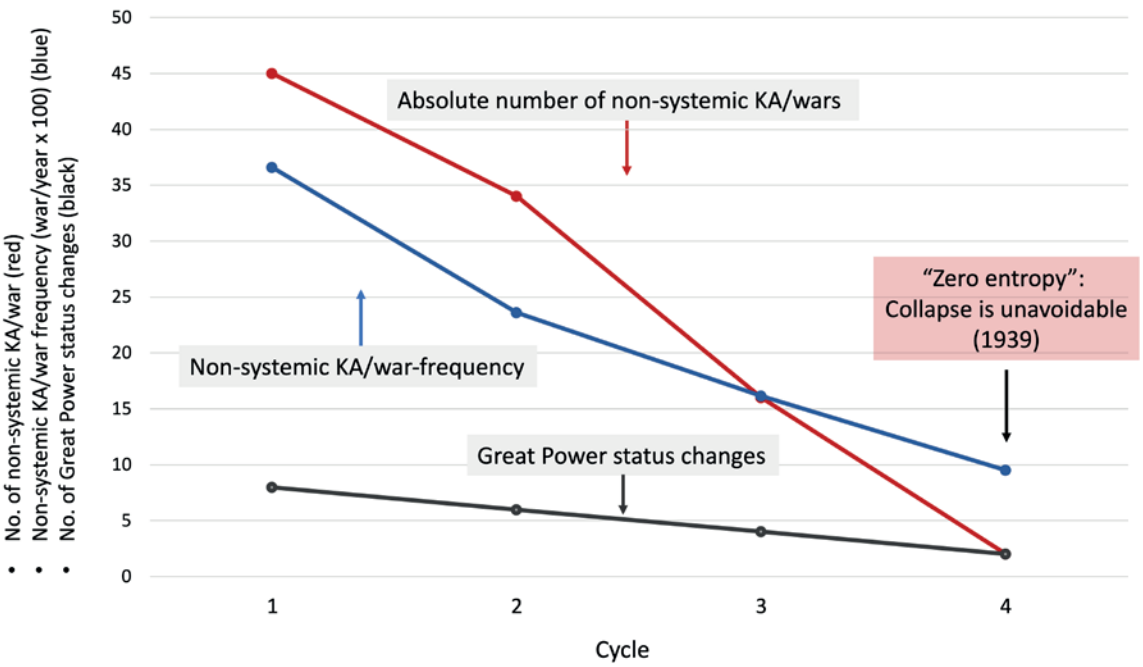


FIGURE 1.17: Properties of R1-dynamics, during successive RSP's, during the transient period (1480-1945). Data from Levy (48).

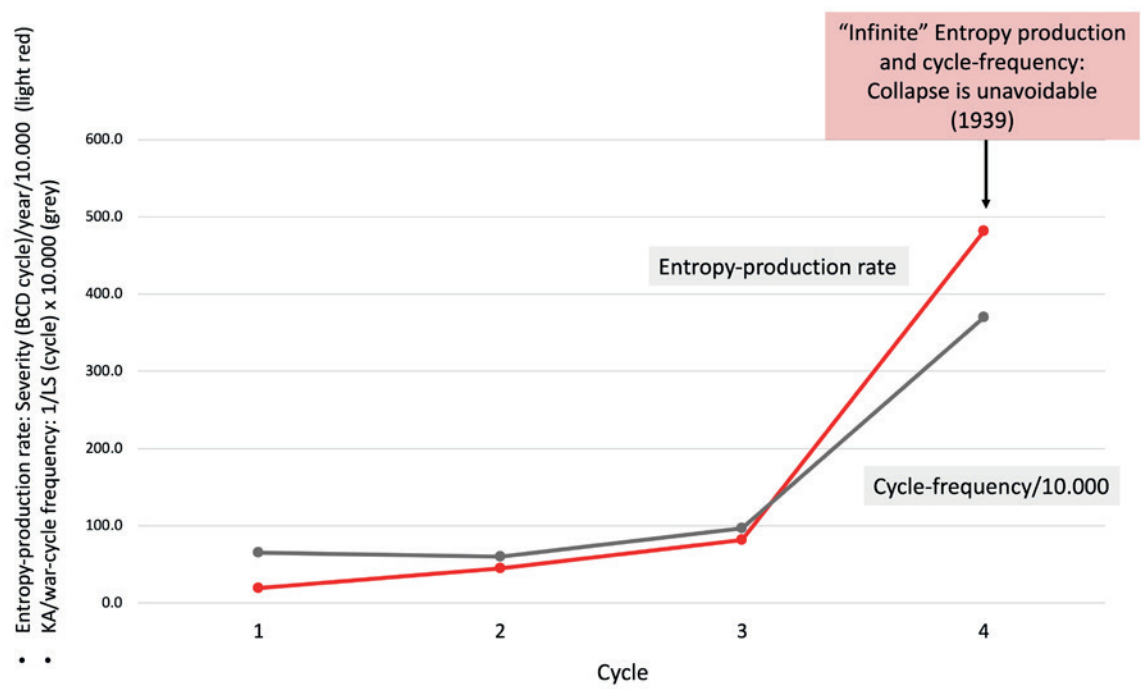


FIGURE 1.18: Properties of R2-dynamics, during successive KA/war-cycles, during the transient period (1480-1945). Data from Levy (48).

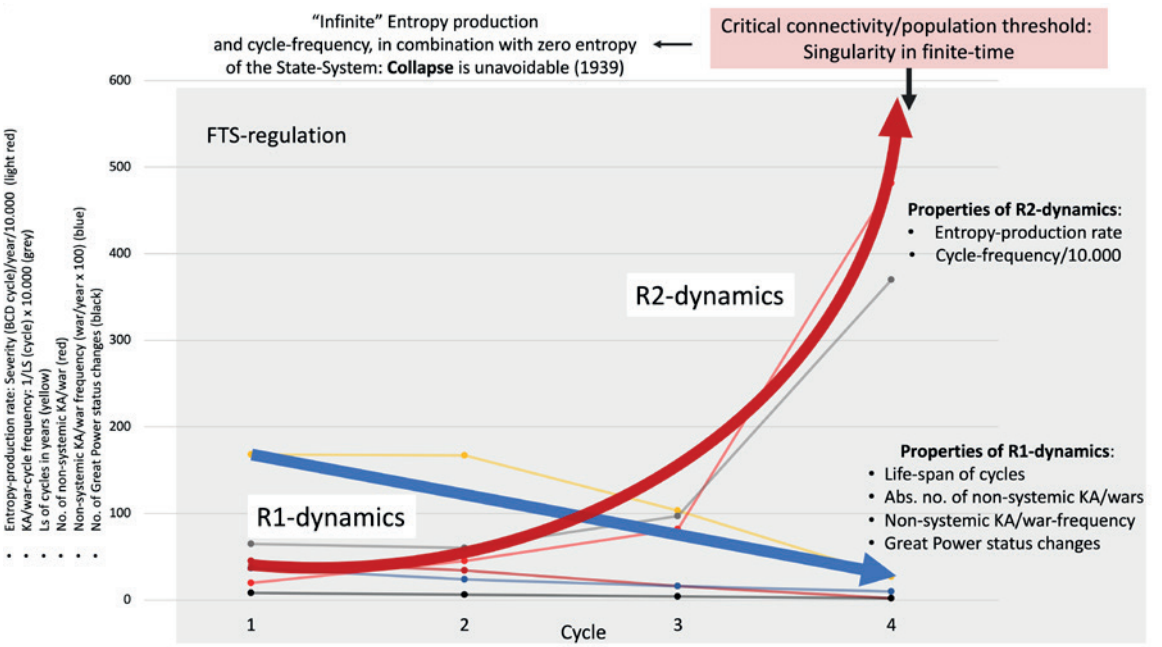


FIGURE 1.19: Properties of R1- and R2 dynamics, during successive KA/war-cycles, during the transient period, the life-span of successive cycles included. Data from Levy (48).

R1 and R2-dynamics the FTS generated (and still generates) and orchestrated are complementary: The R2-dynamics were generated by the R1-dynamics through the network-effect that was activated when the tipping point of the RSP was reached in respectively: 1618, 1792, 1914 and 1939. The network-effect caused the accumulation of entropy and caused the (State-)System to become critical. During criticality, the R2-dynamics (systemic KA) ensured that the order of the (State-)System was upgraded (again). Through the upgrade - produced by the R2-dynamics - the R1-dynamics could continue, during the RSP that followed.

The combination - the interplay - between both types of dynamics was instrumental in accomplishing the phase transition (1480-1945).

The combination of R1- and R2- dynamics also ensured that the 1st FTS was (and stayed) optimized, and that continuity and change were optimally balanced in the (State-)System. The 1st FTS ensured that exponential population growth - the underlying driver of the FTS and the related processes of aggregation, expansion and empowerment - could also be sustained. The related processes were not only instrumental in the redistribution of entropy, but also supported the maximization of entropy-production of the System.

From a thermodynamic perspective, these dynamics and processes ultimately served only a singular objective: To achieve thermodynamic equilibrium in the European State-System (the core), via the most efficient path, in accordance with laws of thermodynamics and related principles. The population growth that was accomplished not only ensured the continuous acceleration of the 1st FTS, but also that a phase transition could be accomplished.

1.6. Two types of dynamics and KA/wars

Based on the analysis of the System - and the 1st FTS in particular - it is possible to distinguish two fundamentally different types of KA/war-dynamics: (1) Non-systemic KA/war dynamics (R1-dynamics), during RSP's of KA/war-cycles, that are normally chaotic in nature, and subject to FFE thermodynamics, and (2) cyclic systemic KA/war dynamics (R2-dynamics), during critical periods, that are subject to near equilibrium thermodynamics.

The two types of KA/war dynamics have fundamentally different properties, whereas - for example - chaotic non-systemic KA/wars are intrinsically unpredictable, cyclic systemic KA/wars are highly predictable; and whereas the purpose of chaotic non-systemic KA/wars during RSP's is to maintain a dynamic steady state - to ensure continuity, in other words to maintain the status quo - the purpose of systemic KA/wars is to implement change (to upgrade the order of the (State-)System. The FTS ensures that continuity and changed are balanced, and the State-System accomplishes thermodynamic equilibrium via the most efficient path, in accordance with the Second Law and related principles.

TABLE 1.1: Fundamental differences between systemic and non-systemic KA/wars.

	Non-systemic KA/war	Systemic KA /war
Type of dynamic	R1, FFE.	R2, near equilibrium.
Phase of war-cycle	During RSP's, relatively long subcritical periods.	During relatively short critical periods.
Attractor	Strange (fractal) attractor.	Limit cycle.
Nature of dynamic	Chaotic dynamics.	Cyclic/periodic dynamics.
Trigger of KA	Through entropic perturbations during RSP's.	An incident triggers a massive response and accumulated entropy is released.
Predictability	Timing, duration, size and severity are intrinsically unpredictable; there is a high sensitivity for initial conditions.	Timing, duration, size and severity of systemic KA (systemic wars) are highly predictable.
Size of kinetic response/KA	Limited in size (in terms of fraction): Not all Great Powers are involved.	The kinetic response is system-wide: All Great Powers are involved.
Correlation length (CL)	CL < 1: System-wide communication and coordination are not enabled.	CL = 1, and a divergence of the correlation length: System-wide communication and coordination are enabled. During criticality (systemic KA), the divergence of the correlation length, ensures the involvement of all Great Powers, and enables the exploration of viable solutions and the selection and implementation of an upgraded order.
Purpose	Continuity: EMIS-regulation of the existing order; maintenance of the status quo; exploration of phase space; the outcome of the KA is embedded in phase space/vulnerable-clusters.	Change: Design and implementation of an upgraded order.
Nucleation	Non-systemic KA (non-systemic wars) is preceded by a process of local nucleation of tensions and issue(s).	Systemic KA (systemic war) is preceded by a system-wide process of nucleation during RSP's (RSP-nucleation).

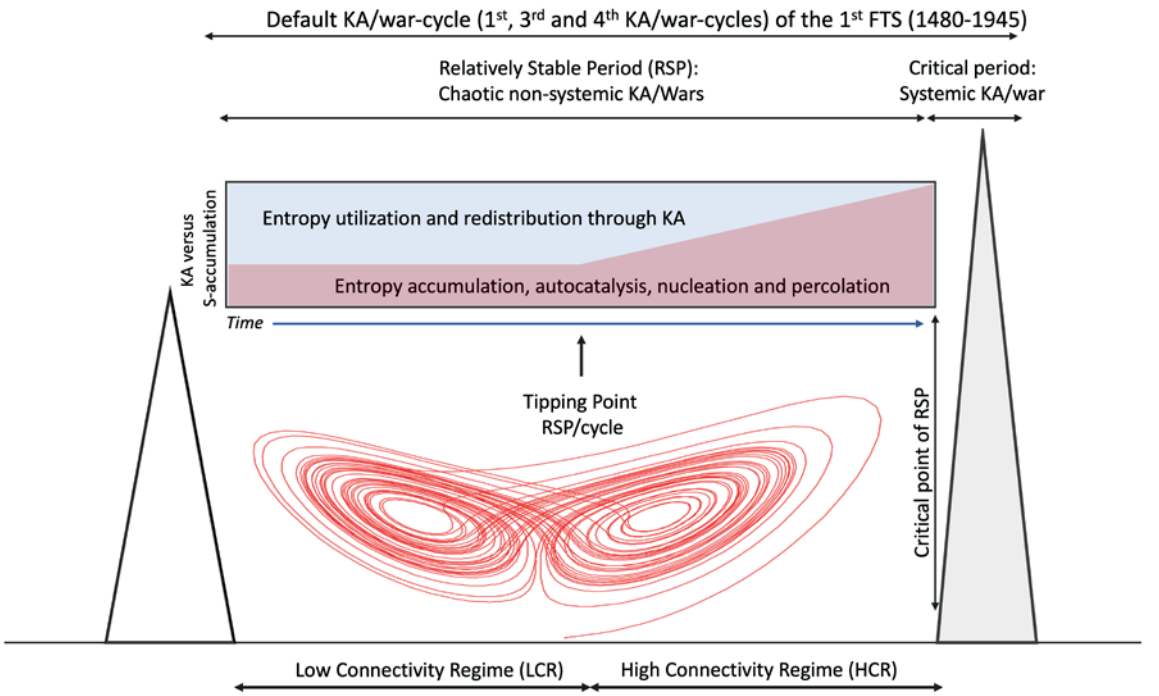


FIGURE 1.20: The chaotic nature of non-systemic KA/wars. Normally, during RSP's non-systemic KA/wars are chaotic in nature.

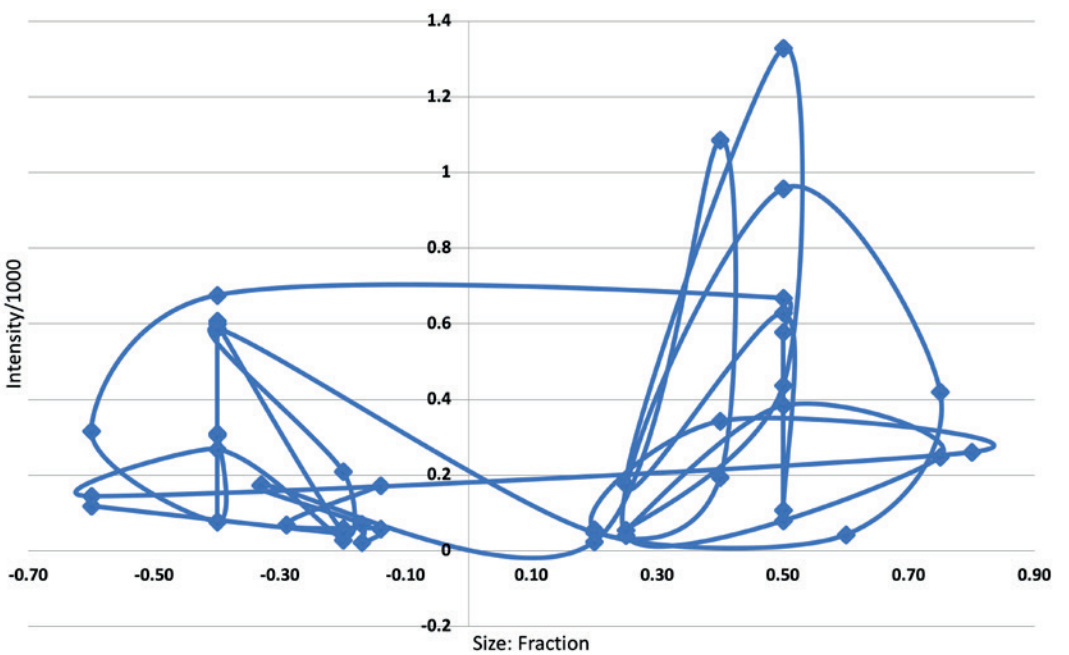


FIGURE 1.21: Orbits in phase space. Analysis of KA/war-data shows that the (State-)System produces orbits in phase space. In this figure phase space of non-systemic KA/wars during the period 1495-1618 is shown. The orbits point to the (possible) chaotic nature of the KA/war dynamics. Data from Levy (48).

Further analysis not only shows that normally during RSP's, non-systemic KA is chaotic in nature and highly optimized, but that during the period 1657-1763 - referred to as the 1st exceptional period - non-systemic KA was (temporarily) not chaotic, but periodic in nature, and that these abnormal KA/wars impacted on the efficiency of the 1st FTS.

In case of chaotic dynamics - between order and disorder - there is a combination of randomness and large-scale regularities. Chaotic war dynamics and the complex state of the (State-)System are related. Through chaotic dynamics new microstates can be explored. The KA of the (State-)System - war dynamics - are instrumental in a process of exploration - finding new solutions and opportunities - and in their selection.

Periodic dynamics on the other hand, are much more limited in their ability to explore. Periodic dynamics are less restrained in their magnitude: Periodic dynamics lack a third - restraining - degree of freedom. This - the absence of a third degree of freedom - explains why the (State-)System produced a series of "unrestrained" non-systemic KA/wars with a large size and magnitude, during the 1st exceptional period.

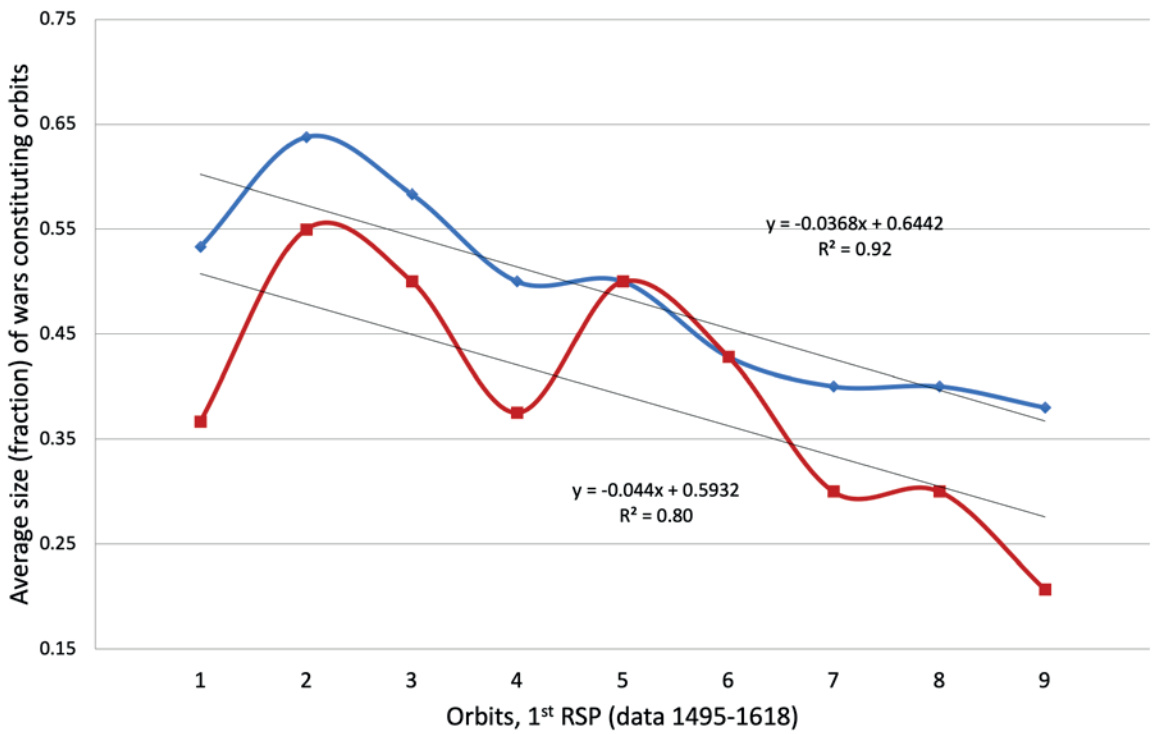


FIGURE 1.22: A damped oscillator (1495-1618). The nine orbits the (State-)System produced during the period 1495-1618), constitute a damped oscillator. Data from Levy (48).

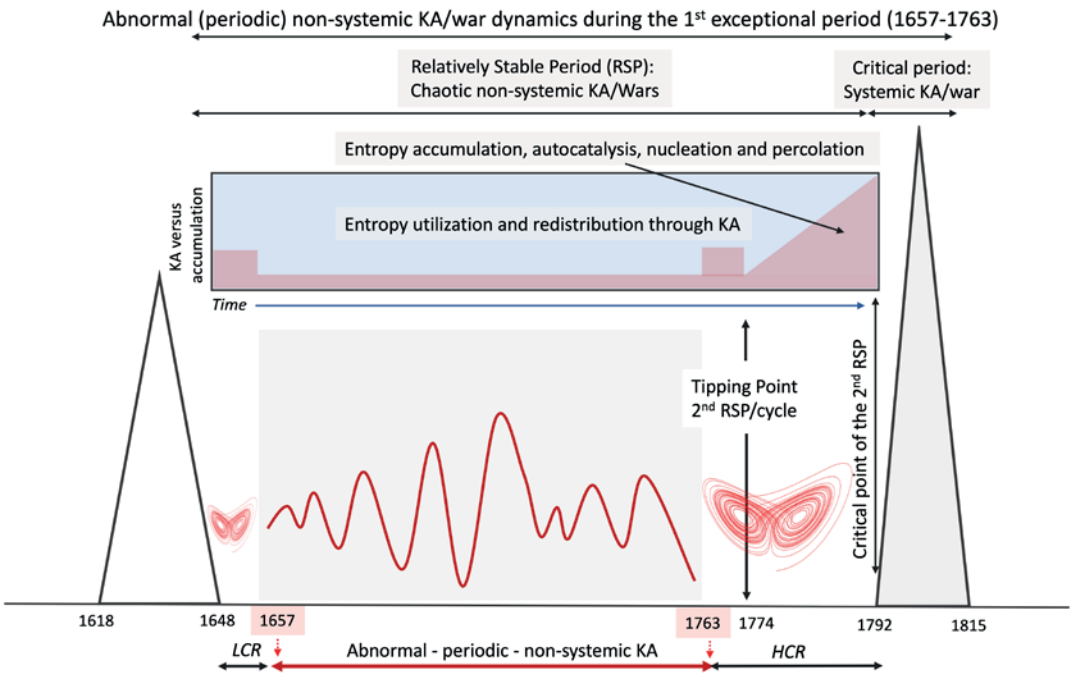


FIGURE 1.23: The 1st exceptional period (1657-1763). During the period 1657-1763, the non-systemic KA/wars were "abnormal" - non-chaotic - and periodic in nature.

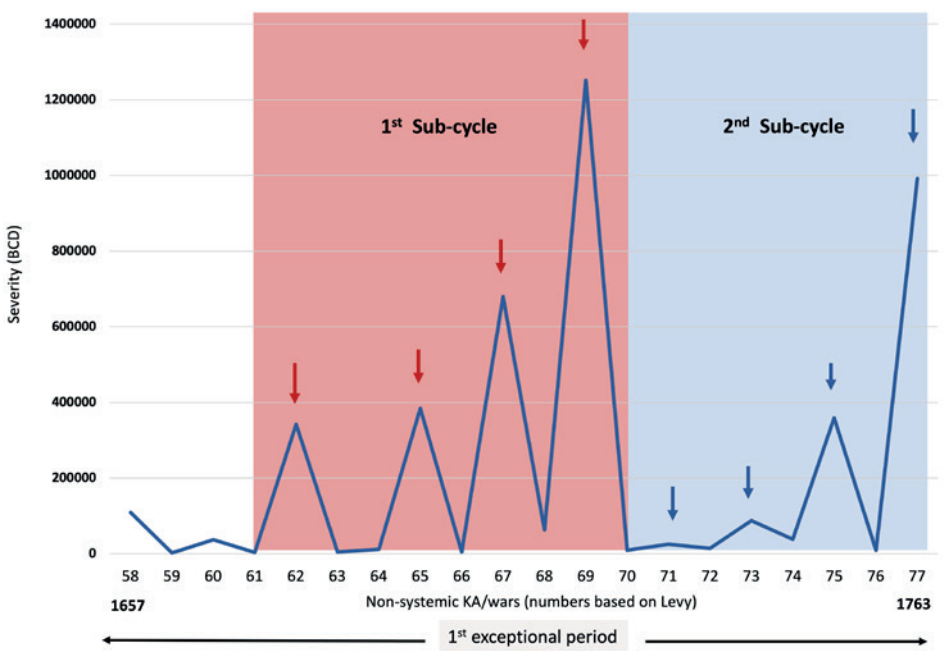


FIGURE 1.24: Two subcycles during the 1st exceptional period (1657-1763). During the 1st exceptional period, the periodic non-systemic KA/wars formed two "identical" subcycles.

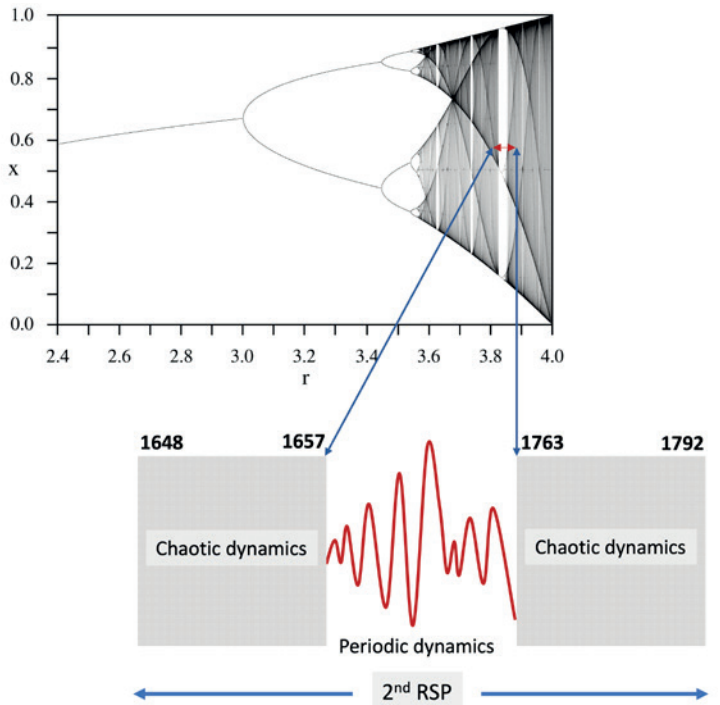


FIGURE 1.25: Periodic window. The 1st exceptional period (1657-1763) can be considered a periodic window, during the 2nd RSP (1648-1792).

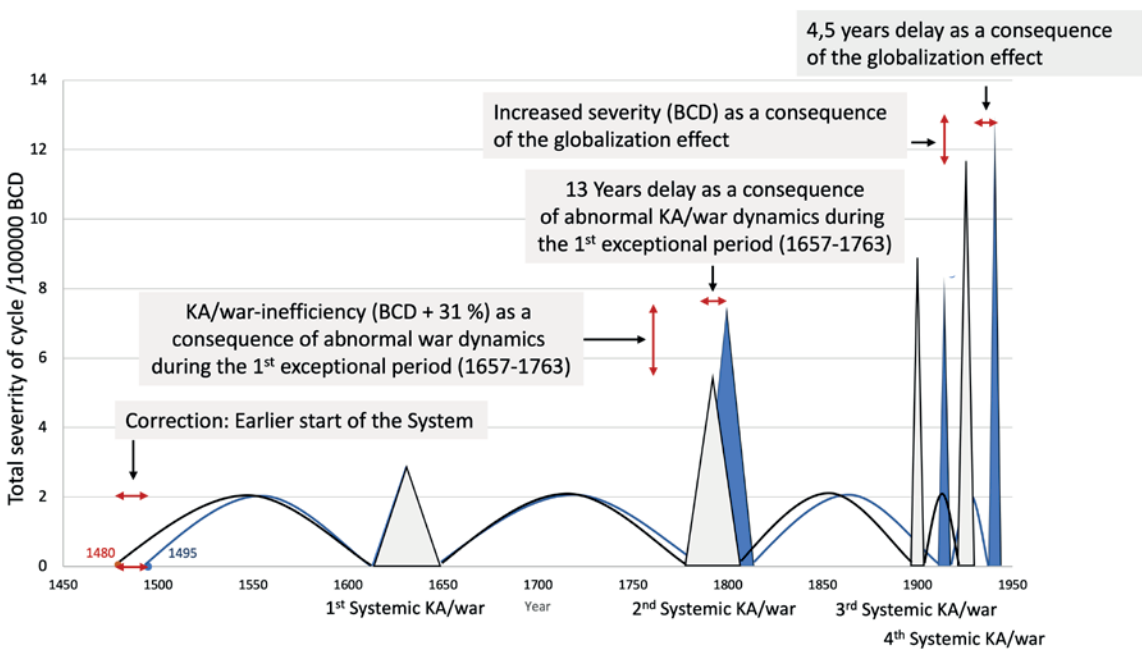


FIGURE 1.26: Inefficiencies of the 1st FTS (1480-1945). The abnormal (periodic) non-systemic KA/wars during the 1st exceptional period (1657-1763), caused several inefficiencies.

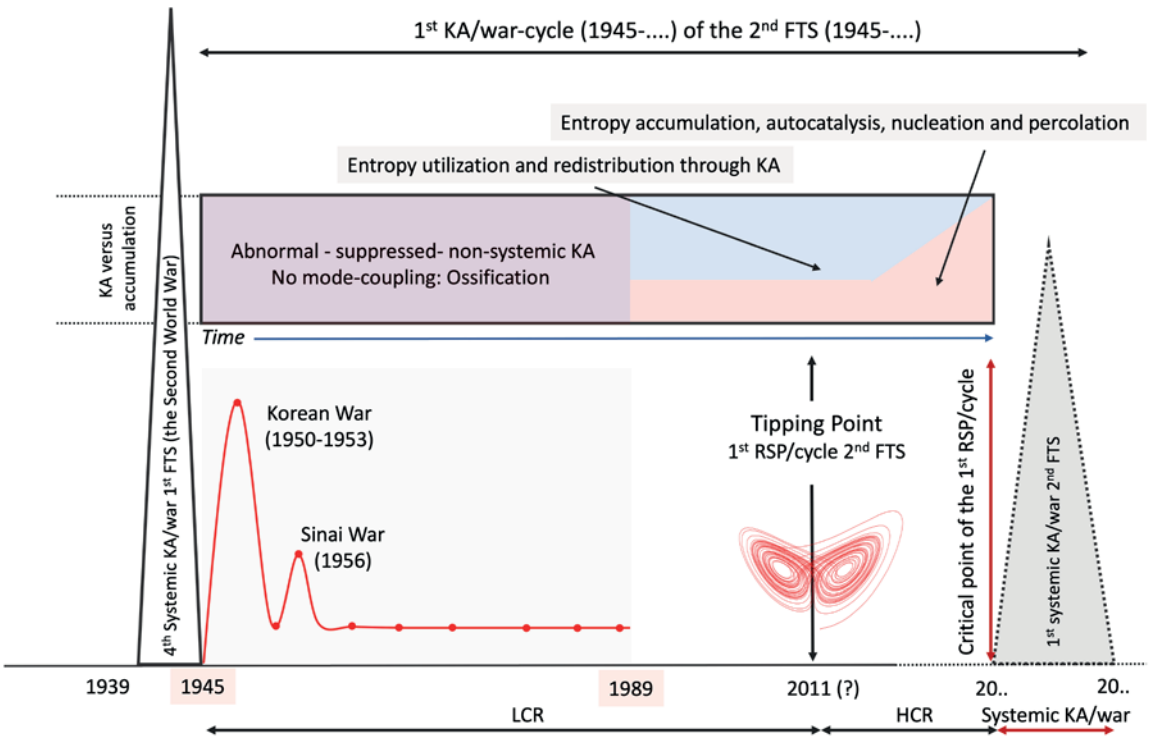


FIGURE 1.27: Phase space of the RSP of the 1st global KA/war-cycle (period 1945-2018).

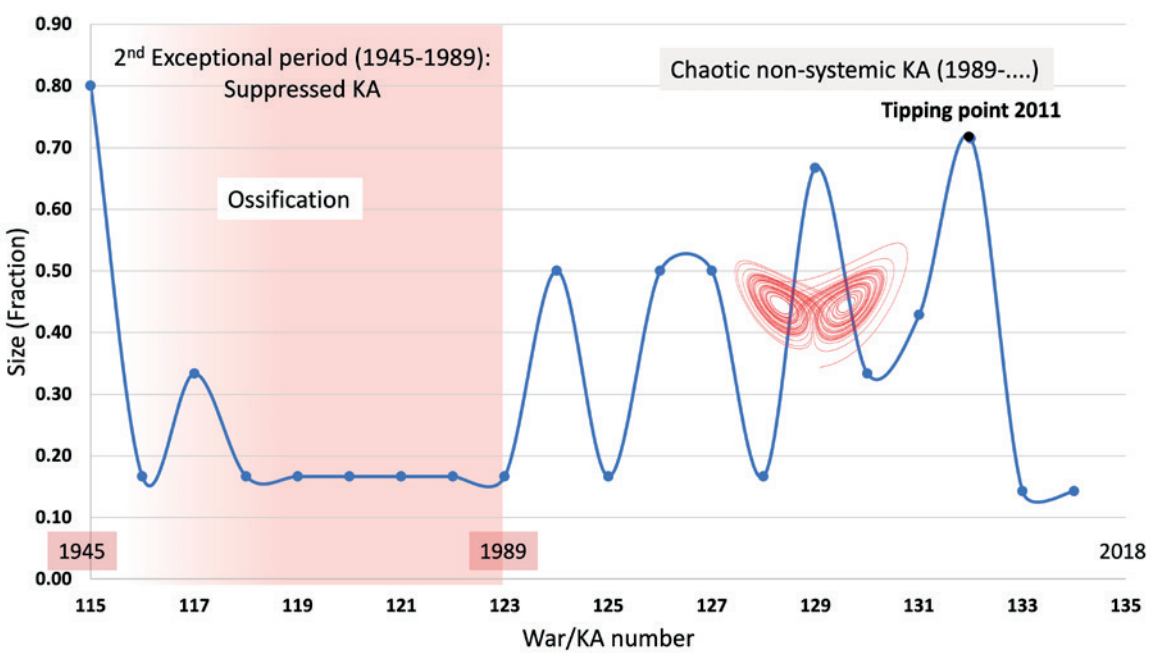


FIGURE 1.28: Schematic representation of phase space of the RSP of the 1st global KA/war-cycle (period 1945-2018).

However, abnormal non-systemic KA/wars were not restricted to the period 1657-1763, the global (State-)System, also produced abnormal non-chaotic - mostly highly suppressed non-systemic KA/wars - during the period 1945-1989, referred to as the 2nd exceptional period, but better known as the Cold War. The abnormal war dynamics during the two exceptional periods, have in common that in both cases, the mode-coupling of the (State-)System (of the respective FTS's) was disturbed by the intense rivalries between two great powers (respectively between Britain and France, during the 1st exceptional period (1657-1763), and between the United States and the Soviet Union, during the 2nd exceptional period (1945-1989)). In both cases, the abnormal KA/war dynamics impacted on the macroscopic behavior of the (State-)System.

1.7. The thermodynamics of KA/war

The (State-)System and societies/states are systems that must obey physical laws, e.g. the Second Law and related principles that apply FFE. KA/war is a kinetic response of the (State-)System to entropic perturbations, in accord with the Second Law and related principles that apply FFE. Non-systemic KA is triggered and regulated by the FTS, to ensure that the System complies with the Second Law and related principles, and that the State-System follows the most efficient path to thermodynamic equilibrium. A combination of probabilistic and deterministic factors determines which perturbations/issues are amplified by the FTS.

In this paragraph, I have a closer look at the interplay between non-systemic KA/war and the (State-) System and determine conditions that determine the 'utility' of KA, of force (military capabilities), from an entropy-/energy-perspective. What KA can be potentially effective/useful to the State-System?

To maintain the coherence of the FTS and the State-System, KA must be generated and sustained. KA of the System - regulated by the FTS - is instrumental in the (State-)System's development and evolution, and of its components (i.e. societies/states).

These processes - the construction and maintenance of order - require free energy, as Military capabilities constitute the free energy that is applied in the State-System during KA/war, in the contingent domain. Military capabilities are generated through the transformation of 'societal' energies into military capabilities; a process that is regulated by the state, and in which entropy (issues and tensions) serve as a catalysator.

The free energy that is released during KA/war is instrumental in the further organization of the (State-) System.

To build structures - to further organize the (State-)System - so-called energetically favorable processes, which release energy (like KA/wars) and produce entropy (in the process), must be coupled to energetically unfavorable processes, which 'absorb' - use - free energy to sustain or upgrade the order of the System. This coupling is accomplished and regulated by the FTS.

Before discussing the utility of KA, I first discuss the terms "energetically favorable" and "energetically unfavorable" processes and explain why they must be coupled.

According to the Second Law, a process can proceed only spontaneously, if it results in a net increase in disorder (entropy, $\Delta \boldsymbol{S} > \mathbf{0}$) of the 'overall' system.

The criterion for an increase in disorder ($\boldsymbol{S}$) of the overall system "can be expressed most conveniently in terms of the quantity free energy", $\boldsymbol{F}$, of a system (2). As explained in chapter 2, $\Delta \boldsymbol{F}$ is a measure for the

disorder $\boldsymbol{S}$ that is created ($\boldsymbol{E}$ (the total energy) = $\boldsymbol{F}$ (free energy) + $\boldsymbol{S}$ (entropy), at least if the system is not open). The value of $\boldsymbol{F}$ is of interest only when a system undergoes a change - as is the case for KA/war (a correction is made, or the order is upgraded) - and the change in $\boldsymbol{F}$ ($\Delta\boldsymbol{F}$), is critical (2).

A reaction or process $\boldsymbol{Y} \rightarrow \boldsymbol{X}$ is said to be energetically favorable - the process can take place spontaneously - if the free energy of $\boldsymbol{Y}$ is greater than the free energy of $\boldsymbol{X}$. Then, $\Delta\boldsymbol{F} < \boldsymbol{0}$ and the disorder of the overall system (environment) can increase during the process ($\Delta\boldsymbol{S} > \boldsymbol{0}$), in accord with requirements of the Second Law.

However, if the reverse process $\boldsymbol{X} \rightarrow \boldsymbol{Y}$ would occur, $\Delta\boldsymbol{F} > \boldsymbol{0}$, and the environment would become more ordered ($\Delta\boldsymbol{S} < \boldsymbol{0}$), this process can only occur, if it is coupled to a second, energetically favorable reaction/process, which supplies the free energy, and ensures the Second Law is not violated (2).

KA/war qualifies as energetically an *un*favorable "reaction": $\Delta\boldsymbol{F} > \boldsymbol{0}$: Based on the thermodynamic analysis of KA/war two minimal requirements are critical for KA/wars to take place spontaneously: (1) The Second Law $\boldsymbol{dS} = \boldsymbol{d_eS} + \boldsymbol{d_iS} \geq \boldsymbol{0}$ cannot be violated, which requires the coupling of the KA/war to a suitable environment (for the exchange ("dumping") of entropy), and because KA/war is an energetically unfavorable reaction/process ($\Delta\boldsymbol{F} > \boldsymbol{0}$), (2) the KA/war must be coupled to a second energetically favorable reaction/process. These basic requirements apply to non-systemic KA/wars, systemic KA/wars, but also to the phase transition that took place during the period 1480-1945. These are deterministic factors that (besides probabilistic factors) impact on the selection of entropic perturbations (issues) for amplification by the FTS.

The fact that the MEP-Principle applies to (State-)System results in the following direction of development of the entropy and free energy of the State-System:

$\boldsymbol{S}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_1}) > \boldsymbol{S}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_2})$ and $\boldsymbol{F}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_1}) < \boldsymbol{F}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_2})$, this can be considered a third requirement that applies to KA/war dynamics in the State-System.

In case of KA/war in the State-System, societies and other states (not involved in the KA/war) and the "wider" System, serve as environments for the exchange of entropy, to ensure that the first requirement ($\boldsymbol{dS} = \boldsymbol{d_eS} + \boldsymbol{d_iS} \geq \boldsymbol{0}$) is not violated.

The coupling of the energetically unfavorable KA/war process to energetically favorable societal processes, ensures the KA/war can spontaneously proceed. These societal processes concern the transformation of societal energies into military capabilities; a process in which entropy (tensions) serve as catalysator. These societal processes are directed by the state, which uses its double linking-pin function (as regulator of societies, and environments of societies, including the State-System, see chapter 12).

The FTS - a manifestation of the Second Law and related principles that apply FFE - ensures that the third requirement $\boldsymbol{S}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_1}) > \boldsymbol{S}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_2})$ and $\boldsymbol{F}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_1}) < \boldsymbol{F}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_2})$ is not violated; this ensures that the most efficient path to thermodynamic equilibrium of the State-System is followed.

If these minimum requirements are not met - apart from the fact that the selection of an entropic perturbation (issue) for amplification also involves probabilistic factors - the KA/war cannot and will not take place. The KA/wars the (State-)System produced - that by definition includes all wars in Levy's database - met the three requirements.

I will use these requirements to discuss two KA/wars in the next paragraphs: A KA/war that did not take place, and the War in Afghanistan, which is considered a failed war.

This study also shows that the (State-)System can only become critical, if the non-systemic KA/wars during RSP's is chaotic in nature; as the effects of abnormal non-systemic war dynamics during the 1st exceptional period (1657-1763) of the 2nd cycle (1648-1815) show (discussed in chapter 30).

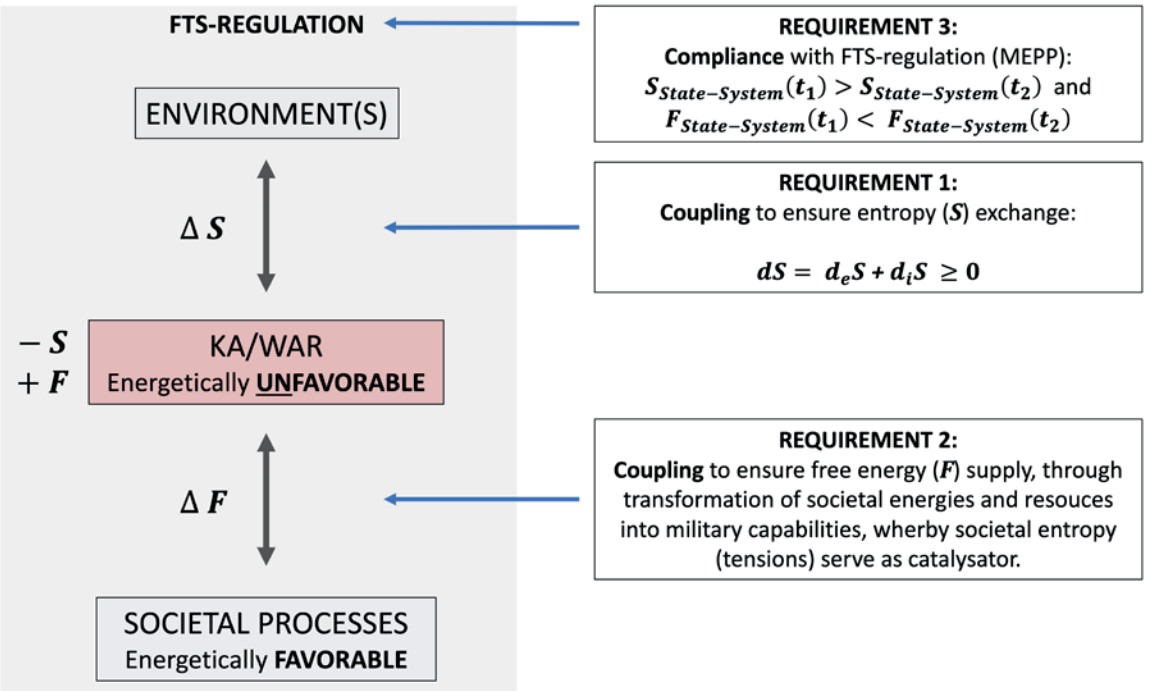


FIGURE 1.29: Thermodynamic requirements for KA/war.

Chaotic non-systemic KA/wars during RSP's ensure that VC 's with fractal structures nucleate and percolate the (State-)System. It is a requirement for the (State-)System to be prepared by chaotic non-systemic KA during RSP's that produce VC's with fractal structures that subsequently enable a critical condition - including a divergence of the correlation length - when these VC's are eventually activated.

1.8. The interplay between probabilistic and deterministic factors and the intrinsic (un)predictability of KA/war dynamics

A general feature of bifurcations is the unpredictability of the organized state - the dissipative structure - that will be "selected" by the bifurcation: "It is curious to observe that the same system may give rise to several types of dissipative structures by only slight changes of the boundary conditions" (62). The 1st FTS (1480-1945) as we (now) know it - including the social and political processes that were "facilitated" by the 1st FTS - is just one of many variants.

In case of a bifurcation, there is an interplay between chance and constraint; between determinism and the probabilistic nature of the system involved.

The systems concerned "obey deterministic laws, such as the laws of chemical kinetics, between two bifurcations points, while in the neighborhood of the bifurcation points fluctuations play an essential

role and determine the "branch" that the system will follow" (63). Prigogine shows how a bifurcation - symmetry-breaking - links dynamical and probabilistic processes (66), and how a microscopic formulation of the Second Law of thermodynamics is obtained (66).

The probability of small fluctuations that are amplified, determine the subsequent configuration and behavior of the system "by choosing one among the many possible solutions a priori available for the system". This choice, "represents the historical element which has to be added to the system to determine, together with the causal laws, its future evolution".

Thus, as a result of random fluctuations, or other random factors such as small inhomogeneities or imperfections, the system evolves to one of the many possible states. Which one of the organized states a particular system will evolve to is, in general, not predictable: It is the result of the interplay between determinism and the probabilistic nature of these systems: "(...) for a given set of nonequilibrium conditions, it is often possible to have more than one state" (62).

"The new states thus attained are often 'ordered states' that possess spatiotemporal organization. Patterns in fluid flow, inhomogeneities in concentrations exhibiting geometrical patterns with great symmetry or periodic variations of concentrations are examples of such ordered states. Because of its fundamental character, we shall refer to the general phenomenon of a nonequilibrium system evolving to an ordered state as a result of fluctuations as order through fluctuations" (44). These fluctuations are intrinsic to the system's (internal) dynamics (as is the case with the harmonica behavior of traffic flows, discussed earlier).

Prigogine explains in reference to the outcome of a bifurcation: "Nothing in the description of the experimental setup (*IP: of experiments Prigogine describes*) permits the observer to assign beforehand the state that will be chosen; only chance will decide, through the dynamics of fluctuations.

"The system will in effect scan the territory and will make a few attempts, perhaps unsuccessfully at first, to stabilize. Then a particular fluctuation will take over. By stabilizing it, the system becomes a historical object in the sense that its subsequent evolution depends on the critical choice" (66). There is an "remarkable interplay between chance and constraint, between fluctuations and irreversibility": "(...) the passage toward complexity is intimately related to the bifurcation of new branches of solutions following the instability of a reference state, caused by the nonlinearities and the constraints acting on an open system" (66).

For a perturbation/ issue to become FTS-regulated, it must have a certain "activation entropy", it seems. The activation entropy depends on nonlinear effects that are generated, i.e. through the amplification of certain aspects of the issue. Besides certain deterministic elements, probabilistic elements and the sensitivity of the (State-)System for certain conditions play also an important role in the selection of entropic perturbations/issues that will be scaled up: There is an interplay between probabilistic and deterministic factors. Because of the probabilistic elements involved in issues and incidents, their entropic potential and 'ability' to generate kinetic responses, cannot be established.

As history and contemporary developments show, we are not able to accurately predict even the most basic properties of issues and wars: Sometimes issues we expect to escalate just fade out, while in other cases, we are taken by surprise when a localized and initially insignificant incident escalates into non-systemic KA, as was for example the case with the Arab Spring that started in Tunisia in 2010, with a seemingly minor incident, but activated a (not yet fully percolated) VC.

The probabilistic nature of bifurcations - of (the laws of) thermodynamics - contributes to the unpredictability of these dynamics. Other factors that contribute to the unpredictability of the dynamics of the (State-)System include: The indeterminateness of the Second Law, probabilistic factors that

determine the selection of fluctuations, the (intrinsic) unpredictability of chaotic non-systemic KA/wars, the available contingent latitude in the (State-)System and the indeterminateness of novelty by combination.

1.9. The interplay between competing thermodynamic potentials: A closer look

The FTS not only involves an interplay between probabilistic and deterministic factors, but also between competing thermodynamics potentials (and their extremization), and the interplay between the so-called entropic- or S-imperative and the homeostatic- or H-imperative (a subject that will be discussed in the next paragraph).

The paradox of the (State-)System is that whereas the principal of *minimum* entropy-production (the MEP-Principle) applied to the State-System and determined and shaped the R1- and R2-dynamics of the System, the principal of *maximization* of entropy-production applied to the System (FFE): By sustaining the FTS, continuity and change were balanced in the System and population growth and thus entropy-production - the basic driver of the (State-)System - were consequently maximized.

The principle of *minimization* of entropy-production that applied to the State-System, and the principle of the *maximization* of entropy that applied to the System, play the same role as thermodynamic potentials in equilibrium theory (62).

The interplay between competing thermodynamic potentials (and their extremization) refers to the competing (conflicting) thermodynamic potentials (sub)systems of the System pursue. The interplay is orchestrated - and utilized - by the FTS to ensure thermodynamic equilibrium of the State-System is achieved via the most efficient path, in accordance with the Second Law and related principles that apply FFE.

A thermodynamic potential is a quantity used to represent the thermodynamic state of a system. I assume that the amounts/levels and production-rates of free energy ($\boldsymbol{F}$) and entropy ($\boldsymbol{S}$) represent the ("defining") thermodynamic potentials of social systems.

Societies (through states), the State-System and the System pursue different thermodynamic potentials, and the interactions - competition in some respects - that consequently take place, in combination with the laws of thermodynamics and related principles that apply, shape these systems and their dynamics.

I assume that societies (regulated by states) pursue minimum $\boldsymbol{F}$ (no military capabilities) and intermediate amounts/levels of (societal) entropy, through homeostatic control; the State-System pursues minimum amounts of entropy (issues and tensions), minimum $\boldsymbol{F}$ (KA), and minimum entropy-production (the MEP-Principle applies to the State-System), through FTS-regulation, and the System pursues maximum entropy and entropy-production, within the limitations imposed by the FTS.

TABLE 1.1: Extremization of thermodynamic potentials during (sub)phases. The respective thermodynamic potentials that directed both types of dynamics competed - so to speak - and resulted in the maximization of entropy-production by the System, and the simultaneous push to zero entropy of the (structure of the) State-System, through the application of the MEP-Principle.

(Sub)system	Corresponding dynamic	Entropy		Free energy/KA	Remarks
		Production	Level/amount		
State-System during RSP's, stationary states	A stationary state is maintained through chaotic non-systemic KA (R1-dynamics) regulated by the FTS (an organized structure FFE).	**Minimization** (= thermo-dynamic potential); MEP-principle.	**Maintain** constant, within certain range.	**Minimization**, but selective use to neutralize entropic perturbations (issues in the contingent domain).	Entropic perturbations trigger KA, to neutralize the perturbations.
State-System	Cyclic systemic KA (R2-dynamics) Near equilibrium dynamics, instrumental in the lowering of the entropy/energy-state and eventually in a phase transition, regulated by the FTS.	**Minimization** (= thermo-dynamic potential); MEP-principle.	**Minimization** to zero entropy.	**Minimization**.	The four upgrades constitute steps in a phase transition.
System (1480-1945)	A dissipative structure dynamic FFE; including processes of KA, aggregation (core), expansion to non-core and empowerment in core; regulated by the FTS.	**Maximization** (= thermo-dynamic potential).			It is a process of growth, contained by the carry capacity of the System, the System itself enhances with the support of the FTS.
The European State-System erstwhile core (>1945)	Thermodynamic equilibrium (following the phase transition.	**No entropy-production**.	**Maximum**.	**Minimum**.	

It is possible to distinguish three conflicts between thermodynamic potentials that are pursued by (sub) systems, and play a role at System-level:

1. *An internal conflict between thermodynamic potentials the State-System pursues*: The State-System tries to minimize free energy (***F***, KA), entropy (issues and tensions, ***S***); and entropy-production, simultaneously; however, this cannot be accomplished. A decrease of entropy (issues and tensions) in the State-System requires organization and the application of free energy; KA (the deployment of military capabilities of states): More entropy(-production) requires more free energy ***F***.
   The State-System is (obviously) not able to overcome (ignore) this basic thermodynamic principle. During RSP's the FTS regulates the competing thermodynamic potentials the State-System pursues through non-systemic KA/wars: Entropic perturbations (issues and tensions) are neutralized through non-systemic KA at a localized scale, in efforts to "correct" and maintain the existing order (the status-

quo). Because entropy is produced at an accelerating rate and a network-effect at a certain point causes the accumulation of entropy, criticality and a systemic kinetic response cannot be avoided. In accord with the MEP-Principle the systemic KA is used to implement an upgraded order, that allows for a lower energy- and entropy state.

2. *A conflict between the thermodynamic potentials the State-System and System pursue*: The State-System pursues minimum F, minimum S, whereas also the MEP-Principle applies; the System on the other hand pursues maximum entropy(-production), through population growth. Population growth directly and indirectly contributes to accelerating entropy-production, the State-System and societies/states subsequently have to deal with.
   The FTS cunningly utilizes the increased entropy-production - as I will explain - to push the State-System to zero-entropy, and eventually to fulfill its purpose (thermodynamic equilibrium of the State-System).
3. *A conflict between the thermodynamic potentials the System and societies/states pursue*: The System pursues maximum entropy(-production), while societies states can only deal with intermediate levels of (societal) entropy. States are responsible for societal entropy-regulation and utilize numerous mechanisms to regulate entropy-input from (e.g.) the System, including empowerment, the State-System, and by raising boundaries.

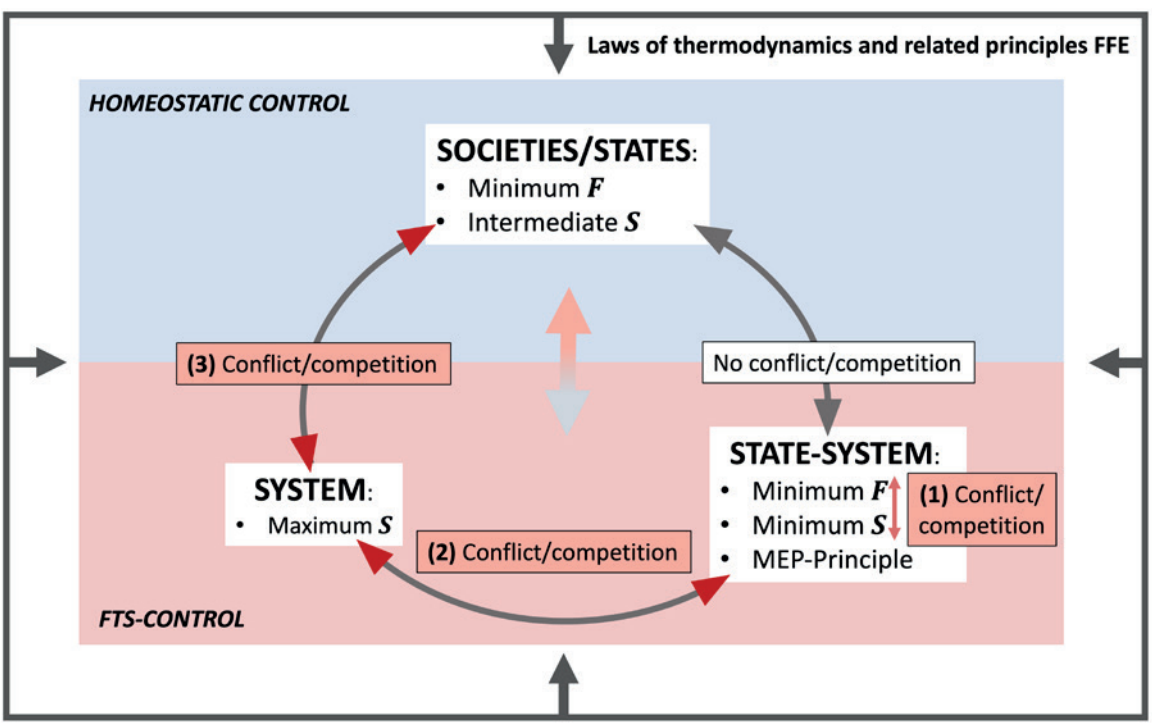


FIGURE 1.30: The interplay between competing thermodynamic potentials in the System.

These conflicts, which are subject to laws of thermodynamics and related principles that apply FFE, resulted in the emergence of a dissipative structure - the 1st FTS - through a bifurcation in 1480, following a period of increasing instability (< 1480).

The FTS utilizes four complementary processes to regulate the System and its components, including conflicting thermodynamic potentials of (sub)systems, to ensure compliance with the Second Law and related principles FFE. These processes are the process of KA (war), of aggregation of societies/states, of expansion to a suitable environment and of empowerment. The four processes were/are regulated by the FTS, and are also shaped by the H-imperative, as far as the "demands" of the H-imperative do not conflict with the S-imperative (the laws of thermodynamic laws and principles that apply FFE).

The State-System can be considered the structural component of the FTS. The overarching purpose of the FTS is to achieve thermodynamic equilibrium in the State-System, by eradicating gradients in the System.

By identifying the conflicts - competition - between thermodynamic potentials and taking the Second Law and related principles FFE into account, it is possible to identify the feedback structures that dominate the dynamics of the System and its components.

Although the impression is that the FTS works at cross purposes, this is not the case: The overall effect of the combined application of these feedback structures is that the FTS not only utilizes, but also purposively contributes to entropy (-production) in the System.

By utilizing the competing thermodynamic potentials, the FTS strengthened the gradient(s) in the System and the flows and forces that were consequently generated, to eventually destroy the gradient. The FTS was/is on a path of self-destruction, to ensure compliance with the Second Law (to achieve thermodynamic equilibrium).

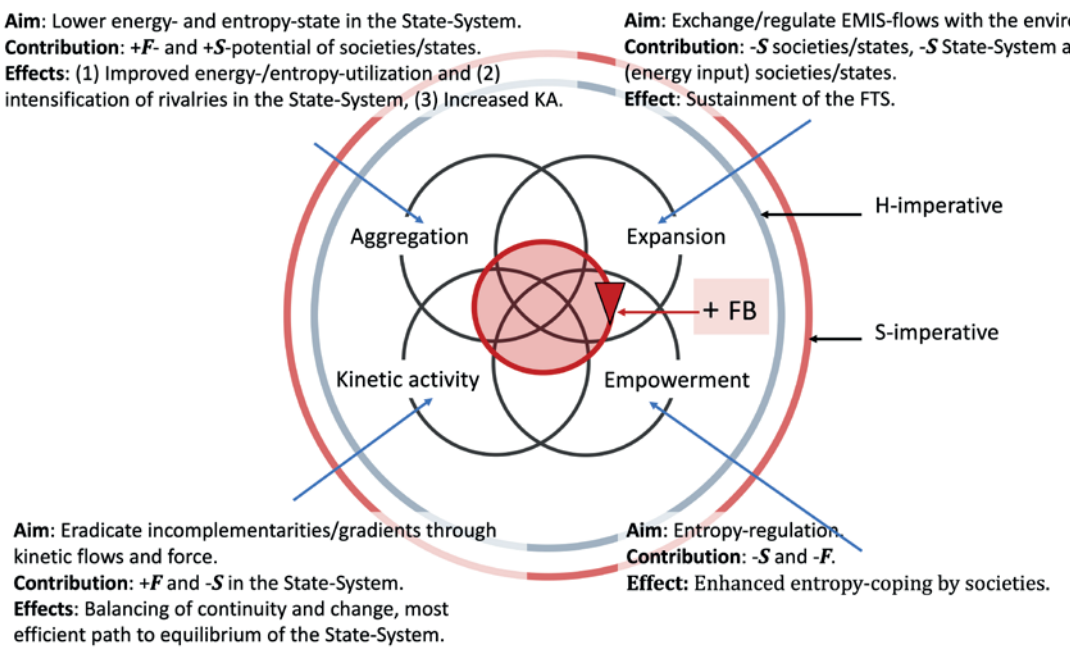


FIGURE 1.31: The interplay between competing thermodynamic potentials in the System from a FTS-process perspective.

TABLE 1.2: Relationships between processes. In this table some relationships between the four FTS-processes are shown. Contrary to the blue relationships are the red relationships more ambivalent; what outcome (effects) dominate depends on the feedback structures that dominate the System and its dynamics.

	Aggregation	Expansion	Empowerment	Kinetic Activity
Aggregation	Aggregation reinforces aggregation, to (further) enable the collective exploitation of economies of scale and scope. Aggregation can also trigger a counter-response.	Aggregation reinforces tendencies for expansion, to ensure entropy-dumping.	Aggregation results in mixing and reinforces tendencies for empowerment.	Aggregation increases entropy-production, which generates KA.
Expansion	Expansion enables aggregation (through entropy-dumping). Opportunities expansion offer stimulate cooperation.	Expansion reinforces further expansion, e.g. because of increased rivalries in the core.	Expansion promotes empowerment of non-core populations. Expansion also results in exploitation.	Expansion generates entropy and consequently kinetic responses from the FTS.
Empowerment	Empowerment improves entropy-coping and enables (further) aggregation. Empowerment can also reinforce tendencies for disaggregation (fragmentation).	Empowerment promotes expansion by reinforcing economic and political initiatives.	Empowerment reinforces empowerment, because identities are reinforced.	Empowerment improves kinetic capabilities because degrees of freedom can be exploited.
Kinetic Activity	KA eradicates incomplementarities and enables (further) aggregation. However, KA can also be instrumental in the destruction of aggregated structures.	KA eradicates incomplementarities and enables (further) expansion.	KA can contribute to empowerment, as was the case in the core, during the transient period, but can also be used to subjugate and deprive populations/societies of degrees of freedom.	KA can reinforce or inhibit KA, this process is directed by the FTS.

The outcome of the combination of positive feedbacks is that the gradient and resulting force that are generated (and applied to the State-System) increased, during the transient period; see figure 1.33.
The dynamic of the FTS/State-System can also be considered as a competition between two tendencies, not only between order and disorder, but also between attractive and repulsive forces. Collective benefits that can be accomplished by cooperation - e.g. through the (collective) exploitation of economies of scope and scale - contribute to attractive forces; whereas, increased competition caused by e.g. scarcity of resources - a dynamic that is reinforced through the security dilemma - contributes to repulsive forces that are at play. Over time, attractive forces - cooperation - were stronger then repulsive forces.

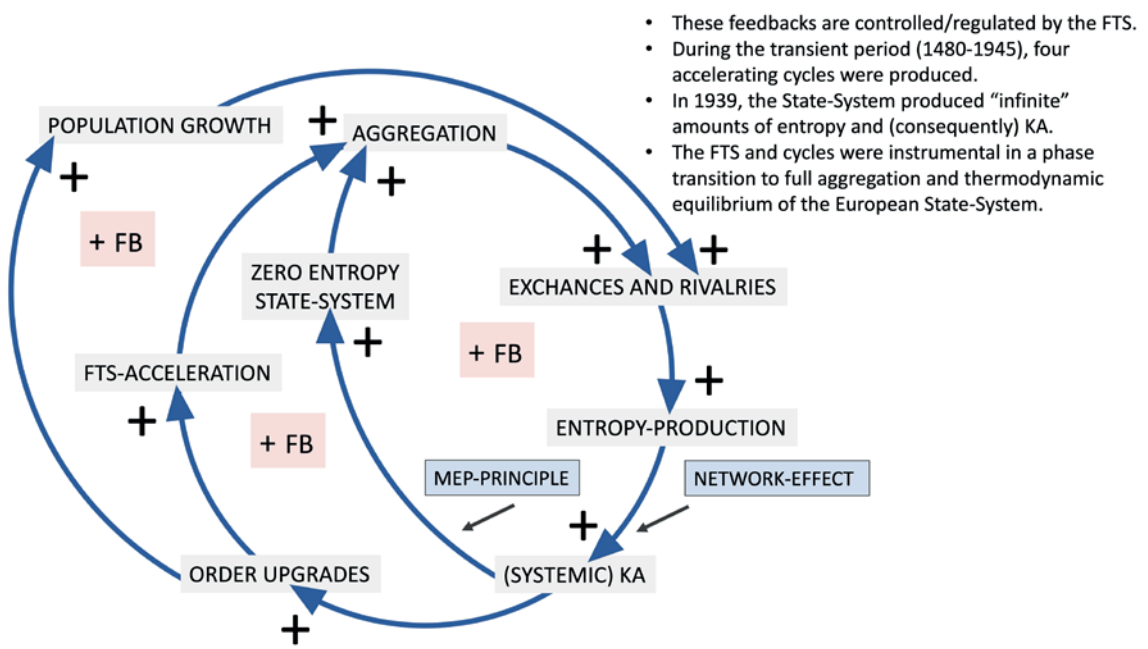


FIGURE 1.32: CLD of variables involved in the interaction between feedbacks in the (State-)System.

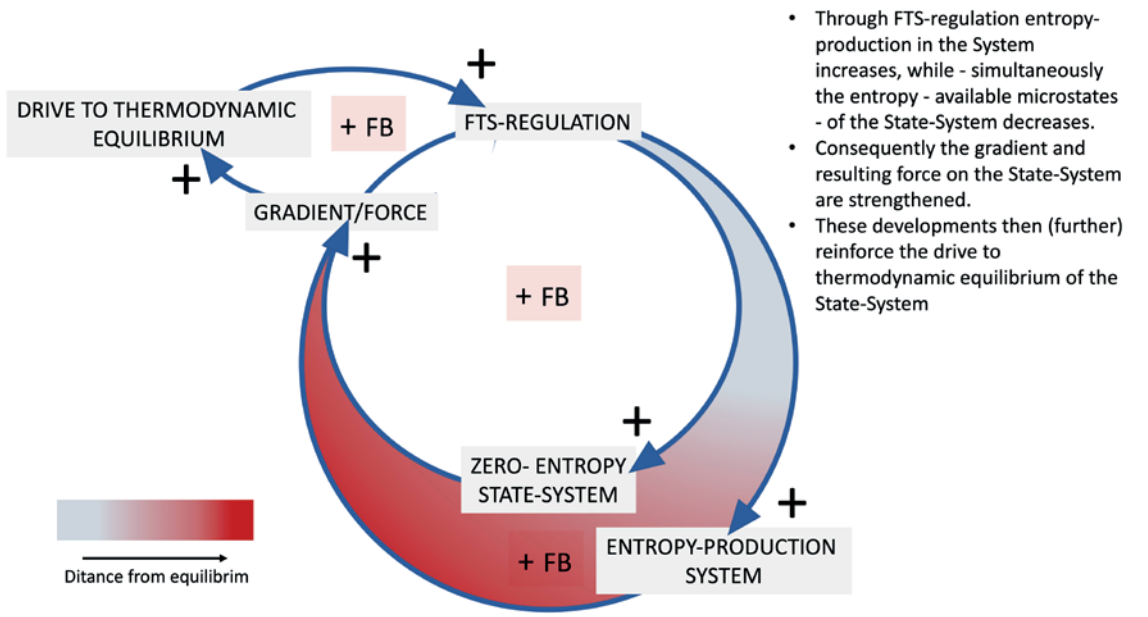


FIGURE 1.33: Strengthening of the gradient and force applied to the State-System. An essential feature of the 1st FTS is that it could only eventually eradicate the gradient (achieve thermodynamic equilibrium), by (four times) upgrading its macroscopic organization (order), during the transient period (1480-1945), which in each case reinforced the gradient (that powered the 1st FTS): Efforts to minimize entropy-production in the State-System contributed to the accelerating production of entropy of the System, and the accelerating entropy-production caused an acceleration of the 1st FTS until in 1939, the 1st FTS (the European State-System) produced infinite amounts of entropy, and consequently collapsed. At that point the last stage of the phase transition could be accomplished through the 4th systemic KA/war (the Second World War, 1939-1945). As mentioned, the interplay between competing thermodynamic potentials and their extremization is at the heart of the (State-)System and drives/powers the FTS.

1.10. The interplay between the S- and H-imperatives

As mentioned, the (State-)system also involves the interplay between the S- and H-imperatives, which are instrumental in respectively FTS-regulation of the (State-)System and homeostatic-regulation of societies, the main "building blocks" of the System.

Fundamental differences exist between the H- and S-imperatives. The S-imperative arises from the laws of thermodynamics and related principles; these laws are non-negotiable. Although the H-imperative 'operates' within certain limits imposed by the S-imperative, the H-imperative is more flexible, and makes use of the available contingent latitude (the availability of different solutions, that in all cases): Whereas the S-imperative is 'universal' and inflexible, the H-imperative is more local, situational, flexible and negotiable.

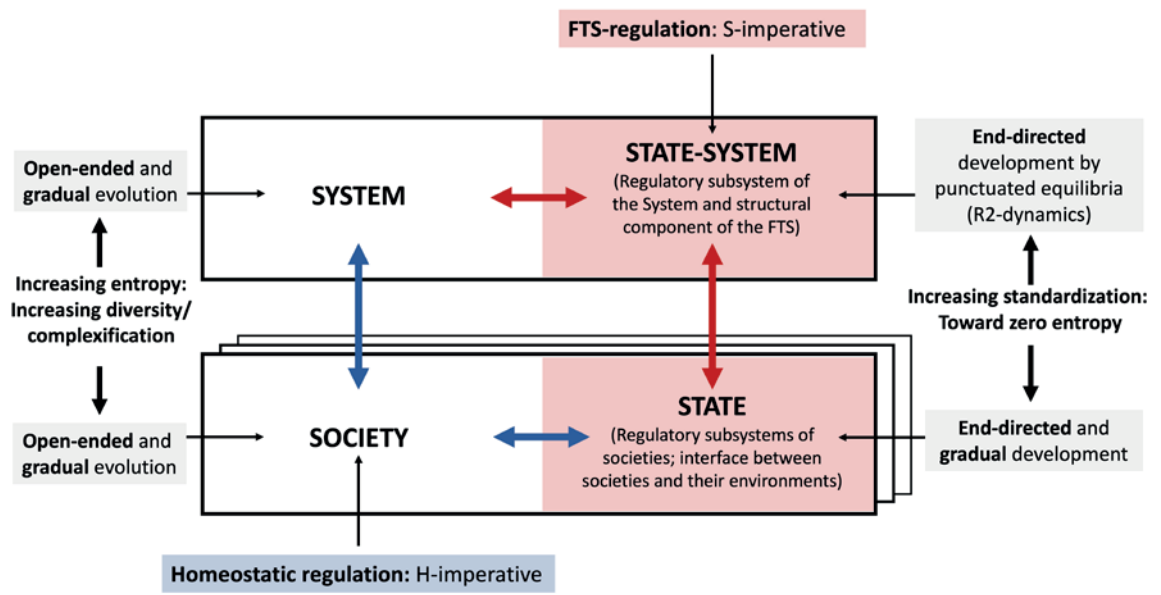


FIGURE 1.34: Relationships between components, regulation and evolution/development.

In above framework (figure 1.34), a framework concerning social evolution in/of the System and its main components is shown.

The State-System and states are responsible for the EMIS-regulation of respectively the System and societies. The FTS regulates the (State-)System and societies/states, in accordance with the laws of thermodynamics and related principles that apply. Thermodynamic principles that apply determine the behavior - dynamics - of the State-System, including the adaptations that are required to ensure optimal functioning. Societies are regulated by states; there is homeostatic control in case of (functioning) states.

In case of the System, societies and state-structures, the evolution/adaptation is gradual, while in case of the State-System there is development through punctuated equilibria: RSP's - stationary periods with little or no adaptations to the State-System - were periodically punctuated by systemic KA, when in short periods of time fundamental adaptations to the organization of the State-System were made.
Contrary to the evolution/adaptation of the System and societies, are adaptations to the State-System and states end-directed: The State-System is driven to thermodynamic equilibrium via the most efficient path in accordance with the laws of thermodynamics and related principles that apply; while states are forced to maximize their kinetic capabilities to satisfy the FTS, and to ensure the societies they represent can survive.

1.11. Institutionalization of thermodynamic principles

As I explain in this study, an important characteristic of the (State-)System and its main components (societies/states) is that thermodynamic potentials and stability conditions that determine the functioning of the FTS are institutionalized in social systems. Depending on the stage of a KA/war-cycle these potentials are "activated" and determine the behavior of its parts (e.g. individual humans, communities and societies/states). Our free will is much more limited than we (want to) belief. We obey the "instructions" of the S-imperative: The H-imperative is also modelled in accordance with the laws of thermodynamics and related principles that apply.
Various mechanisms play a role in the synchronization of the H- and S-imperatives and the (social) behavior. e.g. the mechanisms of conditioning, institutionalization and the interaction between self-fulfilling prophecies.
The monopolization of violence by states can be considered an institutionalized thermodynamic potential. During the transient period (1480-1945), there were two types of control in the System simultaneously in place, in different - but interacting - subsystems: Homeostatic control in societies/states and FTS-control in case of the State-System.
In this paragraph, I discuss their fundamental differences, and the interplay between the two types of control.
In case of homeostatic control of a system, certain checks and balances are internalized, to ensure certain (key-) parameters of the system stay within certain ranges, and the system's operation is optimized, as much as possible. The corrective measures/actions initiated by the system (in homeostasis), can concern the internal and/or the external environment of the system. Social systems (as well as individual humans) have the (unique) ability - albeit within limitations - to manipulate their environment as well.
In case of homeostatic control, goal-seeking behavior - negative feedback structures - dominates a system's behavior.
State-structures provide homeostatic control to societies (they regulate). States ensure that certain societal and environmental parameters are kept within certain ranges. Once societal homeostatic control is established, the use of kinetic energy is minimized, to avoid destruction and destabilization.
The FTS regulates the (sate-)System. In case of the State-System, there is goal-seeking behavior, but this goal-seeking behavior does not qualify as homeostatic control. The goal the State-System seeks is thermodynamic equilibrium (at the level of the State-System). This (overarching) goal, was imposed on the State-System in 1480, through the 1st FTS. The overarching goal of the FTS, produced various

dynamics and mechanisms to achieve this goal as efficient as possible, including: chaotic non-systemic KA (R1-dynamics) to regulate entropic perturbations (issues) during RSP's, and cyclic R2-dynamics to periodically upgrade the order of the System (to lower the State-System's energy-/entropy-state and to enhance its regulatory capabilities), during critical periods.

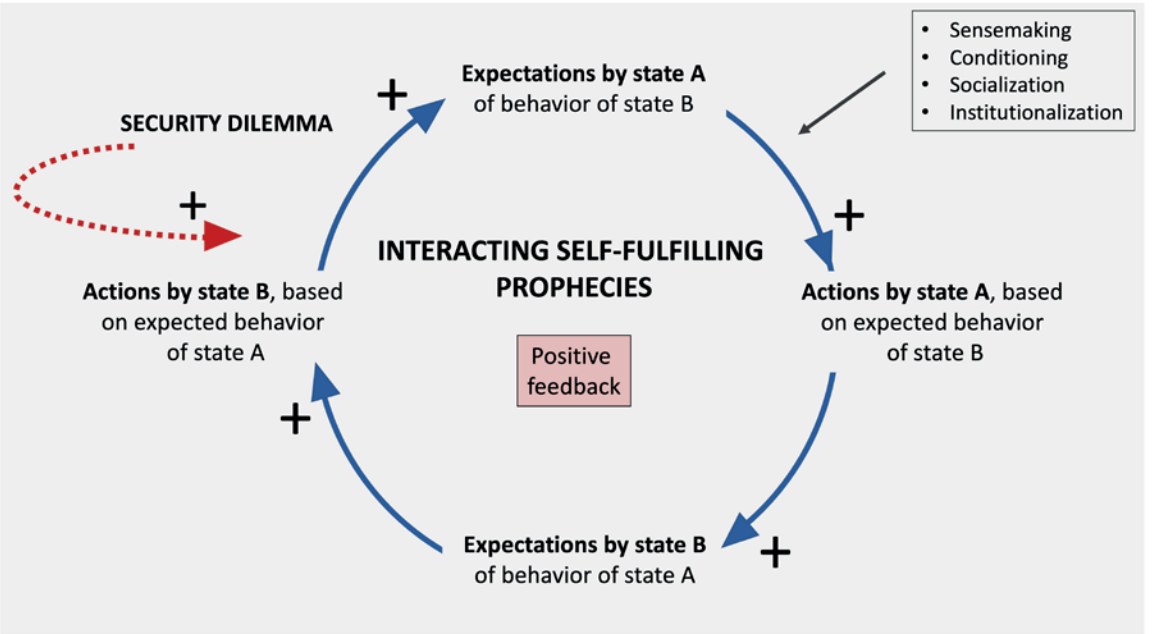


FIGURE 1.35: CLD of the mechanism of interacting self-fulfilling prophecies. The mechanism ensures that expectations and (inter) actions between social systems (e.g. societies and states) are synchronized, and the S-imperative is obeyed. Dynamics of the (State-)System respond to different thermodynamic principles and stability conditions depending on the state of the System (equilibrium or nonequilibrium) and the phase of a KA/war-cycle (RSP or critical period). The (State-)System and its components (societies/states) are conditioned - e.g. through institutionalization - to these principles/conditions. Human behavior, and social and political dynamics, are subject to these principles/conditions as well, we (unknowingly) obey, and through our conditioning - socialization - and the ISFP-mechanism is our subjugation/conformism guaranteed: The four systemic KA/wars, started at exactly the right time, and had a predictable duration and severity. Despite the significant "programmed" dynamics of the (State-)System, has these regularities gone unnoticed, and provides the limited contingent latitude that is left, us with the conviction that we make these decisions out of free will. This is however not the case, at least not in the degree we assume.

During the transient period (1480-1945), in Europe (the core), homeostatic control won terrain through aggregation, but at the same time, FTS-regulation - including KA - also intensified. Through aggregation - enhanced homeostatic control - societies produced more entropy (through their interactions) while their free energy potential also increased.

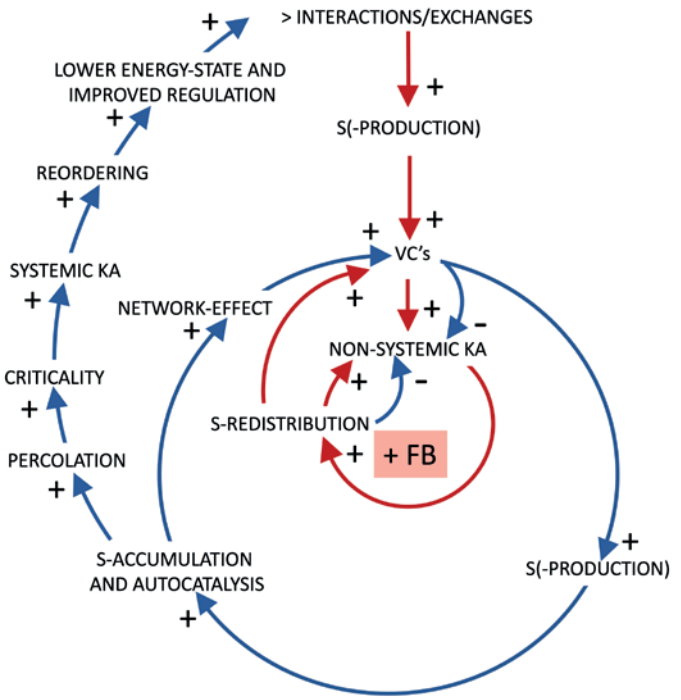
The state not only 'imposed' homeostatic control on societies, but also regulated their external environment - through active participation in the State-System and participation in FTS-regulation. Societies/states had to 'bridge' contradictory regulatory requirements of the H- and S-imperatives, they

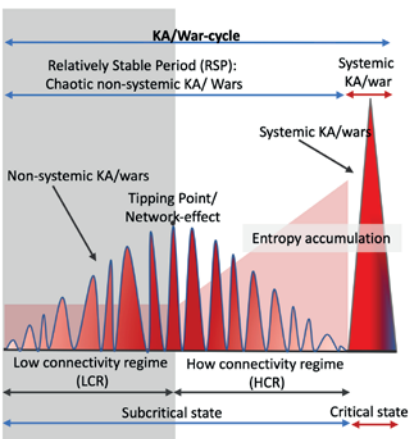
were simultaneously subject to: Whereas the internal (societal) use of free energy was - and had to be - minimized (to maintain homeostatic control), the external use of KA was maximized (to ensure a favorable environment). This was accomplished through the monopolization of violence (kinetic energy) by the State. Through the monopolization of violence (kinetic energy), internal stability was ensured, while the state's capacity to efficiently put kinetic energy to use in the State-System, was simultaneously maximized. The monopolization of kinetic energy by the state, shows how states deal with contradicting thermodynamic potentials, and how thermodynamic potentials are internalized in social structures.

1.12. The FTS-engine

The 1st FTS can also be considered an "engine", that accomplished a certain amount of work - full aggregation and a phase transition of the European State-System - and was accompanied by four identical and accelerating cycles. Each cycle had an identical life-cycle, as I explained. Each cycle consisted of several phases, including the LCR of the RSP, the HCR of the RSP and the critical period. Each phase was dominated by a particular combination of feedbacks.

The interplay between competing thermodynamic potentials and various (other) "drivers" power the FTS-engine. This process also involves the transformation "societal" energies into free (kinetic) energy (military capabilities), in which entropy serves as a catalysator, as I explain in this study.





This causal loop diagram shows the variables and dominant feedback loops during the **low connectivity regime** (LCR) of KA/war-cycles: Increasing amounts of entropy are produced, but are adequately regulated through chaotic non-systemic KA/wars.

FIGURE 1.36: CLD of the LCR of a KA/war-cycle of the 1st FTS (1480-1945).

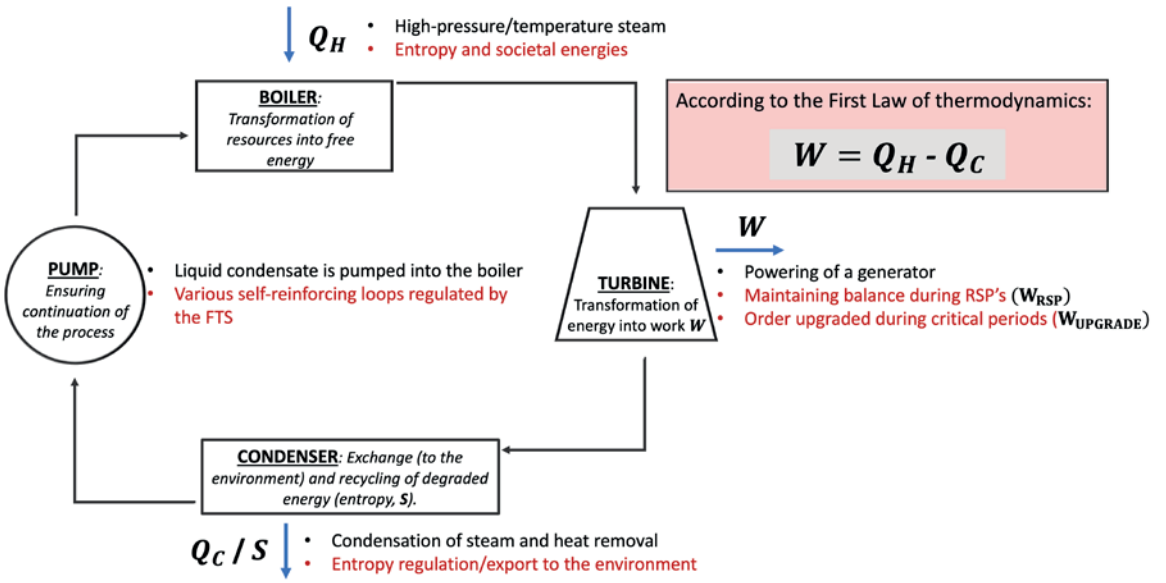


FIGURE 1.37: Comparison between a steam engine and the FTS-engine, based on a classical thermodynamic perspective. This figure is a schematic depiction of a steam- and KA/war-cycle. There are some fundamental similarities, it should however be reminded that the FTS is a FFE-structure and that its operation is based on its relationship and interactions with its environment(s). For each 'device' the function is shown; for the FTS-cycle in red.

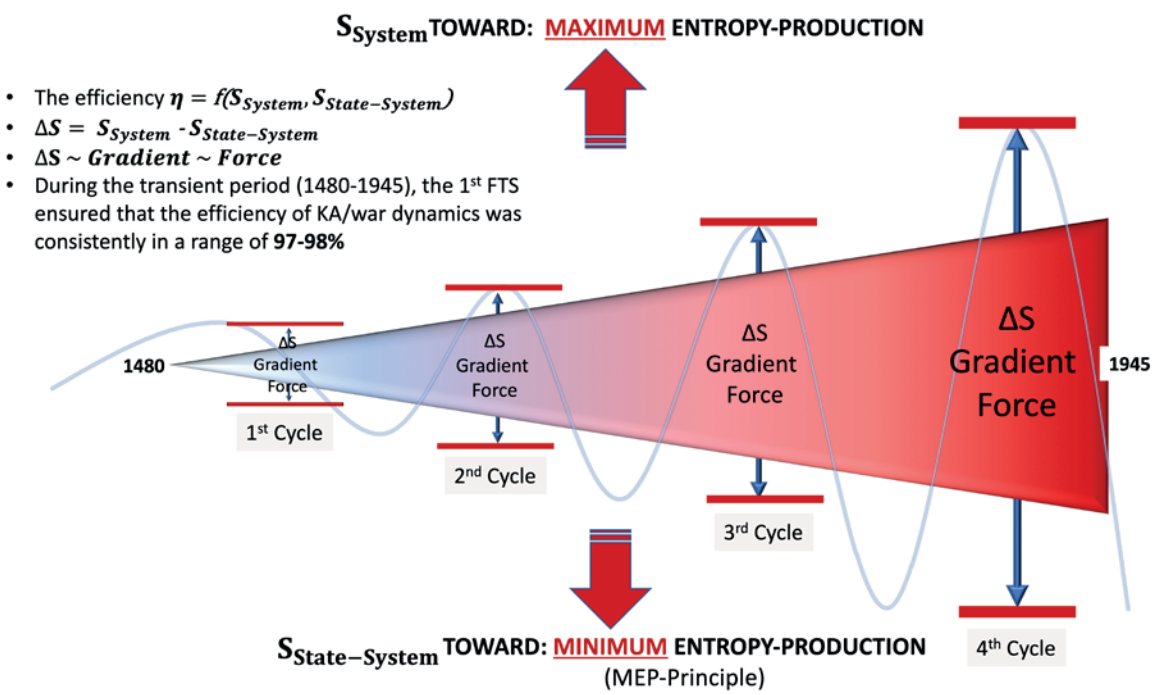


FIGURE 1.38: The 1st FTS depicted as an engine.

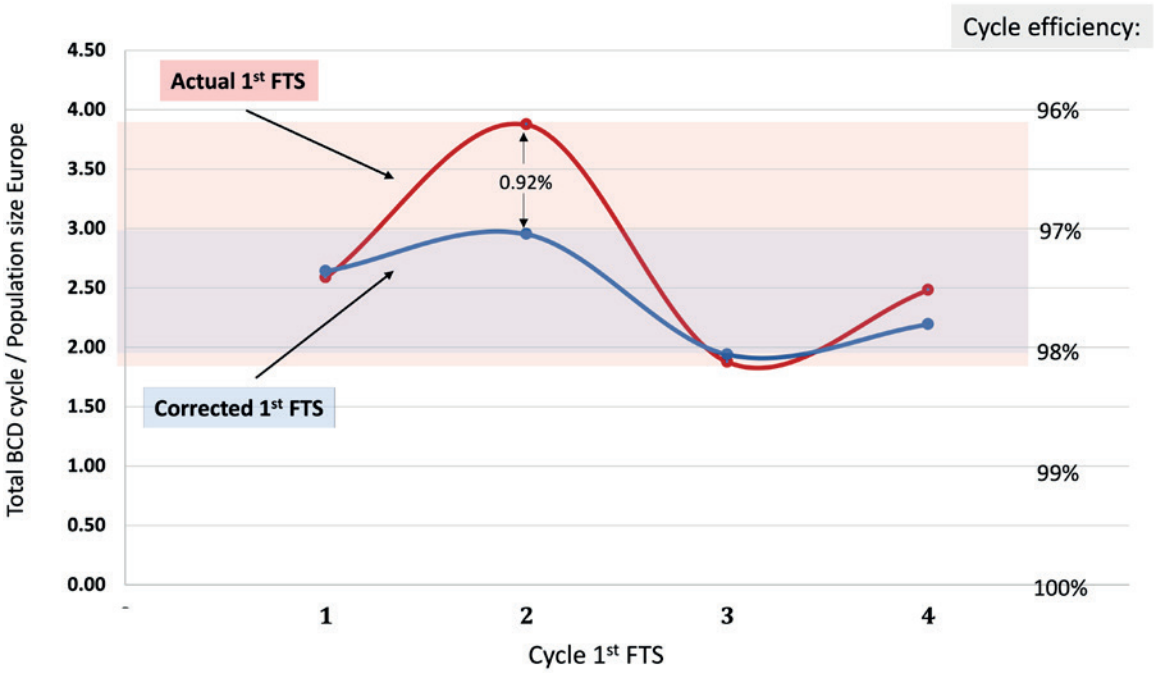


FIGURE 1.39: Efficiency of cycles, 1st FTS (1480-1945).

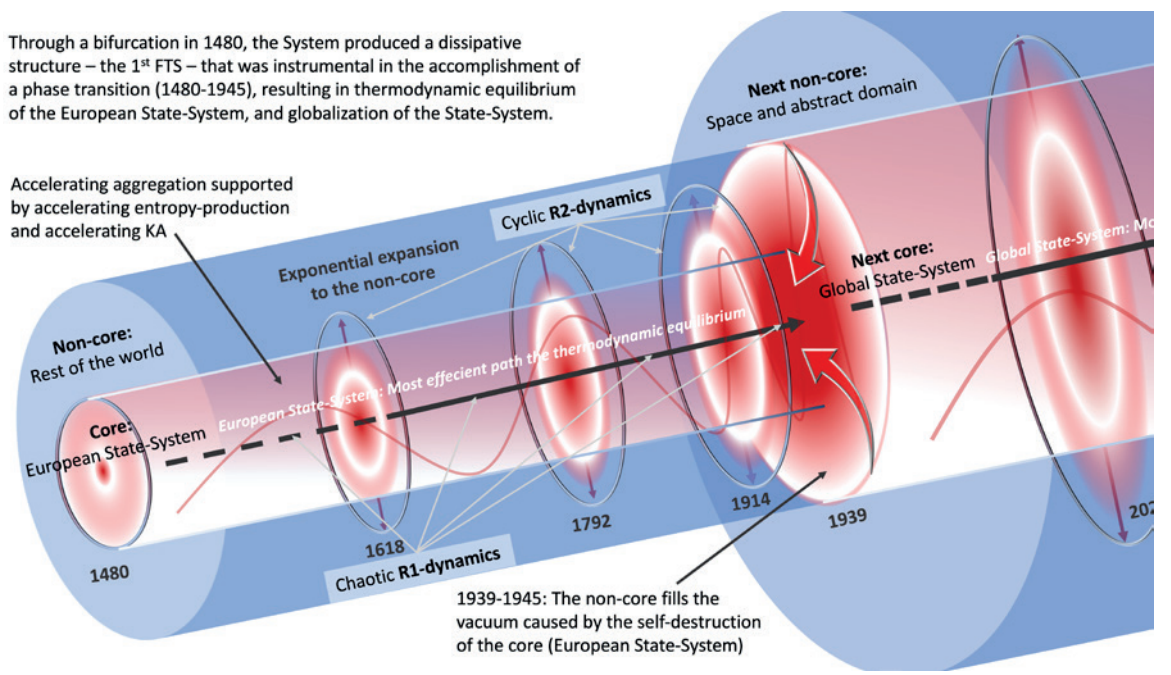


FIGURE 1.40: Competing thermodynamic potentials. The 1st FTS is "powered" by the interplay between competing thermodynamic potentials, and - as this figure shows - the 1st FTs can be depicted as an "engine", with a remarkable high and consistent efficiency, this study shows.

This analysis provides us with some insights in fundamental characteristics of the 1st FTS, including the observation that the 1st FTS achieved a high efficiency, during the transient period (1480-1945), in the range of 97-98%, except for a distortion - inefficiency - caused by the abnormal KA/war-dynamics during the 1st exceptional period (1657-1763); a decrease to 96% efficiency.
Another fundamental characteristic of the 1st FTS is that technology did not (and does not in case of the 2nd FTS) impact on the properties of KA/war-dynamics produced by the 1st FTS, during the four successive cycles. Although factors as technology and strategy impact on the conduct of a (specific) war and can be decisive in its outcome in political and social terms - that is in the contingent domain - they do not impact on the KA/war dynamics of the (State-)System: The efficiency of the KA/war dynamics - the efficiency of the FTS - is only determined by the level of entropy of the System $\boldsymbol{S}_s$ and of the State-System $\boldsymbol{S}_{ss}$; by certain thermodynamic properties.
This basic fact - the determination that Carnot's theorem also applies to the "FTS-engine" - explains why major technological innovations and their application - like the steam engine, the railways, the telegraph, the tank and nuclear capabilities - did/do not impact on the KA/war dynamics of the (State-)System during the transient period (1480-1945): The properties of the KA/war dynamics of the (State-)System are determined by laws of physics, and in particular by the Second Law and related principles.
The 1st FTS can be considered an adaptive "engine" that continuously kept its performance optimized, by maximizing the gradient ($\boldsymbol{S}_s - \boldsymbol{S}_{ss}$), to ensure the most efficient path to thermodynamic equilibrium of the State-System could be accomplished, in accordance with the Second Law and related principles: During the transient period (1480-1945), the 1st FTS achieved maximum efficiency, except for the 2nd cycle (1648-1815), when non-systemic KA was temporarily distorted during the 1st exceptional period (1657-1763).

1.13. Kinetic growth

During the transient period (1480-1945), through the 1st FTS, the European State-System achieved thermodynamic equilibrium and at the same time - through the same process orchestrated by the 1st FTS - the State-System globalized. This process can be considered as a process of kinetic growth: Growth through destruction.
I define destructive growth, as a form a growth in which destruction is functional - required - to ensure continuity of a (social) system. In case of the (State-)System, six stages and accompanying processes can be distinguished in the process of destructive growth: (1) growth and aggregation of a core; (2) growth and development of a non-core enabled by EMIS-exchanges between core and non-core; (3) destruction of the core on completion of the growth (aggregation) process; (4) absorption of the core by the non-core and (5) a process of 'healing' when the destructed core is repaired and processes and structures are formed and allowed to mature, to ensure the proper functioning of a globalized - scaled-up - System. Further growth, based on this model, requires (6) that the 'upscaled' System, "finds"/selects and develops its own non-core to ensure it can grow and develop, and to ensure the next non-core can eventually take control of the vacuum it will produce through its self-destruction.
In below series of figures the growth process of the State-System - involving KA - during successive KA/war-cycles is shown.

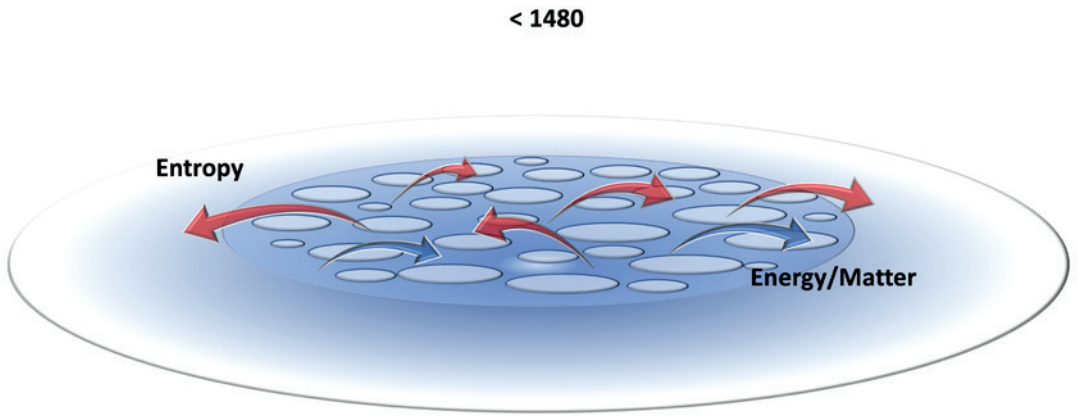


FIGURE 1.41: Schematic representation of the System, before 1480. The System became increasingly unstable but lacked coherent organization.

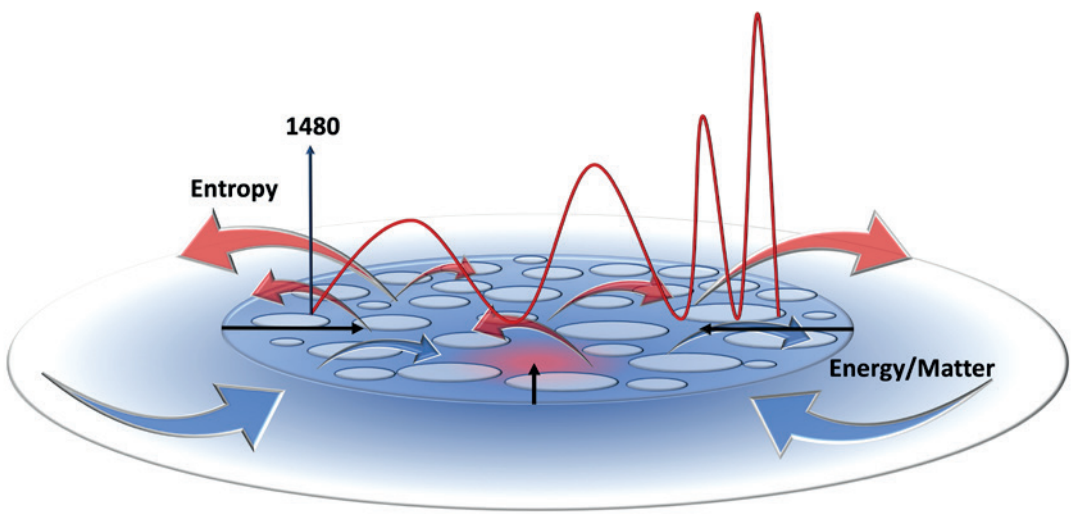


FIGURE 1.42: Schematic representation of the System, bifurcation in 1480. In 1480, the System bifurcated to an organized state FFE, and acquired macroscopic organization. The structure(s) of the (State-)System - the 1st FTS - was sustained through EMIS-flows, that also involved continuous exchanges with the (expanding) non-core.

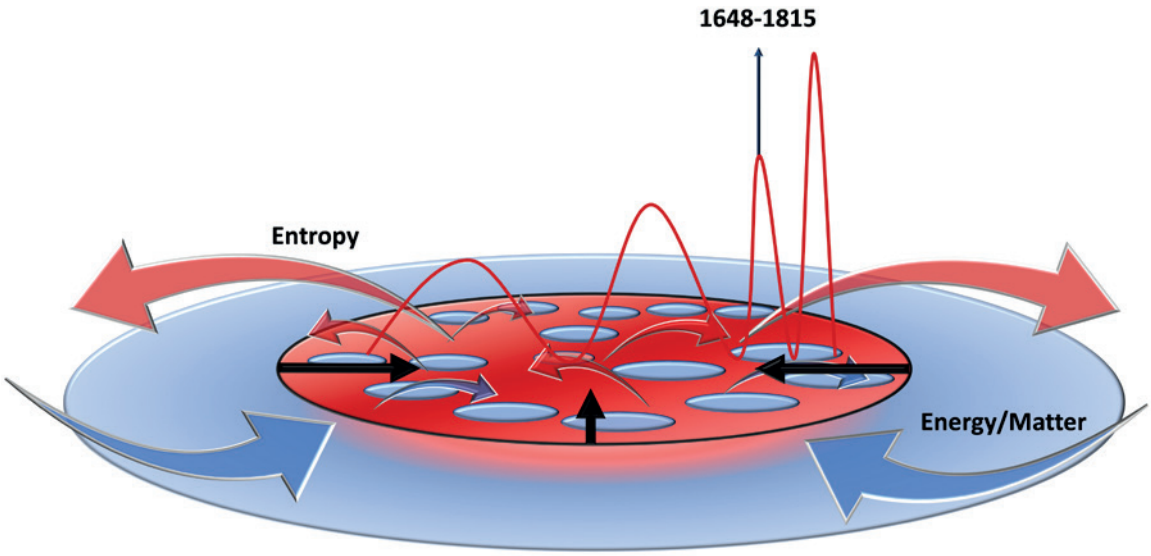


FIGURE 1.43: Schematic representation of the System, during the 2nd KA/war-cycle (1648-1815). During (for example) the 2nd KA/war-cycle, the irreversibility of the (State-)System had increased, and the (State-)System produced accelerating amounts of entropy; consequently, the KA of the (State-)System also increased.

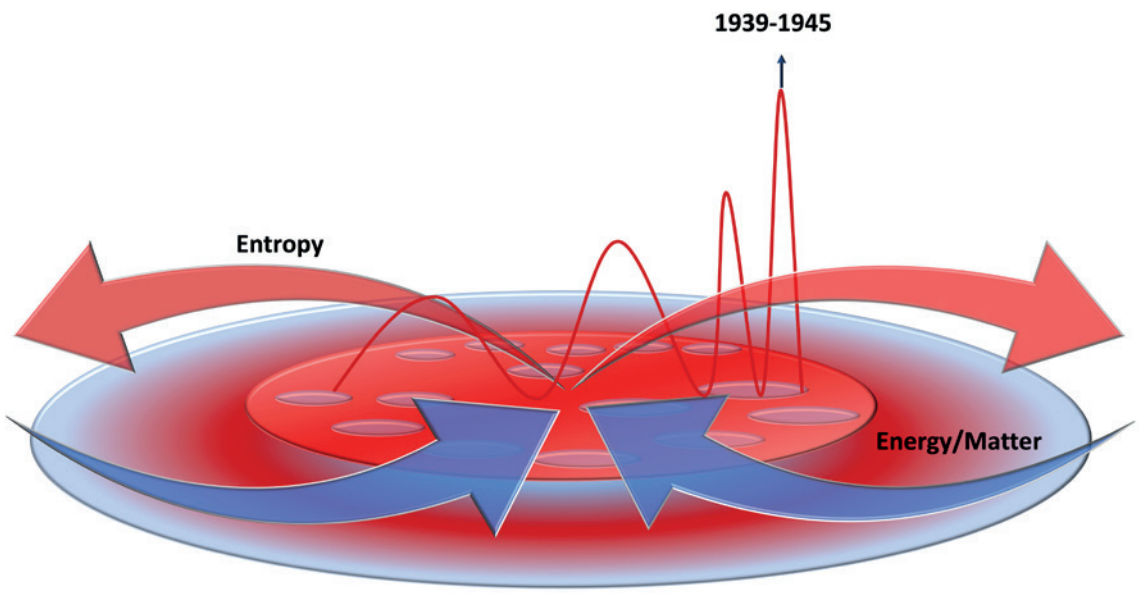


FIGURE 1.44: Schematic representation of the System, following collapse of the European State-System in 1939. In 1939, the European State-System reached the critical connectivity/population threshold - the singularity in finite time - and produced "infinite" amounts of entropy and KA. Consequently, the State-System collapsed and the last stage (the 4th systemic KA/war, the Second World War, 1939-1945) was triggered. The core of the System - the European State-System collapsed and produced a vacuum that was subsequently "filled" by the United States and the Soviet Union.

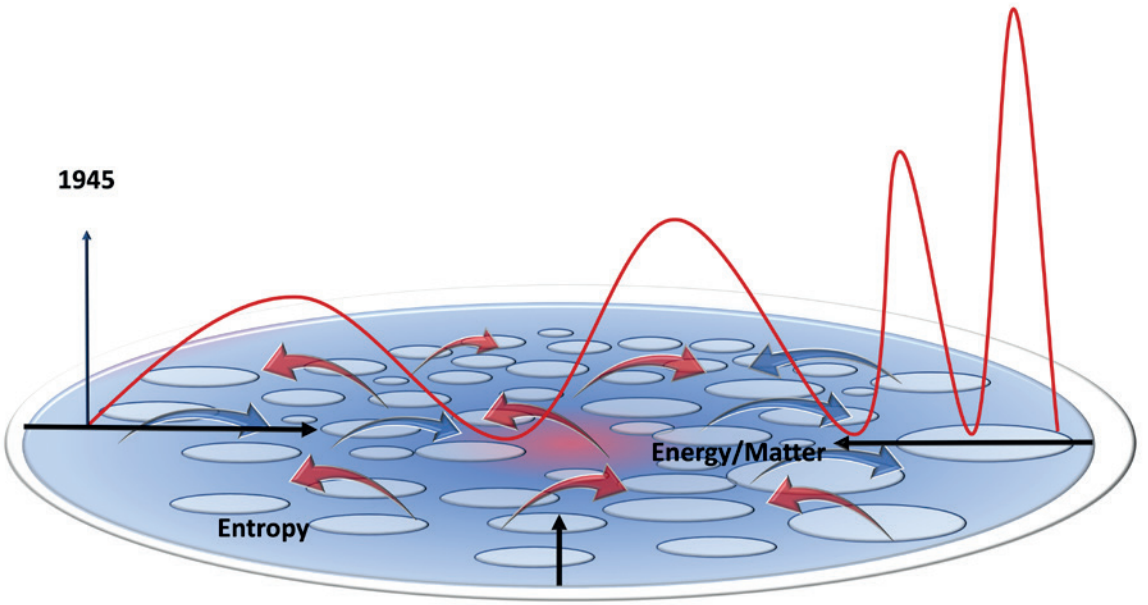


FIGURE 1.45: Schematic representation of the System, following the phase transition (1945). The phase transition accomplished by the 1st FTS (1480-1945).

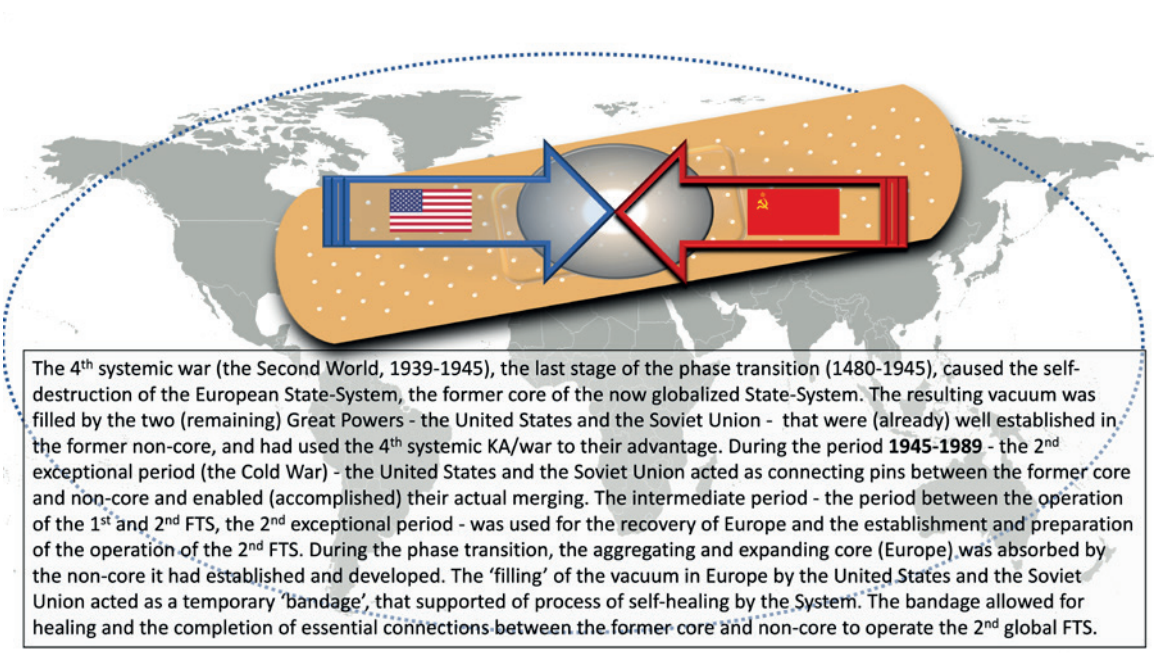


FIGURE 1.46: Self-healing of the System during the 2nd exceptional period (1945-1989).

Through the 1st FTS, the phase transition (1480-1945), a process of growth was accomplished through self-destruction by the core: The moment the core achieved the conditions for full aggregation, the core self-destructed, and the non-core - which was developed by the core, and modelled according to the core - took control over the vacuum the core had created, and at the same time the core and non-core merged into a global State-System.
The recovery of the self-destructed former core, the reconfiguration (at least to a certain extent) of the globalized State-System, and the start-up of a 2nd - global - FTS, required "healing", which was accomplished during the 2nd exceptional period (1945-1989, the Cold War). Self-healing is a property of dissipative structures.

1.14. From a directed to an undirected force

The upscaling of the (State-)System from a core/non-core to a globalized State-System, respectively regulated by the 1st and 2nd (global) FTA, was accompanied by a dramatic shift in the force that was applied in/on the (State-)System: Whereas the 1st FTS (1480-1945) applied a directed force at Europe - the 1st FTS was about achieving thermodynamic equilibrium in the core (Europe) - the 2nd global FTS (1945-...) applies a force at the global State-System, in order to achieve thermodynamic equilibrium at a global scale.
This global force has the effect of a centrifugal force on Europe - it tears the European Union apart, because fracture lines are amplified, and shared interest are not yet (sufficiently) institutionalized - while Europe is still in a precarious and vulnerable process of achieving full aggregation stage 3B.
The centrifugal force also finds points of application at societal/state level and increasingly at community and individual level, through e.g. social media that allow for unrestrained information exchange, and the creation of (virtual) communities: The (accelerating) process of empowerment contributes to the detrimental effects of the global force that is now applied by the 2nd FTS.

1.15. A second infinity war

As explained, in 1939, the moment the 1st FTS reached the critical connectivity/population threshold - the critical point of the European State-System - the singularity in finite time of the 1st FTS was reached and the European State-System (core) consequently produced infinite amounts of entropy and generated infinite KA. The infinite "amounts" of entropy and KA were instrumental in accomplishing the final stage (the 4th systemic KA/war, 1939-1945, the Second World War) of the phase transition (1480-1945).
At that point, the core of the System had reached full aggregation (stage 3A). The infinite KA, resulted in the self-destruction of the European State-System, and the resulting vacuum was 'filled' by the United States and the Soviet Union; the two remaining Great Powers that were (also) well established in the non-core. The core was de facto absorbed - enveloped - by the non-core of the System, and the core and non-core could subsequently merge, under "direction" of non-core Great Powers.

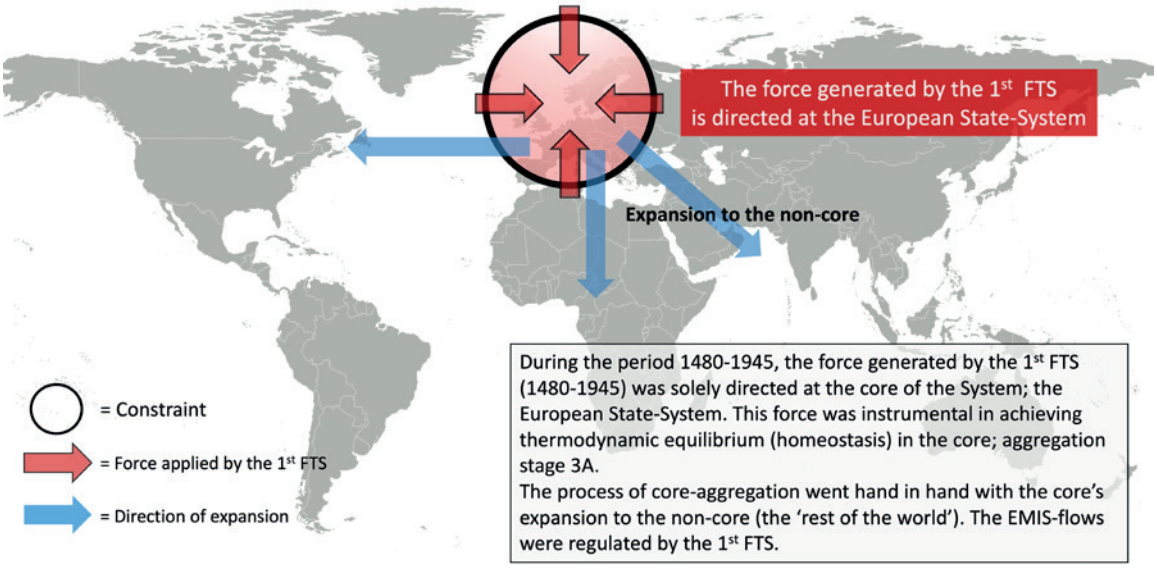


FIGURE 1.47: The 1st FTS directs a force at the European State-System (1480-1945). The force is instrumental in pushing the European State-System to a state of thermodynamic equilibrium.

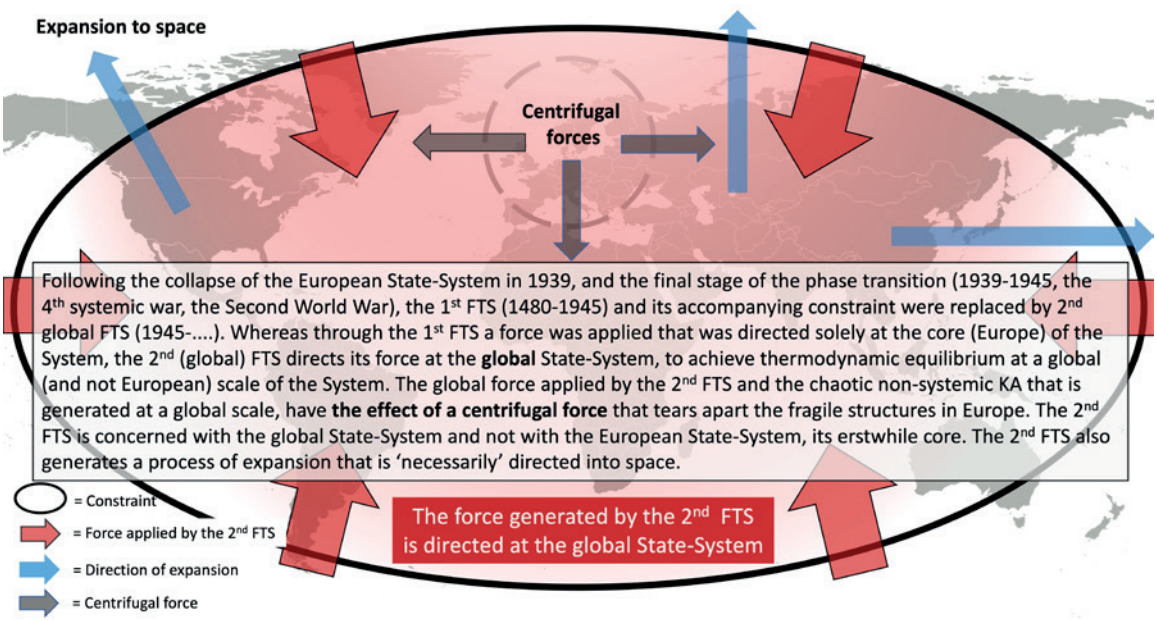


FIGURE 1.48: The 2nd FTS directs a force at the global State-System (1945-....). The force is instrumental in pushing the global State-System to a state of thermodynamic equilibrium and has the effect of a centrifugal force on the former core (the European Union).

The destruction of the (former) core required mending; a process in which the United States and the Soviet Union were instrumental. The temporary "shut-down" - ossification - of the (now) global (State-) System was also used to reconfigure the global (State-)System and to "organize" the start-up the 2nd global FTS.

As explained, the phase transition (1480-1945), can also be considered a process of kinetic - destructive - growth: Aggregation of the core (Europe) was supported by a simultaneous process of expansion of the core to a subordinated non-core - a delineated part of the environment - that eventually - when the non-core was fully matured (1939-1945) - enclosed and absorbed the core; At the same time, the organization of the globalized System was reconfigured, based on blueprint of the former core.

If the global (State-)System follows the same path of development as the 1st FTS and the European State-System, a similar dynamic can be expected, including an "infinity war" when the 2nd FTS reaches the critical point of the (second) phase transition: At that point the global State-System produces infinite amounts of entropy and generates infinite KA in response. The global State-System self-destructs.

During the 2nd transient period (1945-....), the 2nd FTS requires a suitable non-core to sustain its operation: Excess entropy must be exchanged with/to a suitable environment. The question is, if the "next" non-core, which will be developed by the 2nd FTS, will (also) be able to enclose and absorb the global vacuum that is created by the 2nd infinity war, to ensure continuity of the System (and probably humanity).

A non-core that is established "outside" planet Earth - through the colonization of the Moon or other planets, or the utilization of man-made (space) structures - could (theoretically, at least), serve as a viable non-core. The extraterrestrial colonies that are established in the non-core can serve as advanced "stepping stones" for further exploration and exploitation of space, also if the self-destructed global system (core of the 2nd FTS) is beyond repair.

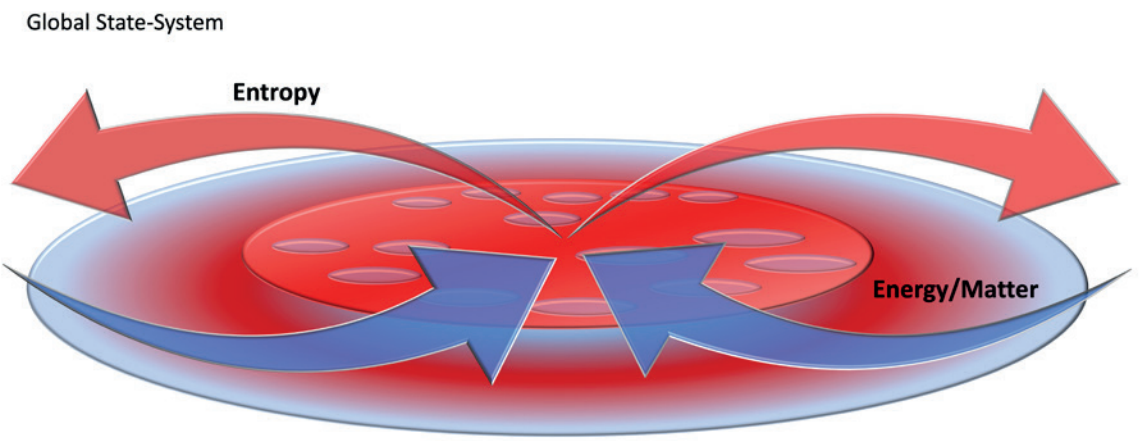


FIGURE 1.49: A 2nd infinity war. Assuming the 2nd FTS follows the same path of development as the 1st FTS, the global State-System (self-) destructs through the 2nd infinity war and is subsequently absorbed by the ("next") non-core that will be developed during the 2nd transient period (1945-....).

1.16. Accumulation of entropy, social and political volatility and radicalization

The existence of a tipping point - the fact that entropy regulation becomes at a certain point (the tipping point) problematic and ineffective - is also not without consequences in the contingent domain. From the tipping point onwards, the average size of non-systemic KA/wars decreases, and entropy instead of being neutralized and redistributed and issues (between states in the (State-)System) being solved, entropy - issues and tensions - starts accumulating in the (State-)System. The entropy also penetrates societies: The entropy tries to find an 'escape' through other means/channels. Because of the increasing accumulation of entropy, also in societies, societal uncertainty and disorder increase. Societal uncertainty results in political volatility and social unrest.
Once the tipping point is reached and entropy starts accumulating, radical ideas - political and religious- find a much more 'fertile' breeding ground in societies. Humans and societies try to make sense of the (increasing) uncertainty and fear. Because moderate political ideas and solutions are seen as the cause of the uncertainty and unrest, moderate politics and moderate solutions are discredited, and more radical ideas and solutions are accepted. More radical ideas are instrumental in reducing entropy and pushing vulnerable societies towards zero-entropy.

1.17. Development and evolution

This study shows that a process of growth and development of the (State-)System - as accomplished by the 1st FTS, during the (1st) transient period (1480-1945), and that is now directed by the 2nd FTS, at a global scale - provides a context for social evolution for societies/states and their subsystems. The process of development and evolution involves the interplay between the S- and H-imperatives.
The growing (State-) System and the sustainment of the FTS initiated the same developments that can be observed in growing and developing biosystems: An increase of the total dissipation, the development of more complex structures with more energy flow, an increase in cyclic activity, and the development of greater diversity and more hierarchical levels (92).
Growth and development of the (State-)System and simple organisms show (remarkable) similarities; their survival strategies are more or less identical.

1.18. The FTS requires expansion

The amount and rate of entropy a system can exchange to its environment - the entropy-absorption capacity of the system's environment - determine the system's rate of evolution/development/ aggregation. If the entropy-absorption capacity of the environment is exceeded - and the law $\boldsymbol{dS = d_iS + d_eS \geq 0}$ is consequently violated - the evolution/development of the system - its order - will be affected.
A system's environment requires active regulation/management, because the entropy exchanged to the environment affects the environment's entropy-absorption capacity. Exceedance of the entropy-absorption capacity of a system's environment is not without consequences and can cause a system's collapse. The entropy that cannot be exchanged to the environment damages the order (organization) of the system generating the entropy.

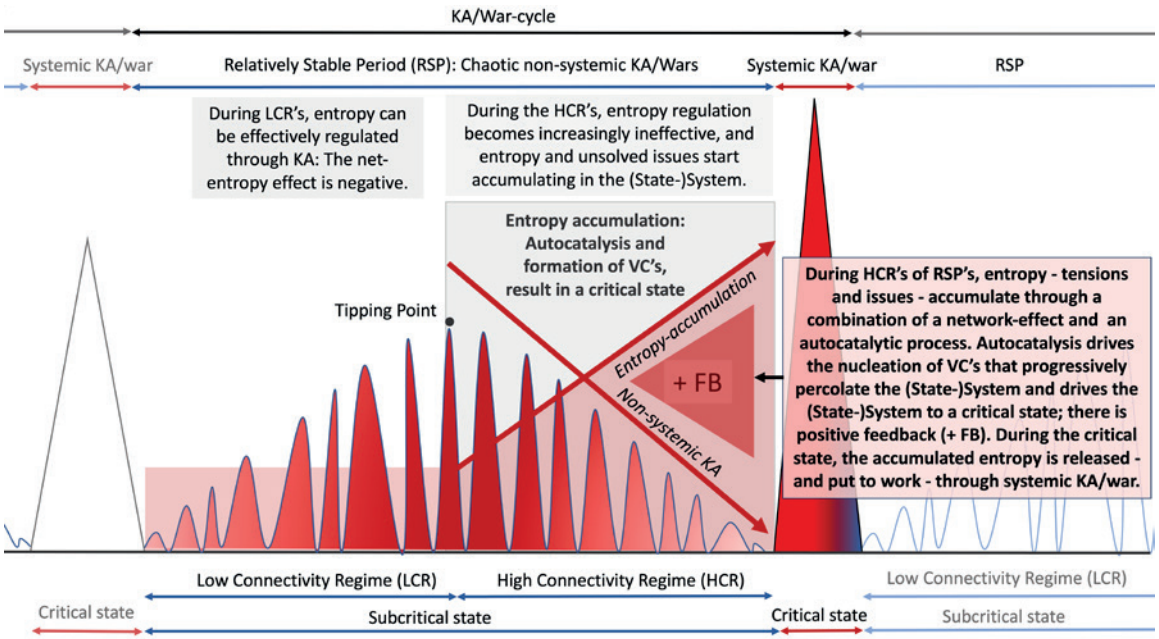


FIGURE 1.50: Entropy-accumulation during HCR's of KA/war-cycles.

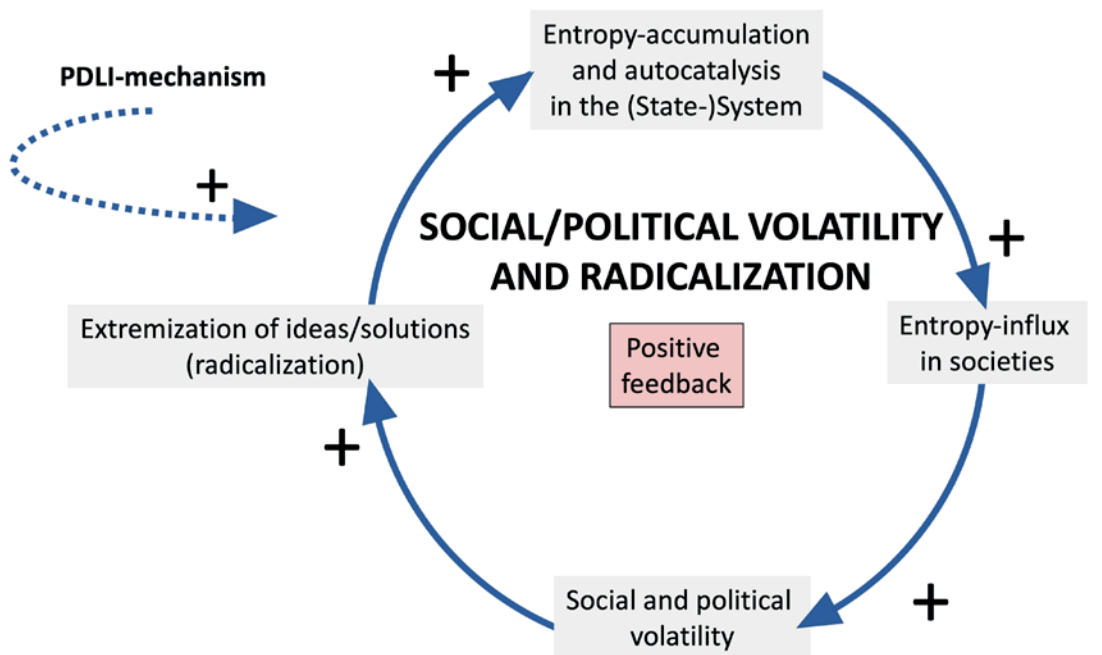


FIGURE 1.51: CLD of the self-reinforcing process of social and political volatility and radicalization, during HCR's of KA/war-cycles.

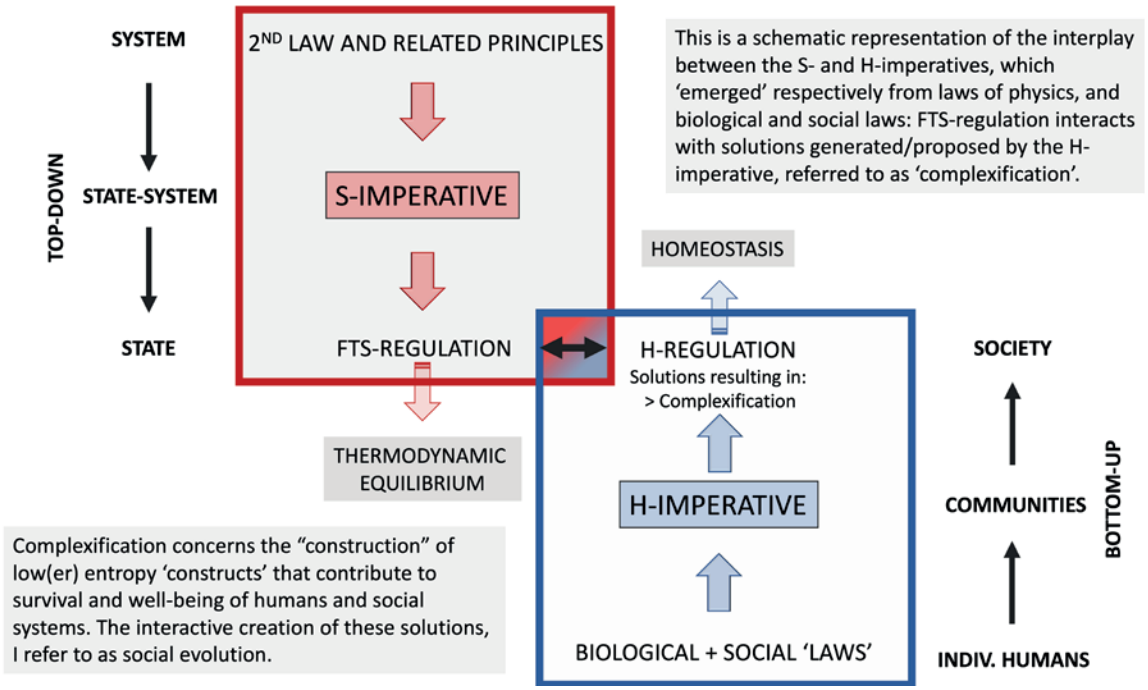


FIGURE 1.52: Interaction between the S- and H-regulation. This figure also explains how the deterministic domain (the footing of the S-imperative) interacts with the contingent domain (the footing of the H-imperative), and how top-down macroscopic dynamics and processes (generated by the S-imperative) are inseparably linked to bottom-up microscopic processes (generated by the H-imperative).

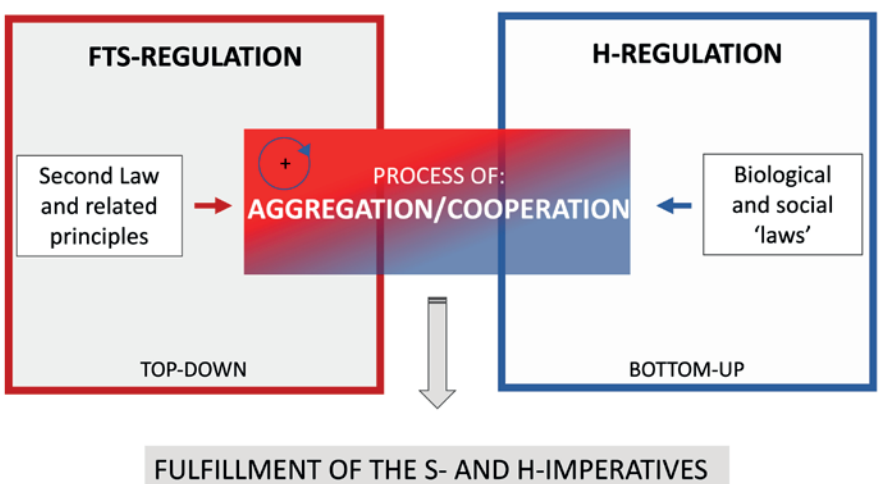


FIGURE 1.53: The process of aggregation/cooperation generated by the S- and H-imperatives links FTS- and homeostatic-regulation in the (State-)System.

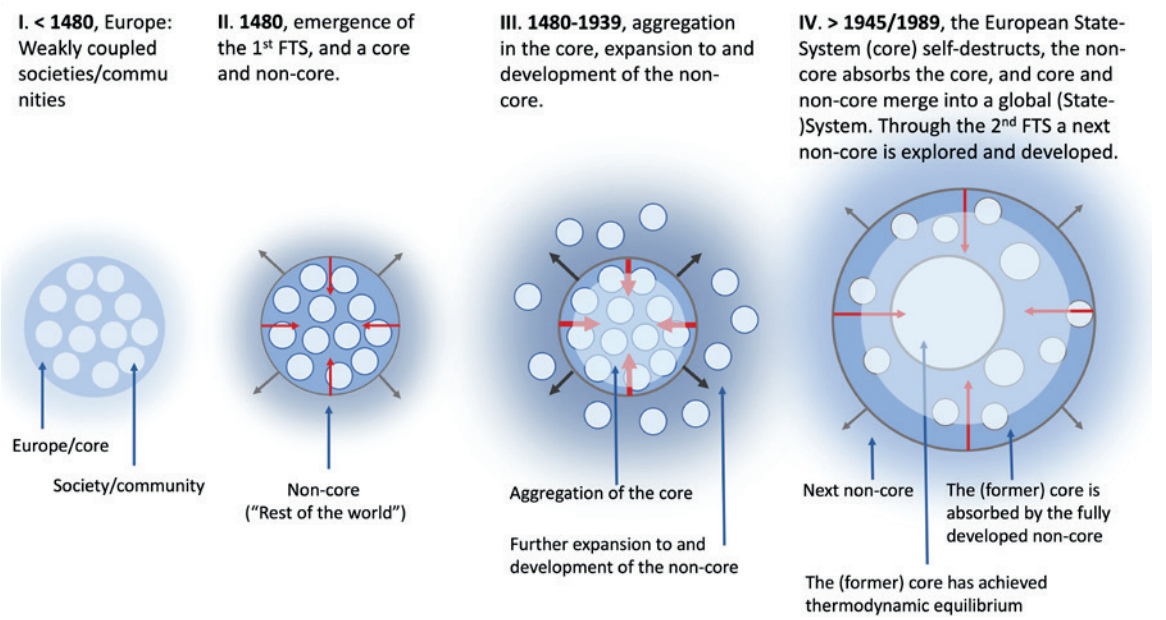


FIGURE 1.54: The phase transition (1480-1945) depicted as a process of biological growth and development. This figure depicts the phase transition as a process of biological growth; during the process, interactions/exchanges of the core (Europe) with its environment (the none-core) continuously intensified; the interactions contributed to the development of the non-core. In the final stage of the process, the core (self-)destructs and the (by then) sufficiently developed non-core absorbed the core. The (State-)System has grown/developed from a regional into a global "organism".

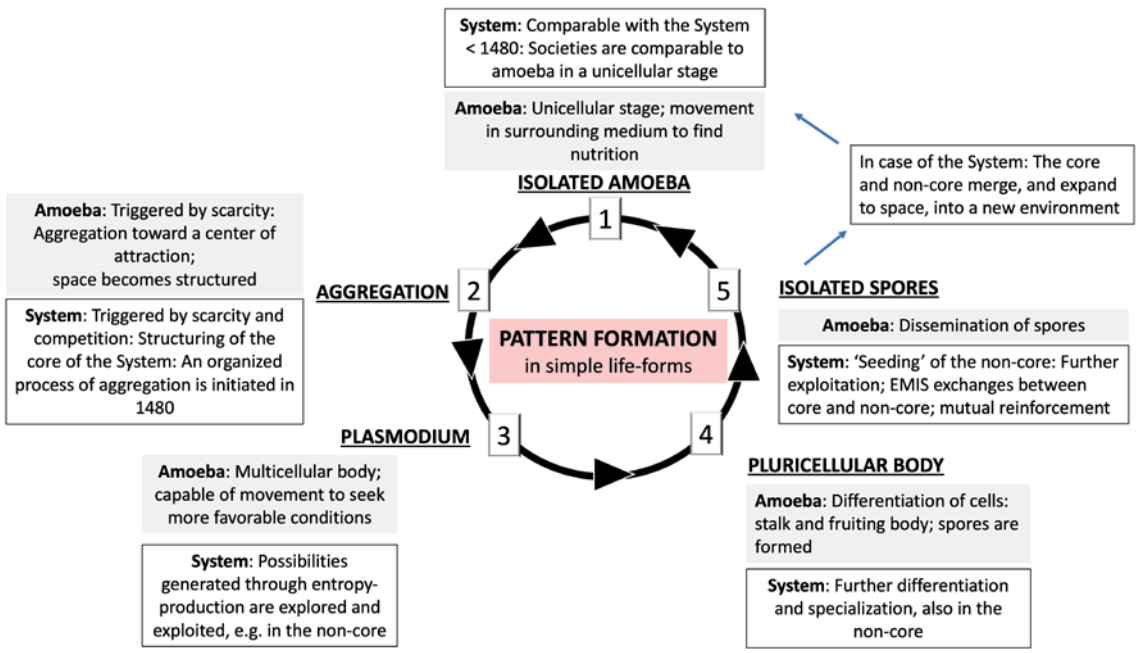


FIGURE 1.55: Pattern formation in simple life-forms. This figure shows some similarities between the (basic) growth dynamics of two simple life forms: Amoeba and the System/societies. When confronted with a constraint (scarce resources), both life forms aggregate, form an increasingly differentiated and 'capable' multicellular body (the State-System in case of human societies), exploit/utilize entropy, and expand by multiplication of their respective life forms and (further) exploitation of their respective environments (the non-core in case of the System); the cycle then repeats itself.

Given a projected growth/development path (goal) of a system, the entropy that must be exchanged to and absorbed by the environment can be calculated, and the suitability of the environment - and the feasibility of the projected growth (goal) - can be assessed.
It is no coincidence that the process of expansion (colonization) started and accelerated in earnest when the bifurcation took place in 1480, the 1st FTS emerged and took control. The process of aggregation in the core and expansion to the non-core were closely related and synchronized, as analysis of the war-data confirms (to be discussed later). It is also no coincidence that the process of expansion and consolidation ended (was accomplished) when the European State-System (core) collapsed and the 1st FTS accomplished - through self-destruction - the final step in the phase transition (1939-1945).
The 2nd FTS has initiated its own process of expansion: In the physical domain, humanity started exploring and is now colonizing space; space is the next frontier and level of expansion. In the abstract domain, there is also expansion, into a virtual world/domain.
If the 2nd FTS is sustained, and the same growth-logic applies to the global State-System, then humanity can only ensure its survival and further growth through further expansion, to ensure that a global State-System that has reached thermodynamic equilibrium through self-destruction, can be incorporated in an extended System.

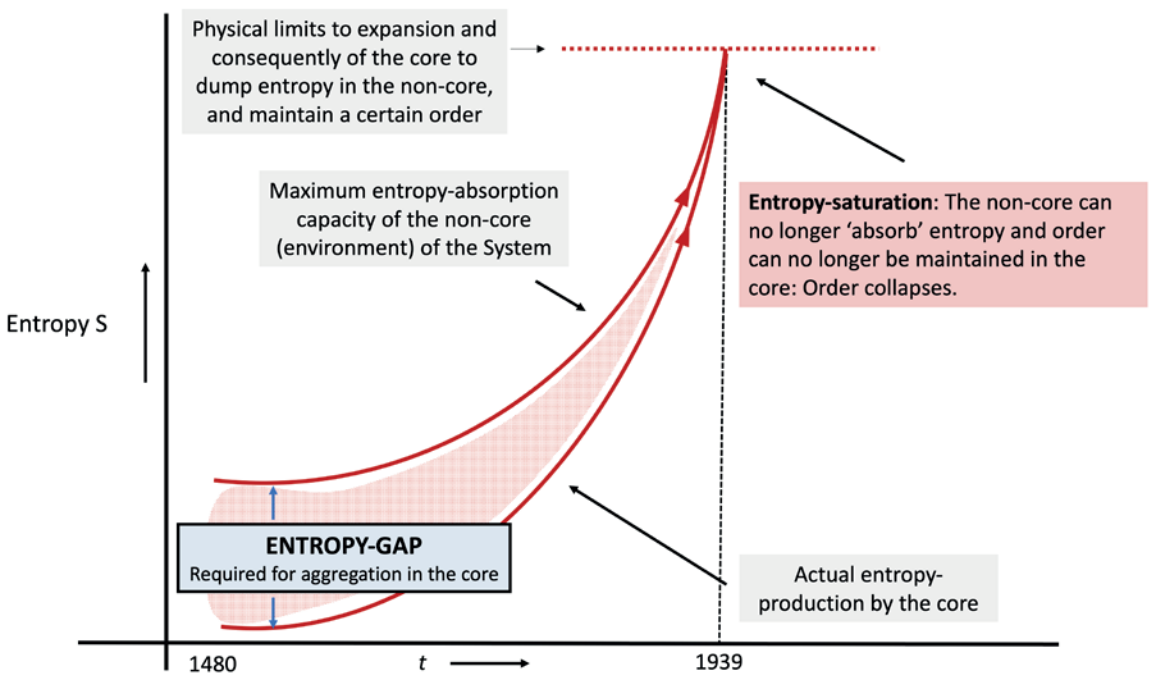


FIGURE 1.56: Limits to development and order. Limits to expansion to the non-core, set limits to the ability to create and maintain order in the core.

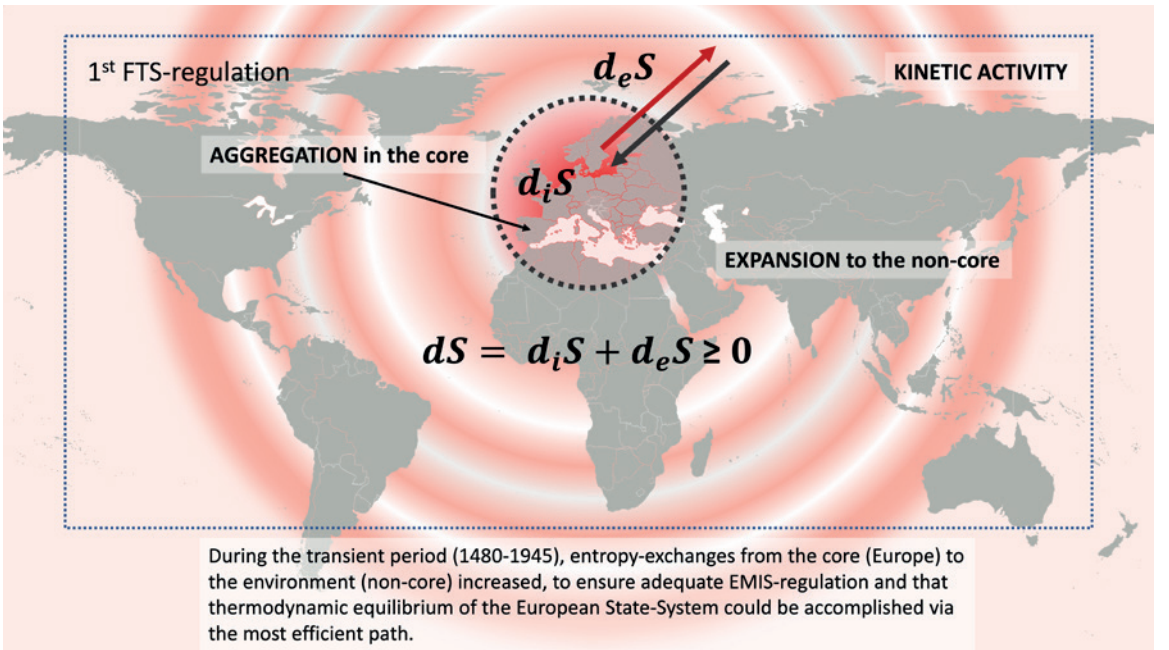


FIGURE 1.57: Expansion by the 1st FTS, during the 1st transient period (1480-1945). During the period 1480-1945, the "rest of the world" and societies constituted the environment, required for the sustainment of the 1st FTS.

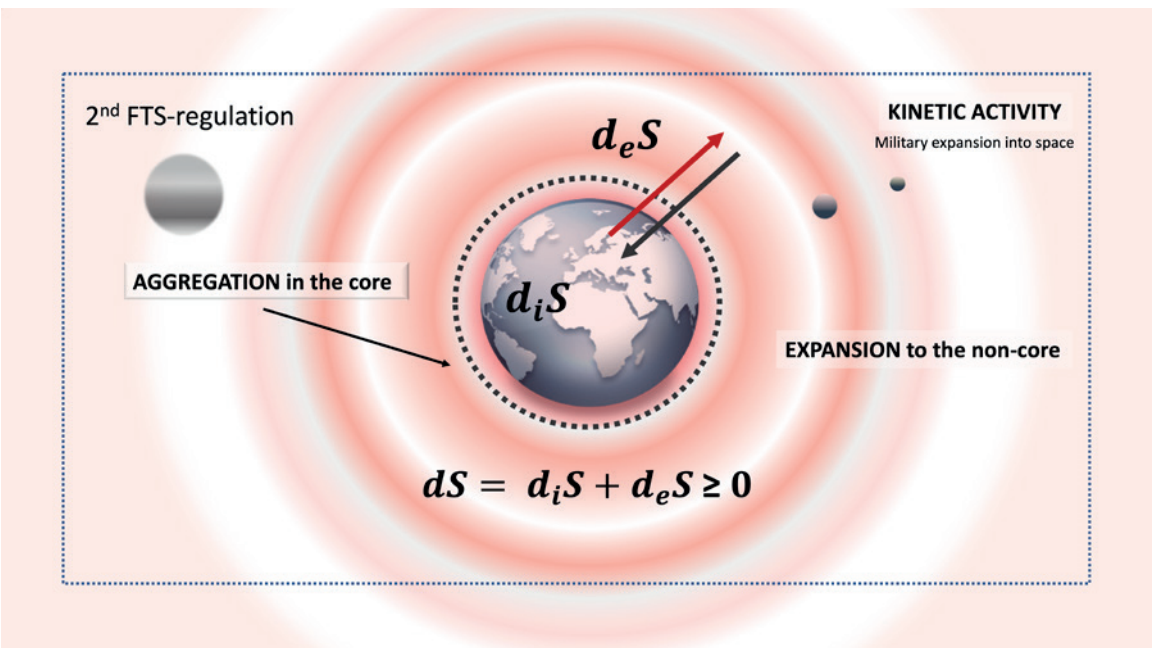


FIGURE 1.58: Expansion by the 2nd FTS, during the 2nd transient period (1945-....)). During the period 1945-...., the space and societies constitute the environment, required for the sustainment of the 2nd FTS.

1.19. The interplay between the (State-)System and the Earth system

The carrying capacity of the human species in an environment is the maximum population size the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment. The (State-)System and societies/states also contribute - determine - the carrying capacity of the environment for the human species, e.g. by providing certain resources and services, but also through the depletion of and damage to the environment these structures cause.

"In population biology, carrying capacity is defined as the environment's maximal load" (35). Through the damage that is caused to the atmosphere and climate system, the human species has (almost) reached the environment's maximum load.

Arguably, an (increasingly) close relationship exists between the 1st and 2nd FTS, the environment and the environment's carrying capacity. In this paragraph I discuss the relationships between population size, the FTS and carrying-capacity.

During the transient period, the population in Europe increased from 83 million in 1480, to 544 million in 1945. Population growth accomplished in other regions (e.g. Asia and Africa) shows that the presence of a FTS is not required to accomplish such a population growth/size.

During the transient period (1480-1945), the 1st FTS served above all as a supercharger of - an accelerator for - scientific and cultural discovery (culture as defined by Damasio (25)) and innovation and was instrumental in the diffusion of these innovations in the core and to the non-core of the (sate-)System. The 1st FTS served as a supercharger for processes of complexification and was instrumental in a dramatic increase in the free energy rate density $\boldsymbol{\Phi}_m$ of the European (State-)System.

The 1st FTS had (and has) its own carrying capacity (as explained, the FTS/(State-)System can also be considered a primitive organism). The carrying capacity of a FTS/state-System in an environment is the maximum size and acceleration of the FTS/State-System, the environment can sustain. Societies/states, the non-core and the physical environment (the Earth system) constitute the environment of the FTS/ State-System.

The energy that was required to sustain the 1st FTS and the processes it produced during the period 1480-1945, was extracted from societies/states, the non-core and the Earth system; from the environment of the FTS. Also because of the damage these processes cause(d), the carrying capacity of the FTS/State-System System was/is increasingly depleted.

Only demands which are within the carrying capacity are sustainable. The problem for the human species and for the 2nd FTS (and global State-System) is that their demands exceed their respective (but overlapping) carrying capacities. Furthermore, the regenerative powers of these environments are also negatively affected. Over time, the carrying capacities of the physical environment and the human species and FTS, have become increasingly tightly coupled; there is not much slack left.

Arguably, the Earth system crisis can be attributed to innovations that were produced by the 1st FTS and 2nd FTS, and the acceleration of (related) processes the FTS's caused. The destructive effects of the FTS are in fact twofold, not only pushes the 2nd FTS the (State-)System toward a 2nd infinity KA/war, but the 2nd FTS is also instrumental in the sustainment of processes and dynamics that further deplete the Earth system and the System's carrying capacity, at an accelerating rate.

There are limited options available to humanity, including: (1) decrease of entropy-production, and alignment of entropy-production with the ability of the available environment(s) to absorb the excess entropy production, (2) create 'alternative' environments (can the abstract domain serve as an alternative?), (3) change entropy- (EMIS-). This basic principle - the need for a suitable environment, to ensure: $\boldsymbol{dS = d_iS + d_eS \geq 0}$ - also provides a practical framework to better understand the impacts of climate change: Climate change and its effects are also related to the basic law: $\boldsymbol{dS = d_iS + d_eS \geq 0}$, that cannot be violated: The entropy - waste - produced by humanity exceeds the entropy-absorption capacity of the physical environment (the biosphere, atmosphere, etc.) and impacts on (control) parameters of the climate- and Earth-systems that determine their stability: The climate- and Earth-system are forced into other stability-domains.

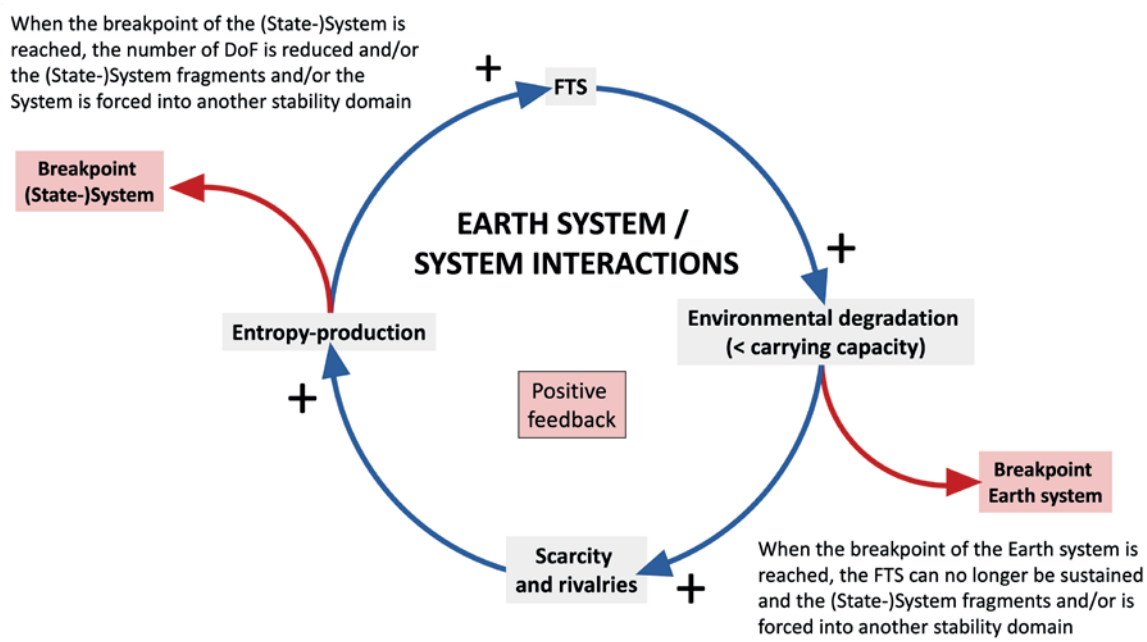


FIGURE 1.59: Interplay between the Earth system and System. The Earth system and FTS/(State-)System have become increasingly tightly coupled due to a decrease in the carrying capacity of the System.

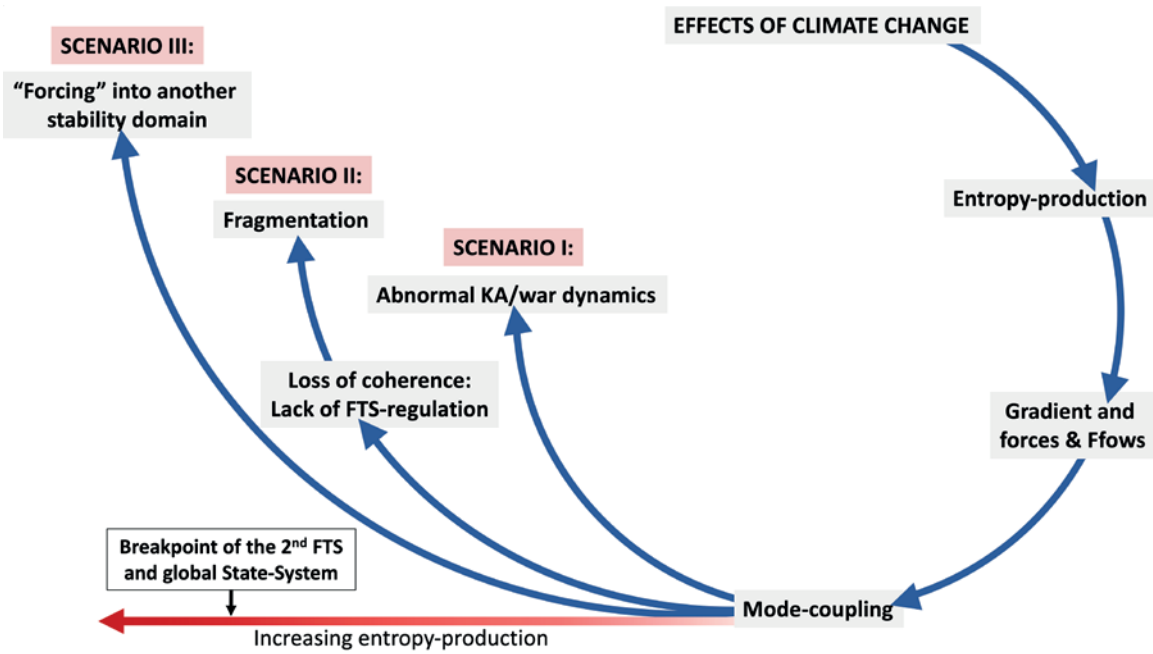


FIGURE 1.60: Three different paths and scenarios for the development of the 2nd FTS and global state-System. This figure shows three paths - and accompanying scenarios - for the further development of the 2nd FTS and global State-System; the entropy-production induced by (effects of) climate change is the control parameter.

1.20. The FTS cannot be (easily) stopped

The 2nd FTS contributes to the (potential) destruction of the global State-System: The 2nd FTS forces accelerating KA/war-dynamics on the (State-)System, which eventually result in an "infinity war", that will cause the (self) destruction of the global State-System. The 2nd FTS also demands an increasing free energy rate density Φ_m to sustain its operation, which causes further - accelerated - depletion of the Earth system. The 1st FTS was, and the 2nd FTS is, a forceful booster of climate change, and cause for the accelerated - and accelerating - depletion of the carrying capacity.

Furthermore, it can also be expected that the 2nd FTS causes even more damage to the Earth system in case nuclear and/or biological weapons are used in future KA/wars.

These damaging effects - which endanger humanity - raise the question if the FTS can be stopped or escaped from.

As the (development of the) 1st FTS shows, the FTS has its own "autonomous" momentum, in which individual humans and societies play a subordinate role: Furthermore, societies/states - and their citizens - have become (increasingly) dependent on a functioning (2nd) FTS for the fulfilment of their basic requirements, well-being (including security) and survival. The S-imperative "governs" the FTS and State-System; to which the H-imperative is subordinated.

Stopping the FTS is not a realistic and feasible option: It requires a coordinated response of societies/states in the (State-)System. It is also not a realistic option for societies/states to decide not to "participate" in the FTS; it is not a matter of choice: The FTS can be considered an accelerating treadmill that at the same time serves as a life support system; which "commands" - through societies/states - increasing amounts of resources that sustain its operation, but at the same time deplete the Earth system.
In this study, I also discuss limitations of designed structures (versus dissipative structures): It is very doubtful if human engineered corrections to the (State-)System can produce the desired effects.
The most likely path of the (State-)System is that it will continue toward thermodynamic equilibrium via the most efficient path, and in case EMIS flows are distorted - e.g. through overcharging (with entropy) of the 2nd FTS, or depletion of the Earth system - the Second Law and related principles will "decide" the response - the adjustments that must be made - to which - as was always the case until now - humans and societies/states will adjust.
Our ability for collective deception and the ISFP-mechanism, will ensure that we can justify the decisions that are required in the contingent domain. Until now, the FTS "decides": It constitutes a KA/war-trap we cannot escape.
Although humanity has achieved (some) control over biological evolution through gene engineering, we have not (yet?) achieved adequate control over human behavior and the (emergent) responses it generates.

Part II

Introduction

In Part II, I introduce some basic concepts that will be applied to analyze and better understand the structure, dynamics and evolution of the (State-)System. These concepts include: The laws of thermodynamics - especially the Second Law - entropy, information, feedback structures, hierarchy theory and some properties of networks.

Contents

2. The second law of thermodynamics
3. Information
4. Entropy and the system
5. Feedback structures
6. Hierarchy theory
7. Networks

2. The second law of thermodynamics

2.1. Introduction

In this chapter, I discuss the Second Law of thermodynamics - also referred to as the Entropy Law - and several related subjects, including statistical mechanics and the probabilistic nature of (certain) systems.

2.2. Thermodynamics

Thermodynamics is "the study of energy and its transformations" (55). Four laws of thermodynamics can be distinguished (47); but "(...) all of thermodynamics is contained in two apparently simple statements called the First and Second Laws of thermodynamics" (55). "The two laws of thermodynamics are best summarized by Rudolf Clausius thus: The energy of the universe is a constant (the First Law); The entropy of the universe approaches a maximum (the Second Law) (44). These laws assign meaning only to energy and entropy differences.

The First Law says that energy E is conserved; it is a description how nature works, not an explanation; the second law says that even within the framework of conservation, there are certain 'limitations; "the Second Law invokes a quantity called entropy ***S*** (...)" (55). "Thermodynamics is the science of macroscopic objects of many parts. The very size and complexity of thermodynamic systems allow us to describe them simply in terms of a mere handful of equilibrium or thermodynamic variables, for instance, pressure, volume temperature, mass or mole number, internal energy and, of course, energy. Some of these variables are related to others via equations of state in ways that differently characterize different kinds of systems, whether gas, liquid, solid" (47).

A system - including the System we are integral 'parts' of - "can exist in many different thermodynamic states. Each of these states can be represented in a multi-dimensional thermodynamic state space. The variables that define the state space depend on the nature of the System" (47).

The First Law of thermodynamics (the law of the conservation of energy) is described as follows: The First Law of thermodynamics states that the total energy of an isolated system is constant; energy can be transformed from one form to another but can be neither created nor destroyed. Thus, the sum of all energy is fixed (energy can neither be created nor destroyed), but energy can appear in various forms, including: heat, light, gravitation kinetic energy, chemical potential, etc. (20). The various forms of energy can be interchanged, including matter transforming into energy and conversely (20).

The First Law is sometimes formulated as follows: $\Delta U = Q - W$. "Q and W are terms representing energy passing the system boundary, by different modes. They are called heat (Q) and work (W), respectively, and both words have a special technical meaning" (55). Q concerns the heat transfer to the surroundings (environment) of a system, without doing work; whereas the work W is the product of the force F that is applied and the distance s that is travelled: $W = F\Delta s$.
It states that the change in the internal energy ΔU of a closed system is equal to the amount of heat Q supplied to the system, minus the amount of work W done by the system on its surroundings. An equivalent statement is that perpetual motion machines of the first kind are impossible (96).
Two complications for thermodynamics - also for the analysis of the System - are the identification of the variables that determine the thermodynamic state (including the identification of the variables that determine the internal energy U, for example, but also the entropy S of the system) and to determine the exact relationships between these variables (55).

2.3. Energy and entropy

Before elaborating on the Second Law of thermodynamics, I make a few remarks about energy and entropy: In thermodynamics, the internal energy of a system is the energy contained within the system, excluding the kinetic energy of motion of the system as a whole and the potential energy of the system as a whole due to external force fields. The internal energy of a system can be changed by transfers of matter or heat or by doing work. The First Law of thermodynamics states that the increase in internal energy is equal to the total heat added plus the work done on the system by its surroundings. If the containing walls of a system do not allow energy or matter to pass, the system is said to be isolated and its internal energy cannot change (96). This is not the case for open systems that can exchange energy and matter with their environment. The type of system - isolated, closed or open - determines its entropic properties: The entropy of an isolated system cannot decrease; whereas in an open system entropy may increase, remain in steady state, or decrease. Open systems can exchange entropy with their environment.
In this study, I explain, that military capabilities of states can be considered (potential) kinetic energy of these states (and the societies they represent); battle casualty deaths (BCD) (48) are indicative for the kinetic energy that is put to use during wars; I refer to wars as kinetic activity (KA).
By putting kinetic energy to use (during war, KA), work is accomplished in the (State-)System: During so-called relatively stable periods (RSP's) of KA/war-cycles, the dynamic steady state (the status quo, the existing order) is maintained ('balanced') through KA; during critical periods of KA/war-cycles, orders are upgraded to a next level of organization.
In this study, the term Gibbs free energy is also used. (Gibbs) free energy is energy that is available to accomplish work (can be transformed into work), in a certain setting. Military capabilities of states - the kinetic energy of states - is energy that is available to accomplish work and qualifies as free energy. Typically, in case of irreversible processes (which include all natural processes), not all free energy is transformed into work (as will be discussed in the next paragraphs): A certain amount of energy is always degraded into heat (Q); heat is energy in its most disordered form. The degraded (or bounded) energy is also referred to as entropy.

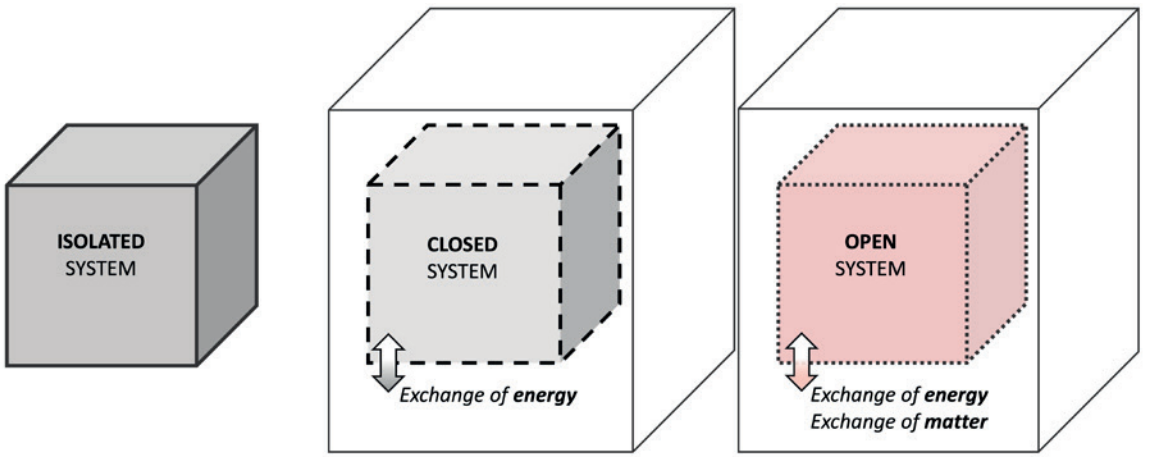


FIGURE 2.1: Isolated, closed and open systems. This figure shows the fundamental differences between isolated, closed and open systems: Isolated systems do not exchange energy and matter with their environment; closed systems exchange energy with their environment, and open systems exchange energy and matter with their environment. The systems discussed in this study are open systems: Societies and the System for example, are also open systems that continuously exchange energy and matter with their respective environments. As I explain later in this study, these exchanges are a precondition for the ordering of the (State-)System.

The 'concept' of entropy was introduced by Clausius and is a physical quantity as fundamental as energy (44). Kondepudi et al explain: "Entropy, encompasses all aspects of transformations of matter: changes in energy, volume and composition. Thus, every system in Nature, be it a gas, an aqueous solution, a living cell or a neutron star, is associated with a certain entropy, just as we associate an energy" (44).
The Second Law concerns the tendency of energy to 'spread out' - to disperse - in processes (when work is accomplished), and the entropy that is produced (the energy that is dispersed, degraded) constitutes a measure for the dispersion (degradation) of the energy. Entropy is about disordered energy and about understanding the relationship between disordered and ordered energy (10).
Although entropy - like energy - is a physical property of systems, entropy is more difficult to conceptualize than energy, it is a somewhat elusive property: "Entropy is not a localized, microscale phenomenon at which we can point" (47). "Entropy can be described in terms of "energy dispersal" and the "spreading of energy (47)". Clausius interpreted the word entropy metaphorically as 'transformation content' (47); a term that points to the inseparable connection of entropy with change and evolution, in other words, with irreversible processes.

2.4. The Second Law of Thermodynamics

The limitation to the convertibility of heat to work that Carnot discovered is one manifestation of a fundamental limitation in all natural processes: it is the Second Law of thermodynamics (44). "The Second Law of thermodynamics requires that if there are any processes underway in the system, the quality of the energy in that system will degrade" (92).

Carnot observed that there are limits to the efficiency and the efficiency improvement of heat engines: "(...) all heat engines convert only a part of their heat intake into work and discard the remainder to the surroundings. This limitation on heat engines is not contained within the First Law of thermodynamics. Nor does it result from imperfections in the engines, for we have found it by examining processes carried out reversibly, that is, as perfectly as we can imagine. This suggests that there must be a Second Law of thermodynamics which imposes limits not expressed by the First Law" (44).

I explain in this study, that the (State-)System during the period 1480-1945 was an integral component of a highly optimized 'kinetic engine' (a dissipative structure, I refer to as the finite-time singularity dynamic), with typical characteristics that can be attributed to the Second Law and the degradation of free energy in the (State-)System.

Chaisson describes the 'meaning' - impact - of the Second Law as follows: "The Second Law of thermodynamics is an unavoidable ground rule. At all times in the Universe, and at all places, the Second Law of thermodynamics is the ultimate arbiter of nature's many varied transactions (*IP: By imposing limits to the application of energy*); it, and the ubiquitous process of energy flow directed by it, embody the underlying physical principle behind the development of all things" (20). How this ground rule impacts on and shapes the dynamics of and in the System, will be discussed in the next chapters of this study.

At the very core of the Second Law of thermodynamics we find the basic distinction between "reversible" and "irreversible processes".

Carnot showed that there is a theoretical maximum to the efficiency of steam engines, and that the ***maximum efficiency*** = $(T1-T2)/T1$ (6). Carnot "discovered that the ratio of the heat content of a closed system to its absolute temperature always increases in any process. He called this ratio the entropy of the system. In the notation of modern thermodynamics, the change in entropy dS (or ΔS) when a small amount of heat dQ (or ΔQ) is transferred to a system is given by: $dS = dQ/dT$" (6). Entropy cannot be directly observed: it is a property, a function of other variables (55).

The mathematical expression for the Second Law of thermodynamics $dS = dQ/dT$, means "that for a given amount of heat (Q) transferred (between two systems), S_{max} will occur for minimum T" (20).

The Second Law of thermodynamics states that the total entropy of an isolated system can never decrease over time. The total entropy can remain constant in ideal cases where the system is in a steady state (equilibrium) or is undergoing a reversible process. In all spontaneous processes, the total entropy always increases, and the process is irreversible. The increase in entropy accounts for the irreversibility of natural processes, and the asymmetry between future and past (96).

Entropy and entropy-producing irreversible processes play a central role in these dynamics and system behavior: "It is the Second Law of thermodynamics that expresses the difference between reversible and irreversible processes through the introduction of entropy. Irreversible processes produce entropy" and it are irreversible processes that then lead to new space-time structures - like the (State-)System - and a so-called 'arrow of time' (44), if certain conditions are met. According to Kondepudi et al: "Entropy and entropy-producing irreversible processes are generally thought of as agents of disorder"; however, "(...) under far-from-equilibrium conditions (*IP: The State-System is sustained far from equilibrium*), irreversible processes are, in fact, the drivers of self-organization and order we see all around us in Nature" (44). And "as is well known today, far-from-equilibrium situations lead to new space-time structures" and entropy increasing irreversible processes play a central role in these processes (44).

"The entropy of an isolated system remains the same only when it undergoes a reversible change. And a reversible change occurs only when the direction of the process can be reversed by an infinitesimal change

in the system or its environment or, alternatively, when the process is quasistatic and without friction or dissipation" (47). In other words, when the process is reversible $\Delta S = 0$ and when irreversible $\Delta S \neq 0$; only irreversible processes contribute to entropy production (63): The Second Law of thermodynamics and irreversibility are related phenomena; entropy is a measure of irreversibility (92).

"There is no real system in nature that can go through a cycle of operations and return to its initial state without increasing the entropy of the exterior, or more generally the 'universe'. Because of the irreversibility of actual processes, "every process in Nature increases the entropy, thus establishing a distinction between the past and future. The Second Law establishes an arrow of time: the increase of entropy distinguishes the future from the past" (44). Because entropy-production - the degrading of energy - is unavoidable in irreversible processes, irreversible processes produce less work than the reversible process (55); the change of entropy due to irreversible processes within a system (d_iS), is for that reason also referred to as entropy change due to 'uncompensated transformation' or 'uncompensated heat' (in case of heat engines).

Contrary to the classical statement of the Second Law of thermodynamics, which states, that the entropy of an isolated system can only increase or remain unchanged, is the modern formulation of the Second Law stronger than the classical statement. According to the modern statement, "the entropy-production due to irreversible processes is positive in every part of a system"; the modern formulation of the Second Law does not require the system to be isolated, and also applies to closed and open systems. The modern formulation is valid for all systems, regardless of the boundary conditions, including for the System.

As mentioned, at the very core of the Second Law of thermodynamics is the basic distinction between "reversible" and "irreversible processes". The classical formulation due to Clausius refers to isolated systems exchanging neither energy nor matter with the outside world; however, all 'real-world' processes are irreversible processes.

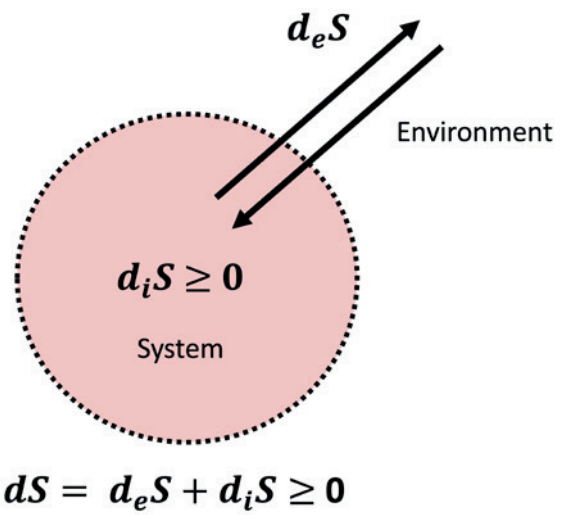


FIGURE 2.2: Entropy-regulation. This figure depicts an open system that interacts with its environment. d_iS is the entropy change due to irreversible processes within the system; d_eS is the change of the system's entropy due to an exchange of energy and matter with the environment/exterior; According to the Second Law of thermodynamics, the net entropy change $dS = d_eS + d_iS \geq 0$.

For open systems - systems which exchange energy and matter with the outside world - a distinction must be made between two terms in the entropy chance $dS = d_eS + d_iS$ (44). "Here, d_eS is the change of the system's entropy due to a reversible exchange of energy and matter with the environment/exterior and d_iS is the change in entropy due to irreversible processes within the system" (44).
The quantity d_eS could be positive or negative, but d_iS can only be equal to or greater than zero" $d_iS \geq 0$ (44). Given the fact that all processes are irreversible, $S = d_eS + d_iS \geq 0$.
The formula $S = d_eS + d_iS \geq 0$ expresses that the Second Law applies to the system and to its surroundings, and does not impose any general restriction on the system alone; thus, in other words:
$\Delta S_{system} + \Delta S_{surroundings} \geq 0$.

2.5. Principles related to the Second Law

Various principles are related to the Second Law, that affect (the dynamics of) the (State-)System and its dynamics as well. Some of these principles I mention in this paragraph, they will be discussed in more detail at a later point:

- The meaning behind the Second Law of thermodynamics is that in isolated systems, energy states (differences in energy) always tend to even out, and these systems achieve equilibrium (...): "equilibrium is the end product" (20). When certain state variables are (kept) constant, "every system evolves to a state of maximum entropy and the rate of entropy production d_iS / dt approaches zero" (44). On other words: "Nature harbors an inherent tendency to eliminate inequalities and realize uniformities in the distribution of matter and energy, to achieve a maximum entropy configuration for any unconstrained system".
- "The equilibrium state achieved within an isolated system is therefore a condition of maximum entropy; a stable state where energy can no longer freely perform useful work. In short, an equilibrium is characterized by an absolute minimum of free energy and a consequent maximization of entropy "(20). "(...) every system then evolves to a state of minimum energy" (44).
- The following equation - a restatement of the First Law - applies $E = F+TS$: The (total) energy E of a System is the sum of its free energy F and of its entropy S (multiplied by the temperature T). In case of a constant temperature, an increase of free energy F goes hand in hand with a decrease of the entropy S (the degraded energy), of the system concerned.
- According to modern thermodynamics, "two or more systems that interact and exchange energy and/or matter will eventually reach the state of thermal equilibrium in which the temperature within each system is spatially uniform and the temperature of all the systems are the same" (44).
- "Processes occur in a direction so as to progress from nonequilibrium toward equilibrium states" (55). Equilibrium implies (is equivalent with) maximum entropy. To avoid increasing entropy in a system, entropy needs to be regulated - redistributed - which is possible in case of open systems that can exchange entropy with their environment. To maintain a state of lower entropy in a system - that is continuously 'pushed' to maximum entropy, in accord with the Second Law - free energy must be available and be put to work.
- In case the entropy in (of) a system in which irreversible processes take place (like societies and the System) is stabilized at a lower entropy 'level', the 'local' entropy level comes at the expense of an

increase of entropy of the environment: "According to the Second Law of thermodynamics, such an entropic decrease can occur only if there were an equivalent or larger increase in entropy elsewhere in the Universe" (20)

- The entropy-production due to an irreversible process is always - and can be expressed as - a product of a thermodynamic force and the flow it drives (44).
- An increase in entropy of a system, impels the system toward greater uniformity (at a macroscopic level); the system will become less structured and more disordered (20).
- Systems have a tendency to 'mix'; "the propensity to equalize, to achieve the lowest energy state, to spread things around evenly, in short to reestablish equilibrium at any and every opportunity" (20).
- Over time, entropy continuously increases, and entropy (disorder) can be generally taken as a measure of the direction of time (20). Although "the Second Law of thermodynamics points the direction of temporal change", it gives no indication of the speed at which change occurs" "The rate of change of entropy differs for each specific event" (20).

2.6. Thermodynamic processes

A system undergoes a thermodynamic process "when the variables that describe the system change from one set of values to another, that is change from one thermodynamic state to another" (47). Entropy (like energy) is also such a state variable. Entropy "is an additive state variable that is a function of the energy E and the other extensive variables of the system" (47).

A thermodynamic process can be specified by an initial state, a final state, and specific conditions under which the change occurs (47). By means of state variables (e.g. entropy, energy, etc.), meaningful comparisons between states of a system are possible. How state variables change (e.g. their rates of change), characterizes how a system evolves and proceeds.

I show in this study, that it is possible to identify state variables that describe the (State-)System; the KA (kinetic activity) - the war dynamics - of the System is a such state variable.

The laws of thermodynamics limit the ways in which a system may proceed from one state to another. The First Law of thermodynamics is the law of conservation of energy applied to the internal energy of a thermodynamic system, as explained. According to the First Law there are only two ways to change the internal energy of a given thermodynamic system: (1) heating or cooling the system and (2) working on the system or arranging for the system to work on its surroundings (47).

"All real processes in the real world are irreversible. Reversible processes represent limiting behavior, the best we can hope for (...) and can be used as standard against which the performance of real processes may be measured" (55). Processes in nature - all actual processes - are irreversible, including processes in the System, and proceed only in one direction.

The existence of entropy "follows inevitably from the First and Second Laws of thermodynamics" and the chief function of entropy is to "quantify the irreversibility of a thermodynamic process" (47). "We found that the maximum work could be obtained only for a reversible expansion" (55).

One of the questions that is addressed in this study (but also needs further research), concerns the identification of variables and conditions that define the entropy(-production) of societies and of

the System. It seems that the entropy of the System is a function of its total energy, its volume (the geographical space it 'occupies'), and the number of its constituents (population size and the number of entities (states) in the System).

2.7. Statistical mechanics

Sometimes other descriptions for entropy are used, depending on the context. Depending on the context, entropy is also used as a measure of for example: disorder, uncertainty, possibility, variety (5), missing information and spread in phase space. More entropy not only means more degraded energy, but also means that a system can have more possible states or configurations; entropy is also a measure for disorder, as I explain in this paragraph.

"The concept of entropy has its foundation in macroscopic processes: The concept of entropy as a state function is entirely macroscopic". "It has not been necessary in our discussions of thermodynamics, to mention the nature of matter (...). As far as classical thermodynamics is concerned, matter may as well not be made up of atoms. But our belief in atoms and molecules is pretty firm, and we gain nothing by ignoring the atomistic nature of matter. It makes much more sense to ask what can be added to thermodynamics by knowing something of the structure of matter. This type of inquiry has led to the development of kinetic theory and statistical mechanics" (55).

"So far, no mention has been made about entropy's meaning at a microscopic (i.e. molecular) level. The question is: How can irreversible macroscopic processes emerge from the reversible motion of molecules? The energy of a macroscopic system is the sum of the energies of its microscopic constituents. What about entropy?" (44). What is the relationship between entropy and molecular properties? And, in case of the System, a question I address in this study: What is the relationship between the entropy of the (State-) System and properties - e.g. KA - of societies/states?

The challenge of the Second Law of thermodynamics was to reconcile this law - which concerns the (macro) state of a system - with microscopic dynamics/interactions of a system (44). This is also a challenge I discuss in this study: The reconciliation of the macro state and behavior of the System - the Second Law of Thermodynamics - and the manifestation of entropy at microscopic level: How does entropy manifest itself at macro and micro level in social, political and historical processes? This subject will be discussed later.

With the concept of statistical mechanics, the relationship between entropy (as a macroscopic concept) and molecular properties - the micro-level of a system - can be established[1]. *The basic idea that underlies statistical mechanics is that increasing order corresponds to decreasing entropy and vice versa* (55).

"Boltzmann related the entropy of a thermodynamic system to the possible dispositions of its atoms and re-interpreted the second law of thermodynamics in terms of the number of its possible atomic arrangements" (47). Boltzmann thus introduced the idea of probability into thermodynamics (44).

1. "On the one hand, quantum mechanics describes the behavior of electrons, atoms and molecules with remarkable success through the concepts of quantum states, quantized energies and energy eigenstates. On the other hand, an equally successful thermodynamics describes the macroscopic behavior of matter in terms of variables such as entropy S, Helmholtz energy F and chemical potential μ. Statistical thermodynamics relates these two theories. It enables us to calculate thermodynamic quantities, such as the Helmholtz energy F, given all the energy states of constituent particles: electrons, atoms or molecules as the case might be." (44).

"When Boltzmann visualized the interior of a thermodynamic system, he saw not only atoms and molecules but also their possible arrangements" (47). These internal possible arrangements are also referred to as microstates. From this perspective, entropy is a probabilistic concept. Thus, *entropy can also be equated with randomness; "the greater the randomness or disorder, the greater the entropy*" (20). The microscopic properties of any system with great randomness (high entropy) are arranged in many different ways and "a system of low entropy has only a few possible arrangements of its inherent properties" (20). *High entropy* (*randomness and disorder*) *can be associated with a large number of possibilities* (*e.g. system configurations*).

"A microstate is identified by a detailed particle-level description of a system" (47). "A microstate of a system is the detailed specification of the state of every particle in the system. For a given total energy $\boldsymbol{U}$ there are a large number of different ways in which that energy can be distributed among the particles in the system. In general, there are a large number of microstates that correspond to a given thermodynamic state" (44).

In other words, *a macrostate - described with a relatively small set of variables - can 'contain' a number of microstates that 'comply' with the macrostate-description*. A gas with a specific volume and temperature etc. - a specific macrostate - can consist of numerous microstates (molecular arrangements) that meet this description. More (potential) microstates means more entropy, and consequently more possibilities and uncertainty. "According to the fundamental postulate of statistical mechanics: the microstates of an isolated thermodynamic system are equally possible" (47). "The assumed equal probability of the microstates of an isolated system is the material out of which we compose the probability of a macrostate. According to the fundamental postulate, the probability of a macrostate is proportional to the number of microstates contained in the macrostate" (47). Boltzmann called the number of microstates that compose a macrostate its multiplicity which is denoted with the symbol omega ($\boldsymbol{\Omega}$)[2].

"The fundamental postulate implies that an isolated thermodynamic system moves probabilistically and without bias among all its possible microstates. But if so, a system may also move among sets of microstates that correspond to unusual macrostates, for instance, to air rushing to one corner of a room or to a cup of hot tea becoming yet hotter on a cold afternoon. We never observe such counter-intuitive macroscopic evolutions, not because they are impossible but rather because they are extremely improbable. The multiplicities of such unobserved counter-intuitive macrostates are overwhelmingly small compared to the multiplicities of the macrostates that are invariably observed (47)".

According to the fundamental postulate, "the microstates of an isolated system are equally probable. While the fundamental postulate is quite powerful, it does not apply directly to systems that are not isolated. For instance, a very common non-isolated system is one in thermal equilibrium with its environment. *When a system is not isolated, we have no reason to believe that its microstates are equally probable*. And when s system's microstates are not equally probable, the entropy will no longer be proportional to the logarithm of the multiplicity" (47).

According to Boltzmann's fundamental postulate, "entropy is a logarithmic measure of the number of microscopic states that correspond to the macroscopic state: in which $\boldsymbol{W}$ is the number of microstates

2. The method that is applied is as follows, in case of an ideal gas: "We start with the relative entropy $\boldsymbol{S}$ (= $\boldsymbol{c}$ + $\boldsymbol{k}$ ($\boldsymbol{ln\Omega}$)) of an $\boldsymbol{N}$-particle ideal gas whose macrostate multiplicity $\boldsymbol{\Omega}$ depends upon the system internal energy $\boldsymbol{E}$, volume $\boldsymbol{V}$, and particle number $\boldsymbol{N}$. The we discretize the available 6N-dimensional phase space and count the number of classical microstates through which the single point representing the system can move, that is, we determine the multiplicity $\boldsymbol{\Omega}$. This procedure produces the entropy $\boldsymbol{S}$ ($\boldsymbol{E}$, $\boldsymbol{V}$, $\boldsymbol{N}$) relative to that of a reference macrostate. Both the multiplicity $\boldsymbol{\Omega}$ and the entropy $\boldsymbol{S}$ determined in this way depend upon the size of the cells into which the phase space is divided. (47).

corresponding to the macrostate (*IP: also referred to as the thermodynamic probability*) whose entropy $S = k_B \, lnW$. In which k_B is called the Boltzmann constant" (44). As was mentioned earlier, a macroscopic thermodynamic state of a system corresponds to a large number of microstates. For instance, if the total energy of an ensemble of N particles (molecules, electrons, etc.) in a volume V is specified, then this energy can be distributed among the N particles in a number of ways. Each distinct distribution of the energy among the N particles corresponds to a microstate. In physics, the set of all microstates that yield the same macrostate is called an ensemble of microstates (88).

Macrostates with larger W are more probable: "The irreversible increase of entropy then corresponds to the evolution to states of higher probability in the future. Equilibrium states are those for which W is a maximum" (44). An increase of entropy can be interpreted as the passages of a system from a less probable to more probable states.

Chaisson describes these tendencies as follows: The Second Law of thermodynamics can be viewed in different ways: "In addition to the notion of energy flowing from available to unavailable states or from high to low concentrations (or temperatures), we can alternatively regard energy in an isolated system as flowing from ordered to disordered states. Minimum entropy states, where energy concentrations are high and available energy is maximized, are considered ordered states. By contrast, maximum energy states, where available energy is more dissipated and diffused, are considered disordered states. Thermodynamically, then, order or organization is measured according to the number of possible arrangements of a system's many parts. If a system can be described in terms of only a few such arrangements, we say that the system is orderly. Conversely, if these parts enjoy great freedom in their arrangement, so that they can be described only in terms of many possible arrangements, then we say that the system is highly random or disorderly. And we know that the degree of randomness determines the entropy" (20).

"This is the way the Second Law works in Nature. Left to itself, nothing will proceed spontaneously toward a more ordered state" (20). "All things, when left alone, eventually degenerate into (...) randomized, less ordered states" (20). The tendency of a system is - in accord with the Second Law of thermodynamics - that natural use causes order to break down into disorder; entropy will tend toward a maximum in any system (20), as explained in the previous paragraphs.

By expending energy, order can be achieved (20). Energy consumption is a "means of ordering, reordering, and maintaining complex systems" (20), as the (State-)System also shows.

2.8. The probabilistic nature of systems and their dynamics

If a system - like the (State-)System - consists of large numbers of elements (components), statistical statements can be made with a probability of success (20), despite fluctuations/inhomogeneities at elementary level. "Thermodynamics describe order in terms of the arrangements of the numerous microscopic states comprising the various macroscopic properties of a system. The larger the number of possible arrangements, the greater the disorder or randomness of the system. The smaller the number, the greater the order, for order itself can be regarded as a restraint in the way in which a system can arrange itself" (20).

Chaisson explains: "Given that the element of chance has some role to play in all events, we are left with the notion that only when vast numbers are involved do events begin to show expected average

patterns consistent with terrestrially familiar behavior of matter in the macrocosm. In this way we can understand how random processes can yield predictable order, though only when working with large numbers and repeated trials, much as probability theory can elaborately predict the results of tossing numerous pairs of dice. Even so, a price is paid; Whenever a system is represented by an average, some information is inevitably lost about the details of the total system." (20). "These statements can be clarified by invoking the nonetheless abstruse subject of statistical mechanics, which supplements the classical, mechanistic physics of old, (...) statistical mechanics employs large aggregates of particles to represent thermodynamic concepts" (20).

In 1877, Ludwig Boltzmann proposed his famous entropy formula: $S = k_B \, lnW$; k_B is known as Boltzmann's constant, "ln is the natural logarithm to the base e, and W is the number of different arrangements of the microscopic states, or 'complexions - positions, velocities, compositions, in addition to various quantum properties - of the individual parts comprising a given macroscopic system."

Boltzmann's entropy formula concerns "statistical reasoning, not strict determinism, and accords well with the laws of thermodynamics (e.g. $E = F + TS$[3]) (20). The multiplicative nature of W (the number of different arrangements in case there are more 'compartments' involved; in case of two compartments: $W_{Total} = W_1 \, W_2$), in contrast with the additive nature of E (and S) ($E_{Total} = E_1 + E_2$ and $S_{Total} = S_1 + S_2$), accounts for the logarithmic function in the Boltzmann formula) (20).

"The role played by statistics can be further appreciated by recognizing that in any macroscopic system the number of microscopic states W, essentially measures the inverse probability, p, of occurrence of those states. That is, $p = W^{-1} = 1$ for a 100 percent, completely certain state. This is true because the most likely configuration of the particles in a system is the high-entropy state for which they are evenly mixed up or 'disordered'; hence the probability is low for any particle to be in a specific microstate" (20).

Regarding a two-body system (or a two-compartment system referred to in above text), "the most likely energy distribution is that for which W is maximized, a condition realized when the temperatures of the two bodies (*IP: compartments in this example*) are equal" (20). Thus, we can rewrite the second law of thermodynamics as: $S = k_B ln \, (1/p) = -k_B ln \, p$, and interpret it in the following way: Any isolated system naturally tends toward an equilibrium state of minimum microscopic probability; namely, a uniformity of temperature, pressure, chemical composition, and so on. And since ordered molecular states (for example where molecules in one part of the system have one property value, but those in the remaining part have another) are less probable than those random or disordered states, *Boltzmann's law then signifies that ordered states tend to degenerate into disordered ones*. This law also explains why any material system's available (free) energy tends to diminish with time; useful energy is orderly (or high-grade energy), whereas heat, associated with the random motions of large numbers of molecules, is usually disorderly energy. Therefore, the energy of an isolated system indeed remains constant but tends to become asymptotically less free to perform useful work as more of it changes into low-grade heat, thereby increasing the disorderliness of its component parts. This is how the principle of increasing entropy has come to be regarded as a measure of the disorder of a system. *The idea of increasing entropy has ceased to be an inviolable law of Nature; rather, it is a statistical law*. Even in equilibrium thermodynamics, a reversal of the usual trend - onward a state of lower entropy - is no longer impossible but only highly improbable."

3. The equation $E = F + TS$, is a restatement of the First Law: The (total) energy E of a System is the sum of its free energy F and of its entropy S (multiplied by the temperature T). In case of a constant temperature, an increase of free energy F, means a decrease of the entropy (the degraded energy) of the system concerned.

Consequently, "the static Newtonian view that treats (idealistically) all substances as stable, fixed, isolated components of matter has given way to the conception that all (realistic) phenomena are intrinsically unstable and share part of a dynamic flow" (20).

Chaisson argues: "Now, since all things are made of matter and energy, both of which regularly change, we can conclude that the process of becoming (*IP: change, evolution*) is governed by the laws of thermodynamics". "The Second Law determines the direction in which matter and energy change (or flow), but it cannot determine the rate of that change. In nature this rate fluctuates, according to the way a system interacts with its environment" (...) change proceeds in jumps and spurts (...) in a punctuated manner" , and "accordingly, the process of change is better characterized by non-equilibrium thermodynamics, and we use this relatively new discipline to stimulate what might happen during any given event, what might result from any given change" (20).

The Second Law, related principles and mechanisms also explain the development of the European State-System toward an equilibrium state that was eventually accomplished in 1945 (albeit with a delay until 1989), through the highly regulated application of KA (war dynamics).

In the equilibrium state - in which the European State-System no longer exists - there is maximum disorder, and the available energy - which was available until 1945 in the core (the European State-System) in the form of high-grade kinetic energy (military capabilities) - has degraded into low-grade disordered energy, in accord with the equilibrium (maximum entropy state) of the (former) European State-System. This development will be discussed in detail in this study.

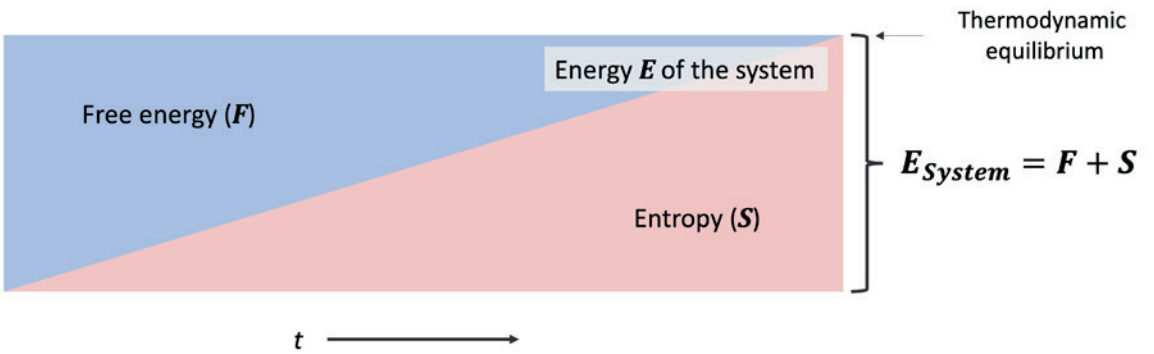


FIGURE 2.3: The natural tendency toward maximum entropy. A system - if not constrained - tends toward an equilibrium state that is equivalent with maximum entropy; maximum entropy implies a state with maximum disorder and maximum degraded energy. Because $E = F + TS$ (this is a restatement of the First Law), The (total) energy E of a System is the sum of its free energy F and of its entropy S (multiplied by the temperature T)); in other words, the free energy change is a direct measure for the entropy change of a system.

2.9. Thermodynamic equilibrium

As mentioned, according to the Second Law of thermodynamics, in all spontaneous processes, the total entropy always increases, and the process is irreversible. "It is a natural tendency of systems to make an irreversible transition from an internally constrained system to one less constrained" (47). Once thermodynamic equilibrium is attained, the entropy of the system is maximum.

In accordance with the Second Law of thermodynamics, a system (including the System), works towards a state of thermodynamic equilibrium, which implies a minimization of free energy. The principle of minimum energy is essentially a restatement of the Second Law of thermodynamics. It states that for a closed system, with constant external parameters and entropy, the internal energy will decrease and approach a minimum value at equilibrium.

However, locally and temporarily, the entropy can be low(er) (and the free energy level consequently higher ($\boldsymbol{E} = \boldsymbol{F} + \boldsymbol{TS}$). To accomplish this, the constant regulation of entropy (a process that itself also generates entropy) is required. Regulation of entropy (new possibilities, uncertainty. disorder, etc.) requires that work must be accomplished, and free energy is put to use.

When (eventually) thermodynamic equilibrium is reached, the entropy of the system (its disorder, uncertainty, etc.) is maximum, and its free energy is minimum (see also above figure). In case of thermodynamic equilibrium - maximum entropy - there is no order and no organization.

The other extreme is 'zero entropy' when all new possibilities (disorder, uncertainty) are 'squeezed' from a system; the system's organization is 'absolute' there is maximum structure - and the system lacks consequently flexibility/adaptation.

As I explain in this study, radicalization - extreme political ideologies - points to near or 'zero' entropy in social systems: There is no variety and diversity, and consequently no adaptability in radicalized systems; while the entropy is (near) zero, the free energy in the system is maximized. For living systems - including communities, societies and the System - the level (amount) of entropy in the system must be balanced between two 'extremes'; between maximum and zero entropy. The sustainment for life and survival require the ability to sustain an intermediate amount of entropy. Nazi Germany (1933-1945) is an example of a radicalized 'zero entropy' society: All variety was squeezed from German society, organization and control were absolute, all behavior was standardized, while at the same time, the free energy (its military capabilities) of the German society/state was maximized. Collapse and self-destruction of (near) zero entropy systems - like Nazi Germany and also the Islamic State (IS) and North Korea - are unavoidable - the low entropy cannot be sustained - and were (at least in case of Nazi Germany and IS) accompanied by the destructive release of the accumulated free energy. The Second Law also determines and shapes social dynamics/developments and social evolution; this subject will also be discussed in detail.

2.10. Application (1): A preview

In this paragraph, in anticipation of the next chapters, I provide some context to the reader and explain how the Second Law of thermodynamics applies to the System.

The laws of thermodynamics also apply to the System and its dynamics: Energy and entropy are also physical properties - state variables - of the System. "When matter undergoes transformation from one

state to another, the total amount of energy in the system and its exterior is conserved; total entropy, however, can only increase or, in idealized cases, remain unchanged" (44). These basic rules also have far-reaching consequences for the (dynamics of the) System.

Interactions between humans, communities and societies consist of a multitude of irreversible processes that cause the production of entropy. Because of the increasing interdependence of societies in the System, the System's connectedness and the intensity of frequency of interactions (irreversible processes), as well as entropy-production, increased.

Entropy can also be understood probabilistically, as explained in this chapter. An increase of entropy of the System means that the number of available microstates - the disorder of the System - increases. In case of the System, the number of available microstates can be established by calculating the number of microstates to a given macrostate by combinatorial analysis.

The point is that social systems (all living systems) - including communities, societies and the System - require a certain order - organization - that must be maintained to ensure their functioning and survival. Social systems must deal with - regulate and restrain - the entropy that is produced through (irreversible) processes taking place: The 'new' microstates and disorder - entropy - challenge social systems.

In case of social systems - living systems in general - order is created out of disorder, "when according to the second law of thermodynamics, disorder ought to be continually increasing" (6).

Organization requires that a level of low(er) entropy is maintained, despite its continuous production. The accomplishment and sustainment of a certain level of organization ('low entropy') requires the use of fee energy, as I will explain later. Organization - life - feeds on free energy, so to speak. War is the application of 'societal' free energy - kinetic energy (military capabilities) - in the State-System, to create and sustain a certain order (low entropy), essential for the survival of its constituents.

Because entropy always increases, the 'lowering' of entropy (the creation and sustainment of order) - by definition locally and temporarily - must be compensated elsewhere, outside of the system concerned; entropy ($\boldsymbol{d_i s}$) must be exchanged (exported) from the social system concerned to its environment ($\boldsymbol{d_e s}$): The ever-increasing order represented by increasing levels of organization in parts of the System is matched by increasing levels of disorder in other parts of the System that were not included in the process of ordering: $\Delta \boldsymbol{S}_{system} + \Delta \boldsymbol{S}_{surroundings} \geq \boldsymbol{0}$ - the Second Law - cannot be ignored. "Social systems produce order within themselves and in other social systems by creating disorder in the universe as a whole" (6).

However, entropy is not (always) just 'waste' that 'only' causes disorder. From a probabilistic point of view, entropy constitutes 'unrealized possibilities' and in social systems entropy can be considered as 'social potential' on which the process of social evolution feeds.

In this study, I explain that in the (State-)System - which is a system far from equilibrium - entropy also serves as a source of order, and how entropy-regulation is accomplished in the System, to ensure societies and the State-System is sustained.

2.11. Application (2): Degradation of energy

The Second Law of thermodynamics specifies the way in which change occurs in a quantity called free energy (also referred to as 'available energy'). The Second Law "stipulates that a price is paid each time energy changes from one form to another. The price paid (to Nature) is a loss in the amount of

available energy capable of performing work of some kind in the future. In physics, entropy is the term characterizing this decrease in available energy" (20). The 'effect' of the Second Law of thermodynamics is that "each time energy flows from one state to another, less energy is available to perform work the next time around. Energy is not lost, just rendered unavailable for useful work." A flow of energy is always accompanied by a flow (or change) of entropy. "Only for ideal (so-called-reversible) processes will the resulting change in entropy be zero" (20). For realistic (i.e. irreversible or asymmetric processes/events; all natural processes), "there must be an increase in the total entropy, for with each such process less energy is available to do something useful" (20). The following statement applies: $\boldsymbol{E} = \boldsymbol{F} + \boldsymbol{TS}$, where $\boldsymbol{E}$ is the total internal energy of the system concerned and $\boldsymbol{F}$ is the system's free (available) energy, capable of doing work (20). In physics $\boldsymbol{F}$ is technically known as the Helmholtz free energy; chemist use the term Gibbs free energy; "conceptually their roles are similar, and their numerical differences only small (inconsequential for biological systems)".

The term $\boldsymbol{TS}$ is equivalent with the entropy of the system ($\boldsymbol{T}$ is the temperature of the system, $\boldsymbol{S}$ the entropy). "Hence, for fixed energy and a given temperature, if $\boldsymbol{F}$ decreases then $\boldsymbol{S}$ must increase" (20).

2.12. Application (3): Destruction versus construction

Depending on the state of a system - in equilibrium, near equilibrium or far from equilibrium (FFE), a subject not yet discussed in this chapter - the effect - impact - of the Second Law is different: "Although the destruction of order always prevails in a system in or near thermodynamic equilibrium, the construction of order may occur in a system far from equilibrium. Whereas classical thermodynamics deals with the first type of physical behavior, novel aspects of non-equilibrium thermodynamics - (*IP; Also referred to as 'modern thermodynamics'*) are only now being developed and are needed to decipher the second type of behavior" (20).

The System displays 'dual behavior' – so to speak -a combination of destruction and construction, as I explain in this study: During the so-called transient period (1480-1945, when the System made a transition from an unorganized state (< (before) 1480) to thermodynamic equilibrium in Europe (the core of the System, > (after) 1945)), there was a combination of destruction - through systemic KA (systemic wars), related to the near-equilibrium cyclic R2-dynamics of the System - and construction, through so-called chaotic non-systemic KA (non-systemic wars), related to the far-from-equilibrium chaotic R1-dynamics.

2.13. Application (4): The 'social potential' of entropy

The entropy produced by heat engines is also referred to as 'uncompensated heat' that results in an increase in disorder of the system and/or its environment. Entropy produced in social systems (i.e. through irreversible (social) processes ($\boldsymbol{d_iS}$)) also causes an increase in possible microstates (disorder), in the system itself, or of its environment (if exchanged to the environment, $\boldsymbol{d_eS}$). In case of the System (as mentioned, and discussed in the next chapters), which is far from equilibrium (FFE) system, entropy serves as a source of order, not only because entropy(-production) contributes to the rearrangement of

societal energies in kinetic energy (military capabilities), under certain conditions, but also because the new microstates that are contained in the entropy that is produced, offer new possibilities and constitute a 'social potential'.

2.14. Application (5): Potential for confusion

There is some potential for confusion, regarding the concept of entropy. Entropy can be considered a probabilistic concept. According to Maxwell, the Second Law of thermodynamics has only statistical certainty. Although, generally, the evolution of an isolated system is in the direction of increasing entropy (disorder), around this general trend there may be small fluctuations: The Second Law can at times be 'violated', and the statistical entropy of an isolated system can momentarily decrease (47).

Descriptions like 'disorder' can cause confusion: At a microscopic level, the term disorder may correctly suggest an increased range of accessible possibilities, whereas at the macroscopic level of perception the (increased) disorder is perceived as more ordered. It is important to note that "disorder" (more microstates) in a thermodynamic sense, relates to a full microscopic description of the system, rather than its macroscopic properties (96).

In reference to entropy defined as uncertainty, "the larger and more varied the ensemble from which a system can be chosen and the larger and more varied the message source from which a message can be drawn, the more uncertain the outcome and the higher the entropy" (47). The larger the set of possibilities from which either a microstate or a message can be realized or chosen, the larger the entropy of the physical system or the Shannon entropy of the message source (47).

3. Information

3.1. Introduction

In this chapter, I discuss information and the relationship between information and entropy. It is important to understand that information is (also) a physical property, but "can connote different ideas in different contexts, like news, knowledge, intelligence, and so on" (20).

3.2. The relation between entropy and information (1)

The basic idea of statistical mechanics is that increasing order corresponds to decreasing entropy, and vice versa (55). Maxwell (with the help of a thought experiment also referred to as "Maxwell's' demon") made several important observations concerning sorting processes that are required to create order: Sorting - an 'activity' inseparably related to increasing order - requires information[4].

If - as is the case in Maxwell's thought experiment - a 'demon' sorts (separates) slow from fast moving molecules in two separated compartments - implying an increase of organization and a decrease in entropy - and the partition is taken away so that the hot gas (fast moving molecules) is mixed with the cold gas (slow moving molecules), the mixing will cause an increase in entropy. "During this mixing, the entropy of the system will increase, and information (about where to find fast particles and where to find slow ones) will be lost. Entropy is thus seen to be a measure of disorder or lack of information. To decrease the entropy of a system, and to increase its order, Maxwell's demon needs information. In the opposite process, the mixing process, where entropy increases and where disorder increases, information is lost (6)".

"The apparent link between information and entropy has been exploited and developed into the subject called information theory, which has important applications in the design of communication systems. The fundamental equation of information theory is identical with the equation for entropy in statistical mechanics (*IP: See next paragraph*), and the quantity calculated, having to do with the information content of messages, is even called entropy (the actual messages is one selected from a set of possible messages). In statistical mechanics we deduce the properties of matter by applying statistics to large numbers of molecules. In information theory we deduce the information-carrying capacity of communications systems by applying statistics to large numbers of messages" (44).

4. There is a categorical difference between shuffling and sorting; shuffling goes on by itself: it is automatic. But not so with sorting. The more deeply biologists have penetrated into the biological transformations the more they have been struck by "the amazing specificity with which elementary biological units pick out of the building materials available just the 'right ones' and annex them just ate the right places", all recognize that such orderly processes occur only in life-bearing structures (34).

"The notion of the amount of information attaches itself very naturally to a classical notion in statistical mechanics: that of entropy. Missing information in general cases has come to be known as Shannon entropy" (6).
"From the standpoint of information theory, the thermodynamic entropy S of an ensemble of N identical weakly-interacting systems in a given macrostate can be interpreted as the missing information which we would need in order to specify the state of each system, i.e. the microstate of the ensemble. Thus, thermodynamic information is defined to be the negative of thermodynamic entropy, i.e. the information that would be needed to specify the microstate of an ensemble in a given macrostate. Shannon's formula allows this missing information to be measured quantitatively" (6).
"Just as the amount of information in a system is a measure of its degree of organization, so the entropy of a system is a measure of its degree of disorganization; and the one is simply the negative of the other" (6). From an entropic perspective, "Information is that what removes uncertainty" and is measured by the uncertainty it removes (s): Information is the negative of uncertainty.
We can also see (…) that Gibbs free energy is measure of a system's content of thermodynamic information (to be discussed later). If the available free energy is converted into heat, a certain quantity of thermodynamic information is lost, and we can deduce that in the initial state of the system, this quantity of information was available (6).

3.3. The relation between entropy and information (2)

A relationship consists between order and information content, I discuss in more detail in this paragraph.
"The extent to which a system is ordered can be estimated by appealing to information theory; the more ordered a system, the greater the information content (or negentropy) it possesses" (20).
"The statistical character of the Second Law arises from the fact that the laws of probability govern the direction in which natural processes occur" (20). These laws cannot be dictated by some human agency as 'Maxwell's demon' demonstrates (20).
This (thought) experiment confirms that the creation of order requires energy, as Chaisson puts it: "(...) an energy flow through an open system is an absolute necessity if order is to be created from disorder" (20).
A decrease in entropy - the creation of order - requires selection, and an input of energy to accomplish this: Order creation, an increase in complexity, requires selection and energy, "both within and beyond the realms of physics and biology" (20).
Entropy can also be regarded as "a lack of information about the internal structure of a system, and it is this lack of information that allows a great variety of possible structural arrangements among the system's microscopic states; the positions, motions, and orientations of the many varied parts of a high-entropic system cannot in practice be specified precisely. Since any one of many microscopic states might be realized at any given time, the lack of information (or ignorance) about a system corresponds to what we have earlier labeled disorder (or uncertainty). For example, when a system is at equilibrium - the state of greatest diversity on the microscopic scale but the greatest uniformity as seen by the human observer on the macroscopic scale - we have the least possible knowledge of how the various parts of the system are arranged, where each one is, and what they are doing. Close to equilibrium all such microstates have nearly equal (large) probabilities, p, where $p \leq 1$,which is why the information itself, I, varies inversely as the probability: $I \propto log(1/p) = -K \log p$. The proportionality constant, K, is a dimensionless unit of information commonly taken as 1 bit (binary digit)" (20).

Chaisson explains: "Communicating a message inevitably results in a change to a state of greater in inaccuracy; the integrity of the message is unavoidably corrupted, some information invariably lost" (20), as is also the case when free energy is put to use, and energy is 'degraded' (in entropy). "If we associate the loss of information with a decrease of order, or likewise an increase of disorder, and if we note that the above equation for information resembles that for entropy, we can then relate a gain of information directly to negative entropy" (20) also referred to as 'negentropy': "(...) when system is orderly (that is, low in entropy and rich in structure), more can be known about that system than when it is disorderly and high in entropy. And if entropy measures disorder or the lack of information about a system, then negentropy must be a reasonable assessment of the order, or presence of information. All these latter terms - order, negentropy, information - become approximately synonymous for our purposes. In short, if we gain some information about a system, any previously existing uncertainty about that system is diminished" (20).

The following relation for information exchange exists: $dI = I_f - I_i = K\,log(B_i/B_f)$. This formula "stipulates that information depends inversely on the logarithm of the probability distribution of states within a system" (20): dI is the information transmitted; I_f is the information content after receiving additions information; I_i is the information content before receiving additional information; B_i is the number of possible initial structural arrangements; B_f is the number of possible states after some information is received, so that $1 \leq B_f \leq B_i$. The "relation for information exchange has an uncanny resemblance to that describing a change in entropy, S, for a system having different numbers of microscopic states, W, before (i) and after (f) the change": $S = Sf - S_i = k_B\,ln(W_i/W_f)$; an explicit connection between entropy and the net information that is exchanged exists (20).

Chaisson explains: "Since $S_i = S_{max}$, because the initially large number of receivers (microstates) relates to the maximum entropy, the information gain of a system can be expressed as the difference between the system's maximum possible entropy and its actual entropy at any given time". "This is the origin of the well-known argument that order, information gain ($+dI$), and negentropy ($-dS$) are intimately related. This is also consistent with the definition of order as an absence of disorder, for the amount of order present in any system can be measured by the size of the gap by which the actual randomness differs from the maximum possible randomness" (20).

3.4. Thermodynamic information

A distinction between two types of information can be made between: thermodynamic information and cybernetic information (6).

Thermodynamic information is a physical quantity. Energy, entropy and information are closely related properties: energy contains information (thermodynamic information), and each unit of information (bit) is equivalent with a certain amount of energy.

This example of Avery (6) explains the concept of thermodynamic information and its relation with entropy: When a photon from the sun reaches (for example) a drop of water on Earth, the initial entropy of the system consisting of the photon plus the drop of water is smaller than at a later stage, when the photon's energy has been absorbed and shared among the water molecules, with a resulting very slight increase in the temperature of the water (indicative for an entropy-increase). This entropy-increase difference can be interpreted as the quantity of thermodynamic information which was initially

contained in the photon-drop system, but which was lost when the photon's free energy was degraded into heat. This energy difference can be expressed in terms of bits. In our example, the information is lost; but if the photon had instead reached the leaf of a plant, part of its energy, instead of being immediately degraded, might have stabilized in the form of high-energy chemical bonds. When a part of the photon energy is thus stabilized, not all of the thermodynamic information which it contains is lost; a part is conserved and can be converted into other forms of information (6).

Thus, under certain circumstances the available thermodynamic information can be partially conserved. In living organisms, chemical reactions are coupled together, can be transferred from one compound to another, and ultimately converted into other forms of information.

For example, in case of the burning of glucose, "if the glucose is simply burned, this amount of information is lost; but in a living organism, the oxidation of glucose is usually coupled with other reactions in which part of the available thermodynamic information is stored, or utilized to do work, or perhaps converted into other forms of information" (6). In that case, the available free energy - and its accompanying thermodynamic information - is used to build up a statistically unlikely (information containing) structure, and consequently, the entropy is 'locally' lowered, but unavoidably part of the energy is degraded into heat and causes an increase of entropy of the environment of the structure. Order always comes at a price.

According to Avery's information perspective on evolution (6), "Gibbs free energy carries a content of information and the "thermodynamic information" obtained by the autocatalysis from the free-energy-rich molecules in the primitive ocean was the source of the order which developed during the process of chemical evolution". According to Avery, thermodynamic information derived from free energy "is today the driving force behind all forms of life, behind the local order which life is able to produce" (6). "All of the information contained in the complex, beautiful, and statistically unlikely structures which are so characteristic of living organisms can be seen as having been distilled from the enormous flood of thermodynamic information which reaches the earth in the form of sunlight" (6). "Like all other forms of life on Earth, humans pass information from one generation to the next, coded into the base sequences of their DNA. However, humans have developed a second, highly effective mode of information transmission: language and culture" (6).

3.5. Cybernetic information

Contrary to thermodynamic information being a physical quantity, cybernetic information is an abstract quantity. Cybernetic information is a specific 'category' of information, for example used by biological and social systems to control and communicate. "In cybernetics, stress is placed on the quantitative flow of an intangible attribute (that is information), from transmitter to receiver".

The word "Cybernetics" was coined by Wiener who defined it as: "the entire field of control and communication theory, whether in the machine or in the animal". Cybernetic concepts - like homeostasis and feedback - also apply to control and communication in social systems (6), including societies and the System. Wiener was aware of the relation between information and entropy.

Social systems are (also) controlled and regulated by feedback structures. Because the flow of information is essential for the functioning of feedback structures, a change in the flow of information impacts on the use of energy by the system, and consequently on the production of entropy.

3.6. Relationship between thermodynamic and cybernetic information

A close relationship exists "between cybernetic information and thermodynamic information. However, despite the close relationships, there are important differences (...). Cybernetic (also called semiotic information) is an abstract quantity related to messages, regardless of the physical form through which the physical form through which the messages are expressed, whether it is through electrical impulses, words written on paper, or sequences of amino acids. Thermodynamic information, by contrast is a temperature-dependent and size-dependent physical quantity. Doubling the size of the system changes its thermodynamic information content; but neither doubling the size of a message written on paper (…) will change its cybernetic information content. Furthermore, many exact copies of a message do not contain more cybernetic information than the original message. The evolutionary process consists in making copies of a molecule or a larger system. The multiple copies then undergo random mutations; and after further copying, natural selection preserves that drives the copying process, while the selected favorable mutations may be said to contain cybernetic information. The cybernetic information distilled in this process is always smaller than the quantity of thermodynamic information required to create it (both measured in bits) since all information must have a source" (6).

3.7. Social information

Avery observes that there is a self-reinforcing accumulation of information: "during a brief space of ten thousand years, our species exploded in numbers from a few million to seven billion (...). This population explosion, which is still going on, has been the result of dramatic cultural changes (*IP: and vice versa, I argue*) (...) cultural evolution has changed our way of life beyond recognition; it was driven by an equally explosive growth of stored cultural information. Beginning with the development of speech, human cultural evolution began to accelerate. It started with the agricultural revolution, and faster still with the invention of writing and printing. Finally, modern science has accelerated the rate of social and cultural change to a completely unprecedented speed. The growth of modern science is accelerating because knowledge feeds on itself. A new idea or a new development may lead to several other innovations, which can in turn start an avalanche of change (*IP: also referred to as 'novelty by combination'*). The self-reinforcing accumulation of knowledge - the information explosion - which characterizes modern human society is reflected not only in an explosively-growing global population, but also in the number of scientific articles published, which doubles roughly every ten years. Another example is Moore's law - the doubling of information density of integrated circuits every two years. Yet another example is the explosive growth of Internet traffic. The Internet itself is the accumulation of a trend towards increasing societal information exchange - the formation of collective human consciousness" (6).

3.8. Application (1): Zero entropy: Maximum order and information, no adaptability

In this paragraph, I shortly discuss the decreasing entropy of the State-System during the transient period (1480-1945), ahead of the next chapters.

During the transient period (1480-1945), the entropy of the core of the System - of the European State-System - decreased continuously and eventually reached a state of (near) zero entropy in 1939. At that point, there was no disorder and adaptability left in the State-System; 'all' entropy was (continuously) 'exported' to the environment of the European State-System, consisting of societies and the non-core of the System (the "rest of the world"). Consequently, the core of the System (Europe) had run out of microstates that could 'fit' (comply with) the thermodynamic macrostate imposed by the so-called finite-time singularity dynamic (FTS, a dissipative structure, I discuss in more detail later). When zero-entropy was reached, the European State-System - the core of the System - collapsed.

When entropy is considered as uncertainty or information, this development can be understood as follows: During the transient period (1480-1945) - that is during the unfolding of the 1st FTS - all uncertainty was removed from the State-System; the ensemble of microstates available to the European State-System eventually decreased to zero. This resulted in the collapse of the core - of the European State-System - in 1939.

The fact that the Great Power status dynamics and non-systemic KA were reduced to 'zero' in 1939, are consistent with the 'zero entropy' state of the European State-System at that point in time; effective entropy-regulation was no longer possible. Zero entropy means death, also for a State-System or society.

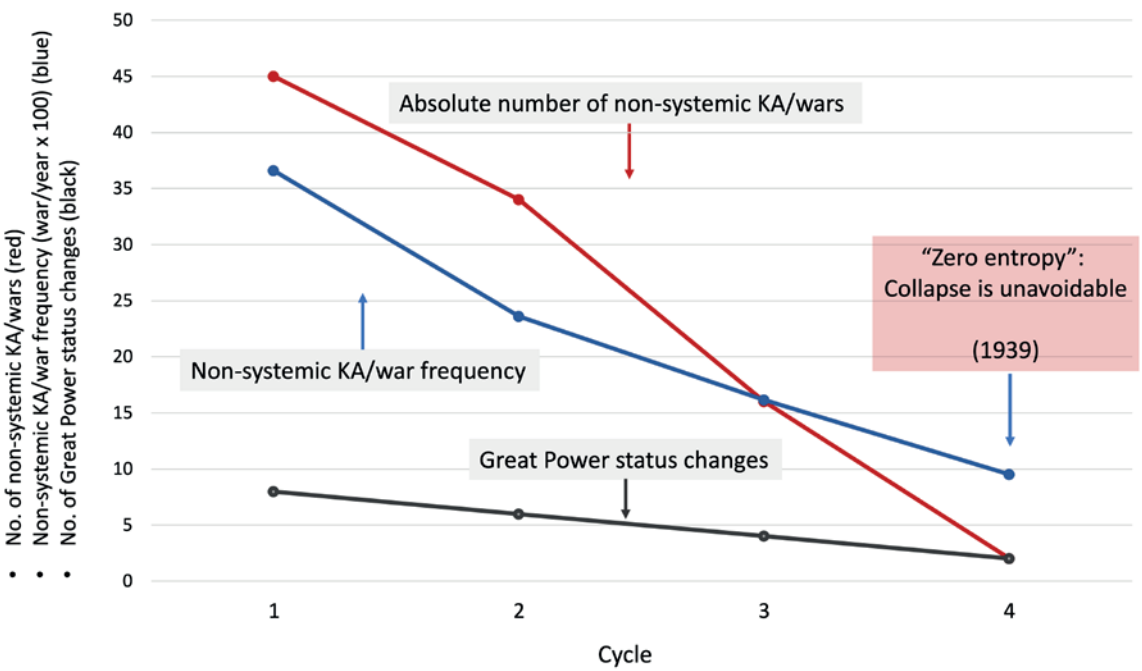


FIGURE 3.1: Toward zero-entropy. This figure shows the development of certain properties of the European State-System; of the four cycles (oscillations) that accompanied the 1st FTS, during the transient period (1480-1945): Of the absolute number of non-systemic KA/wars (in red, data period 1495-1945), of the non-systemic KA/war frequency during successive cycles (in blue, data period 1495-1945), and of the Great Power status changes during successive cycles (in the core and non-core). These properties decreased about linearly toward zero (59). The development of these properties of the (State-)System, are indicative of increasing ossification and a decrease in flexibility and adaptability, and that collapse - which happened in 1939 - was a matter of time. These typical dynamics will be discussed later in more detail. Data from Levy (48).

4. Entropy and the system

4.1. Introduction

In the preceding chapters, I have discussed entropy and its various 'appearances', e.g. as degraded energy, disorder and uncertainty. Individual humans, communities, societies, states, etc. continuously exchange - and transform - energy (***E***), matter (***M***) and information (***I***). These exchanges constitute irreversible processes that also generate entropy (***S***), in accordance with the Second Law of thermodynamics; energy is degraded in these processes and generates uncertainty.
Living systems - including social systems (like societies, states, and the (State-)System) - can be considered dynamic steady states of EMIS-flows (flows[5] of energy, matter, information and entropy) - that are successfully sustained and obey the Second Law of thermodynamics and related principles FFE.
In case of heat engines, entropy (degraded energy) manifests itself as heat, that is exported - 'dumped' in - the environment. The question is how entropy manifests itself in social systems and how it is regulated to ensure that a certain order is maintained; that is the subject of this chapter.
In this chapter, I also present several applications of the ideas and concepts I have so far introduced, including: A measure for the degree/amount of entropy and kinetic activity (KA, war) in the System (the BCD, battle casualty death), and a notion for the degree of aggregation of social systems.

4.2. Social entropy

Entropy in social systems appears - manifests itself - as tensions. Tensions - 'social entropy' - are generated by interactions - irreversible processes - between humans, between humans and communities, between communities, and between societies and states in the (State-)System, etc. Tensions can be compared with the heat produced by friction, e.g. in engines. Tensions can be considered social entropy.
A closer look reveals that tensions have the same qualities and properties as entropy; we never recognized tensions as a form of entropy.
Tensions can be considered degraded energy, an unavoidable byproduct of (human/social) interactions. Tensions are also equivalent with (new) possibilities and (thus) uncertainty; tensions allow for - are the source of - new arrangements (microstates) in social systems. Tensions - new possibilities - can be considered threats or opportunities, depending on how these tensions are qualified in a social/human context. In fact, also threats constitute also opportunities; possibilities to adopt new - more favorable - arrangements.

5. The presence of flows, points to the presence of a certain order in the system concerned. In case there are flows, there is no equilibrium and the entropy (disorder) of the system is not maximum.

A living system - be it an individual human, community or society - must (one way or the other) regulate its energy in- and output, but also the entropy - tensions - it produces. Living systems have various mechanisms to regulate energy and entropy, to maintain a certain balance (homeostasis).
As I discuss later, a relationship exists between the ability of living systems to explore and exploit entropy - new possibilities and opportunities - and their well-being and survival chances. The survival changes of societies (humanity) are (also) contained in their ability to generate, explore and exploit new possibilities (diversity).
For living systems - including humans, societies and the (State-)System - a certain entropy balance - an intermediate level/amount of entropy - must be maintained (besides the availability of a certain level of energy): Not too much entropy - resulting in too much disorder, and a lack of structure - but also not too little entropy, resulting in ossification; a lack of opportunities and adaptability. This subject will be discussed later, in more detail.



FIGURE 4.1: Manifestations of entropy in social systems.

4.3. Sources of entropy in the System

Because of their open character and continuous exchanges with their environment, all open systems - including societies and the System (and their subsystems/components) - experience a constant influx of entropy from their respective environments. The sources of entropy have in common that they increase the number of microstates (possible arrangements, disorder), the available possibilities, variety, and uncertainty in the system concerned.

In below table, I specify several sources of entropy, relevant in the context of this study.

TABLE 4.1: Sources of social entropy. This table shows the main sources of entropy in the System. The sources of entropy-production 'interact' and often produce reinforcing feedbacks.

Source of entropy	Explanation
Population growth	Population growth is the main ('underlying') source of entropy. More humans ('parts') mean more possible arrangements. Humans and the social structures they form, require the inputs of various resources to fulfill their basic requirements, to ensure a certain level of well-being and their survival. Humans and social systems generate EMIS-flows that must be regulated. Population growth also contributes to the rivalries between social systems, because of the increasing competition for (scarce) resources.
Rivalries between social systems	To fulfill their basic requirements, societies and states compete for (scarce) resources. Rivalries involve exchanges that generate entropy (tensions), especially in the anarchistic State-System.
Increasing connectedness of societies and states	Over time the connectedness of societies - and the intensity and frequency of their (inter) actions, of irreversible entropy producing processes - increased (and is still increasing). Population growth was (and is) an important driver of this process. The increased connectedness - and interdependence - of societies, caused the entropy-production to accelerate, while at the same time entropy-regulation became more problematic.
Expansion	Expansion - an increase in volume available to a system - allows for more arrangements and results in an increase in entropy. Expansion also allows for the export of entropy, as I discuss later. *Expansion is also a method of entropy-regulation.*
Empowerment	Empowerment refers to the (degrees of) freedom available to parts of a system. Empowerment makes more (potential) arrangements possible. *Empowerment is also a method of entropy-regulation*.
Mixing	In case of mixing, more microstates become available (44). Mixing also involves irreversible processes and consequently the production of entropy. Social integration/aggregation involves mixing and contribute to entropy-production; certain barriers must be overcome to achieve mixing.
Kinetic activity (KA, war).	War involves the use of kinetic energy and involves various irreversible processes and consequently contributes to the production of entropy. However, *KA* (*war*) *is also a method of entropy-regulation*.

4.4. Entropy-regulation

Entropy can be regulated in a system. Some methods available for entropy-regulation by social systems are summarized in below table.

TABLE 4.2: Methods of entropy-regulation in/by social systems.

Method of regulation	Explanation
Utilization for other purposes	Entropy can be utilized - e.g. serve as energy-input - for other systems. FFE, entropy is a source of order (as I explain later).
Serve as a catalyst	FFE, entropy (tensions) can serve as a catalyst for the rearrangement of energies, e.g. of societal energies that are transformed - with tensions (entropy) as a catalyst - into kinetic energy (military capabilities) that is put to use during KA (war), to regulate the entropy in the State-System.
'Export': exchange with the environment	Entropy can be 'exported' out of a system, by exchanging it to - dumping it in - the environment of the system.
Expansion	Through expansion - an increase in the volume of a system - the entropy increases; the 'volume' available to export entropy is larger. Entropy generated in the core of the System (Europe), as a consequence of rivalries between societies, was exported to the non-core (its colonies) and was partly (re-)utilized. Through the export of entropy new entropy was also generated. *Expansion is also a source of entropy*.
Compartmentation: 'de-mixing'	Grouping/clustering in communities - based on certain characteristics/properties - means that the entropy (disorder) of the system is reduced; there is more organization. In social systems this is for example accomplished by separation in social classes, religions, etc. Through social stratification, uncertainty is reduced.
Aggregation	Aggregation is a form of mixing: Compartments (e.g. sates) are merged. Aggregation results in an increase in entropy.
Empowerment.	Through empowerment - by providing more degrees of freedom to communities and individual humans (suffrage), for example - entropy increases (more microstates are possible) and can be regulated. *Empowerment is also a source of entropy*.
Standardization	Through standardization - reducing variety - the order (organization) of a system increases, and entropy(-production) is regulated.
Kinetic activity (KA, war).	KA (war) is a thermodynamic response of the (State-)System to regulate tensions (entropy); KA is regulated by the FTS in accordance with the Second Law. A distinction can be made between non-systemic KA, which typically takes place during relatively stable periods (RSP's) of war-cycles, to maintain the existing order/status quo (regulate tensions in the State-System), and systemic KA which takes place when the State-System is in a critical condition (typically following a RSP), to upgrade the order of the State-System to a next level of organization. However, *KA is also a source of entropy*.

4.5. Application (1): Entropy-regulation in the System

To give perspective to the reader, I introduce in this paragraph the subject of entropy-regulation in the System, ahead of detailed discussions in the next chapters.
Living systems - including social systems like the System - require a certain order - an intermediate level of entropy - to ensure their 'operation' (and survival). To that end, entropy needs to be regulated - e.g. redistributed - and free energy must be made available and put to work to accomplish this.

The System consists of various subsystems (like societies, states and the State-System) that continuously interact; the System - and these subsystems - are in a dynamic steady state.
In chapter 2, the Second Law and the equation $\boldsymbol{dS = d_eS + d_iS \geq 0}$, were discussed.
For open systems, including the State-System - systems which exchange energy and matter with the outside world - a distinction must be made between two terms in the entropy chance $\boldsymbol{dS}$, $\boldsymbol{dS = d_eS + d_iS}$ (44). During the period 1480-1939, the State-System was a *European* State-System (not a global State-System); the System consisted of a core (the European State-System) and a non-core ('the rest of the world'). Societies in the core (Europe) and the non-core (the "rest of the world"), can be considered the environment of the European State-System, during the period 1480-1939.
The term $\boldsymbol{d_iS}$ ($\boldsymbol{d_{State\text{-}System}S}$ in this context) concerns the change of entropy due to irreversible processes within the European State-System. Here, in this context, $\boldsymbol{d_eS}$ is the change of the State-System's entropy due to exchanges of energy, matter and entropy with the State-Systems environments, consisting of societies (in the core) and the non-core. Thus, $\boldsymbol{d_eS = d_{societies\ core}S + d_{non\text{-}core}S}$.
Four processes played (and still play) a central role in the regulation - redistribution - of entropy in the System: (1) The process of KA (war), (2) the process of aggregation, the merging ('mixing') of societies (states), that allows for (results in) an entropy increase; (3) the process of expansion to the non-core that allows for an increase in the exchange of entropy to the expanding non-core; and (4) the process of empowerment of 'parts' (individual humans and communities) of societies. The four processes are regulated through the FTS.
During the period 1480-1945, the European State-System - with population growth and rivalries between states as the main drivers - produced accelerating amounts of entropy that had to be redistributed - mainly through aggregation, expansion, empowerment and KA - at an accelerating rate, to ensure that the State-System could maintain a certain order.
Not only were accelerating amounts of entropy produced, but the European State-System at the same time (that is during the period 1480-1939) was driven to near zero entropy through (the application of) the Minimum Entropy Production (MEP)-Principle, that applied to the (State-)System's dynamics. The MEP-principle also had an effect on the (need for) redistribution of entropy in the System.
The drive of the State-System to near zero entropy - a state reached in 1939 - resulted in an increase in available free energy ($\boldsymbol{F}$) in the State-System (because, as explained: $\boldsymbol{E = F + S}$), during the period 1480-1939:

$$\boldsymbol{E_{State\text{-}System} = F_{State\text{-}System} + S_{State\text{-}System}}$$

The energy in the State-System is equivalent with the sum of the free energy ($\boldsymbol{F}$) and degraded energy (entropy $\boldsymbol{S}$) of the State-System. $\boldsymbol{E_{State\text{-}System}}$ continuously increased (and still increases) through population growth, etc.; $\boldsymbol{S_{State\text{-}System} \rightarrow 0}$ (through the effect of the MEP-principle), and consequently $\boldsymbol{F \rightarrow E}$.
The increasing amounts of free energy in the State-System were required and used to regulate the accelerating entropy(-production) in the (State-)System and manifested itself through the increasing amounts of kinetic energy (KA), that was produced during successive cycles.
During the period 1480-1945, the KA of the System accelerated.
In case of the System, the following equation applies to the production and redistribution of entropy:

$$\boldsymbol{dS = d_eS + d_iS = (d_{societies\ core}S + d_{non\text{-}core}S) + d_{State\text{-}System}S = d_{aggregation}S + d_{expansion}S + d_{empowerment}S + d_{KA}S \geq 0}$$

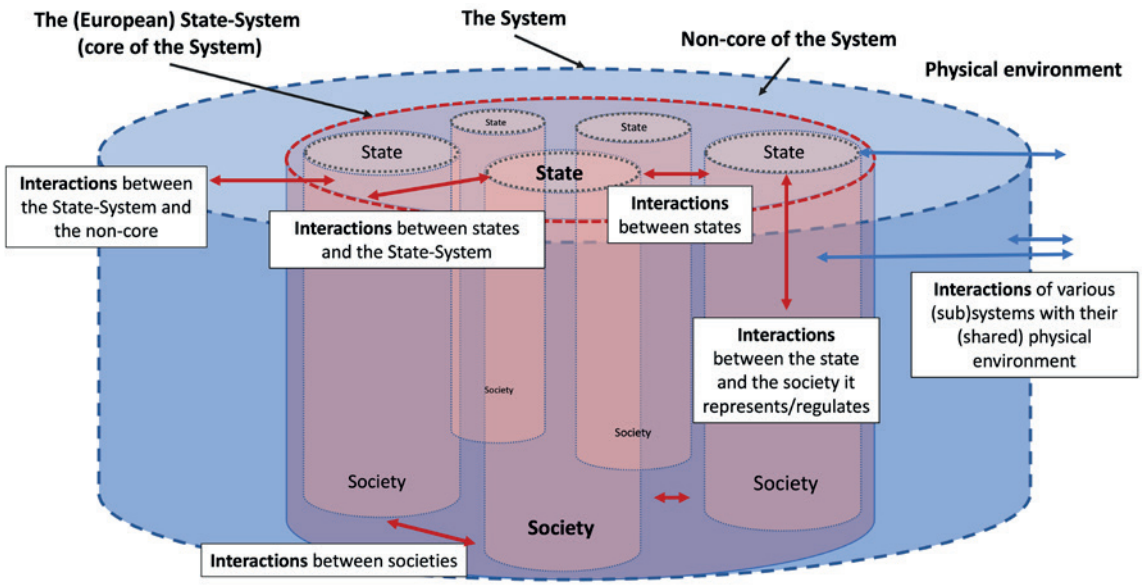


FIGURE 4.2: Organization of the System, during the period 1480-1939. The System consists of a core - the European (State-)System - a non-core (the 'rest of the world') and a physical environment. The European State-System is a subsystem of the System. States - representing and regulating societies - are subsystems of the European State-System. These (sub)systems interact. During the transient period (1480-1945), the 1st FTS - a dissipative structure - regulated EMIS-flows in/of the (State-)System.

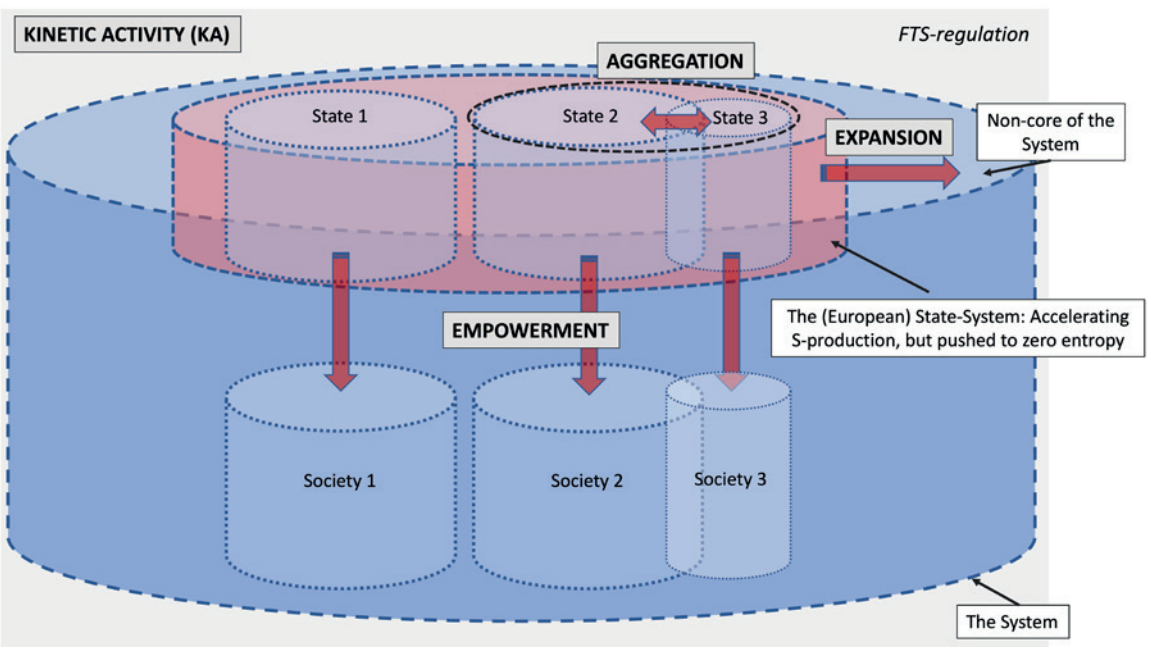


FIGURE 4.3: Entropy regulation. This figure shows schematically the regulation of the entropy(-production) of the European State-System by the 1st FTS, during the transient period (1480-1939), through the processes of KA, aggregation, expansion and empowerment. Despite the accelerating entropy-production in/of the State-System, the State-System was simultaneously driven toward near zero-entropy, causing a decrease in available microstates; consequently, the European State-System collapsed in 1939.

This is a somewhat simplified explanation of matters; these processes - a combination of entropy-production (new possibilities) and free energy use - shape(d) the (State-)System. These processes - aggregation of societies (states) in Europe, expansion of Europe to the non-core (colonization), empowerment and KA (war dynamics) - are closely related and complementary processes.
These processes were regulated by - integral components of - a dissipative structure (the 1st FTS) that emerged through a bifurcation in 1480, when the System was pushed sufficiently far from equilibrium (FFE). These processes reinforced each other and were responsible for the acceleration the System - and its evolution and development - experienced (and still experiences) since 1480.
I show in this study, that the processes and rates of aggregation (the decrease of the number of states in Europe, during the period 1480-1945) and Europe's expansion (to the non-core) were synchronized, and that the KA - war dynamics - of the System (not surprisingly) obeyed the Second Law.

4.6. Application (2): Entropy is a source of order and drives the process of social evolution and social development

Like energy, entropy is a source of order and a driver of evolution. The ability of living systems to explore and exploit new possibilities - new microstates, entropy - determines their well-being and survival changes. The exploration and exploitation - utilization - of possibilities (entropy) require the availability of free energy.

4.7. Application (3): Macro- and microstates of the System

As I show in this study, during the period 1480-1945 - the transient period, the life-span of the 1st FTS - four very regular accelerating kinetic cycles - KA/war-cycles - can be distinguished (a subject I discuss in detail later). These cycles accompanied the 1st FTS and were instrumental in a phase transition of the State-System.
The macrostate of the (State-)System can be described in terms of its KA.
Each cycle - the macro-state of the System - can be described in terms of a set of variables, including: (1) a cycle's KA-(war-)frequency, (2) the absolute number of non-systemic KA (non-systemic wars) during a cycle, (3) a cycle's life-span, and (4) so-called Great-Power status changes taking place during cycles, (5) the control the core (Europe) had achieved over the non-core, and (6) the energy (in terms of BCD) that is put to use through KA (war), to accomplish this. Other variables are population size and the number of states in the System (that is the European State-System during the period 1480-1945).
In figure 4.4, the very regular development of some of these variables is shown. The development of these variables is consistent with the constraints imposed by the Second Law and related principles FFE, as I will explain later.

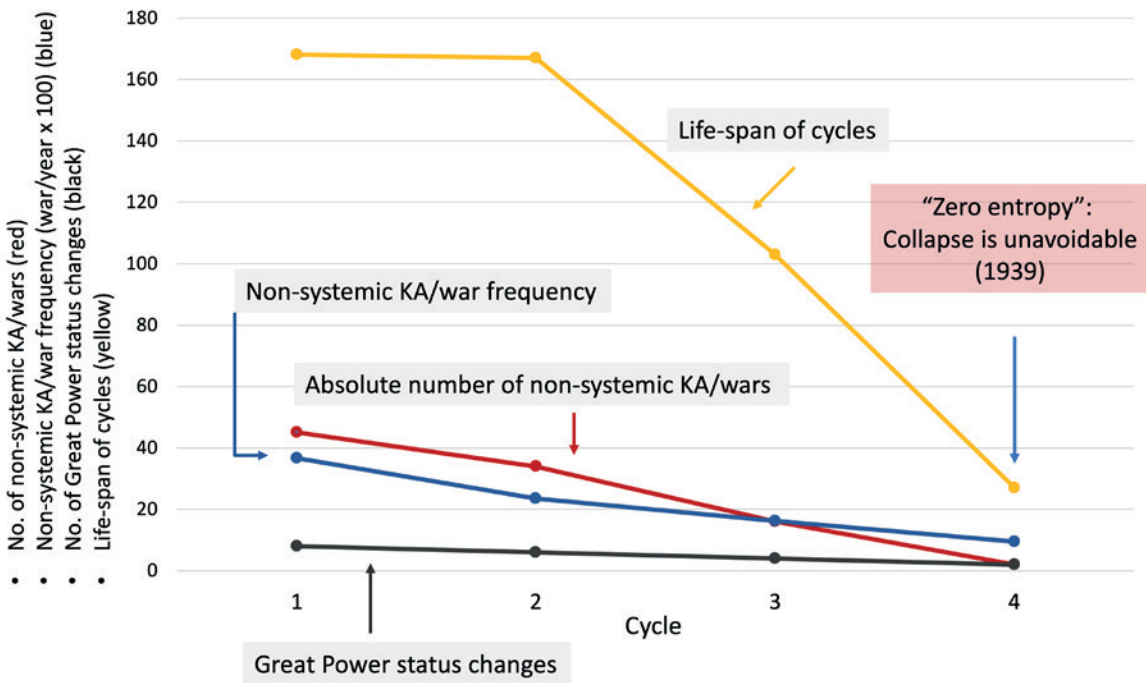


FIGURE 4.4: Regular development of the State-System. This figure shows the development of certain properties of the European State-System; of the four cycles (oscillations) that accompanied the 1st FTS, during the transient period (1480-1945): Of the absolute number of non-systemic KA/wars (in red, data period 1495-1945), of the non-systemic KA/war frequency during successive cycles (in blue, data period 1495-1945), and of the Great Power status changes during successive cycles (in the core and non-core). These properties decreased about linearly toward zero (59). The development of these properties of the (State-)System, are indicative of increasing ossification and a decrease in flexibility and adaptability, and that collapse - which happened in 1939 - was a matter of time. These typical dynamics will be discussed later in more detail. Data from Levy (48).

4.8. Application (4): The process of aggregation during the European State-System's development toward zero entropy

During the period 1480-1945, the (European) State-System accomplished 'full aggregation'; the European State-System evolved from a system consisting of circa 300 diverse and loosely connected 'state-structures', with a total population of circa 83 million in 1480, into a State-System of circa 25 highly standardized and tightly coupled states, with a total population of 544 million, in 1939 (see also: (91)). Through the 4th systemic war (the Second World War, 1939-1945) - the last 'step' in a phase transition (1480-1945) was accomplished - and a single structure was imposed 'on' Europe (albeit with a delay until 1989, as I explain later); at the same time as the European State-System reached a single structure - thermodynamic equilibrium - the System globalized (and the core and non-core became equivalent).

During the transient period, the number of microstates (arrangements) the European State-System could adopt, decreased regularly, in accordance with its decreasing entropy (the European State-System's increasing organization and (consequently) ossification).
In 1939, the entropy of the European State-System was near zero, and there were no more viable microstates available that 'fit' into - could obey - the constraints (requirements) imposed by the State-System's macro-state; collapse of the European State-System - and a transition to thermodynamic equilibrium (in Europe) - were consequently unavoidable.

4.9. Application (5): Degrees of aggregation

The process of aggregation was generated and regulated by the 1st FTS. With (the process of) aggregation, I refer to the merging of societies and their regulatory structures; states are the regulatory structures of societies.
To accomplish 'full' aggregation, EMIS-flows and their regulatory structures and mechanisms, including a range of feedbacks (control) structures, must also be integrated. This is required, to ensure their optimized operation/functioning of the aggregated structure, in compliance with laws of thermodynamics and related principles FFE.
I distinguish five 'stages of aggregation' of the State-System, see below table.

TABLE 4.3: Five stages of Aggregation.

Stages of aggregation		Remarks
0	Fully decomposable	The 'System' consists of a collection of more or less closed structures.
1	Nearly-decomposable	The State-System consists of hierarchical structures that interact but are still highly 'autonomous'.
2	Tightly coupled	Connections and interactions between societies/states undermine their 'autonomous' regulation and overall efficiency. The tightly coupled societies/states are highly autonomous in certain respects, on the one hand, but also highly interdependent, on the other hand. During the transient period (1480-1939), societies/states became increasingly tightly coupled. The contractionary nature of societies/states in the European (State-)System- their simultaneous attraction and repulsion - were regulated by the 1st FTS
3A	Aggregated, not yet implemented	In accordance with thermodynamic requirements, the system accomplished a transition to another thermodynamic regime/state and thermodynamic potentials are adjusted accordingly. Aggregation is a fact, but the transition is not yet implemented - embedded - in (modified) structures of the aggregated structure. This stage is also referred to as 'aggregation enabled'. At present, Europe (the European Union) is in this stage: Full homeostatic control is not (yet?) achieved.
3B	Aggregated and fully implemented	At this (final) stage, EMIS-flows and their regulation and feedback/control structures are fully integrated and optimized. This stage is also referred to as 'fully aggregated'.

Full aggregation (stage 3B), can be accomplished in three ways:

TABLE 4.4: Methods of accomplishing full aggregation (stage 3B).

	Methods of aggregation (Stage 3B)	Remarks
1	Addition of a next regulatory (hierarchical) level.	(a) The additional regulatory level is added 'on top' of the other regulatory structures.
		(b) The additional regulatory level is added 'on top' of the other regulatory structures, and (eventually) replaces the underlying structures.
		(c) Additional regulatory structures are added 'on top' of the existing structures and specialize in the regulation of specific aspects of the system.
2	Absorption	A regulatory structure absorbs - takes over - another regulatory structure and takes over its functions.
3	Merging on the basis of equality	Two or more regulatory structures merge - fuse - on the basis of equality.

4.10. Application (6): BCD's: A measure for the degree/ amount of entropy and kinetic activity (KA, war)

For practical reasons, I introduce a measure for the degree/amount of entropy and KA in the (State-) System, at this stage (of this study).
The measure is 'BCD', which stands for battle casualty deaths, the number of battle-connected deaths of military personnel of Great Powers that are involved in KA (wars). I use the BCD's from Levy's dataset, concerning Great Power wars (48). For further explanation of Levy's research and dataset, I refer to appendix B.
I consider BCD's a measure - indicative - for:

1. The kinetic energy that is put to use/work during KA (war);
2. The entropy that is produced in the (State-)System through regular interactions and exchanges between societies and states;
3. The entropy that is produced as a consequence of the kinetic energy that is put to use during KA (war).

Thus, I assume that the amount of BCD's produced by the System is proportional to the kinetic energy that is put to use during KA, the entropy that is produced by the System (e.g. during KA/war-cycles), and the entropy that is generated during KA (as a byproduct). As I explain later, far from equilibrium - the (State-)System is a system far from equilibrium - entropy serves as a source of order (44), not only because entropy contains new possibilities, but also - in case of the System - entropy serves as a catalyst in the rearrangement of 'societal energies' into kinetic energy (military capabilities) that are put to use (work) by states and the State-System, to maintain the existing order (through non-systemic KA, during RSP's of KA/war-cycles) and to periodically upgrade orders (through systemic KA, during critical periods of KA/war-cycles).

1. **ENTROPY-PRODUCTION** through regular interactions and exchanges between components of the System.

2. **TRANSFORMATION OF** (societal) **ENERGIES** in (potential) kinetic energy (military capabilities, ***F***) by states; Entropy acts as a catalysator.

3. **KINETIC ENERGY** (military capabilities) is **PUT TO USE** during KA/war to **ACCOMPLISH WORK**: (1) to neutralize entropic perturbations to maintain the existing steady state/order (during RSP's) or (2) to upgrade the existing order to a next level of organization (during critical periods).

4. **KA PRODUCES ENTROPY**; BCD's are a measure for the energy that is utilized, and for the entropy that is produced by the State-System during KA.

*During the transient period 1480-1945, entropy and free energy (**F**) were continuously '(re)supplied' through population growth, and the processes that were generated and regulated by the 1st FTS.*

FIGURE 4.5: Energy/entropy-transformation in the System. This figure shows the various transformations taking place.

This study shows that the number of battle-connected deaths of military personnel of Great Powers - BCD's - during Great Power wars, developed very regularly during the transient period (1480-1945), in accordance with 'demands' by the Second Law and related principles FFE. These (and other) regularities were generated by the 1st FTS, a dissipative structure that was responsible for EMIS-regulation of the (State-)System, during the transient period. The 1st FTS was - and the 2nd FTS is - a highly optimize kinetic engine, calculations show (to be discussed).

5. Feedback structures

5.1. Introduction

Another perspective, I consider very useful to better understand the dynamics and development of societies/states and the (State-)System, is a dynamical systems perspective.
From a dynamical system perspective, the dynamics of a system are to a high degree determined by its feedback structures and how they interact. Also, in case of the (State-)System, there are multiple interacting feedbacks at play, e.g. between the EMIS-flows of societies and states, and of states and the State-System (etc.).
The dominance of certain feedback structures (loop-dominance) can change over time, depending on the conditions of a system.
In this chapter, I discuss feedbacks, stocks and flows, and path dependence, based on Sterman (87).
To provide some context, I first discuss (but not yet in detail), KA/war-cycles that can be identified in the war dynamics of the System, and the fundamental differences between non-systemic KA/wars and systemic KA/wars; at this stage.

5.2. KA/war-cycles and the fundamental differences between non-systemic and systemic KA/wars

Analysis of war data (48) shows that during the transient period (1480-1945), the System produced four accelerating KA/war-cycles, each cycle consisting of a relatively stable period (RSP) - when through non-systemic KA/wars a dynamic steady state (a certain order) was maintained - followed by a relatively short critical period, when through systemic KA - a systemic war - the order of the System was 'upgraded' (again), to a next level of organization. These accelerating cycles accompanied the 1st FTS (1480-1945), a dissipative structure that emerged in 1480, when the System was driven far from equilibrium. The 1st FTS was instrumental in a phase transition of the System.
The purpose of *non-systemic* KA/wars was (and still is) to maintain the existing order (dynamic steady state), to ensure continuity, while the purpose of *systemic* KA/wars is to accomplish change. The 1st FTS balanced continuity and change in the (State-)System, in accordance with the demands of the Second Law and related principles FFE.
The KA - war dynamics - of the System were remarkably regular, and - as far as systemic KA/wars are concerned - highly predictable, at least during the period 1480-1945.
The KA - the war dynamics - the System produced during the period 1480-1945, qualify as a punctuated equilibrium dynamic: Relatively stable dynamic steady states were periodically punctuated by systemic KA/wars, when fundamental changes were implemented.

Entropy-production - and the need to regulate entropy to ensure a certain order, also through KA/war - was the driver of the FTS.
The analysis of war data also shows that at a certain point - the tipping point of KA/war-cycles (RSP's) - entropy-regulation through non-systemic KA (wars) becomes problematic: The average size of non-systemic KA (wars) starts to diminish and consequently entropy - issues and related tensions - starts to accumulate in the (State-)System.
The accumulating entropy - and the percolation of entropy in the (State-)System - then drives the System toward a critical state, when the System in response to the accumulated issues and tensions (entropy), produces systemic KA; a systemic war.

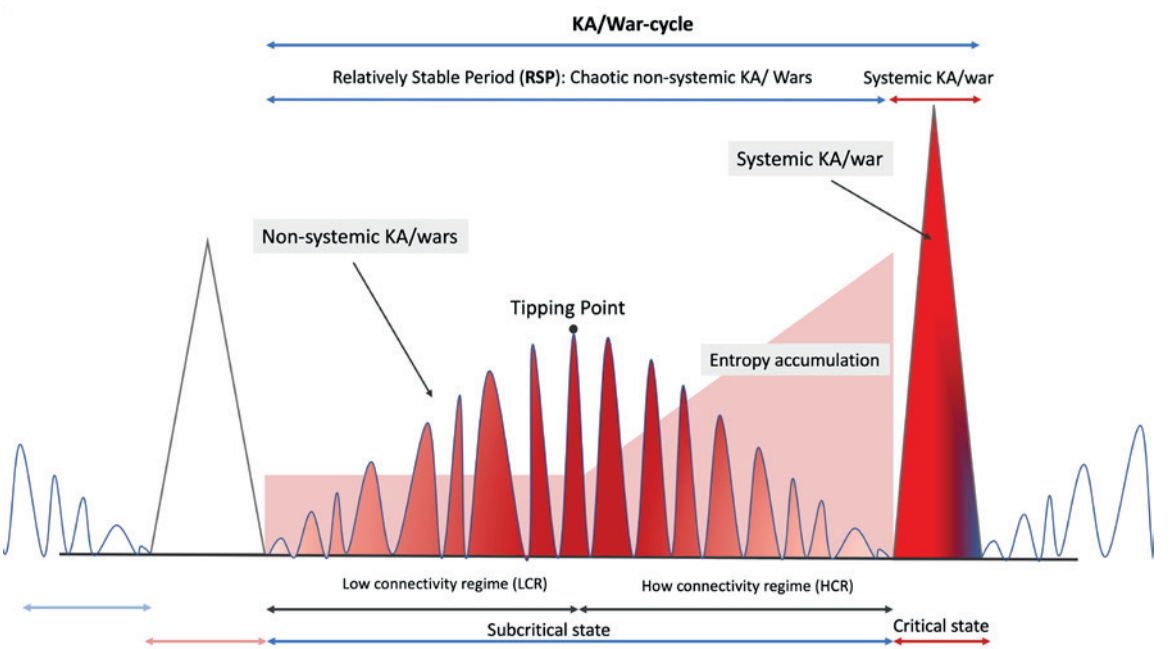


FIGURE 5.1: Schematic representation of a KA/war-cycle. During the transient period (1480-1945), the 1st FTS was accompanied by four accelerating KA/war-cycles, each cycle consisting of a RSP and a critical period, when (regulated by the 1st FTS) the (State- System produced respectively non-systemic KA/wars (to ensure continuity) and systemic KA/war (to ensure change). Once the tipping point of a cycle was reached, non-systemic KA/wars decreased, and entropy (issues and tensions) started accumulating in the System.

5.3. Feedbacks

Because "the feedback structure of a system generates its behavior", "much of the art of systems modeling is discovering and representing the feedback processes, which, along with stock and flow structures, and with time-delays, and nonlinearities, determine the dynamics of a system" (87).

Real systems, like the System, are nonlinear, meaning that the feedback loops and parameters governing the dynamics vary depending on the state of the system.
Most complex behaviors arise from the interactions (*feedback*) *between components of the system, not from the complexity of the components themselves*. Dynamics arise from the interaction of just two types of feedback loops, positive (or self-reinforcing) and negative (or self-correcting). Loops can be illustrated using causal loop diagrams (CLD's), which are maps that show causal links among variables with arrows from a cause to an effect. Correlations are not included in these diagrams: "Correlations among variables reflect the past behavior of a system. Correlations do not represent the structure of the system" (87). Correlations among variables will emerge from the behavior and dynamics of the system.
Positive loops tend to reinforce or amplify whatever is happening in the system. This is also the case in the System. Negative loops, on the other hand, counteract and oppose change.
Sterman also explains: "Most dynamics observed in the real world are examples of a small set of basic patterns or modes of behavior. Three of these modes are fundamental: exponential growth, goal seeking, and oscillation. Each of these modes is generated by a particular underlying feedback structure. Positive feedback processes generate exponential growth. However, goal seeking is generated by negative feedback, and oscillations are generated by negative feedback with delays. More complex patterns of behavior, such as S-shaped growth, growth with overshoot, and overshoot and collapse, result from the nonlinear interaction of these basic feedback structures" (87).
All systems, no matter how complex, consist of networks of positive and negative feedback loops, and, as already mentioned, all dynamics arise from the interaction of these loops with one another. When multiple loops interact, it can be difficult to determine what the dynamics will be.
System dynamics emphasizes the multi-loop, multistate, nonlinear character of the feedback systems, as well as the multiple connections in which we live; the System meets all these system dynamics conditions.

5.4. Stocks and flows

Stocks and flows are besides feedbacks the two central concepts of dynamic systems theory. According to Sterman (87), "stocks are accumulations. They characterize the state of the system and generate the information upon which decisions and actions are based." Because stocks define the state of the system, they are also mostly referred to as state variables. "Flows are the rates at which these system states - stocks - change." "Stocks give systems inertia and provide them with memory. Stocks create delays by accumulating the difference between the inflow to a process and its outflow. By decoupling rates of flow, stocks are the source of disequilibrium dynamics in systems." "Stocks accumulate or integrate their flows; the net flow into the stock is the rate of change of the stock." Issues, tensions (entropy) and (potential) destructive energy are accumulations that are temporarily 'stocked' in the System, in so-called vulnerable clusters (VC's), generated by various entropy sources (inflows), as I explain later in this study. KA (wars) can be considered release events (outflows). Whereas the inflow is relatively gradual, taking place during RSP's of KA/war-cycles, the outflow (in case of systemic KA) is always abrupt, producing a punctuated equilibrium dynamic.
According to Sterman (87), stocks are critical in generating the dynamics of systems for a number of reasons:

- "*Stocks characterize the state of the system and provide the basis for actions*".
- "*Stocks provide systems with inertia and memory*". Sterman explains this particular property of stocks as follows: "Stocks accumulate past events. The content of a stock can only change through an inflow or outflow. Without changes in these flows, the past accumulation into the stock persists". This is also the case for the stock (accumulation) of entropy (tensions and their related issues) in the (State-) System, during RSP's.
- "*Stocks are the source of delays*". "All delays involve stocks. A delay is a process whose output lags behind its input." Systemic KA (systemic wars) are delayed responses of the (State-)System to accumulated entropy, during the preceding RSP.
- "*Stocks decouple rates of flow and create disequilibrium dynamics*". "Stocks absorb the differences between inflows and outflows, thus permitting the inflows and outflows to a process to differ. In equilibrium, the total inflow to a stock equals its total outflow so the level of the stock is unchanging." In the case of disequilibrium, that is not the case.
- Sterman explains (87): "adding time delays to negative feedback loops increases the tendency for the system to oscillate." Delays create instability in dynamic systems. From a dynamic system perspective, the four cycles that accompanied the 1st FTS during the transient period (1480-1945), were a consequence of a delayed response of the State-System to counter the accumulation of entropy in the (State-)System.

5.5. Path dependence

"Path dependence is a pattern of behavior in which small, random events early in the history of a system determine the ultimate end state, even when all end states are equally likely at the beginning. Path dependence arises in systems whose dynamics are dominated by positive feedback." Path dependence can also be observed in the System.

"Path dependence is a pattern of behavior in which the ultimate equilibrium depends on the initial conditions and random shocks as the system evolves. In a path-dependent system, small, unpredictable events early in the history of the system can decisively determine its ultimate fate. The eventual end state of a path-dependent system depends on the starting point and on small, unpredictable perturbations early in its history. Even when all paths are initially equally attractive, the symmetry is broken by microscopic noise and external perturbations. Positive feedback processes then amplify these small initial differences until they reach macroscopic significance. Once a dominant design or standard has emerged, the costs of switching become prohibitive, so the equilibrium is self-enforcing: the system has locked in" (87). In case of path dependence, "microscopic differences in initial conditions lead to macroscopic differences in outcomes."

Lock-in is another feature of path dependence. Initially, the trajectory, or direction of development, of the system is relatively flexible and can still change direction. However, it is a matter of time and the system becomes progressively locked in. The measure of lock-in of system determines the costs (e.g., energy) that are required to change its path. Based on: Sterman (87).

5.6. Application (1): A dynamic system perspective: Path dependence and lock-in of the European State-System (1480-1945)

Following the bifurcation of the System in 1480 - in response to the increasing instability of the System (< 1480) - and the subsequent emergence of the 1st FTS (1480-1945), the European State-System chose a path - there were numerous options - to thermodynamic equilibrium, which was (and still is, but now at a global level) the end-state of the European State-System, in accord with the Second Law.
The perturbations the System had to respond to and four secondary bifurcations (in 1618, 1792, 1914 and 1939) during the transient period (1480-1945), increasingly narrowed the path (options) of the (State-)System and its constituents; the System became progressively locked-in through the dynamics and demands of the 1st FTS.
During the transient period (1480-1945) - when the path dependence and lock-in of the State-System were continuously reinforced through the positive feedback mechanism that dominated the dynamics of the 1st FTS and of its structural component (the State-System) - the State-System was increasingly pushed FFE but was structurally stable until its collapse in 1939.

5.7. Application (2): The powerful-become-more-powerful-mechanism

In the so-called contingent domain (to be discussed later), there is also path dependence and lock-in in case of certain processes. In this paragraph, I discuss - what I name - the powerful-become-more-powerful-mechanism (PBMP-mechanism or effect), that had a big impact on the development of the (nature of the) (State-)System.
As I explained, systemic KA/wars - the 1st FTS produced four of these systemic events during the transient period (1480-1945) - were instrumental in the periodic upgrading of the order of the (State-)System.
Typically, the most powerful states that emerged from a systemic war could impose arrangements on the order of the (State-)System that in particular promoted their own interests and of their allies; they could grant themselves certain privileges. These favorable arrangements and privileges were included in the upgraded order.
Through this mechanism - I refer to as the PBMP-effect or mechanism - the most powerful states could further reinforce - entrench - their already powerful positions. The PBMP-mechanism was instrumental in the co-evolution of state-structures and the State-System. As I discuss later in more detail, the United Kingdom (Great Britain) emerged as the most powerful and influential state in the European State-System, during the transient period (1480-1945). The first global order - the United Nations (1945-....) - the 1st FTS produced (1480-1945) - especially reflects British values, or values that originate in Great Britain.
Below figure is a CLD (causal loop diagram) that depicts the PBMP-mechanism.

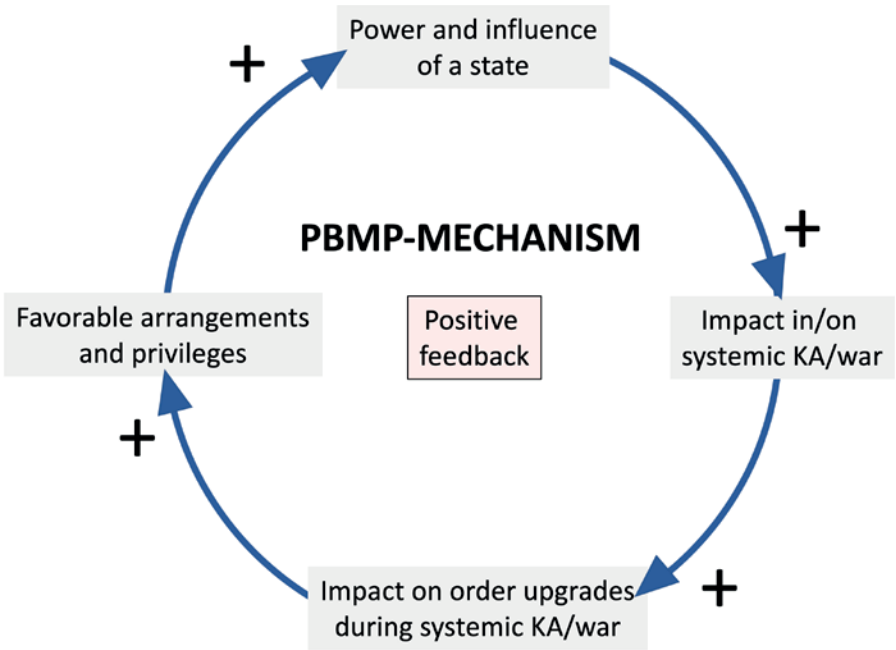


FIGURE 5.2: CLD of the PBMP-mechanism.

6. Hierarchy theory

6.1. Introduction

In this chapter, I introduce hierarchy theory and near-decomposability, introduced by Simon in the essay: *The Architecture of Complexity* (77). Hierarchy as defined by Simon, has a different meaning than 'authority'. The relevance of hierarchy theory for this study is the idea of 'near-decomposability', and how this property of the System affects its dynamics, the regulation of EMIS-flows and its evolution. The hierarchical order of the System (hierarchy as defined by Simon), stems from the activity of millions of individual humans grouped into societies and states (hierarchical structures), that emerged FFE, in accord with the Second Law and related principles that apply FFE.

6.2. Hierarchical structures

Simon means by a hierarchic system, or hierarchy, "a system that is composed of interrelated subsystems, each of the latter being, in turn, hierarchic in structure until we reach some lowest level of elementary subsystem. In most systems in nature, it is somewhat arbitrary as to where we leave off the partitioning and what subsystems we take as elementary".

Simon describes a complex system as a system that is "made up of a large number of parts that interact in a non-simple way. In such systems, the whole is more than the sum of the parts, not in an ultimate, metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole".

According to Simon "Empirically, a large proportion of the complex systems we observe in nature exhibit hierarchic structure. On theoretical grounds we could expect complex systems to be hierarchies in a world in which complexity had to evolve from simplicity. In their dynamics, hierarchies have a property, near decomposability, that greatly simplifies their behavior". The System - consisting of a State-System and states, etc., also has a hierarchical structure.

Simon argues: "... the central theme that runs through my remarks is that complexity frequently takes the form of hierarchy, and that hierarchic systems have some common properties that are independent of their specific content. Hierarchy, I shall argue, is one of the central structural schemes that the architect of complexity uses."'Hierarchy' has a different meaning than how this term is normally used. According to Simon: "Etymologically, the word "hierarchy" has had a narrower meaning than I am giving it here. The term has generally been used to refer to a complex system in which each of the subsystems is subordinated by an authority relation to the system it belongs to. More exactly, in a hierarchic formal organization, each system consists of a "boss" and a set of subordinate subsystems. Each of the subsystems has a "boss" who is the immediate subordinate of the boss of the system. We shall want to consider systems in which the

relations among subsystems are more complex than in the formal organizational hierarchy just described. We shall want to include systems in which there is no relation of subordination among subsystems. (In fact, even in human organizations, the formal hierarchy exists only on paper; the real flesh-and-blood organization has many inter-part relations other than the lines of formal authority.) For lack of a better term, I shall use "hierarchy" in the broader sense introduced in the previous paragraphs, to refer to all complex systems analyzable into successive sets of subsystems and speak of "formal hierarchy" when I want to refer to the more specialized concept."

6.3. Fractality and span

Simon proposes to identify social hierarchies by observing who interacts with whom; by defining hierarchy in terms of intensity of interaction.

Simon argues that social systems often have "parts-within-parts" structures: "Almost all societies have elementary units called families, which may be grouped into villages or tribes, and these into larger groupings, and so on. If we make a chart of social interactions, of who talks to whom, the clusters of dense interaction in the chart will identify a rather well-defined hierarchic structure". These types of self-similar structures are now often referred to as fractal structures.

A typical property of hierarchic systems (including formal organizations) is their span (span of control in case of formal organizations): Simon speaks of a span of a system, by which he means "the number of subsystems into which it is partitioned."

Regarding hierarchies Simon furthermore observes: "There is one important difference between the physical and biological hierarchies, on the one hand, and social hierarchies, on the other. Most physical and biological hierarchies are described in spatial terms."

6.4. Near-decomposability

According to Simon, "In hierarchic systems, we can distinguish between the interactions among subsystems (*IP: For example, between states in the State-System*), on the one hand, and the interactions within subsystems - e.g., among the parts of those subsystems (*IP: within societies*) - on the other. The interactions at the different levels may be, and often will be, of different orders of magnitude. In a formal organization there will generally be more interaction, on the average, between two employees who are members of the same department than between two employees from different departments. In organic substances, intermolecular forces will generally be weaker than molecular forces, and molecular forces weaker than nuclear forces."

Based on the forces between parts of a system, Simon distinguishes between systems that are *decomposable* into subsystems comprised of the individual parts, and nearly-decomposable systems, "in which the interactions among the subsystems are weak, but not negligible." Simon argues: "At least some kinds of hierarchic systems can be approximated successfully as nearly-decomposable systems. The main theoretical findings from the approach can be summed up in two propositions: (a) in a nearly-

decomposable system, the short run behavior of each of the component subsystems is approximately *independent* of the short run behavior of the other components; (b) in the long run, the behavior of any one of the components depends in only *an aggregate way* on the behavior of the other components."
Simon argues: "In the dynamics of social systems, where members of a system communicate with and influence other members, near-decomposability is generally very prominent". This implies - as Simon argues - that because many social systems are nearly-decomposable, the short-run dynamics relate to the internal structures of the subsystems (states), the long-run dynamics to interactions between these subsystems (states)[6].
Simon points to the practicality of hierarchical structures (which also helps explain the evolutionary advantage of these types of systems: evolving complexity tends to be hierarchic): "In studying the interaction of two nations, we do not need to study in detail the interactions of each citizen of the first with each citizen of the second. The fact, then, that many complex systems have a nearly-decomposable, hierarchic structure is a major facilitating factor enabling to us understand, to describe, and even to 'see' such systems and their parts. Or perhaps the proposition should be put the other way around: If there are important systems in the world that are complex without being hierarchic, they may to a considerable extent escape our observation and our understanding. Analysis of their behavior would involve such detailed knowledge and calculation of the interactions of their elementary parts that it would be beyond our capacities of memory or computation."
Simon also makes some observations regarding the hierarchic span of systems: "To understand why the span of hierarchies is sometimes very broad - as in crystals - and sometimes narrow, we need to examine more detail of the interactions. In general, the critical consideration is the extent to which interaction between two (or a few) subsystems excludes interaction of these subsystems with the others."

6.5. Separation of high- and low-frequency dynamics

Simon summarizes his observations regarding near-decomposability as follows: "We have seen that hierarchies have the property of near-decomposability. Intra-component linkages are generally stronger than inter-component linkages. This fact has the effect of separating the high-frequency dynamics of a hierarchy - involving the internal structure of the components - from the low-frequency dynamics, involving interaction among components."

6.6. Hierarchical structures have evolutionary advantages

In his essay, Simon also focuses on the evolution of complex systems. Simon observes that "The time required for the evolution of a complex form from simple elements depends critically on the numbers and distribution of potential intermediate stable forms", "the complex forms can arise from the simple

6. A number of the important approximations employed in physics depend for their validity on the near-decomposability of the systems studied. The theory of the thermodynamics of irreversible processes, for example, requires the assumption of macroscopic disequilibrium but microscopic equilibrium. Similarly, computations in quantum mechanics are often handled by treating weak interactions as producing perturbations on a system of strong interactions.

ones by purely random processes", and that "direction of development of the structure of the (at least is some cases) is provided to the scheme by the stability of the complex forms, once these come into existence. But this is nothing more than survival of the fittest— i.e., of the stable".
Simon concludes, regarding the evolutionary explanation of hierarchy: "We have shown thus far that complex systems will evolve from simple systems much more rapidly if there are stable intermediate forms than if there are not. The resulting complex forms in the former case will be hierarchic. We have only to turn the argument around to explain the observed predominance of hierarchies among the complex systems nature presents to us. Among possible complex forms, hierarchies are the ones that have the time to evolve.

6.7. Application (1): From nearly- to non-decomposable

A hierarchical structure is a compartmentalized structure. Compartmentalization is a form of organization and implies lower (than maximum) entropy.
During the transient period (1480-1945), the core of the System (Europe) developed from a collection of nearly-decomposable structures - from a collection of circa 300 loosely connected (relatively small) societies with a total population of 83 million in 1480 - into a network of circa 25 tightly connected and *non*-decomposable structures (societies, states) in 1939 (59).
The decrease in the number state-structures (from circa 300 in 1480 to circa 25 in 1939), the increase in population size (from circa 83 million in 1480 to circa 544 million in 1939), and the decrease in near-decomposability (implying an increase in interdependence) had a significant impact on the organization of EMIS-flows and in particular on entropy-production and regulation of the (State-)System. The entropy-production accelerated, while regulation became increasingly problematic. As I explain later, KA played an important role in this process.
When in 1939, the European State-System (the core of the System), reached near zero entropy, adequate regulation was no longer possible. '1939' is equivalent with a critical connectedness of European societies, in other words, with a critical degree of *non*-decomposability; in 1939, the core of the System reached a critical connectivity threshold that resulted in the production of infinite amounts of entropy, while at the same time its regulation had become impossible.
The development of the degree of near-decomposability and the process of aggregation are closely related: Decreasing near-decomposability (increasing interdependence) caused by population growth, etc. drove the process of aggregation.
In fact, the evolving structures - including the process of aggregation - were determined and shaped - carved out - by EMIS-flows and their regulation in accordance with the laws of thermodynamics and related principles FFE that apply. A change in flows implies a change in organization and structure, and vice versa.

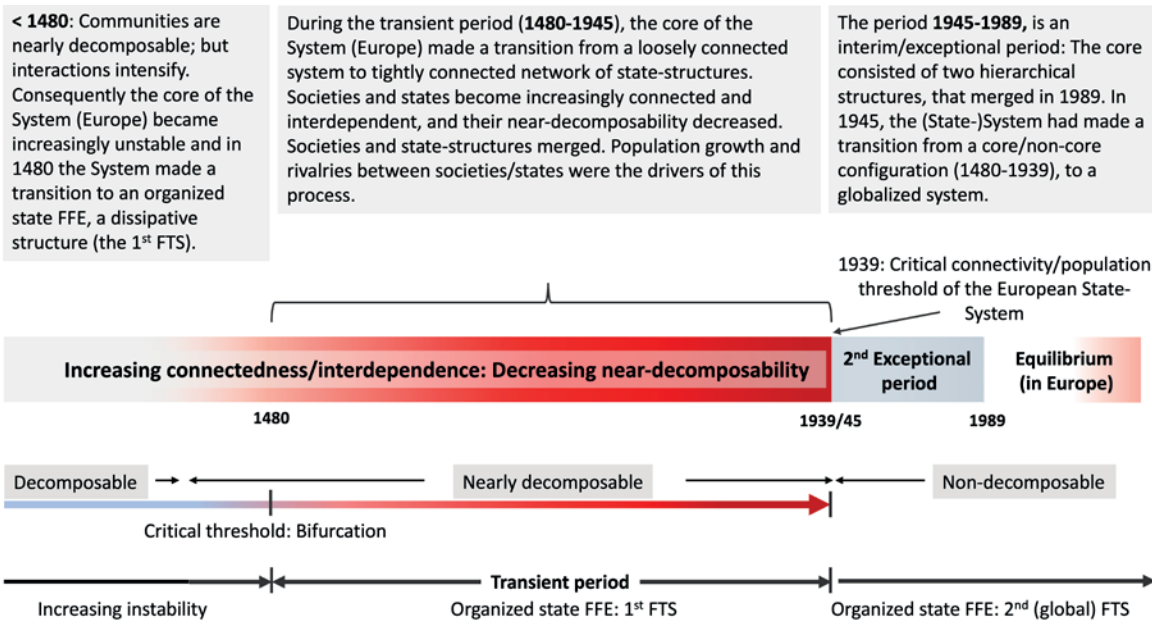


FIGURE 6.1. Development of the decomposability of the core of the System (Europe).

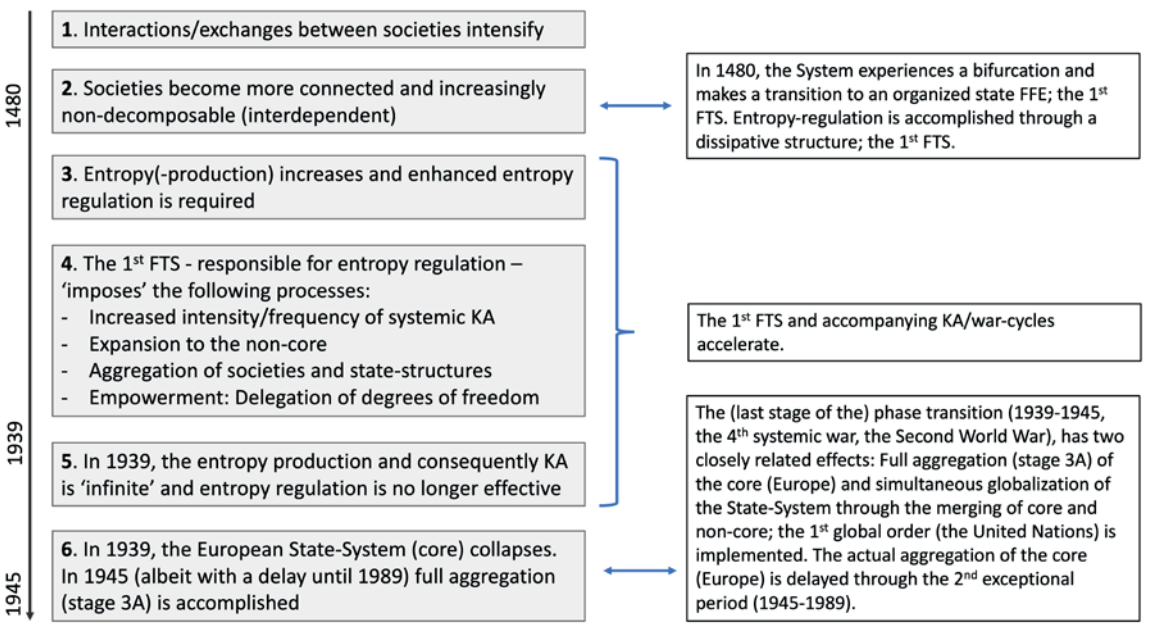


FIGURE 6.2. From decomposable to full aggregation.

6.8. Application (2): 'Levels of entropy' and the Entropy/Tension-field

At each hierarchical level of the System, entropy is produced through (irreversible) processes and exchanges. Entropy can be exchanged between levels of organization. Each level of organization has its mechanisms to regulate and cope with entropy(-production); see below table.

TABLE 6.1. Entropy-regulation at different hierarchical levels of the System. This table shows the four levels or social hierarchy that can be distinguished, the appearances of social entropy at the various levels, and how these levels cope with (regulate) social entropy. The community-level includes: families, tribes, religious groups, businesses, etc.

Level	Appearance of entropy	Regulation/coping mechanisms (include:)
Individual human	Tensions, anxieties, uncertainty, concerns, possibilities, opportunities, perceived threats	Personality traits, learning, social skills, communication, social structures, norms, identity, export/transfer of entropy to the environment, etc.
Community	Tensions, uncertainty, possibilities, disorder, opportunities, perceived threats	Team work, identity, communication, strategies, culture, structuring of decision making, norms and values, standardization, regulating degrees of freedom, export/transfer of entropy to the environment, etc.
Society/state	Tensions, uncertainty, possibilities, disorder, opportunities, perceived threats	Identity, policy, strategy, political process, governance, culture, identity, laws and regulations, structuring of decision making, forecasting, socialization, education, norms and values, standardization, regulating degrees of freedom, export/transfer of entropy to the environment, etc.
(State-)System	Tensions, uncertainty, possibilities, disorder, opportunities, perceived threats	Dissipative structure (FTS), processes of aggregation, expansion, empowerment and KA, containing entropic perturbations (issues and tensions), order upgrades (through systemic KA), institutionalization of norms and values, export/transfer of entropy to the environment, etc.

The System has a 'nested' structure; and constitutes network of networks. Individual humans are part of and are represented in various communities, probably a society and a state, and are part of the overall System.

Entropy - tensions, possibilities, uncertainty, etc. - is 'shared', which is often the explicit or underlying purpose of certain social systems. All parts and subsystems must maintain an intermediate level of entropy and free energy to achieve a certain well-being and ensure their survival.

I assume that the (inter)connected hierarchical levels of the System - each level with its 'own' entropy, and its contribution to the overall entropy of the System (through the export of entropy to their respective environments) - are connected to - and contribute to - an entropy - or tension - field, I refer to as the S/T-field.

This study is especially concerned with the behavior - the dynamics - of the (State-)System; this behavior is however inseparably linked to the other social levels of organization. The nested hierarchical structure of the System explains how individual behavior is 'connected' to the behavior of the System, and how personal anxieties feed the S/T-field, and vice versa. The four levels continuously interact and transfer entropy. At the level of the (State-)System is the FTS responsible for entropy-regulation.

The entropy contained in the S/T-field is a physical property the System. The S/T-field is more or less 'charged'. Because of the relationship between entropy(-production) and KA in the System, the S/T-field also represents an energy potential. These thermodynamic properties of the System and the S/T-field will be discussed later in more detail.

6.9. Application (3): Aggregation from a hierarchical and entropic perspective.

In this chapter, I have explained that during the transient period (1480-1945), the near-decomposability of the core (Europe) decreased; that the core eventually became non-decomposable when a certain critical connectedness was achieved, and that the European State-System - consequently - accomplished a phase transition to thermodynamic equilibrium: Full aggregation, stage 3A was accomplished in 1945 (albeit implementation was delayed until 1989). The number of states in the European State-System decreased from circa 300 in 1480 to one in 1945/1989; the average span of control of states increased from 2.77 x 10^5 (83 million / 300) in 1480, to 5.44 x 10^8 (544 million / 1) humans per state in 1945/1989. The 1st FTS was instrumental in this process (the phase transition).

Aggregation - the need for (logic of) aggregation - can also be understood from a thermodynamic perspective: The moment EMIS-regulation can be optimized - made more efficient - by replacing different regulatory mechanisms by a single mechanism, the Second Law will enforce the implementation of the more optimized solution, when the barriers that hinder such an integration of mechanisms (state-structures) are taken away. The kinetic energy, the core has produced during the transient period (1480-1945) and put to use/work during KA/war, can be considered the activation energy that was required to eradicate these barriers (separate state-structures in the core of the System).

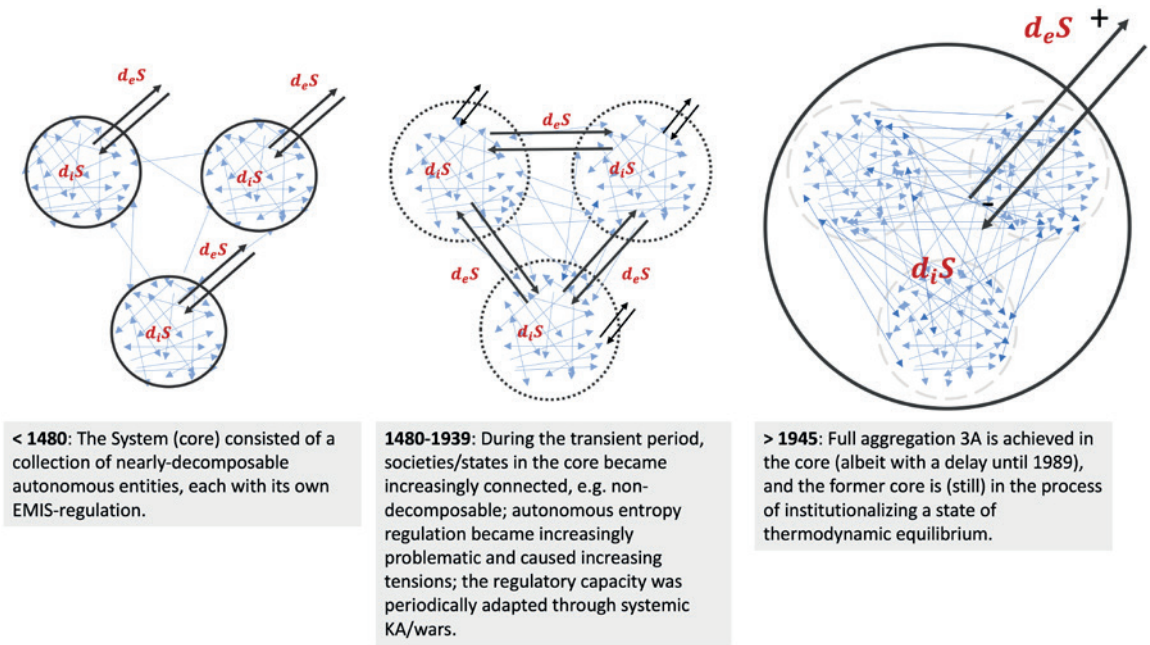


FIGURE 6.3. Merging of EMIS-regulation through the aggregation of hierarchical structures in the core.

7. Networks

7.1. Introduction

It is also possible to consider the System - including the redistribution of entropy - from a network perspective. In this chapter, I discuss some characteristics of networks and show how a network perspective can contribute to our understanding of the structure and dynamics of the (State-)System.

7.2. Some basic network characteristics

The entities - parts - of the System (like societies/states) can be considered nodes (or vertices) of a network, and their EMIS-exchanges - EMIS-flows - as interactions (connections) between these nodes. The number of connections of a node (for example of a state-structure) is referred to as its degree k.
Networks can have different types of structures (different configurations), and a relationship exists between the structure of a network and its dynamics. (Types of) networks can for example be distinguished based on the statistical distribution of the degrees of their nodes.

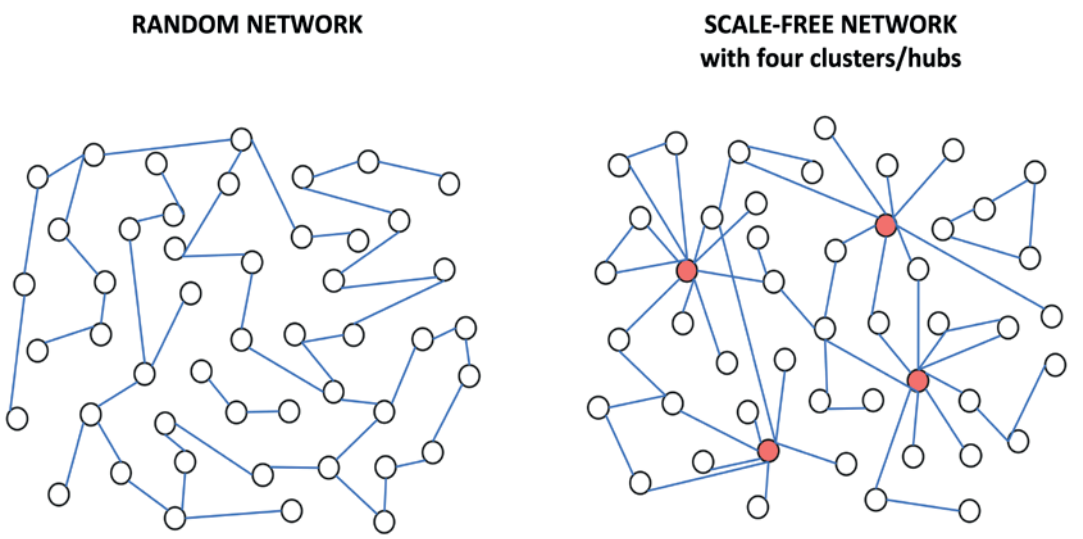


FIGURE 7.1: Random and scale-free networks. This figure shows two types of network-configurations: A random and a scale-free network, with the 'hubs' in red.

The coupling topology of nodes determines the pattern of interactions in a system (93).
The System has characteristics of a scale-free network: A scale-free network is a network whose degree distribution (of its connections; that is interactions in this context) follows a power law, at least asymptotically. A scale-free network has no natural scale.
Other types of distributions include Poisson and exponential distributions.
A characteristic of networks can be 'clustering'. The clustering coefficient characterizes the 'density' of connections in the environment close to a node. The clustering coefficient reflects 'cliquishness' of the environment of a node, that is the extent of the mutual 'acquaintance' of its closets 'friends' (26).
A characteristic of scale-free networks is that it is possible to distinguish a relatively small number of 'hubs' in these networks; these are the (relatively few) 'highest degrees' nodes.
It is also possible to determine the shortest path - the distance - between nodes; the number of degrees that separates two nodes. The betweenness of a node is the total number of shortest paths between all possible pairs of nodes in the network that pass through this node. This measure characterizes the role - relevance - of a node in the network. Nodes with a larger betweenness are more influential, but also more influenced. This 'quantity' is also called the load or the betweenness centrality of a node; it indicates whether or not a node is important in traffic on a network. Great Powers typically have a high betweenness (centrality).

7.3. Small world networks

"A small-world network is a type of mathematical graph in which most nodes are not neighbors of one another, but the neighbors of any given node are likely to be neighbors of each other and most nodes can be reached from every other node by a small number of hops or steps" (96). In social networks with small world network characteristics, "strangers are linked by a short chain of acquaintances"; also referred to as the small world effect.
Dorogovtsev et al. explain that small world networks are "graphs obtained from regular lattices by rewiring bonds or by making shortcuts between randomly chosen vertices. The resulting random structures, which have been named small-world networks, are, in fact, superpositions of lattices and classical random graphs. One can say that in these networks, the crossover from lattices to random graphs is realized. So, they combine the high clustering of regular lattices and the smallness (small world effect) usual for 'normal' random networks" (26).
These characteristics result in networks with regional specialization (through clustering) and the possibility for efficient interactions and exchanges (through the small characteristic path lengths). "Small-world properties are found in many real-world phenomena, including websites with navigation menus, food webs, electric power grids, metabolite processing networks, networks of brain neurons, voter networks, telephone call graphs, and social influence networks. Cultural networks and word co-occurrence networks have also been shown to be small-world networks" (96). The prevalence of small world networks in biological systems may reflect an evolutionary advantage of such an architecture.
I assume that the State-System also has small-world properties; further research is required.

7.4. Percolation, vulnerable clusters and the S/T-field of the System

Percolation is also an important 'dynamic' of a network (system). Percolation theory (86) deals with the number and properties of clusters in a network (system). At a certain point a system can reach the so-called percolation threshold, at that point, a percolation cluster can form; a cluster that percolates the whole system.
As I discussed, once the System during RSP's of KA/war-cycles reaches the tipping point, entropy-regulation through non-systemic KA becomes less effective, and entropy - issues and tensions - start to accumulate in the System. These issues and tensions then start to reinforce each other, and issues also become increasingly connected. At present, in the current cycle (the 1st cycle of the 2nd FTS (1945-....), issues and tensions accumulate and become increasingly connected. These issues and tensions form - what I name - vulnerable clusters (VCs); clusters of issues and tensions that are not (yet) 'activated'; there is not yet KA/war.
As I explain later, the network of vulnerable clusters provides a certain stability to nodes (states) in the System; I refer to as the network-effect.
The network of vulnerable clusters grows) once the tipping point is reached, and increasingly percolates the State-System. At a certain point, the percolation threshold is reached, and a 'single' cluster of issues and tensions (VC's) spans the System. At that point, the State-System is in a critical condition and a single event can trigger systemic KA (a systemic war).
The network of issues and accompanying tensions are embedded in the entropy/tension-field (S/T-field) of the System.
I assume, that the configuration ('topology') of the network of VC's embedded in the S/T-field determines the KA/war dynamics of the (State-)System. It is possible to make a distinction between the structure and dynamics *of* the network of vulnerable clusters embedded in the 'underlying' entropy/tension field, and the structure and dynamics *on* this network, in other words of the KA (war) dynamics the network of vulnerable clusters embedded in entropy/tension field generates.
It is obvious that network science in combination with a thermodynamic perspective, can provide us with very useful insights in the workings of the System.

7.5. Correlation length

Vulnerable clusters also have a correlation length. The correlation length is a measure for the connectedness of vulnerable clusters, in relation to the size of the System: The higher the correlation length, the more issues and tensions in the System have become connected. Initially, during relatively stable periods (RSP's) of war-cycles, following a systemic war when an upgraded order is just implemented, the correlation length of vulnerable clusters is still limited: Issue and tensions are not connected and still unrelated (isolated). Entropy-regulation through non-systemic KA is still effective.
However, at a certain point - when the tipping point of the RSP is reached - entropy-regulation becomes problematic and issues and tensions start to accumulate, resulting in the percolation of vulnerable clusters and in an increase of the correlation length of these clusters.

At a certain point, the correlation length of the connected vulnerable clusters becomes one, which means that the vulnerable clusters are connected and have fully percolated the System: The connected vulnerable clusters 'span' the whole System. Initially the increasing connectedness provides local stability to the System and non-systemic KA is suppressed.
However, because of the (accelerating) production of tensions in the System - further reinforced by the inability of the FTS to regulate entropy through kinetic releases (KA, war) - the percolated network of vulnerable clusters causes the System to become critical. When the System is in a critical condition, there is a *divergence of the correlation length* of the network of VC's that has fully percolated the System.
At the critical point, the percolated network of vulnerable clusters is also fully 'charged' with tensions (entropy), and a small incident or event can (and will) trigger a massive (system-wide) kinetic response (a systemic war), involving all Great Powers in the System.
In case of a divergence of the correlation length - when the System is in a critical condition - the configuration of the System enables system-wide 'communication' and coordination: An incident will cascade - reverberate - through the System; an incident and the kinetic response that follows cannot stay localized.
This typical critical dynamic/mechanism was clearly visible in the System, in 1914, when a relatively small incident - the assassination of Archduke Franz Ferdinand of Austria, in Sarajevo on 28 June 1914 - triggered a massive systemic response: The third systemic war (1914-1918) during the transient period (1480-1945), better known as the First World War.

7.6. Application (1): Centrality of Great Powers

Great Powers are the hubs of the System. Great Powers have a high load or betweenness centrality in the System; they are important in shaping the traffic - EMIS-flows - in the System, and in configuring the tension field.
The United Kingdom[7] and France were the most central nodes in the System, during the transient period (1480-1945). They were able to maintain their Great Power status - maintain their centrality - during the transient period (until now), and also through the PBMP-mechanism had a decisive impact on the shaping of the State-System.
Presently, the United States is the most central node, economically, but also (not coincidentally) in the network of issues and tensions in the System. The United States is directly or indirectly involved - and has become a stakeholder - in all issues that are presently accumulating in the (State-)System.
The participation of Great Powers in Great Power wars can also be considered a measure for their centrality, see figure 7.2.

7. In this study, I refer to 'Britain', 'Great Britain' as the United Kingdom (UK).

TABLE 7.1: Membership of the Great Power System (1495-1975). Data from Levy (48).

State	Start	End
France	1495	-
England/Great Britain	1495	-
Austrian Hapsburg/Austria/Austria-Hungary	1495	1519
Austrian Hapsburg/Austria/Austria-Hungary	1556	1918
Spain	1495	1519
Spain	1556	1808
Ottoman Empire	1495	1699
United Hapsburg	1519	1556
The Netherlands	1609	1713
Sweden	1617	1721
Russia/Soviet Union	1721	-
Prussia/Germany/West Germany	1740	-
Italy	1861	1943
United States	1898	-
Japan	1905	1945
China	1949	-

TABLE 7.2: Rank order of Great Power participation in non-systemic wars (expansion wars excluded), at least involving two Great Powers. (n = 63, data from Levy (48)).

Rank	Great Power	Number of wars
1	France	35
2	Austrian Hapsburg/Austria/Austria-Hungary	26
3	England/Great Britain	25
4	Spain	24
5	Ottoman Empire	14
6	United Hapsburg	9
7	Russia/Soviet Union	9
8	The Netherlands	6
9	Prussia/Germany/West Germany	6
10	Sweden	3
11	Italy	1

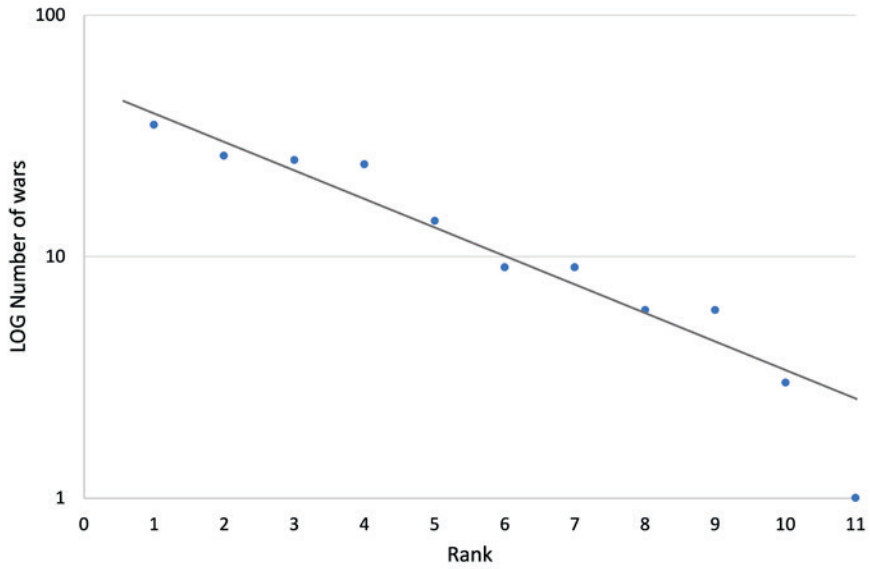


FIGURE 7.2: Rank order of Great Power participation in non-systemic wars (expansion wars excluded), at least involving two Great Powers (period 1495-1945. (n = 63, data from Levy (48)). The distribution approximates a Zipfian distribution, (59).

7.7. Application (2): Attack tolerance

Scale-free networks have a typical 'error and attack tolerance' (1), which is related to the distribution of nodes with a certain degree in these types of networks. Characteristically, scale-free networks contain many nodes with a relatively low degree (sparsely connected nodes), and a few nodes with a high degree (these are the hubs, Great Powers).

In case of a *random* 'attack' on a scale-free network, or a random error of a node (a failing node) in such a network, the probability that a sparsely connected node is involved, is much higher than the involvement of one of the few highly connected nodes (sparse hubs). For that reason, the probable effect of a *random* attack or error on the overall network will be limited.

However, the distribution of nodes in scale-free networks makes these networks vulnerable for *targeted* (directed) attacks; for attacks on (and errors of) one of the few highly connected nodes (sparse hubs). When (one of the few) highly-connected nodes are attacked (or fails), the effects will reverberate through the System, and cannot be contained (stay localized). The 'same' attack - on a single node - has is completely different impact.

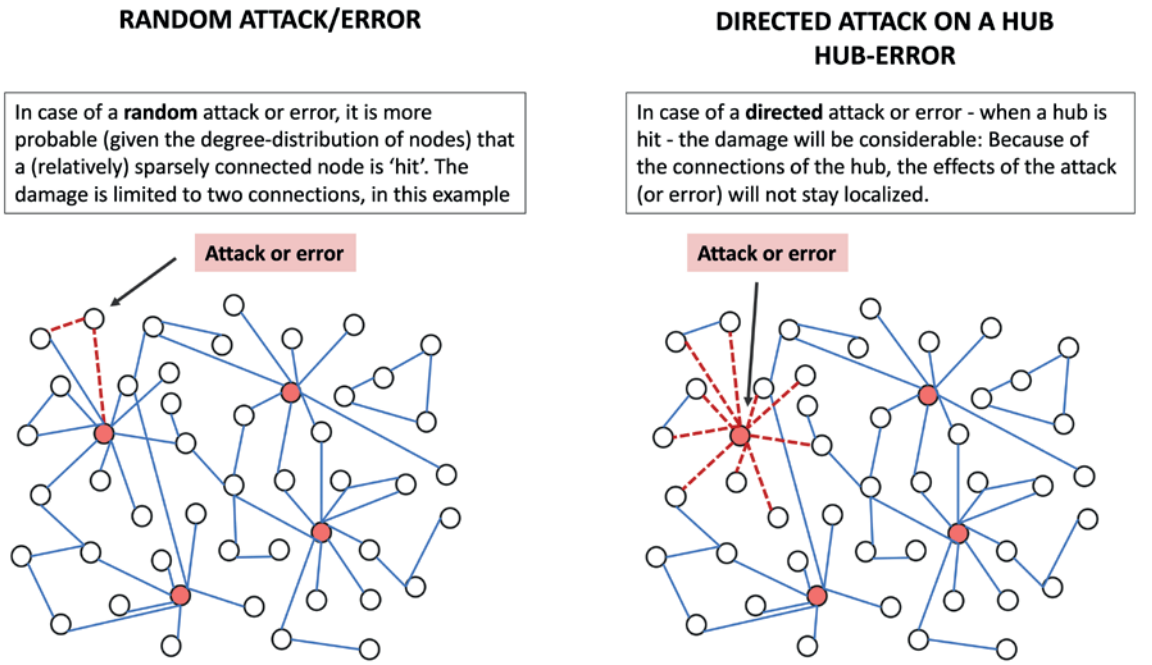


FIGURE 7.3: Attack and error tolerance of scale-free networks. Typically, a scale-free network has many nodes with a low degree and just a few nodes with a high degree: The degree distribution of the nodes of a scale-free network obeys a power law. The probability that in case of a random attack, a node with a few degrees is 'hit', is much higher than the probability that one of the few hubs (highly connected nodes) is hit. In case of a random attack (left) a node with a low degree is hit and just two links are affected: The attack has a limited impact. In case a hub - a highly connected node - is hit, the impact is much more significant.

Presently, the United States is the node with the highest centrality in the System ('hub of hubs'); the System is now in the 1st cycle (I explain later) of the 2nd FTS (globalized State-System (1945-....)).
At this stage, the 2nd FTS struggles to regulate the (State-)System; entropy (issues and tensions) is accumulating, and vulnerable clusters are percolating the System and become increasingly connected. Data-analysis shows (to be discussed later) that the current cycle had reached its tipping point in 2011.
The United States is linked to - an integral part of - all increasingly connected vulnerable clusters in the System; in fact, the United States connects these clusters, and is instrumental in their percolation and in the increase of their correlation length of the vulnerable clusters. Because of the centrality of the United States in the scale-free System, *the United States is very vulnerable for a directed attack (or error)*; such an attack will then 'reverberate' through the System, because of the configuration of the (network of the) global System.
It seems, that the United States struggles with its entropy-regulation - its homeostasis - due to external and societal developments. In response, the United States now tries to reduce the influx of entropy by isolating itself from the (State-)System; a typical response to entropy-overloads.
Because of the scale-free characteristics of the System and the centrality of the United States, its 'repositioning' - e.g. its decisions to disengage from current arrangements and obligations - impacts on

the basic architecture of the current international order, on the (regulation of) EMIS-flows in the System and consequently on the configuration of the S/T-field. The State-System will (further) fragment and lose its consistency.

7.8. Application (3): The origin and function(s) of VC's

In this chapter, I mentioned that the moment the tipping point of a cycle (a RSP) is reached, that entropy-regulation through non-systemic KA/war becomes less effective, and that entropy - issues and tensions - starts to accumulate in the (State-)System.

In this paragraph, I explain (ahead of a more detailed explanation of this subject, at a later stage), the relationship between chaotic non-systemic KA, VC's, the storage of information and criticality of the System.

Once the tipping point of a cycle is reached, issues and tensions (entropy) start to accumulate in the (State-)System, an autocatalytic process is triggered and VC's form - crystallize - with *fractal* structures.

The *fractal* structures of the network of VC's result in - 'enable' - the divergence of the correlation length of these (percolating) vulnerable clusters: Fractality is required for the State-System to become critical, and to produce systemic KA (systemic wars) in response, to upgrade the order of the System. *An upgrade of the order requires system-wide communication and coordination, which is ensured through a critical state of the System*.

Analysis of war data (48) shows, that fractality of VC's is not a matter of course: For VC's to have fractal structures, *chaotic* non-systemic KA/wars is required to produce them.

Analysis of the abnormal (periodic instead of chaotic) war dynamics of the System, during the 1st exceptional period (1657-1763), shows that *periodic* (non-chaotic) KA/war dynamics do *not* support the formation of VC's with fractal structures, and that consequently the efficiency of the 1st FTS (as I explain later) was negatively affected and the (further) development of the System delayed, during the 2nd RSP/cycle (1648-1815).

The *chaotic* nature of non-systemic KA/wars also serves other purposes: The chaotic nature of non-systemic KA/wars also ensures that the phase space of the System - microstates that are (potentially) available to the System - is optimally explored during RSP's: The Second Law and related principles that apply FFE (see also chapter 2) demand - and ensure - that the State-System finds and uses the most efficient path to thermodynamic equilibrium. To find this 'path', exploration is required.

Analysis furthermore shows that *chaotic* non-systemic KA is more restrained than *periodic* non-systemic KA (during the 1st exceptional period (1657-1763)), and the restraint in KA (non-systemic wars) is a factor that probably also contributes to the forming of fractal VC's.

Finally, chaotic non-systemic KA - through the formation and percolation of fractal VC's - ensures that information (produced through the kinetic exploration of phase state) about possible future utilization of microstates, can be stored in the System It is in fact stored in the clusters).

When the System eventually becomes critical (and the network of VC's has thus percolated the System), the System produces systemic KA (a systemic war) in response. During the systemic KA/war (when the System is in a critical condition), the accumulated free energy in the System is released and put to work, as well as the information that is contained in the VC's. The (State-)System utilizes the divergence of the correlation length during criticality.

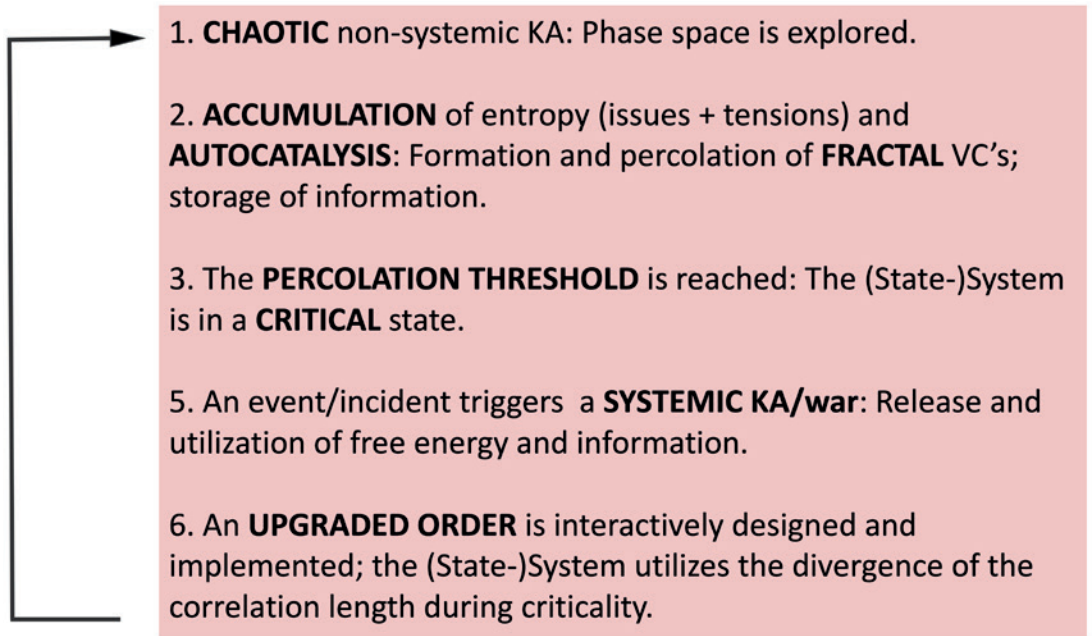


FIGURE 7.4: The relationship between chaotic non-systemic KA, VC's, the storage of information and criticality of the System.

Part III

Introduction

In Part II, I have introduced several basic concepts/ideas that will be applied to better understand the functioning of the (State-)System from a thermodynamic perspective.
In this part - Part III - the focus is on living systems, homeostasis and the homeostatic imperative (the H-imperative). To ensure their "operation", well-being and survival, humans and social systems have to maintain homeostasis. The drive to "persevere in its being" is the hallmark of all living systems, including societies and the (State-)System.
The regulation of life requires the ability to maintain internal structures and their operations; a certain integrity - cohesiveness - that can deal with internal and external perturbations. Life requires efficient EMIS-regulation.
This part consists of some introductory subjects and includes chapters that focus on the H-imperative and its relationship with the so-called entropic (or S-) imperative: The H- and S- imperatives are closely related.
The following subjects will be discussed in the chapters that follow: General properties of living systems, life and its 'relationship' with entropy, steady states and homeostasis, the homeostatic-imperative and the regulatory functions of the state.

Contents

8. Living systems
9. Life, entropy and information
10. Steady states and homeostasis
11. Homeostasis and the S-imperative
12. The regulatory-role of the state

8. Living systems

8.1. Introduction

In this chapter, I discuss so called 'living systems'. Miller has extensively analyzed the structure and process of seven hierarchical levels of living systems, that can be distinguished, "in order to demonstrate similarities and differences across these levels" (53).
Miller has developed a *general* theory of living systems and mainly focuses on processes[1] involving matter, energy and information, including some of their entropic aspects.
In this study, I focus on very specific systems: Societies and the (State-)System, and (especially) from a thermodynamic - entropic - perspective. The thermodynamic concepts I apply were not yet fully crystallized when Miller made his extensive analysis.
In this study I make use of what is referred to as 'modern thermodynamics' (44). However, these new(er) insights and Miller's analysis do not contradict each other but are complementary.

8.2. Typical characteristics of living systems

The general living systems theory Miller presents is "a conceptual system concerned primarily with concrete systems which exist in space-time". According to Miller, complex structures which carry out living processes can be identified at seven hierarchical levels: the (1) cell, (2) organ, (3) organism, (4) group, (5) organization, (6) society, (7) supranational system.
Miller's central thesis is that systems at all these levels are open systems composed of subsystems which process inputs, throughputs, and outputs of various forms of matter, energy, and information. Miller "identifies 19 critical subsystems (see table) whose processes are essential for life, some of which process matter or energy, some of which process information, and some of which process all three. Together they make up a living system."

1. Some remarks regarding structure and process: There is a close relationship between structure and process (dynamics): A structure can be considered a physical and/or abstract ordering of matter, energy, information and entropy. A structure 'contains' the 'permanent' elements of a process. Structures are shaped by processes and vice versa. They represent the same phenomenon, in different appearances: structure represents permanence, while process represents 'movement' and change. In German language a distinction is made between 'Aufbau' (refers to structure) and 'Ablauf' (refers to process). Structure is about 'architecture'. Structure during a certain period of time, constitutes a process; a process at a specific moment in time - a snapshot of a process - exposes its structure. It is important to distinguish between two levels of processes: The process (or dynamics) on a structure, enabled/ supported by the structure, and the process (of evolution) of the (underlying) structure itself.

TABLE 8.1: Critical subsystems of living systems. This table specifies the 19 critical subsystems - essential processes - of living systems, as identified by Miller (53).

Subsystems which produce both matter-energy and information	
1. **Reproducer**, the subsystem which is capable of giving rise to other systems similar to the one it is in.	
2. **Boundary**, the subsystem at the perimeter of a system that holds together the components which make up the system, protects them from environmental stresses, and excludes or permits entry to various sorts of matter-energy and information.	
Subsystems that process matter-energy	**Subsystems that process information**
3. **Ingestor**, the subsystem which brings matter-energy across the system boundary from the environment.	11. **Input transducer**, the sensory subsystem which brings markers bearing information into the system, changing them to other matter-energy forms suitable for transmission within it.
4. **Distributo**r, the subsystem which carries inputs from outside the system or outputs from subsystems around the system to each component.	12. **Internal transducer**, the sensory subsystem which receives, from subsystems or components within the system, markers bearing information about significant alterations in those subsystems or components, changing them to other matter-energy forms of a sort which can be transmitted within it.
5. **Converter**, the subsystem which changes certain inputs to the system into forms more useful for the special processes of that particular system.	13. **Channel and net**, the subsystem composed of a single route in physical space, or multiple interconnected routes, by which markers bearing information are transmitted to all parts of the system.
6. **Producer,** the subsystem which forms stable associations that endure for significant periods among matter-energy inputs to the system or outputs from its converter, the materials synthesized being for growth, damage repair, or replacement of components of the system, or for providing energy for moving or constituting the system's outputs of products of information markers to its supra-system.	14. **Decoder**, the subsystem which alters the code of information to it through the input transducer or internal transducer into a 'private' code that can be used internally by the system.
7. **Matter-energy storage**, the subsystem which retains in the system, for different periods of time, deposits of various sorts of matter-energy.	15. **Associator**, the subsystem which carries out the first stage of the learning process, forming enduring associations among items of information in the system.
8. **Extender**, the subsystem which transmits matter-energy out of the system in the forms of products or wastes.	16. **Memory**, the subsystem which carries out the second stage of the learning process, storing various sorts of information in the system for different periods of time.
9. **Motor**, the subsystem which moves the system or parts of it in relation to a part or all of its environment or moves components of its environment in relation to each other.	17. **Decider**, the executive subsystem which receives information inputs from all other subsystems and transmits to them information outputs that control the entire system.
10. **Supporter**, the subsystem which maintains the proper spatial relationships among components of the system, so that they can interact without weighing each other down or crowding each other.	18. **Encoder,** the subsystem which alters the code of information input to it from other information processing subsystems, from a 'private' code used internally by the system into a 'public' code which can be interpreted by other systems in its environment.
	19. **Output transducer**, the subsystem which puts out markers bearing information from the system, changing markers within the system into other matter-energy forms which can be transmitted over channels in the system's environment.

Miller explains that "systems at each of the seven levels have the same 19 critical subsystems. The structure and the processes of a given subsystem are more complex at a more advanced level than at the less advanced ones" (53). This is explained by what Miller calls "the evolutionary principle of 'shred-out', a sort of division of labor". Cells have the 19 critical subsystems. When mutations occurred in the original cells, the mutant could continue to exist only if it could carry out all the essential processes of life of the 19 subsystems; otherwise it would be eliminated by natural selection. "If at any single point in the entire evolutionary sequence any one of the 19 subsystem processes had ceased, the system would not have endured" (53).
The general direction of evolution is toward greater complexity: "As more complex cells evolved, they had more complex subsystems, but still the same 19 basic processes."

8.3. Spatiotemporal unity of living systems

Miller has also developed valuable ideas concerning historical change in societies. According to Miller societies are "complex and vigorous organisms" that "have many of the characteristics of life at other levels".
Miller observes that "nature is a structure of evolving processes", and 'events' can be considered "spatiotemporal unities". The 1st and 2nd FTS's can be considered evolving processes; spatiotemporal unities, as meant by Miller.
Miller looked at an event - a spatiotemporal unity - "as pulling together assemblages into unities, making systems out of unorganized heaps. It not only dynamically mirrors the impact of its own contemporary and preceding events but also anticipates and to an extent determines future events. The event is the organism or system at the present moment, an interlocked community of connexity which is part of the vast organization of the universe, yet bounded and constrained" (53). The System/FTS also "pulls together assemblages" ('lower-level' social systems, like communities and societies), and "makes a system (*IP: the (State-)System*) out of unorganized heaps".
The (State-)System also "mirrors the impact of its own contemporary and preceding events and anticipates and to an extent determine future events". The (State-)System and its building blocks (like humans, communities, societies, etc.) are (reflect) the FTS at the present moment and can be considered a bounded and constrained part of the universe. In the terminology of thermodynamics (of this study): The System/FTS is bounded and a (temporary) low entropy construct; that can be maintained through the constant input of free energy; the System can only survive if EMIS-exchanges with a suitable environment can be sustained. This is not only a requirement for the System and its components, but for all living systems.

8.4. The mechanism of shredding out

The mechanism of 'shredding out' - as Miller names it - can also be observed in the evolution of the State-System. During the transient period (1480-1945) - during the operation of the 1st FTS, with Europa at its core - a process of among other things, aggregation took place. The aggregation process can be

considered a process of 'shredding out': the 19 critical subsystems Miller identified were embedded - accommodated - at a higher level of hierarchical organization (hierarchy as defined by Simon). The same time as societies evolved into more complex system, certain subsystems of societies (including their state-structures) shredded out into increasingly complicated and more efficient processes.
The shredding out of the governance of societies from states into an integrated 'super-state' (e.g. the European Union), was - and is - driven by the basic requirements societies must fulfill to survive: Societies can be better served, if they are organized into a more effective and efficient supra-system. 'Size' matters in social systems, because increased size means that the potential for economies of scale and scope is larger, while (at the same time) the transaction costs between societies and subsystems are reduced. Aggregation (integration) means better survival chances.

8.5. Application (1): Biological order at the level of the cell

As explained in chapter 2, the movement of a system toward disorder is a spontaneous process in accordance with the Second Law: An isolated system will move toward thermodynamic equilibrium, a state with maximum entropy (disorder). However, order can also be spontaneously produced in (open) systems FFE, when entropy serves as a source of order. However, to create and maintain order, an organized effort - the in- and outflows of EMIS - is required; free energy must be put to work.
At the level of the cell - the first level of living systems (53) - thermodynamics works as follows, according to Alberts et al.: "Living cells - by surviving, growing, and forming complex organisms - are generating order and thus might appear to defy the Second Law of thermodynamics. How is this possible? The answer is that a cell is not an isolated system: it takes in energy from its environment in the form of food, or as photons from the sun (or even, as in some chemosynthetic bacteria, from inorganic molecules alone), and it then uses this energy to generate order within itself (*IP: as the System, through the FTS, also does*). In the course of the chemical reactions that generate order, the cell converts part of the energy it uses into heat. The heat is discharged into the cell's environment and disorders it, so that the total entropy - that of the cell plus its surroundings - increases, as demanded by the laws of thermodynamics. To understand the principles governing these energy conversions, think of a cell surrounded by a sea of matter representing the rest of the universe. As the cell lives and grows, it creates internal order. But it constantly releases heat energy as it synthesizes molecules and assembles them into cell structures. Heat is energy in its most disordered form - the random jostling of molecules. When the cell releases heat to the sea, it increases the intensity of molecular motions there (thermal motion) - thereby increasing the randomness, or disorder, of the sea. The second law of thermodynamics is more than compensated for by an even greater decrease in order (increase in entropy) in the surrounding sea of matter" (2).
The process - EMIS-transformations and regulation - at the level of the cell, is - at a basic level - identical with regulatory processes in the (State-)System, involving the FTS. That should not come as a surprise: The same laws of thermodynamics apply.

8.6. Application (2): Incomplete shredding out; 'stuck in the middle'

The reason that Europe still struggles with the accomplishment of 'complete unity' - the institutionalization of aggregation stage 3B - is that the process of shredding out is not yet fully accomplished (Europe is still in aggregation stage 3A), while the pressure on the European Union (because of the present condition of the System, and the buildup of entropy) increases. Presently, Europe is 'stuck in the middle'. This makes Europe - the European Union - vulnerable as a viable living system that can maintain - survive - in the current, increasingly volatile environment.

9. Life, entropy and information

9.1. Introduction

In a book with the title *What is life?* Erwin Schrödinger proposes some answers to this fundamental question (74).
The more extended version of the question Schrödinger addresses is: "How can the events in space and time which take place within the spatial boundary of a living organism be accounted for by physics and chemistry? (74) . Schrödinger points to the 'paradox' that systems evolve to equilibrium states and maximum entropy, but life is above all about order, negative entropy: "Life seems to be orderly and lawful behavior of matter, not based exclusively on its tendency to go over from order to disorder but based partly on existing order that is kept up (74)".
I discuss the observations of Schrödinger, because of their relevance for this study: How can the order in the (State-)System and the very regular patterns in its dynamics be explained, and how evolves the (State-)System toward thermodynamic equilibrium and a state of maximum entropy?
In addition to Schrödinger 's observations regarding the relationship between life and entropy, I discuss in this chapter the perspective of Avery (6). Avery focuses on the relationship between information and life.

9.2. Feeding on negative entropy/free energy

Schrödinger explains that an organization - 'physical orderliness' - must obey strict physical laws. I argue that this is also the case for the System and FTS, which are both highly ordered structures.
According to Schrödinger, the laws of physics are statistical laws and "They have a lot to do with the natural tendency of things to go over into disorder" (74). Schrödinger refers to the Second Law of thermodynamics: "(...) the statistical tendency of matter to go over into disorder (...). The general principle involved is the famous Second Law of thermodynamics (entropy principle) and its equally famous statistical foundation. (74)".
According to Schrödinger living matter evades "the decay to equilibrium", which is the "characteristic feature of life". While "When a system that is not alive is isolated or placed in a uniform environment, all motion usually comes to a standstill very soon as a result of various kinds of friction; differences of electric or chemical potential are equalized, substances which tend to form a chemical compound do so,

temperature becomes uniform by heat conduction. After that the whole system fades away into a dead, inert lump of matter. A permanent state is reached, in which no observable events occur. The physicist calls this the state of thermodynamical equilibrium, or of 'maximum entropy' (74)".

"It is by avoiding the rapid decay into the inert state of 'equilibrium' that an organism appears so enigmatic (...)". Despite the fact that "Every process, event, happening (...) everything that is going on in Nature means an increase of the entropy of the part of the world where it is going on. Thus, a living organism continually (...) produces positive entropy and thus tends to approach the dangerous state of maximum entropy, which is death. It can only keep aloof from it, i.e. alive, by continually drawing from its environment negative entropy (...). What an organism feeds upon is negative entropy. Or, to put it less paradoxically, the essential thing in metabolism is that the organism succeeds in freeing itself from all the entropy it cannot help producing while alive" (74).

Schrödinger also addressed the question: "How would we express in terms of the statistical theory the marvelous faculty of a living organism, by which it delays the decay into thermodynamical equilibrium (death)?" "We said before: 'It feeds upon negative entropy', attracting, as it were, a stream of negative entropy upon itself, to compensate the entropy increase it produces by living and thus to maintain itself on a stationary and fairly low entropy level. If $\boldsymbol{D}$ is a measure of disorder, its reciprocal, $\boldsymbol{1/D}$, can be regarded as a direct measure of order. Since the logarithm of $\boldsymbol{1/D}$ is just minus the logarithm of $\boldsymbol{D}$, we can write Boltzmann's equation thus: -($\boldsymbol{entropy}$) = $\boldsymbol{k\ log(1/D)}$ Hence the awkward expression 'negative entropy' can be replaced by a better one: entropy, taken with the negative sign, is itself a measure of order. Thus, the device by which an organism maintains itself stationary at a fairly high level of orderliness (a fairly low level of entropy) really consists in continually sucking orderliness from its environment. This conclusion is less paradoxical than it appears at first sight. Rather could it be blamed for triviality. Indeed, in the case of higher animals we know the kind of orderliness they feed upon well enough, viz. the extremely well-ordered state of matter in more or less complicated organic compounds, which serve them as foodstuffs. After utilizing it they return it in a very much degraded form, not entirely degraded, however, for plants can still make use of it. (These, of course, have their most powerful supply of 'negative entropy' in the sunlight.)" (74).

The statement by Schrödinger, 'Life feeds on negative entropy' can be interpreted as 'life feeds on free energy'; energy that is available to do work, that contributes to the maintenance of the order of the living system.

9.3. Life and information

Avery observes that "one theme seems to characterize life: It is able to convert negative entropy in the form of thermodynamic information contained in food or in sunlight into complex and statistically unlikely configurations of matter (...) (6).

Avery explains: "All living organisms draw a supply of thermodynamic information from their environment, and they use it to "keep aloof" from the disorder which constantly threatens them. In the case of animals, the information-containing free energy comes in the form of food. In case of green plants, it comes primarily from sunlight. The thermodynamic information thus gained by living organisms is used by them to create configurations of matter which are so complex and orderly that the chance that they could have arisen in a random way is infinitesimally small" (6).

Humans and social systems - all types of living systems - also draw information from their environment, and they use it to contain disorder which constantly threatens them. It is important to note that social systems (orders) are abstract 'constructs' (concepts) that are also embedded in the physical world. Humans exploit both domains to ensure the fulfilment of their basic requirements (I discuss the decoupling of the matter (physical) and information (abstract) 'domain', at a later stage in more detail).
In case of the abstract domain, there is (also) cybernetic information; cybernetic information is exchanged through communication. All interactions between humans and social systems contain information and can be (for that reason) considered a form of communication. All human artefacts contain information and can be considered a reflection of an abstract construct.
The information gained by social systems is used to create and maintain configurations - abstract and of matter - which are so complex and orderly that the chance they could have arisen in a random way is infinitesimally small.

9.4. Application (1): Entropy-processing

Life and its sustainment - order and organization - require the sustained input of free energy that is put to work. Organized structures have to deal with the entropy they themselves generate through irreversible processes ($\boldsymbol{d_iS}$), and with the entropy they 'confront' in their environment ($\boldsymbol{d_eS}$). Sustainment of life - the operation of low entropy structures - requires that EMIS-flows are generated, regulated and sustained: Living systems are nonequilibrium systems FFE, that are able to maintain a certain order through the EMIS-flows they generate and regulate. Effective and efficient EMIS-flow regulation (including entropy redistribution) are vital.
Such a sustained process requires the maintenance of various interrelated feedback structures, of various life-functions. These feedback structures generate the urge to survive of living systems.
Because the System evolves to increasing levels of complexity - novelty creates more novelty - humans and social systems (the parts of the System) must constantly adapt. The pace of life in the System accelerates, so does the need for adaptation. Humans and social systems must be able to explore and exploit entropy - new possibilities - that comes available and avoid that 'entropy' takes control by damaging them, or that other humans and social systems are better able to exploit (utilize) new possibilities (opportunities and threats). Entropy processing is a process of 'filtering' and 'sorting', in which basic requirements, and (for example) ideologies serve as filters.
Humans have developed various responses - skill-sets - to deal (cope) with (social) entropy, including: (1) Neutralization and reduction of entropy, which can include the use of kinetic energy (KA, also at an individual level); (2) 'evasion' of entropy, a response that contributes to expansion of social systems; (3) 'taking control', by (for example) shaping the environment, and (4) putting entropy - new possibilities that come available - to use and exploit them.
Human characteristics - skill-sets - that ensure well-being and survival, include: (1) the ability to deal with uncertainty, (2) the ability - e.g. social skills - to recognize and exploit opportunities and threats, (3) the ability to communicate and coordinate with other humans, and (4) the ability to influence and shape one's environment. The function of the brain is not information processing, but entropy processing, which includes information.

9.5. Application (2): Evolution, according to Avery

According to Avery (6): "A flood of information-containing free energy reaches the earth's biosphere in the form of sunlight. Passing through the metabolic pathways (info processing brains) of living organisms, this information keeps the organisms far away from thermodynamic equilibrium ("which is death"). As the thermodynamic information flows through the biosphere, much of it is degraded into heat (noise), but part is converted into cybernetic information and preserved in the intricate structures which are characteristic of life." "The principal of natural selection ensures that as this happens, the configurations of matter in living organisms constantly increase in complexity, refinement and statistical improbability. This is the process which we call evolution, or in case of human society, progress."

9.6. Application (3): Other perspectives on life

In this and the preceding chapters, I have discussed different perspectives on life; not only of Schrödinger, but also of Miller (53). Other perspectives include the perspective of Georgescu-Roegen (34). Georgescu-Roegen argues that "an essential difference between living and non-living systems" is the ability to sort energy - to make a distinction between free (usable) and bound/latent - energy, and extract it from its environment, to preserve its order/functioning. If life is defined as an ability to sort energy, then the process of evolution can be understood as 'meta-sorting'; the sorting of sorting abilities of competing living systems.

Chaisson describes life as: "an open, coherent, spacetime structure maintained far from thermodynamic equilibrium by a flow of energy through it", and Chaisson observes that "life likely differs from the rest of clumped matter only in degree, not in kind." (20).

In this study, I make use of these perspectives of/on life.

10. Steady states and homeostasis

10.1. Introduction

In this chapter, I discuss steady states as defined by Miller in the context of living systems. Miller's conception of steady states and stability is related to a general theory of living systems and mainly focuses on processes involving matter, energy and information. This study focuses on societies and the (State-)System, with a strong focus on entropy and its regulation.
Furthermore, I discuss the homeostatic-imperative, a concept introduced by Damasio (25); this concept is useful to better understand the behavior of social systems (including of it 'parts' (individual humans)), and how micro- and macroscopic behavior in the System are related and interact; a subject that will be discussed in detail in the next chapters.
Because of the insights and its usefulness, I discuss 'Damasio's framework', in more detail in the next chapter.

10.2. The need for steady states (homeostasis)

"When opposing variables in a system are in balance, that system is in equilibrium with regard to them. The equilibrium may be static and unchanging or it may be maintained in the midst of dynamic change (*IP: As is the case for societies and the System, for example*). Since living systems are open systems, with continually altering fluxes of matter-energy and information (*IP: and entropy*), many of their equilibria are dynamic and are often referred to as flux equilibria or steady states. These may be unstable, in which a slight disturbance elicits progressive change from the equilibrium state (...); or stable, in which a slight disturbance is counteracted so as to restore the previous state (...); or neutral, in which a slight disturbance makes a change but without cumulative effects of any sort (...)". Steady states are dynamic in nature, and is also referred to as
"All living systems tend to maintain steady states (or homeostasis) of many variables, keeping an orderly balance among subsystems which process matter-energy or information. Not only are subsystems usually kept in equilibrium, but systems also ordinarily maintain steady states with their environments and supra-systems, which have outputs to the systems and inputs from them. This prevents variations in the environment from destroying systems. The variables of living systems are constantly fluctuating, however. A moderate change in one variable may produce greater or lesser alterations in other related ones. These alterations may or may not be reversible" (53).

10.3. Stress, strain and threats

"There is a range of stability for each of numerous variables in all living systems. It is that range within which the rate of correction of deviations is minimal or zero, and beyond which correction occurs. An input or output of either matter-energy or information which, by lack or excess of some characteristic, forces the variables beyond the range of stability, constitutes stress and produces a strain (or strains) within the system. Input lack and output excess both produce the same strain: Diminished amounts in the system. Input excess and output lack both produce the opposite strain: Increased amounts. Strains may or may not be capable of being reduced, depending upon their intensity and the resources of the system. The totality of the strains within a system resulting from its template program and from variations in the inputs from its environment can be referred to as its values. The relative urgency of reducing each of these specific strains represents its hierarchy of values" (53).

"Stress may be anticipated. Information that a stress is imminent constitutes a threat to the system. A threat can create a strain. Recognition of the meaning of the information of such a threat must be based on previously stored (usually learned) information about such situations. A pattern of input information is a threat when - like the odor of the hunter on the wind, or a change in the acidity of fluids around a cell, or a whirling cloud approaching the city - it is capable of eliciting processes which can counteract the stress it presages. Processes - actions or communications - occur in systems only when a stress or a threat has created a strain which pushes a variable beyond its range of stability: A system is a constantly changing cameo, and its environment is a similarly changing intaglio, and the two at all times fit each other. That is, outside stresses or threats are mirrored by inside strains. Matter-energy storage and memory also mirror the past environment, but with certain alterations" (53).

"Ordinarily there is a standard range of rates at which each sort of input enters a system. If the input rate falls below this range, it constitutes a lack stress. If the input rate goes above this range, it is an excess stress" (53).

10.4. Types of stress

Miller (53) distinguishes two types of stresses:

- *Matter- energy stress*: Systems undergo stress in various ways. One class of stresses is the matter-energy stresses, including: (a) matter-energy input lack or underload - starvation or inadequate fuel input; (b) matter-energy input excess or overload; and (*c*) restraint of the system, binding it physically. (Alternative *c* may be the equivalent of *a* or *b*) (53).
- *Information stress*: Systems also undergo information stresses, including: (a) information input lack or underload, resulting from a dearth of information in the environment or from improper function of the external sense organs or input transducers; (b) injection of noise into the system, which has an effect of information cutoff, much like the previous stress; and (c) information input excess or overload. Informational stresses may involve changes in the rate of information input or in its meaning (53).

I add a third type of stress:

- *Entropy stress.* Entropy stress is stress caused by an overload of entropy - too much entropy resulting in a lack of order, structure and/or organization - or by a shortage of entropy; a too low level of entropy, resulting in too much order and structure, causing ossification and a lack of flexibility and adaptability.

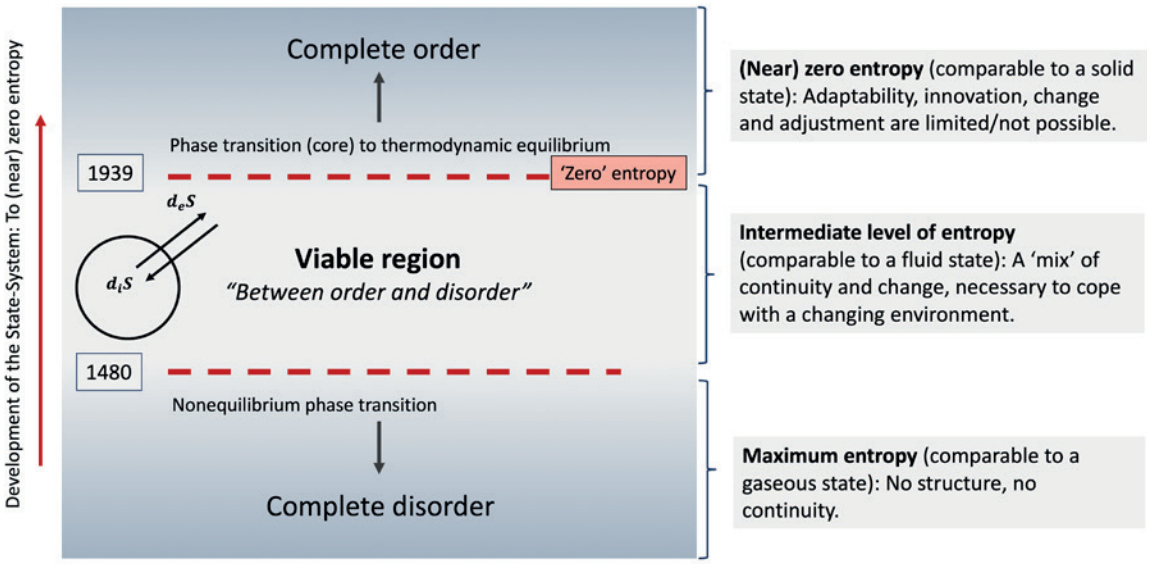


FIGURE 10.1: Viability and levels of entropy. Viability of social (all living) systems requires a (dynamic) steady state at an intermediate level of entropy; between too much order (a shortage of entropy) and too much disorder (too high levels of entropy). During the transient period (1480-1945), the System achieved a dynamic steady state - through a dissipative structure (the 1st FTS), FFE - that ensured the State-System's viability. The 1st FTS was instrumental in a phase transition. The moment (1939), the entropy-production of the System exceeded the regulatory capabilities of the 1st FTS, the FTS and its structural representation (the European State-System) collapsed.

10.5. Minimization of stress

The Le Châtelier principle in closed and open systems is concerned with the minimization of stress. The Le Châtelier principle not only applies to chemical systems. "Le Châtelier stated his principle (1888), which applies to nonliving systems and possibly also to living systems, as follows: 'Every system in chemical equilibrium undergoes, upon the variation of one of the factors of the equilibrium, a transformation in such a direction that, if it had produced itself, would have led to a variation of opposite sign to the factor under consideration.' A common restatement of this principle is: '*A stable system under stress will move in that direction which tends to minimize the stress.*' That is, a compensatory force will develop which will tend to minimize the effect of stress; it will be exerted opposite to the stress, and it is usually accompanied

by changes in other related, subsidiary variables. By this we mean system variables not primarily and directly affected by the applied stress" (*IP: this principle is closely related to - a consequence of - the Second Law, see also chapter 2*) (53).
"This principle or theorem was originally stated after a consideration of the thermodynamics of closed systems, but it has been adapted for open systems by Prigogine. Within the system this variable or equilibratory force tends to operate at the expense of certain other associated variables related to adjustment processes of the system. There are, of course, fluctuations in these variables over time. Systems which maintain stability over long periods of time apparently tend to reduce the costs involved in the activation of these associate variables" (53).

10.6. Feedback

In this paragraph, I discuss Miller's explanation of feedback (53). "Those processes of subsystems which maintain steady states in systems, keeping variables within their ranges of stability despite stresses, are adjustment processes. In some systems a single variable may be influenced by multiple adjustment processes. In a living system, if one component cannot handle a stress, more and more others are recruited to help. Eventually the entire capacity of the system may be involved in coping with the situation" (53). Feedback can contribute to stability.
"The term feedback means that two channels exist, carrying information, such that channel B loops back from the output to the input of channel A and transmits some portion of the signals emitted by channel A" (53).
"The feedback signals have a certain probability of error. They differ in the lag in time which they require to affect the system *(IP: The oscillations of war dynamics during the 1st RSP can be explained by a time-lag in feedback, see also chapter 5)*. Their lag may be minimal, so that each one is fed back to the input of the latter channel before the next signal is transmitted. Or their lag may be longer, and several signals may be transmitted before they arrive to affect the decision about what signal to transmit next. Feedback signals also differ in their gain or extent of corrective effect. When the signals are fed back over the feedback channel in such a manner that they increase the deviation of the output from a steady state, positive feedback exists. When the signals are reversed, so that they decrease the deviation of the output from a steady state, it is negative feedback (*IP: goal seeking in the terminology of Sterman, see chapter 5*). Positive feedback alters variables and destroys their steady states. Thus, it can initiate system changes. Unless limited, it can alter variables enough to destroy systems (*IP: The 1st FTS constitutes a positive feedback mechanism/dynamic, that eventually destroyed the European State-System, in 1939*). Negative feedback maintains steady states in systems. It cancels an initial deviation or error in performance." (53).
"Cybernetics, the study of methods of feedback control, is an important part of systems theory. It has led to the recognition of certain formal identities among various sorts of nonliving and living systems. In a complex system, control is achieved by many finely adjusted, interlocking processes involving transmissions of matter-energy and information *(IP: The FTS is a manifestation of emergent control)*." (53, 5). Information flow is essential for feedback, and (as explained) information is closely related to energy and matter, and entropy: In case of feedback control, information flow "markedly alters energy utilization and the rate of development of entropy" (53, 5).

"Steady states in all living systems are controlled by negative feedbacks. A living system is self-regulating because in it input not only affects output, but output often adjusts input. The result is that the system adapts homeostatically to its environment" (53).
"At every level of living systems numerous variables are kept in a steady state, within a range of stability, by negative feedback controls. When these fail, the structure and process of the system alter markedly - perhaps to the extent that the system does not survive" (53). "Feedback control always exhibits some oscillation and always has some lag" (53).
In anticipation of the next chapters, I provide an example of a change in energy-utilization in the System, as a consequence of feedback control during RSP's of war-cycles: During RSP's of war-cycles, at a certain point, a tipping point is reached when the average size of non-systemic KA (non-systemic wars) starts to decrease. This is the consequence of a 'network-effect' (I discuss later in more detail). When the network-effect 'kicks in' (at the tipping point of the RSP), tensions (entropy) can no longer be effectively redistributed through KA (war) and issues can consequently no longer be adequately solved. The moment the network-effect is activated, the information flow, feedback control and energy-utilization are fundamentally changed. Instead of being redistributed, tensions (entropy) and issues accumulate in the System, vulnerable clusters become increasingly connected and 'charged' (with tensions), and these vulnerable clusters percolate the System. When the System becomes critical and the correlation length of the clusters is (thus) one, an in itself insignificant perturbation can trigger a massive - systemic - response. This example shows the close relationship between EMIS-flows, feedback control and system-behavior: Patterns in KA (war dynamics) in the System - free energy utilization by the FTS - include accompanying patterns of information.

10.7. The homeostatic and entropy imperative

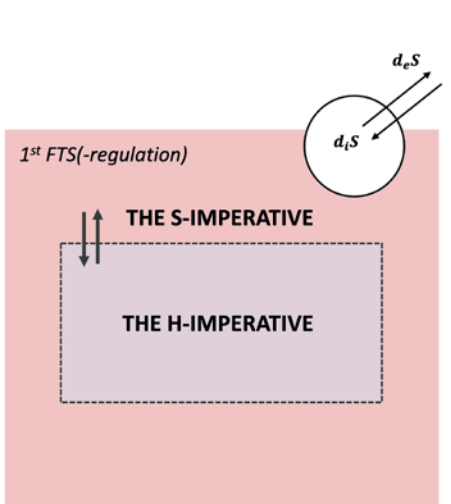
So far, in the preceding chapters (and in the paragraphs of this chapter), I have discussed the 19 essential life processes (53), the relationship between life and entropy (74), between life and information (6) and the need for steady states to ensure life.
In the paragraphs that follow, I discuss the *homeostatic imperative* - a term coined by Antonio Damasio in a book with the title: "*The Strange Order of Things, Life, feeling, and the Making of Cultures*" (25). I refer to the homeostatic imperative as the H-imperative.
As I will explain, the homeostatic imperative is an important 'link' - concept - in (understanding) the dynamics and development of the (State-)System, and the relationship between its micro- and macroscopic behavior, as well.
Damasio explains the relationship between the need for homeostasis for life, the role of feelings in the process of life (for homeostasis), and how *culture can be considered as innovations that serve the homeostatic imperative*. Damasio's theory explains how the homeostatic imperative drives cultural innovation and other collective interactions.
According to Damasio, cultures and the cultural mind, concern the following broad range of phenomena: "Dictionaries tell us that "culture" refers to manifestations of intellectual achievement regarded collectively, and unless otherwise specified, the word refers to human culture. The arts, philosophical inquiry, religious beliefs, moral faculties, justice, political governance, economic institutions - markets, banks- technology, and science are the main categories of endeavor and achievement that are conveyed

by the word "culture." The ideas, attitudes, customs, manners, practices, and institutions that distinguish one social group from another belong to the overall scope of culture as does the notion that cultures are transmitted across peoples and generations by language and by the very objects and rituals that the cultures created in the first place" (25).

Whereas Damasio focuses on the origins of the cultural mind and cultures, from a biological perspective (the need for homeostasis for life), I focus in this study, on the entropy that is generated in social and cultural interactions (culture as defined by Damasio), and how social systems generate self-organized (emergent) structures (the FTS in case of the System) to regulate entropy(-production), in accordance with the laws of thermodynamics and related principles that apply FFE.

The need for entropy-regulation to sustain the (state-)System, can be referred to as the *entropic-imperative* (or S-imperative). Obviously, homeostasis requires entropy-regulation: There must be an interplay between the homeostatic- and entropy-imperatives of social systems, to ensure their viability.

Because the S-imperative - in 'cooperation' with the H-imperative - produces emergent structures (the FTS), the S-imperative also contributes to the shaping of cultures and the cultural mind: There is a close relationship between both imperatives; these subjects will be discussed in the next chapters.



- Life - including societies - requires that certain processes are maintained within certain ranges: Homeostasis.
- Life requires a certain amount of entropy: Not too much - then there will be a lack of structure and too much disorder - and not too low, then the living system will lack diversity (a source for innovation) and adaptability.
- Societies/states in the (State-)System confront a contradiction: Societies require homeostasis, while at the same time the System - through the interactions between the societies/states that make up the (State-)System in their efforts to maintain homeostasis - is increasingly pushed FFE.
- In 1480, in accordance with the Second Law and related principles, the System experienced a bifurcation, and 'dynamic order' - the 1st FTS (1480-1945) - was imposed on the System.
- The FTS ensured EMIS-regulation of/in the (State-)System and the 'coordination' between the S- and H-imperatives.
- The S-imperative was (and still is of course) dominant and imposed constraints on the H-imperative. The H-imperative was instrumental in producing complexity; in the complexification - the evolution - of the System. The H-imperative utilized - what I name - the contingent latitude in the System (to be discussed later).

FIGURE 10.2: The interplay between the entropic- and homeostatic-imperatives. The S-imperative imposes constraints on the H-imperative.

10.8. Homeostasis defined by Damasio: "More than just regulation"

In this paragraph, I discuss homeostasis, as defined by Damasio; it is a somewhat different perspective (but complementary to Miller (53)).

According to Damasio, "Homeostasis refers to the process by which the tendency of matter to drift into disorder is countered so as to maintain order but at a new level, the one allowed by the most efficient steady state. This countering takes advantage of the principle of least action - enunciated by the French mathematician Pierre Maupertuis - whereby free energy will be consumed most efficiently and as fast as possible" (25).

Homeostasis is about regulation of living systems. A living system is a nonequilibrium system; there are numerous flows and forces at play. This nonequilibrium state must be maintained and related processes must be regulated.

To accomplish homeostasis a set of basic requirements must be fulfilled: The fulfilment of basic requirements requires the input of scarce resources, for which humans and social systems cooperate, but also compete.

Homeostasis is about resisting a 'natural' tendency of systems towards thermodynamic equilibrium. According to Damasio, comes life "equipped with a precise mandate: resist and project itself into the future, no matter what" and are living systems 'oriented' to survival' (25). "The homeostatic imperative that pervaded the organization of early organisms led to the selection of programs of chemical pathways and specific actions that ensured the maintenance of organism integrity": The H-imperative must be obeyed, to ensure a certain well-being and viability (survival).

Damasio defines homeostasis as: "The natural process of life regulation orients living organisms so that they operate within the range of parameters compatible with life maintenance and flourishing. The heroic process of maintaining life requires a precise, herculean process of regulation, in individual cells as well as in whole organisms".

Through the mechanism of homeostasis are excessive deviations of the lower and/or upper limits of processes regulated. Perturbations are corrected; if the living system fails to take adequate corrective measures it can fail.

But - Damasio explains (25) - this narrow definition fails to capture the range of circumstances in which it can be applied to living systems:

The homeostatic process not only strives for a mere steady state, but also for optimized life regulation.

Regulation is not only about strict set points, "there are shades and grades of regulation", that (in case of a certain organisms) are experienced as feelings, which reflect the "relative goodness and badness of a given life state".

Furthermore, according to Damasio, "a comprehensive view of homeostasis must include the application of the concept to systems in which conscious and deliberative minds, individually and in social groups, can both interfere with automatic regulatory mechanisms and create new forms of life regulation that have the very same goal of basic automated homeostasis, that is, achieving viable, upregulated life states that tend to produce flourishing. I see the effort of constructing human cultures as a manifestation of this variety of homeostasis."

And, "whether one considers single-celled or multicellular organisms, the essence of homeostasis is the formidable enterprise of managing energy- procuring it, allocating it to critical jobs such as repair,

defense, growth, and participation in the engendering and maintenance of progeny. This is a monumental endeavor for any organism, all the more so for human organisms given the complexity of their structure, organization, and environmental variety."

Damasio observes that two varieties of internal homeostatic control can be distinguished: (1) the 'automated' search for energy resources, and (2) H-control related to mental experiences - feelings - that express a certain value related to the condition of the living system. The second type of homeostatic control requires the existence of a mind, consciousness and related mental phenomena (25). Minds allow for the "deliberate interference with preset homeostatic mechanisms and even later allowed creative and intelligent invention to expand homeostasis into the sociocultural domain" (25).

10.9. Application (1): Costs and efficiency

Steady states and homeostatic control require the utilization of energy. Miller explains: "All adjustment processes have their costs, in energy of nonliving or living systems, in material resources, in information (including in social systems a special form of information often conveyed on a marker of metal or paper money), or in time required for an action. Any of these may be scarce. (Time is a scarcity for mortal living systems). Any of these is valued if it is essential for reducing strains. The costs of adjustment processes differ from one to another and from time to time. They may be immediate or delayed, short-term or long-term" (53).

"How successfully systems accomplish their purposes can be determined if those purposes are known. A system's efficiency, then, can be determined as the ratio of the success of its performance to the costs involved. A system constantly makes economic decisions directed toward increasing its efficiency by improving performance and decreasing costs. Economic analyses of cost effectiveness are equally important in biological and social science but much more common and more sophisticated in social than in biological sciences. In social systems such analyses are frequently aided by program budgeting. This involves keeping accounts separately for each subsystem or component that carries out a distinct program. The matter-energy, information, money, and time costs of the program in such analyses are compared with various measures of the efficiency of performance of the program. How efficiently a system adjusts to its environment is determined by what strategies it employs in selecting adjustment processes and whether they satisfactorily reduce strains without being too costly" (53).

10.10. Application (2): The H-imperative and development of general systems

Damasio explains that the emergence of 'general systems' - systems that concern the whole system - is closely related to the homeostatic imperative. The emergence of state structures - as regulatory structures of societies can - from the perspective of Damasio - be attributed to the homeostatic imperative that applies to societies (and their building blocks, like communities and individual humans). Damasio explains: "The homeostatic imperative stands behind the processes of cooperation and also looms large behind the emergence of "general" systems, ubiquitously present throughout multicellular organisms. Without such "whole-body systems", the complex structures and functions of multicellular organisms would not be viable. The main examples of such developments are circulatory systems, endocrine systems (which

are in charge of distributing hormones to tissues and organs), immune systems, and nervous systems. Circulatory systems make possible the distribution of nutrient molecules and oxygen to every cell in a body. They distribute the molecules that result from digestion carried out in a gastrointestinal system and that need to be delivered throughout an organism. The cells cannot survive without the molecules, and the same applies to oxygen; (...) Circulatory systems also accomplish something remarkable: they collect most of the waste products (*IP: waste is entropy*) that result from metabolic exchanges and succeed in getting rid of them. Last, they extend two critical assistants of homeostasis: hormonal regulation and immunity." (...) "Nervous systems are the pinnacle of organism-wide, homeostatically dedicated systems" (25).

11. Homeostasis and the S-imperative

11.1. Introduction

In this chapter, I discuss a schematic representation of the homeostatic imperative and its workings, as described and explained by Damasio's; I refer to this schematic representation, as Damasio' framework. The framework shows how "biological phenomena can prompt and shape events that become cultural phenomena" (25).
The framework is a simplification. The purpose of this framework is to serve as a reference for this study: To better understand the dynamics and development of the (State-)System, and how it evolves. Damasio's framework helps explain and understand how human behavior and the behavior of social systems (humans are integral parts of), through the constraints that are imposed by the Second Law and related principles that apply FFE (by the S-imperative), produced the macroscopic behavior of the System, i.e. of the FTS and the State-System, we can observe. The H-imperatives of individual humans are connected to the H-imperatives of communities and societies, that together produced the entropy, that served as a source of order for the (State-)System, FFE, and ensured that free energy was (and still is) purposively utilized.

11.2. Damasio's framework

The basic idea behind Damasio's framework is that living systems are "oriented to survival" and that the H-imperative must be obeyed to achieve this. Survival and a certain level of well-being require the fulfilment of a set of basic requirements, I argue. Human/social basic requirements include: Energy-input and waste (entropy) disposal, identity and sense-making, security, and integration/balancing of these requirements (through governance in case of societies).
Living systems must compete to ensure their basic requirements are fulfilled and homeostasis can be maintained: Resources and certain facilities (sometimes also security) are (often) scarce, and their inputs are not a matter of course. In their efforts to ensure well-being and survival - driven by the H-imperative - living systems have developed - and still develop - certain attributes and properties to optimize their functioning and survival chances. This all happens, within the constraints imposed by the entropic imperative, introduced in the preceding chapter.

"In early organisms, homeostasis generated the precursors to feeling and subjective perspective in the absence of mental processes" (25) homeostasis has (*IP: over time*) been responsible for the emergence of behavioral strategies and devices capable of ensuring life maintenance and flourishing, in simple as well as complex organisms, humans included (25).

At a certain stage, some living systems developed 'general systems'; often specialized systems with a system-wide (global) purpose. Humans for example, eventually acquired advanced nervous systems.

The predecessors of nervous systems (as we now know them), consisted of "nerve nets" a "network of wires". According to Damasio, were these nerve nets not capable of producing maps and images.

Nervous systems however, "allowed complex, multicellular organisms to cope better with organism-wide homeostasis and thus permitted physical and functional expansions for such organisms". Feelings - "the subjective experiences of the momentary state of homeostasis within the living body" - require a nervous system. "Feelings are the result of operations necessary for homeostasis in organisms such as ours."

"Nervous systems gradually enabled a process of multidimensional mapping of the world around them, a world that begins in the organism's interior, so that minds - and feelings within those minds - would be possible" (25). Nervous systems make the minds not by themselves but in cooperation with the rest of their own organisms: "We need to note that a partnership of nervous systems and bodies was required to generate human minds and that human minds occurred not to isolated organisms but to organisms that were part of a social setting" (25).

The nervous system gradually assumed the role of *master coordinator* for all other global systems, while it manages the relationship between the organism and its surrounding environment; like the state in case of a society, and the State-System in case of the System.

"To arrive at what we call minds, feelings, and consciousness, evolution required a number of critical structural and functional increments that largely occurred within nervous systems" (25).

Mapping preceded feeling and subjectivity. "The maps of each sensory modality are the inputs (basis) for the integration that makes images possible, and those images as they flow in time are the constituents of minds". Images are the basic units for the mind and according to Damasio, most images "have a feeling by their side" (25).

Feelings conformed to the goals of the H-imperative and helped implement them by "making them matter to their owner" (...), and "force attention on the situation" (25). The feeling of pain for example, activates the living system to search for context (danger for example) and take appropriate action, to ensure homeostasis is maintained. Feelings are "mental expressions of homeostasis and instrumental in governing life" (25).

Feelings contribute to well-being and survival: "(...) *Feelings let the mind know about the current state of homeostasis and thus added another layer of valuable regulatory options*. Feelings were a decisive advantage that nature would not have failed to select and use as consistent accompaniment to mental processes" (...) and "natural selection made certain that feelings would become a permanent feature of mental states" (25).

In complex organisms, feelings play a critical role in the process of homeostasis, at two levels. "First, as we have seen, when organisms are forced to operate outside the well-being range and they drift into disease and toward death. As that happens, feelings are powerful disturbances that inject into the thinking process a striving for a desirable homeostatic range. Second, besides generating concern and compelling thinking and action, feelings serve as arbiters of the quality of response. Ultimately, feelings are the judges of the cultural creative process. This is because, in good part, the merits of the

cultural inventions end up being classified as effective or not so by a feeling interface. When feeling pain motivates a solution to make the pain vanish, the reduction of the pain is indicated by a feeling of pain subsiding. That is the critical signal to decide on whether the effort worked" (25).

"The simple idea, then, is that feelings of pain and feelings of pleasure, from degrees of well-being to malaise and sickness, would have been the catalysts for the processes of questioning, understanding, and problem solving that most profoundly distinguish human minds from the minds of other living species.

By questioning, understanding, and problem solving, humans would have been able to develop intriguing solutions for the predicaments of their lives and to construct the means to promote their flourishing. They would have perfected ways of nourishing, clothing, and sheltering themselves, nursing their physical wounds, and beginning the invention of what became medicine. When the pain and the suffering were caused by others - by how they felt about others, by how they perceived others to feel about them - or when the pain was caused by considering their own conditions, such as confronting the inevitability of death, humans would have drawn on their expanding individual and collective resources and invented a variety of responses that ranged from moral prescriptions and principles of justice to modes of social organization and governance, artistic manifestations, and religious beliefs."

"Consciousness in the full sense of the term occurs when such mental experiences are properly integrated in a broader canvas". Consciousness requires two critical components: "Subjectivity and integrating experiences; this are "essential enablers of the cultural mind".

"Subjectivity is a process that relies on two critical ingredients: the building of a perspective for the images in mind and the accompaniment of the images by feelings" (25).

"When feelings, which describe the inner state of life now, are 'placed' or even 'located' within the current perspective of the whole organism, subjectivity emerges. And from there on, the events that surround us, the events in which we participate, and the memories we recall are given a novel possibility: they can actually matter to us; they can affect the course of our lives. Human cultural invention requires this step, that events be made to matter, that they be automatically classified as beneficial or not to the individual to which they belong. Conscious, owned feelings permit a first diagnosis of human situations as problematic or not. They animate the imagination and excite the reasoning process on the basis of which a situation will be found to be problematic or a false alarm. Subjectivity is required to drive the creative intelligence that constructs cultural manifestations. Subjectivity was able to endow images, minds, and feelings with novel properties: a sense of ownership related to the particular organism in which these phenomena were happening; the mineness that allows entry into the universe of individuality. Mental experiences gave minds a new impact, an advantage to countless living species. And with humans, mental experiences were direct levers in the deliberate construction of cultures: the mental experiences of pain, suffering, and pleasure became foundations for human wants, stepping-stones of human inventions, in sharp contrast to the collection of behaviors assembled up to that point by the workings of natural selection and genetic transmission" (25).

"Images cannot be experienced, in and of themselves, until they are part of a context that includes specific sets of organism-related images, those that naturally tell the story of how the organism is being perturbed by the engagement of its sensory devices with a particular object. Where the object is - out in the world, elsewhere in the body proper, or recalled from a memory created by a prior imaging of

something internal or external to the organism - is not important. Subjectivity is a relentlessly constructed narrative. The narrative arises from the circumstances of organisms with certain brain specifications as they interact with the world around, the world of their past memories, and the world of their interior."
Damasio explains that "after the development of conscious minds capable of feeling and creative intelligence, the way was open for the creation, in the social and cultural space, of complex responses whose existence began as homeostatically inspired but later transcended homeostatic needs and gained considerable autonomy" (...). According to Damasio, a relation exists between feelings and cultures: "feelings, as deputies of homeostasis, are the catalysts for the responses that began human cultures" (25). "The idea, in essence, is that cultural activity began and remains deeply embedded in feeling. Feelings are integral to cultural evolution". According to Damasio, "feelings tell the mind, without any word being spoken, of the good and bad direction of the life process, at any moment, within its respective body. By doing so, feelings naturally qualify the life process as conducive or not to well-being and flourishing" (25). "Feelings are not an independent fabrication of the brain. They are the result of a cooperative partnership of body and brain" (25).

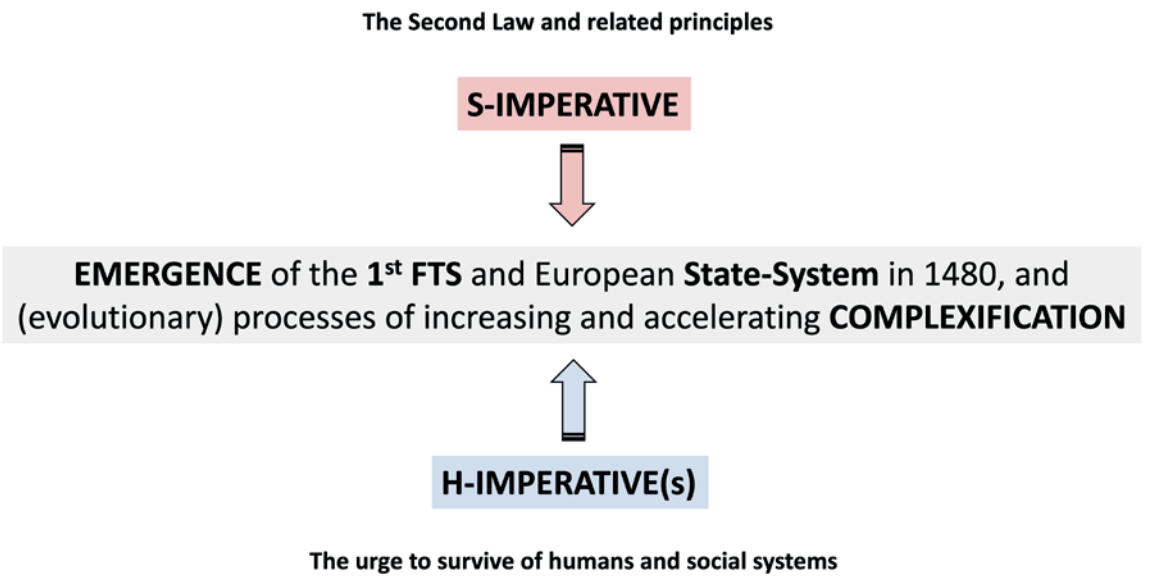


FIGURE 11.1: The interplay between the S- and H-imperatives. The interplay between the S- and H-imperatives produced the 1st FTS and European State-System in 1480, and generated processes of accelerating complexification.

Feelings are "behind some creative human processes that gave rise to the now staggering complex instruments of culture". "Feelings became motives for new forms of response, engendered by the uniquely rich creative intellect and motor ability of humans. These new forms of response were able to control physiological parameters and achieve the sorts of positive energy balances that are essential for homeostasis. But the new forms of response were innovative in yet another way. The ideas, practices, and instruments of human cultures could be transmitted culturally and were open to cultural selection. In

addition to the genetic antecedents that allowed organisms to respond in a particular way under certain circumstances, cultural products now marched in part to their own drum, surviving or becoming extinct on their merits, as guided by homeostasis and the values it determined." (25). Culture, in other words, generated its own momentum and logic; the FTS can also be considered a product of the cultural mind (albeit emergent), that was shaped by the laws of thermodynamics, which imposed certain constraints. According to Damasio, feelings contribute in three ways to the cultural process: (1) as motives "by prompting the detection and diagnosis of homeostatic deficiencies" and "identifying desirable states worthy of creative effort", (2) as "monitors of the success or failure of cultural instruments and practices", and (3) "as participants in the negotiation of adjustments required by the cultural process over time".

TABLE 11.1: The main components of Damasio's framework.

	Step/stage	Remarks
1	The **H-imperative** is the manifestation of the urge to survive.	
2	Survival and well-being require the fulfilment of a set of **basic requirements**.	
3	Living systems start to develop '**general systems**' (system-wide systems), including '**nerve nets**', to optimize their performance.	The nervous system gradually assumes the role of **master coordinator**.
4	Living systems develop **nervous systems**, eventually (in case of humans) capable of: • Mapping • Image generation (accompanied by feelings) • Feeling • Subjectivity • Integrating experiences • Consciousness	• Image generation, feeling, subjectivity, integrating experiences and consciousness make up the mind. • Mind and body constitute an evolutionary and functional partnership. • The mind coordinates between the organism (the interior) and its environment.
5	The mind allows for the **exploitation of cultural space**, initially to fulfil homeostatic needs.	
6	**Feelings contribute in three ways** to the cultural process, as: (1) motives, (2) monitors and (3) as participants.	

11.3. Fundamental differences between the H- and S-imperative

Fundamental differences exist between the H- and S-imperatives. The S-imperative arises from the laws of thermodynamics and related principles that apply FFE; these laws are non-negotiable. Although the H-imperative 'operates' within certain limits imposed by the S-imperative, the H-imperative is more flexible, and makes use of the available contingent latitude (the availability of different solutions, that in all cases): Whereas the S-imperative is 'universal' and inflexible, the H-imperative is more local, situational, flexible and negotiable.

11.4. Application (1): Application of Damasio's framework

Damasio's framework can be used as a reference for the development of societies: Societies/states are homeostatic structures; the System is not yet fully developed as such. See below table:

TABLE 11.2: Application of Damasio's framework to societies and the System.

	Step/stage	Remarks
1	The **H-imperative** is the manifestation of the urge to survive	Societies ant their constituents are driven by the H-imperative: H-imperatives of individual humans and communities, etc., are connected and form a hierarchical and 'nested' structure (as defined by Simon). The State-System consists of homeostatic structures that compete for scarce resources.
2	Survival and well-being require the fulfilment of a set of **basic requirements**	Societies - and to a degree the System - must fulfil a set of basic requirements, to ensure their operation and their well-being and viability/ survival.
3	Living systems start to develop '**global systems**', to optimize their performance, including '**nerve nets**'.	The System is in the process of developing 'global systems', integrative subsystems with a system-wide reach to increase the System's overall performance: The State-System can be considered the (still evolving) master coordinator of the System. The 1st FTS (1480-1945), was instrumental in establishing homeostasis in the core of the System (Europe).
4	Living systems develop **nervous systems**, eventually (in case of humans) capable of: • Mapping • Image generation (accompanied by feelings) • Feeling • Subjectivity • Integrating experiences • Consciousness	The state fulfils the function of brain and nervous system for societies. The state coordinates between the society (its 'interior') and its environment (including the State-System). In case of an effective state, there is an inseparable partnership between the state and the society (it represents). The state serves a society and the H-imperative. A state generates maps and images - 'perspectives' on the functioning of the society and its environment - and is able to identify threats and opportunities, represents 'national sentiments', has a certain subjectivity (also contained in its dominant values and norms, and in the definition of its national interest), is able to integrate experiences and design and implement policies, and also has a collective memory and consciousness. At societal level there is homeostasis. Entropy in societies, can be regulated without KA: Other mechanisms are available that do not cause damage to the 'fabric' of the state/society-partnership, and the finely tuned homeostatic mechanisms. The System has not yet reached this stage of development; there still is a lack of integration and homeostatic control. The System responds to entropy(-production) by 'automated' kinetic responses. This automatic kinetic response is regulated by the FTS, in accordance with the laws of thermodynamics and related principles that apply FFE. KA is triggered when an entropic-threshold is reached. Kinetic responses of the System to entropic perturbations (through the FTS), are comparable to the detection of certain chemical conditions by unicellular organisms in their environment, and the automatic responses these conditions generate (by these organisms). *Data from Levy (48).*
5	The mind allows for the **exploitation of cultural space**, (initially) to fulfil homeostatic needs.	The state allows for the exploitation of the environment to fulfil homeostatic needs of societies. The System still lacks a comparable homeostatic structure.
6	**Feelings contribute in three ways** to the cultural process, as: (1) motives, (2) monitors and (3) as participants.	Culture also contributes in various ways to the cultural processes in societies and in the System; culture defined by Damasio, includes: Political governance, economic institutions, technology and science, and for that matter military activity, and doctrine.

12. The regulatory-role of the state

12.1. Introduction

In this chapter, I discuss the key-role of the state. A state 'represents' and controls a society and should have a full 'partnership' with society, to ensure its effectiveness in maintaining social homeostasis (the homeostasis of a social system, in this case a society). The state fulfils several functions: Direction setting (which requires information processing and decision-making), integration and coordination, etc. Not only must the state have a clear understanding of the state (condition) of its 'own' society (interior), but also of its external environment, including of other societies it depends on, and of the State-System. The state must coordinate responses to threats and opportunities to ensure the fulfilment of its basic requirements, and well-being and survival. In short, the State is responsible for maintaining societal homeostasis. The functions of the State are comparable to the functions of the brain and nervous system.

12.2. Social homeostasis

In the previous chapter, I discussed homeostasis and (dynamic) steady states. Social homeostasis can be defined as (a form of) regulation of a social system - a society in this case - to maintain its internal environment in a (dynamic) steady state, in order to ensure the well-being and survival (viability) of the system itself and its constituents. The state has an internal environment - a society it represents and controls - and an external environment, which includes the State-System, where it is (also) an integral part of. To maintain (societal) homeostasis, states control and respond to changes - perturbations - in internal and external conditions of the system; Homeostatic control is a form of goal-seeking; negative feedback, in dynamic systems terminology (87). Homeostasis requires the regulation of EMIS-flows, and availability of cybernetic information to accomplish this; a state must continuously monitor and assess its internal and external environments, to be able to determine adequate adjustments/corrections.

Social homeostasis of societies - societal homeostasis - involves a multitude of regulatory mechanisms, at various levels of (hierarchical) organization (as defined by Simon), and in/by different domains (the economic, cultural etc. domains).

Homeostatic regulation is - so to speak - superimposed on the entropy- (EMIS-) regulation of the System; as discussed in the previous chapter, entropy-regulation is dominant.

12.3. Some characteristics of the State

The (State-)System has a 'nested' hierarchical structure, as defined by Simon (77). The state is the organizational structure that regulates and represents a society. The state - as we know it today - is the outcome of an evolutionary process, which was taking place during the transient period (1480-1945). The state is a product of the 1st FTS and vice versa.

The state has a number of specific (organizational) properties: The state represents - is to a certain extent equivalent with - a society, has control over a specific territory, has over time (during the unfolding of the 1st FTS) acquired a monopoly of violence, and has a centralized structure.

The appropriation of the monopoly of violence by the state, had several important effects, including: (1) By appropriating a monopoly of violence, the state could more easily maintain internal stability (social unrest could be better controlled), (2) the state - the established power structure - could not be easily challenged by (internal) competitors, and (3) by monopolizing and centralizing violence (military capabilities), states/societies could more effectively and efficiently cope with external threats and opportunities.

The state (as we know it), is an optimized solution for the selection pressures societies had to deal with during (especially) the transient period (1480-1945), in the core of the System (Europe).

The state is - above all - a European solution and organizational construct.

The state has several roles/functions, these functions include: Internal stabilization, setting goals, (re) distribution of resources, balancing conflicting interests, and, this concerns the 'external' functions of states: Control of the environment, neutralizing threats, ensuring sufficient inputs (resources, etc.), maintaining relationships with other societies and states, etc. The state is an enabler, and if necessary, accomplishes this through (kinetic) enforcement.

Over time, the state became a provider of basic resources and certain facilities.

For the state to be effective, it must have and maintain a certain legitimacy. Society - a state's population - is supposed to support the state, to be an integral part of it.

Societies, states and their environments are in constant flux and legitimacy is not self-evident. Over time, forced by the accelerating 1st FTS, the power and influence of state-structures over societies they represented, increased.

12.4. Empowerment

Societies and their members expect(ed) 'compensation' for the 'offerings' they (had to) make on behalf of the state. This was a dynamical process in which 'war' also played a significant role: Over-time, during the transient period (1480-1945), the KA of the System increased: The frequency and magnitude of systemic wars accelerated. War became more 'total' and increasingly involved all domains of societies. In the early nineteenth century (during the 2nd systemic war, the French Revolutionary and Napoleonic Wars, 1792-1815), conscription was introduced; over time the tax-demands on societies increased to fund the expanding role of the state. During the 3rd and 4th systemic wars (respectively the First (1914-1918) and Second (1939-1945) World Wars), war further 'totalized': All available societal resources were mobilized to enable the KA the 1st FTS generated and demanded, in accord with the Second Law and related principles that apply FFE.

These offerings were 'compensated' by voting rights (suffrage) that were introduced. Societies acquired increased voice (participation) in the objectives, choices and policies of the state.
At the same time when the state expanded its power and influence, it became under increased control (and scrutiny) of society. I refer to this process as the process of empowerment. Through empowerment, the partnership between a society and the increasingly powerful and omnipresent state was maintained, and states could consequently make better use of societies. e.g. to maximize kinetic energy (KA), that had to be put to use to control the external environment (The State-System).
The underlying driver of the process of empowerment (in societies) is the need for entropy-regulation in the (State-)System (to be discussed later).

12.5. The security dilemma

Societies are represented by states. The state must not only coordinate and integrate - balance - internal interests and contradictions, but must also cope with a challenging external environment, including other states and the State-System. During the transient period (1480-1945), societies became increasingly connected and interdependent on other societies and states, while their homeostatic regulation was not integrated; continuous adjustments were required.
Providing security - to ensure the fulfilment of (other) basic requirements, and survival - is the main pre-occupation of states in the (State-)System: Security is a state's reason of existence and an important source of legitimacy.
The State-System is anarchistic in nature. The State-System lacks a fully legitimized 'government' (and homeostatic-regulation); states in the System are sovereign.
The so-called security dilemma is intrinsic to the anarchistic State-System: In the anarchistic State-System states are (ultimately) responsible for their own security. Security is typically acquired through a combination of alliances and military capabilities. The problem is that in the (anarchistic) State-System, the security of one state (in terms of military capabilities and alliances) is (potentially) the insecurity of other states. If a state acquires military capabilities and builds alliances in response to a perceived threat by another state, these 'precautions' will be perceived as a threat by the other state and trigger a similar 'counter' response. The effect is an arms race. This dynamic constitutes a positive feedback - self-reinforcing mechanism.
Anarchistic systems are intrinsically unstable, given the fact that entropy production - the production of tensions - is unavoidable. "More" interdependence means more exchanges and interactions between societies, in other words, means more irreversible entropy-producing processes.

12.6. The State is a double linking pin

States are responsible for homeostatic control of societies and must respond to changes in conditions in their respective internal environments (the society a state represent/control) and external environments (which includes the State-System). A state constitutes a double linking pin: to the society it represents/controls, and to the State-System.

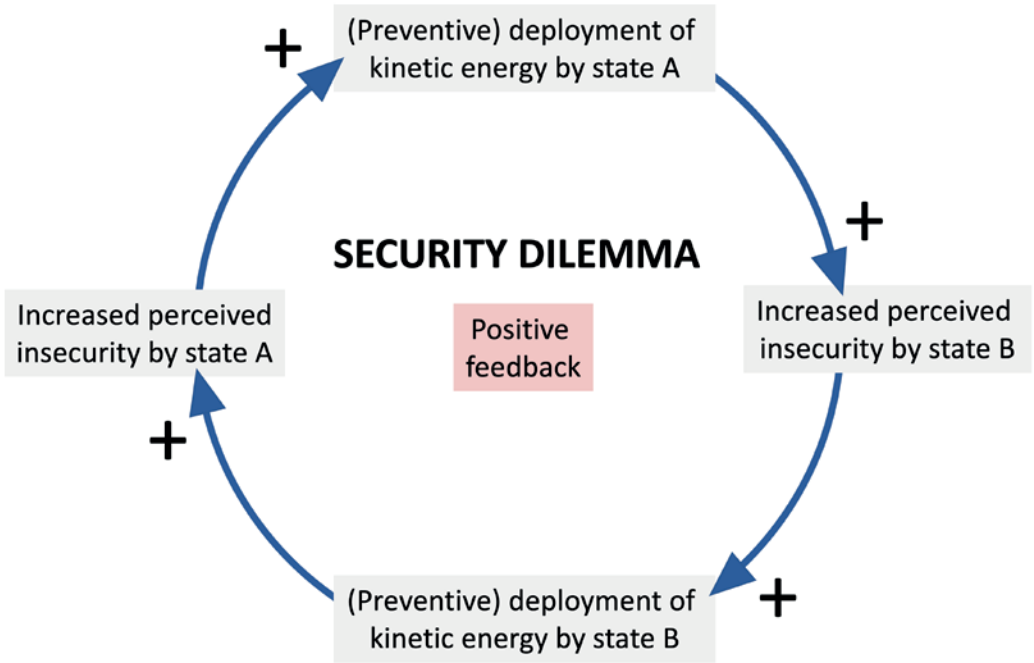


FIGURE 12.1: The security dilemma.

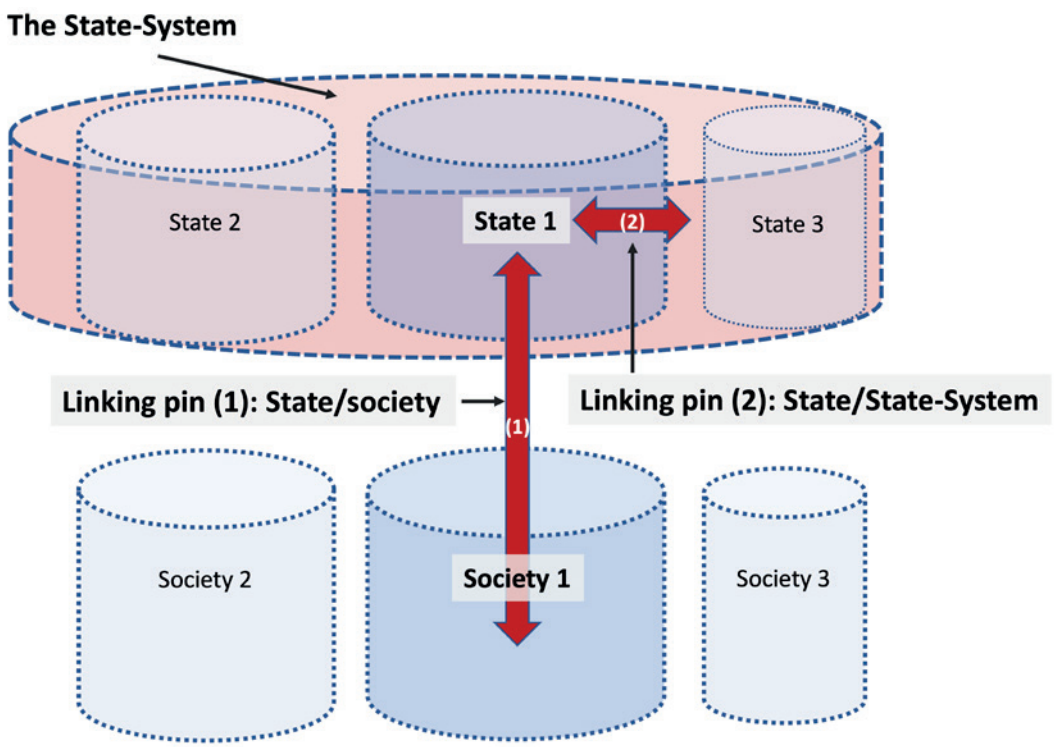


FIGURE 12.2: The state constitutes a double linking pin.

12.7. Application (1): The state is a European 'invention'

The state is a European creation; and co-evolved with the European State-System, during the transient period (1480-1945). Following, the 4th systemic war (1939-1945, the Second World War) - and the subsequent globalization of the System and process of decolonization - the state has become the only organizational structure that is recognized by the current international order (the United Nations, 1945-....) as a legitimate representative structure of a society. The problems with fragile and failing states, are related to the origins of the state in Europe, as a product of the 1st FTS. A subject that will be discussed later in more detail.

12.8. Application (2): Requirements for effective control

From a cybernetic perspective, a set of requirements must be met to ensure effective control of a system, these requirements include: The availability of (1) a model of the system that has to be controlled, and 'explains' its workings and can serve as a frame of reference, (2) an objective - target/goal - that has to be achieved, (3) information about the actual state of the system, to determine the differences between the desired and actual state, and (4) sufficient measures - requisite variety - to be able to respond effectively to disturbances and perturbations of the steady state.
Effective responses require 'collective' thinking, imagining, reasoning, and decision making. Because of constant changes and 'new' challenges, learning is also required.

Part IV

Introduction

In the two preceding parts, several basic concepts were introduced (Part II) and the concept of living systems and the requirement for living systems to regulate EMIS(-flows) to ensure their viability (in Part III).

In this part, the focus is on nonequilibrium thermodynamics, and "Modern Thermodynamics" is introduced (44). Modern thermodynamics "is a theory of irreversible processes in contrast to nineteenth century thermodynamics, which is a theory of states. In the latter, thermodynamics is confined to initial and final states, the processes that transform a state are not central to the theory; they are treated as another subject, 'kinetics'. In Modern Thermodynamics, however, entropy-increasing irreversible processes are central to the theory." According to Kondepudi et al. entropy and entropy-producing irreversible processes are generally thought of as agents of disorder, but under far-from-equilibrium conditions, irreversible processes are, in fact, the drivers of self-organization and order we see all around us in Nature. Far from equilibrium "there is in general no longer any extremum principle that governs the dynamics of the system" and as a result, "fluctuations are no longer necessarily damped. Stability is no longer the consequence of the general laws of physics. Fluctuations may grow and invade the whole system" (44).

"In far-from-equilibrium situations we begin to observe new properties of matter that are hidden at equilibrium" and irreversibility - and the accompanying production of entropy - in combination with long-range correlations, play a constructive role, and dissipative structures can emerge.

The following subjects will be discussed: The distinctions between (three) thermodynamic states, so-called bifurcations, dissipative structures, chaotic dynamics, phase transitions, and self-assembly. In the next part (Part V), these concepts will be applied the System.

Contents

13. Characteristics of thermodynamic states
14. Bifurcations
15. Dissipative structures
16. Chaotic and periodic dynamics
17. Phase transitions
18. Self-assembly

13. Characteristics of thermodynamic states

13.1. Introduction

According to Prigogine two disciplines have "dramatically modified our outlook on complexity: Nonequilibrium physics and the modern theory of dynamical systems. As far as nonequilibrium physics is concerned, the most unexpected outcome is the discovery of fundamental new properties of matter in far-from-equilibrium (FFE) conditions; in the modern theory of dynamical systems is the central discovery the prevalence of instability, meaning that small changes in initial conditions of a system may lead to large amplifications of changes in the system concerned (66).

"A number of mechanisms are repeatedly encountered in far from equilibrium systems, despite that these systems are concerned with different phenomena (like turbulence in liquids, phase transitions, etc.), they are: nonequilibrium, stability, bifurcation and symmetry breaking, and long-range order" (66).

In this chapter, I introduce mechanisms and concepts related to 'Modern Thermodynamics' (44). I make use of several publications from e.g. Prigogine et.al. (44): "Modern Thermodynamics' is a theory of irreversible processes in contrast to nineteenth century thermodynamics, which is a theory of states (44)". The thermodynamics discussed in the previous chapters concerns 'states' of systems and is "confined to initial and final states, the processes that transform a state are not central to the theory; they are treated as another subject, 'kinetics'".

In Modern Thermodynamics, "entropy-increasing irreversible processes are central to the theory" (44). "Entropy and entropy-producing irreversible processes are generally thought of as agents of disorder. A central message of Modern Thermodynamics is that, under far-from-equilibrium conditions, irreversible processes are, in fact, the drivers of self-organization and order we see all around us in Nature" (44).

It is possible to distinguish three fundamentally different thermodynamic states: States of (1) equilibrium, of (2) near-equilibrium and of (3) far from equilibrium. Near-equilibrium and far from equilibrium states are also referred to as nonequilibrium states. During nonequilibrium states macroscopically distinct parts can become correlated and long-range coherence can appear.

According to Kondepudi et al. "one of the most remarkable aspects of nonequilibrium systems that came to light in the twentieth century is the phenomenon of self-organization. *Under certain nonequilibrium conditions, systems can spontaneously undergo transitions to organized states, which, in general, are states with lower entropy*" (44). According to Kondepudi et al. this is in contrast to equilibrium situations where the range of correlations is determined by short-range intermolecular forces (44).

"As is well known today, far-from-equilibrium situations lead to new space-time structures" and "for this reason the restriction to equilibrium situations hides, in our opinion, some essential features of the behavior of matter and energy. An example is the role of fluctuations" (44). "The type of dissipative structure depends critically on the conditions in which the structure is formed" (44, 65).
In FFE conditions we may have transformation from disorder into order: New dynamic states of matter may originate, states that reflect the interaction of a given system with its surroundings (environment) (65). These emergent structures, called dissipative structures, are distinct from machines and are a good thermodynamic basis on which we may begin to build a theory of biological organisms (44, 65), and of social systems.
Below table, provides an overview of the main characteristics of the three thermodynamic states; these characteristics will be discussed in this chapter.

TABLE 13.1: Fundamental differences between thermodynamic states.

		Non-equilibrium	
Characteristics:	**Equilibrium**	**Near-equilibrium**	**Far-from-equilibrium (FFE)**
General principles	Do apply	Do apply	Do not apply
Properties	No flows/fluxes and forces (44, 65). Maximum entropy.	Flows/fluxes and forces are weak (44, 65), there are linear relations between flows (rates) and forces; the linear regime applies (i.e. Onsager's reciprocity relations).	Flows and forces are strong, and rates are in general more complicated functions of the forces (44, 65); Irreversible processes drive self-organization; New organized states can emerge through self-organization.
Stability conditions	The dynamics of closed and isolated systems are governed by so-called extremum principles and general thermodynamic relationships apply. In case there are fluctuations, local perturbations of the equilibrium are damped; there is extremization of certain thermodynamic quantities (thermodynamic potentials): Minima of thermodynamic potentials are points of equilibrium.	The dynamics of closed and isolated systems are governed by so-called extremum principles and in case there are fluctuations, local perturbations of the equilibrium are damped: The Minimum-Entropy-Production-, MEP-Principle applies; The MEP-Principle guarantees the stability of the steady state (62).	Irreversible entropy producing processes are taking place and drive the system towards the equilibrium state (44); Extremum principles no longer govern the dynamics of FFE systems and as a result of fluctuations are no longer necessarily damped. To maintain the organized state FFE, continuous EMIS exchange with the system's environment (a constraint) must be maintained, for this reason, they can be called dissipative structures (62); stability properties depend on specific characteristics of the system concerned, like kinetics properties.

The following subjects will be discussed in this chapter: The basic responses of systems to perturbations, the distinction between equilibrium and nonequilibrium thermodynamics, equilibrium -, near-equilibrium - and far from equilibrium thermodynamics, and (emergent) organization FFE.

13.2. 'Basic' responses to perturbations

Three basic situations can be identified from the point of view of stability: The steady state is (1) (marginally) stable, (2) asymptotically stable, or (3) the steady state is unstable. In case of a marginally stable steady state, that mode will neither decay nor grow but may oscillate.
Because of perturbations and fluctuations, the state of natural systems continuously deviates from their reference states (66). A system can respond to these deviations, as follows:

- *Stable*. Despite perturbations, stable systems remain in the vicinity of their respective reference states. Isolated systems in equilibrium are globally stable: Thermodynamic equilibrium (maximum entropy) is the attractor of these systems.
- *Asymptotically stable.* After being perturbed, these systems tend back to their reference states and perturbations decay to zero as a matter of time; asymptotically stable systems 'remember' the effects of perturbations. *Dissipative systems are asymptotically stable and are capable of eliminating the effect of perturbations that may act on them and can reestablish the reference state*. This ensures the predictability and reproducibility of what is termed an attractor (66).
- During the RSP's of cycles of the 1st FTS (during the transient period, 1480-1945), the RSP's of KA/war-cycles were asymptotically stable and the FTS ensured that the (State-)System, through chaotic non-systemic KA (R1-dynamics, to be discussed later), reestablished the reference state (the dynamic steady state).
- Stability of RSP's could be maintained until the respective RSP's reached a critical point (respectively in: 1618, 1792, 1914 and 1939).
- *Unstable*. In case of an unstable system, a perturbation is amplified, and the system does not remain in the vicinity of its reference state. The four accelerating systemic fluctuations - the four KA/war-cycles - the (State-)System experienced during the period 1480-1945, are indicative for the increasing instability of the State-System; despite the four periodic upgrades of the order of the System (through systemic KA/war, R2-dynamics) the increasing instability of the State-System could not be contained.
- *Locally stable, but globally unstable*. A system is locally stable but globally unstable, if for certain values of perturbations less than a certain threshold the state of the system remains in some vicinity of the reference state but moves away from the reference state for perturbations beyond this threshold. The European State-System was locally stable, but globally unstable.

In reference to stability FFE, Prigogine observes: Whereas isolated systems are globally stable, this is not the case for nonisolated systems, which interact with their environment. This raises the problem of stability of states far from equilibrium for these systems. According to Prigogine for these systems, "*The possibility of loss of stability under certain conditions opens the way to transition phenomena that may lead to internal differentiation and complex behavior*"; in those systems, under certain conditions, low entropy can be sucked in from the environment. This is the case for the State-System, I explain in this study.

13.3. The distinction between equilibrium and nonequilibrium thermodynamics

In Modern Thermodynamics, a distinction is made between equilibrium thermodynamics and nonequilibrium thermodynamics.

Kondepudi et al. observe that "one of the most profound lessons of nonequilibrium thermodynamics is the dual role of irreversible processes: as destroyers of order near equilibrium and as creators of order far from equilibrium" (44).

According to Kondepudi et al. (44), the stability of equilibrium and nonequilibrium systems are closely related to entropy and entropy-production in the system.

Kondepudi et al. explain that a stability theory based on entropy-production, can be "applied to obtain conditions for stability of equilibrium and nonequilibrium states of a system" (44).

Kondepudi et al. observe that "for almost all systems that we encounter, thermodynamics based on local equilibrium has excellent validity, (...) because almost all systems are locally in thermodynamic equilibrium" (44). However, in some cases - as is the case for the (State-)System - thermodynamics that describes equilibrium states is not sufficient to understand and explain the behavior of these (nonequilibrium) systems.

In case of equilibrium thermodynamics, general thermodynamic relations can be identified, and so-called extremum principles apply. Equilibrium thermodynamics is concerned with phase equilibrium and phase change, (chemical) transformations', fields, radiation, internal degrees of freedom, and what is referred to as classical stability theory (the response of equilibrium systems to fluctuations, and its impact on the stability of systems).

In case of nonequilibrium thermodynamics, extremum principle in general no longer apply and as a result, fluctuations are no longer necessarily damped; stability is no longer the consequence of the general laws of physics. Fluctuations may grow and invade the whole system (44).

"In non-equilibrium thermodynamics one studies macroscopic states on the basis of their entropy production" (62).

In case of nonequilibrium thermodynamics, a further distinction can be made between a situation (state) when a linear regime applies (in case of near-equilibrium) and far-from-equilibrium (FFE-) thermodynamics, when systems that are subject to a flow of energy and matter are driven far from thermodynamic equilibrium into a nonlinear regime. In the nonlinear regime, "the thermodynamic flows are no longer linear functions of thermodynamic forces" (44).

"In Nature, far-from-equilibrium systems are ubiquitous. The Earth as a whole is an open system subject to the constant flow of energy from the Sun. This influx of solar energy sustains the biosphere and is ultimately responsible for maintaining an atmosphere out of thermodynamic equilibrium. Every living cell lives through the flow of matter and energy" (44); as do societies and the (State-)System.

In FFE situations, systems in certain conditions create order through fluctuations, experience bifurcations, and may produce dissipative structures.

In the linear regime (that is near equilibrium), "the stationary states are those in which the total entropy production reaches a minimum. This criterion also assured the stability of the stationary state. In the linear regime, a perturbation in the total entropy production from its stationary state value will monotonically decrease to its stationary state value, in accordance with the principle of minimum entropy production (MEP-Principle) (44).

In the far-from-equilibrium nonlinear regime, there is no such general principle for determining the state of the system. "Far-from-equilibrium states can become unstable and evolve to new organized states" (44).

13.4. Equilibrium thermodynamics

According to Kondepudi et al. "For isolated systems entropy increases and is therefore maximum at equilibrium. In other situations (such as constant temperature) there exist functions called thermodynamic potentials (to be discussed) which are also extrema (that is maximum or minimum) at equilibrium. This has important consequences" (44).

"A fluctuation that leads to a temporal deviation from equilibrium is followed by a response that brings back the system to the extremum of the thermodynamic potential. The equilibrium world is also a stable world" (44).

All isolated systems evolve to a state of equilibrium in which entropy reaches its maximum value, and the rate of entropy production is zero (44)). In other words: "Isolated systems irreversibly evolve towards a time-invariant state in which there is no further physical of chemical change"; this is the state of thermodynamic equilibrium (44).

At equilibrium both the flows and forces in a system have disappeared. Maximum entropy is the basic extremum principle of equilibrium dynamics; a state of maximum entropy is - so to speak - the attractor of the System: "All isolated systems evolve to the state of equilibrium in which the entropy reaches its maximum value or, equivalently, the rate of entropy production is zero". Thus a "fluctuation can only reduce the entropy", and "in response to a fluctuation, entropy-producing irreversible processes spontaneously drive the system back to equilibrium. Hence, the state of equilibrium is stable to any perturbation that results in a decrease in entropy. Conversely, if fluctuations can grow, the system is not in equilibrium" (44). Consequently, in these equilibrium systems fluctuations in thermodynamic quantities are extremely small, except near critical points, as I will discuss later.

Because certain constraints (like constant pressure) can apply to such systems, the positivity of entropy change due to irreversible processes taking place in the system (i.e. $\boldsymbol{d_i S > 0}$), "imply the evolution of certain thermodynamic functions to their minimum (…) the evolution to the state of equilibrium corresponds to the extremization (minimization of maximization) of a thermodynamic quantity" for example the Gibbs free energy in the System (44). These thermodynamic quantities that are (or can be subject to) extremization are also called thermodynamic potentials, whose minima are points of equilibrium (44). This behavior can be observed in isolated and closed systems.

Kondepudi et al. discuss the conditions (referred to as 'stability conditions') that must be obtained for the stability of the equilibrium state of systems. As mentioned, the entropy is maximum at equilibrium. These conditions concern certain types of boundary conditions that are imposed on systems, and have a more general validity (44). "The main reason for the general validity of the stability conditions (*IP: For systems in equilibrium*) is that all of these conditions are a direct consequence of the fact that for all natural processes $\boldsymbol{d_i S > 0}$" (44). The assumption is that the entropy-effect of a fluctuation (a perturbation) is negative because the entropy of the system is maximum (for systems in equilibrium); consequently, a fluctuation cannot result in an increase in entropy. In response to the decrease in entropy (caused by the fluctuation), the system will then trigger a response to increase the entropy to maximum again (to

restore equilibrium). "The essence of stability of the equilibrium state is that "fluctuations decrease the entropy whereas the irreversible processes restore the system to its initial state" (...) "The approach to equilibrium under different conditions is such that a thermodynamic potential is extremized" (44).

The following example explains the working of thermodynamic potentials: "In many practical situations, the physical or chemical system under consideration is subject to constant pressure or temperature or both. In these situations, the positivity of an entropy change due to irreversible processes, i.e. $\boldsymbol{d_iS} > \mathbf{0}$, implies the evolution of certain thermodynamic functions to their minimum values. Under each constraint, such as constant pressure, constant temperature or both, the evolution of the system to the state of equilibrium corresponds to the extremization of a thermodynamic quantity. These quantities are the Gibbs energy, the Helmholtz energy and enthalpy (…) they are also called thermodynamic potentials" (44).

These thermodynamic potentials ensure that the state of equilibrium is stable, in other words, that these systems are kept stable: "irreversible processes drive the system to the equilibrium state in which one of the potentials is extremized"**: "**irreversible processes restore the state of equilibrium" (44). "The stability of the equilibrium state is related to the existence of thermodynamic potentials" (44).

A somewhat more technical explanation: When certain pairs of variables of a system are held constant: "one of the thermodynamic potentials $\boldsymbol{F}$ (the Helmholtz energy), $\boldsymbol{H}$ (Gibbs free energy) or $\boldsymbol{G}$ (enthalpy) is minimized" (44). In accordance with the Second Law[1]:

$$\boldsymbol{dF} = -\boldsymbol{Td_iS} \leq \mathbf{0} \text{ (T, V = constant)}$$
$$\boldsymbol{dG} = -\boldsymbol{Td_iS} \leq \mathbf{0} \text{ (T, p = constant)}$$
$$\boldsymbol{dH} = -\boldsymbol{Td_iS} \leq \mathbf{0} \text{ (S, p = constant)}$$

Through these relations, the change of the thermodynamic potentials $\boldsymbol{dF}$, $\boldsymbol{dG}$ or $\boldsymbol{dH}$, due to a fluctuation can be related to the entropy production $\boldsymbol{d_iS}$. The system is stable to all fluctuations that result in $\boldsymbol{diS} < \mathbf{0}$, because irreversible processes that arise as a result of the fluctuation increasing the entropy restore the system to its equilibrium state: $\boldsymbol{d_iS} < \mathbf{0}$ is referred to as the stability condition of systems in an equilibrium state.

"Based on above relations, it is possible to characterize stability of the equilibrium state by stating that the system is stable to fluctuations for which $\boldsymbol{dF} > \mathbf{0}$, $\boldsymbol{dG} > \mathbf{0}$ or $\boldsymbol{dH} > \mathbf{0}$" (44).

However, as Kondepudi et al. observe, "A theory of stability that is based on the positivity of entropy production in natural processes can also be used to obtain conditions for the stability of nonequilibrium states" (44).

However, - as will be discussed later - the 'mechanism' of extremization is not limited to isolated systems and equilibrium thermodynamics. Kondepudi et al. observe, that "In addition to simplicity, Nature (*IP: open and systems not in equilibrium*) also seems to 'optimize' or 'economize': Natural phenomena occur in such a way that some physical quantity is minimized or maximized – or to use one word for both, 'extremized' (44): "In case of mechanics the principle of least action applies[2]" (44).

1. $\boldsymbol{T}$ = temperature, $\boldsymbol{V}$ = total volume and $\boldsymbol{p}$ = total pressure.
2. Le Chatelier's principle can be used to predict the effect of a change in conditions for some chemical equilibria: "When a system is perturbed from its state of equilibrium, it will relax to a new state of equilibrium. Le Chatelier and Braun noted in 1888 that a simple principle may be used to predict the direction of the response to a perturbation from equilibrium. Le Chatelier stated this principle thus: Any system in chemical equilibrium undergoes, as a result of a variation in one of the factors governing the equilibrium, a compensating change in a direction such that, had this change occurred alone it would have produced a variation of the factors considered in the opposite direction. The compensating change in the

For the perspective of the reader (at this point of the study): In case of the State-System, the thermodynamic situation seems (at first sight) 'inconclusive', so to speak: However, as I will show, in case of the (State-)System, there was (and is) a 'combination' of thermodynamic states and related properties 'present', during the transient period (1480-1945): After a period of increasing instability, the System experienced a bifurcation in 1480, which resulted in the emergence - the 'imposition' - of a dissipative structure (the 1st FTS). During the transient period, the 1st FTS was responsible for EMIS-regulation and the accomplishment of a phase transition. It is possible to distinguish two levels - layers - of dynamics in the 1st FTS, I refer to as respectively R1- and R2-dynamics. To the first layer - the chaotic non-systemic R1-dynamics - FFE thermodynamic (stability) principles apply, while the cyclic R2-dynamics are determined and shape by near-equilibrium thermodynamic principles: the MEP-Principle. In both cases there is a profound relationship between entropy-production and free energy; in case of R1-dynamics the 1st FTS responds to entropic perturbations with chaotic non-systemic kinetic activity, and in case of R2-dynamics with cyclic/periodic systemic activity (systemic war), to reestablish a certain balance. The interplay between competing thermodynamic potentials and their extremization is at the heart of the (evolution) of the (State-)System.
These subjects will be discussed in more detail in the next chapters.

13.5. Near-equilibrium thermodynamics

As mentioned, in case of nonequilibrium dynamics two thermodynamic states can be distinguished: Near and far from equilibrium (FFE) states. In this paragraph, I discuss near-equilibrium thermodynamics. Prigogine et al. (44, 63) have determined that systems near-equilibrium are dominated by two principles: (1) Linear homogeneous relations between flows and forces (the so-called Onsager reciprocity relations), and (2) the theory of minimum entropy production (the so-called MEP-Principle). Their "validity has for the first time shown that nonequilibrium thermodynamics leads, as does equilibrium thermodynamics, to general results independent of any specific molecular model" (63).
"The states corresponding to thermodynamic equilibrium, or the steady states corresponding to a minimum of entropy production in linear non-equilibrium thermodynamics (*IP: a system near-equilibrium*), are automatically stable" (63). If a system near-equilibrium is perturbed, "the entropy production will increase, but the system reacts by coming back to the minimum value of the entropy production", this response then ensures the damping of all fluctuations.
"Linear thermodynamics describes the stable, predictable behavior of systems tending toward the minimum level of activity compatible with the fluxes that feed them" (65).
"The fact that linear thermodynamics, like equilibrium thermodynamics, may be described in terms of a potential, the entropy production, implies that, both in evolution toward equilibrium and in evolution toward a stationary state (....) whatever the initial conditions, the system will finally reach the state determined by the imposed boundary conditions. As a result, the reaction of such a system to any change

system is in a direction opposite to that of the perturbation. Le Chatelier's principle only describes the response of a system in thermodynamic equilibrium; it says nothing about the response of a system that is maintained in a nonequilibrium state" (44). The FTS (the System) has 'layered' dynamics; there is a combination of equilibrium and nonequilibrium states, and related dynamics (respectively R2- and R1-dynamics). In case of the System, thermodynamic potentials compete and the FTS is powered through this competition, as I explain later.

in its boundary conditions is entirely predictable" (65). "We see that in the linear range the situation remains basically the same as at equilibrium. Although the entropy production does not vanish, neither does it prevent the irreversible change from being identified as an evolution toward a state that is wholly deducible from general laws. This "becoming" inescapable leads to the destruction of any difference, any specificity" (65).

"The theorem of minimum entropy production (the Minimum Entropy Production - Principle, MEP-Principle) does show that in the linear region a system evolves toward a stationary state characterized by the minimum entropy production compatible with the constraints imposed upon the system" (63, 65). *The MEP-Principle plays the same role as the thermodynamic potentials in equilibrium theory and guarantees the stability of the steady state* (62).

According to Prigogine et al. (62), the MEP-Principle "provides an evolution criterion, as it implies that a physical system will necessarily evolve to the steady nonequilibrium state starting from an arbitrary state close to it". The theorem of minimum entropy production expresses a kind of "inertial" property of nonequilibrium systems. When given boundary conditions prevent the system from reaching thermodynamic equilibrium (that is, zero entropy production) the system settles down to the state of "least dissipation" (= MEP) (63)

As will be discussed in more detail, in the next paragraph: In case of far-from-equilibrium situations (that apply to the (State-)System) fluctuations may be amplified by irreversible dissipative processes and lead to new space-time structures which Prigogine has named 'dissipative structures' to distinguish them from 'equilibrium' structures such as crystals (44). The 1st FTS - a dissipative structure - is such a dissipative structure, which emerged in 1480 through a bifurcation.

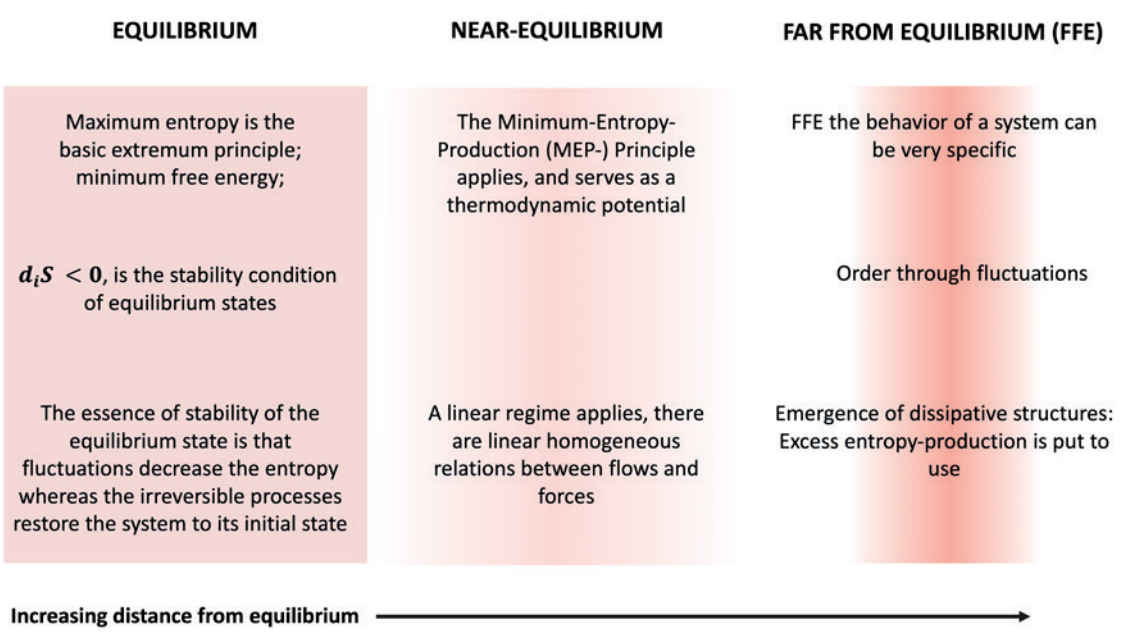


FIGURE 13.1: The distance from equilibrium functions as a control parameter.

Kondepudi et al explain, that the distance from equilibrium becomes a parameter, that impacts on the (thermodynamic) behavior of a system, as was (is) also the case for the System, this study shows. According to Kondepudi et al.: "Therefore distance from equilibrium becomes a parameter somewhat similar to temperature. When we lower the temperature, we go from the gaseous state to a liquid and then a solid. As we shall see, here the variety is even greater. Take the example of chemical reactions. Increasing the distance from equilibrium we may obtain in succession oscillatory reactions, new spatial periodic structures and chaotic situations in which the time behavior becomes so irregular that initially close trajectories diverge exponentially" (44).

13.6. Far from equilibrium (FFE) Thermodynamics

As Kondepudi et al. explain: "When a system is isolated, $\boldsymbol{d_e S} = \mathbf{0}$, the entropy of the system will continue to increase due to irreversible processes and reach the maximum possible value, the state of thermodynamic equilibrium. In the state of equilibrium, all irreversible processes cease. When a system begins to exchange entropy with the exterior, then, in general, it is driven away from equilibrium and the entropy-producing irreversible processes begin to operate. Systems that exchange entropy with their exterior do not simply increase the entropy of the exterior, but may undergo dramatic spontaneous 'self-organization', as the response/behavior of the System also shows" (44).
If a system is sufficiently far from equilibrium, the linear-regime and the MEP-principle no longer apply: Contrary to what happens in case of equilibrium and near-equilibrium situations, fluctuations no longer play a corrective and subordinate role and stability is no longer ensured (63).
Prigogine et al. explain that there are essential differences between the laws of equilibrium and the laws far away from equilibrium: "The laws of equilibrium are universal. However, far from equilibrium the behavior may become very specific" (63).
FFE, the linear regime is 'exceeded', fluctuations can become a source of order, and can be amplified and 'invade' the entire system: "The lack of extremum principles that uniquely predict the state to which a nonequilibrium system will evolve is a fundamental aspect of nonequilibrium systems. In stark contrast to equilibrium systems, which evolve to a state that minimizes a free energy, nonequilibrium systems can evolve unpredictably; their state cannot always be uniquely specified by macroscopic rate equations" (44). Far from equilibrium, the system may still evolve to some steady state, but in general this state can no longer be characterized in terms of some suitable chosen potential such as entropy production for near-equilibrium states (65).
The stability property that is valid near-equilibrium can at a certain distance from equilibrium not be extrapolated: The situation changes in the FFE-range, and the form of interactions in the system start to play an essential role: Prigogine et al. explain that autocatalytic reactions - when the product of a chemical reaction is involved in its own synthesis - contribute to the breakdown of the stability of the thermodynamic branch, which was still 'in place' near-equilibrium, and are "a convenient way to introduce non-linearity"; non-linearity is a prerequisite for the occurrence of instabilities and an organized state FFE (62). The absence of any potential function FFE (e.g. defined by a minimum potential as entropy-production) raises a question: What can we say about the stability of the states toward which the system evolves? (65).

(As I explain later, in the period before the bifurcation in 1480, the production of entropy (issues and tension) in the System, caused by the intensifying interactions between societies/states (more than 300 at that stage), became involved in its own synthesis, when autocatalytic loops emerged and tensions and issues (entropy) produced more tensions and issues through self-reinforcing loops. Social autocatalysis also takes place during the HCR of RSP's (once the tipping point of a RSP is reached), and entropy (tensions and issues) starts accumulating in the (State-)System and form (percolating) VC's. Autocatalysis - autocatalytic loops - play an important role in the development of the System: They resulted in the bifurcation in 1480 and in a critical condition during cycles.

13.7. Towards an organized state FFE

"It was clear since the formulation of this theorem (*IP: the MEP-Principle*) that this property is strictly valid only in the neighborhood of equilibrium. For many years great efforts were made to generalize this theorem to situations further away from equilibrium. It came as a great surprise when it was finally shown that far from equilibrium the thermodynamic behavior could be quite different, in fact, even opposite to that indicated by the theorem of minimum entropy production" (63). Contrary to equilibrium systems, in case of "for far-from-equilibrium systems, there are no general extremum principles that predict the state to which it will evolve" (44), there is not an identifiable thermodynamic potential that is minimized due to the second law of thermodynamics.

While in case of thermodynamic equilibrium so-called extremum principles apply and a loss of stability leads to phase separation (phase separation and phase transitions will be discussed in the next chapters), this is not the case FFE (44). In FFE-systems, loss of stability can lead to a wide variety of complex nonequilibrium states (as was also the case in the System, during the period 1480-1945).

In case of FFE-systems, before a certain critical point is reached, these systems typically become increasingly unstable and fluctuations no longer die out or are damped (62), and beyond the critical point (threshold) dissipative and convective processes become coupled, and the behavior of these systems becomes remarkably coherent and pattern formation takes place (62).

"It is remarkable that this new type of behavior appears already in typical situations studied in classical hydrodynamics. The example which was first analyzed from this point of view is the so-called "Bénard instability" (...). For a sufficiently large value of the "adverse" gradient $(\boldsymbol{T}(\mathbf{1}) - \boldsymbol{T}(\mathbf{2})) / (\boldsymbol{T}(\mathbf{1}) + \boldsymbol{T}(\mathbf{2}))$, the state of rest becomes unstable and convection starts. The entropy production is then increased as the convection provides a new mechanism of heat transport. Moreover, the state of flow, which appears beyond the instability, is a state of organization as compared to the state of rest. Indeed, a macroscopic number of molecules have to move in a coherent fashion over macroscopic times to realize the flow pattern" (63). The Bénard convection, is "a good example of the fact that non-equilibrium may be a source of order" (63). "In the case of Bénard convection, we may imagine that there are always small convection currents appearing as fluctuations from the average state; but below a certain critical value of the temperature gradient, these fluctuations are damped and disappear. However, above some critical value certain fluctuations are amplified and give rise to a macroscopic current. A new supermolecular order appears which corresponds basically to a giant fluctuation stabilized by exchanges of energy with the outside world.

In case of fluids studied by Prigogine et al. far from equilibrium, there appeared "an unexpected relation between chemical kinetics and the "space-time structure" of reacting systems" (63). This is the order characterized by the occurrence of "dissipative structures" (63). The formation of a dissipative structure "requires a thermodynamic threshold corresponding to a minimum level of dissipation" and is a far more phenomenon than originally thought (62).

A dissipative structure can be considered a "a giant fluctuation" that is stabilized by the flow of energy and matter from the outside world (the system's environment) (62). This has "a lower entropy compared to the uniform steady-state entropy" and the "entropy decrease is translated by the emergence of space order". The FTS - the 1st FTS, during the transient period (1480-1945) - was such a "giant flow" that was stabilized and sustained by the flow of energy and matter from the environment (societies and the non-core), and that resulted in a lower entropy-state (than before 1480).

This, the emergence of order (a dissipative structure), is an example of order through fluctuations (44, 62), Prigogine et al. explain. The dissipative structure ensures that the excess entropy that was produced during the preceding phase (when the system became increasingly unstable) is "put to use" by the emergence of space order.

As I explain later, this is also what happened (and happens) in the (State-)System: In the System there were and are always fluctuations from the average state; below a certain level of entropy-production (below a certain connectedness and level of exchanges and interactions), these fluctuations were damped and disappeared. However, above a certain critical level of entropy-production, fluctuations were amplified and gave rise to macroscopic currents. The System FFE, adopted an organized state through a bifurcation in 1480, and a dissipative structure - the 1st FTS - was established. When the bifurcation took place (in 1480), the excess entropy-production was 'put to use' by the 1st FTS, a space order (a system of states) was produced, and processes of aggregation, expansion and empowerment were initiated (as integral components of the FTS). The 1st FTS was maintained by a continuous EMIS-flows through the State-System's boundaries; as I explained, societies and the non-core constituted the environments of the State-System.

In case of hydrodynamics (turbulence in fluids), Prigogine et al. observe that beyond a critical value of the control parameter (temperature in case of Bénard instabilities in fluids), limit cycles can be observed: "any initial point in the space X, Y tends to the same periodic trajectory (…) the chemical reaction leads to coherent time behavior; it becomes a chemical clock" (63).

In the literature, a critical point where a system's stability switches and a periodic solution arises, is called a Hopf bifurcation. This typical behavior that can be observed, raises the question, if the emergence of chaotic KA around 1480 in the System, was (also) preceded by a limit cycle. However, data to determine the presence of a limit cycle (before 1480), is not available. A limit cycle is however not a necessary precondition for chaotic dynamics to arise, Prigogine et al. observe that (different) boundary conditions can give rise to other types of instabilities (62).

Bénard instabilities have been studied extensively over the last decades, and it has been observed that in addition to the limit cycle there are the possibility of other nonuniform steady states (63).

In succession to the initial bifurcation - the switch FFE from an increasingly unstable to an organized state - "other solutions may then be obtained as successive bifurcations from this basic one, or as higher order bifurcations from a non-thermodynamic branch, take place when the distance from equilibrium is increased" (63). During the period 1480-1945, the initial 1480-bifurcation was followed by four successive 'secondary' bifurcations (in 1618, 1792, 1914 and 1939, I also refer to as critical points of RSP's/cycles),

which took place when the distance from equilibrium of the State-System had further increased. These bifurcations were instrumental in ensuring that the core of the State-System (Europe) followed the most efficient path to thermodynamic equilibrium, in accord with the Second Law and related principles that apply FFE.

Prigogine et al. also observe (63), that dissipative structures are very sensitive to global features such as size and form, and boundary conditions that are imposed; "these features influence in a decisive way the type of instabilities which lead to dissipative structures" (63).

I argue - as is the case for the fluids studied by Prigogine et al. - in case of the System FFE, there also exists a relationship between social interactions between communities and societies (states) in the System ('short-range') and certain space-time structures that consequently emerge (long-range). "It is true that the interactions which determine the values of the relevant kinetic constants and transport coefficients *(IP: In the fluids discussed by Prigogine et al.)* result from short range interactions" between molecules (63). "However, the solutions of the kinetic equations depend in addition on global characteristics. This dependence, which on the thermodynamic branch, near equilibrium, is rather trivial, becomes decisive in chemical systems working under far-from equilibrium conditions" (63). For example, the occurrence of dissipative structures generally requires that the system's size exceeds some critical value. In case of the systems studied by Prigogine et al. the critical value (that dissipative structures generally require to emerge) is a complex function of the parameters that describe the reaction-diffusion processes; that is - I assume - also the case for the (State-)System.

In the next chapters, I explain that in 1480, certain critical values were reached and exceeded in the System that allowed for the emergence of the 1st FTS (a dissipative structure). From 1480 onwards, the inter-societal/state-instabilities (instabilities in the System) and a 'long-range' - a macroscopic - order, produced very coherent System-behavior.

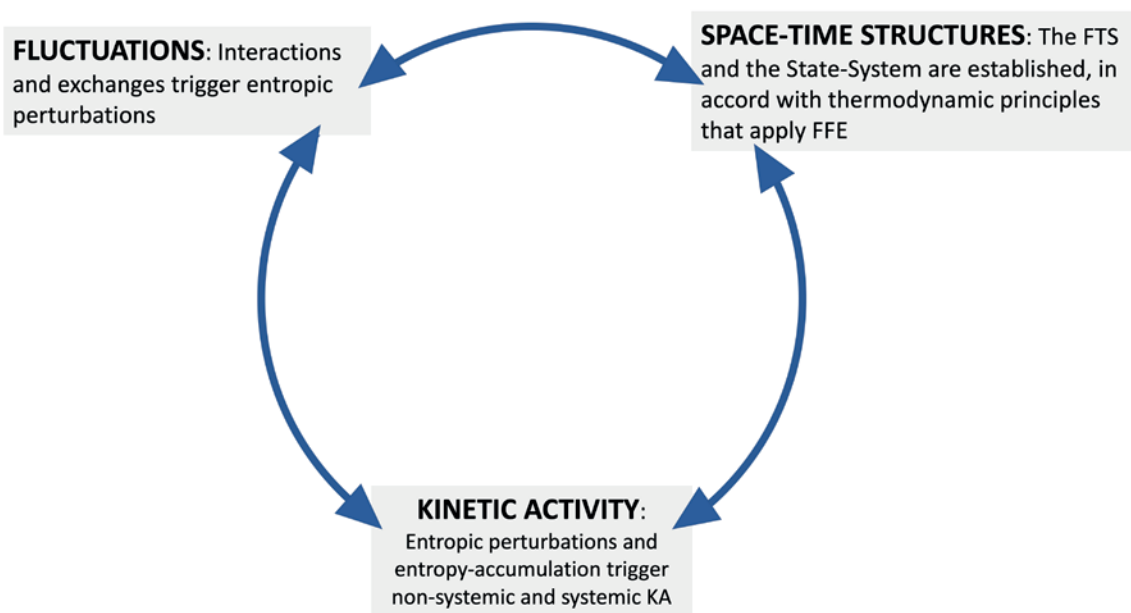


FIGURE 13.2: The interplay between three aspects in case of the FTS (based on (62)).

FFE, order can emerge through fluctuations. According to Prigogine et al. (63), in case of dissipative structures - for the emergence of 'order through fluctuations' - there is an interplay between three aspects, that are always linked in dissipative structures: "(1) the function as expressed by the chemical equations, (2) the space-time structure, which results from the instabilities, and (3) the fluctuations, which trigger the instabilities" (63).
According to this perspective, there was (is) also an interplay between several linked aspects in case of the 1st FTS (and 2nd FTS), that include: (1) the (unknown) function as expresses by the (unknown) kinetic equations (at this stage), (2) the space-time structures that resulted from the instabilities, and (3) the fluctuations, which triggered the instabilities.

13.8. Application (1): Competing thermodynamic potentials and their extremization

In this paragraph, ahead of some concepts that will be introduced and further explained in the next chapters, I introduce an important aspect/element of the theory I present in this study. The reason I introduce this aspect - element - at this stage, is to provide the reader with a perspective that can serve as guidance.
This study shows that the System was increasingly pushed FFE, and that the interplay between competing thermodynamic potentials of (sub)systems and their extremization were (and still are) at the 'heart' of the FTS and State-System: In case of the (State-)System, two 'competing' thermodynamic states - at different levels of the System - had simultaneously their impact: While the System was maximizing its entropy-production (through e.g. population growth and increasing rivalries between societies/states), the State-System was in a state near equilibrium, ''subjugated' to the MEP-Principle, and pushed to "zero entropy", and was (consequently) making a transition to thermodynamic equilibrium.
The two fundamentally different thermodynamics states - and accompanying behaviors/dynamics - resulted in two contradictory tendencies: The System was maximizing its entropy-production, whereas the State-System was simultaneously pushed toward minimum entropy production. Consequently, the gradient and force applied to the State-System increased.
I refer to this phenomenon - which is at the heart of the FTS and (State-)System - as the "interplay between competing thermodynamic potentials and their extremization". This interplay not only underpinned the 1st FTS and the dynamics of the European (State-)System, but also shaped social developments and the process of social evolution; the hierarchical structure of the System (also) is a fundamental (and necessary) aspect of this dynamic.
In Part VII, I explain that through the process of social evolution and driven by the homeostatic imperative, we are conditioned to these competing thermodynamic potentials and their extremization; the competing thermodynamic potentials and their extremization are institutionalized (in our social systems). Conditioning and institutionalization of competing thermodynamic potentials and their extremization 'allow' us to switch - as demanded by the Second Law and related principles that apply FFE - between kinetic behavior (war) and non-kinetic behavior, and to rationalize and justify this behavior within a social context we create in the abstract domain.

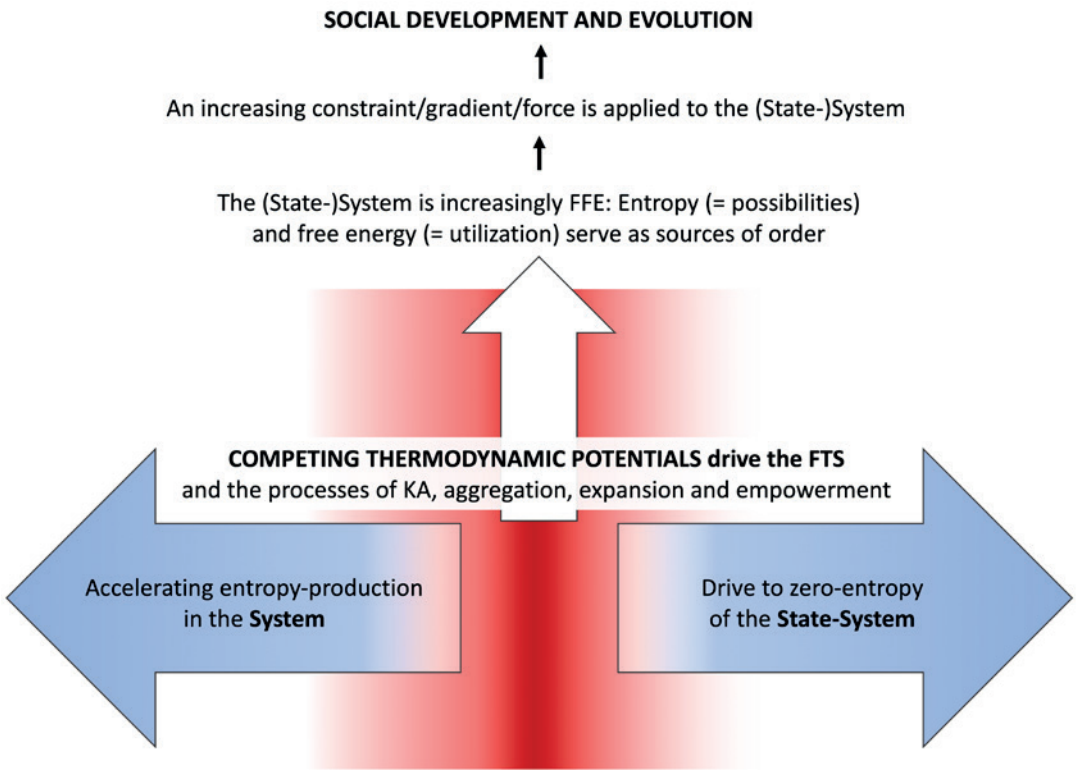


FIGURE 13.3: Competing thermodynamic potentials and their extremization drive the FTS and (State-)System. This figure shows the basic driver that underpins the (State-)System's development and evolution. The interplay between competing thermodynamic potentials lies at the 'heart' of the FTS and of the (State-)System.

13.9. Application (2): Different thermodynamic states provide different opportunities

The three thermodynamic states discussed in this chapter, provide different opportunities. As Chaisson explains: "Although the *destruction* of order always prevails in a system in or near thermodynamic equilibrium, the *construction* of order may occur in a system far from equilibrium" (20).

As explained in the previous paragraph, the (State-)System is driven by the interplay between competing thermodynamic potentials and their extremization; consequently, the (State-)System shows 'ambiguous' behavior; there is a combination of destruction - related to near equilibrium behavior (of which the cyclic behavior (R2 dynamics) during the transient period, 1480-1945, is a manifestation) - and construction, of which the chaotic non-systemic KA during RSP's of war-cycles is a manifestation. During the transient period (1480-1945), these 'competing' dynamics were regulated by the 1st FTS and constitute a coherent 'behavior', that ensures that continuity and change in the System (and its components) are balanced, that its operation is optimized, and the fulfilment of the System's basic requirements - including survival - is ensured.

14. Bifurcations

14.1. Introduction

Kondepudi et al. explain that "far-from-equilibrium states can lose their stability and evolve to one of the many states available to the system. Irreversible processes and the boundary conditions do not uniquely specify the nonequilibrium state to which the system will evolve; driven by internal fluctuations or other small external influences, the system leaves the unstable state and evolves to one of the many possible new states. These new states can be highly organized and are called dissipative structures" (44).
The 'switch' to the organized state FFE is also referred to as a bifurcation. A bifurcation occurs when a sudden qualitative or topological change in the system's behavior takes place, caused by (small) changes made to the values of the bifurcation parameters of the system.
Prigogine observes that there is a deep unity among widely diverse systems, "and this allows us to assert that the passage toward complexity is ultimately related to the bifurcation of new branches of solutions following the instability of a reference state, caused by the nonlinearities and the constraints acting on an open system (66)".
In 1480, the System experienced a bifurcation - I argue - to an organized state FFE and a dissipative structure - the first finite-time singularity dynamic (the 1st FTS) - emerged. The bifurcation was preceded by a period of increased instability when the System was driven increasingly farther from equilibrium.
In this chapter I discuss bifurcations, and their characteristics.

14.2. General and specific features

Kondepudi et al. explain, that at a certain point when a system is driven FFE, the stability of the thermodynamic branch is no longer assured: "beyond this point, there are a multiplicity of states and is unpredictability" (44). However, "the exponential growth of the perturbation does not continue indefinitely; the growth eventually stops due to the nonlinear terms" (44) and the system can make a transition to an organized stable state, with lower entropy. *These organized states are also referred to as dissipative structures and can "be maintained indefinitely as long as the flows are maintained*" (44).
A bifurcation - the emergence of dissipative structures FFE - shows that irreversible processes associated with randomness and openness, and the production of entropy in systems FFE are a source of order, and how order emerges out of disorder (c). According to Prigogine et al. "*entropy is not merely a downward slide toward disorganization. Under certain conditions, entropy itself becomes the progenitor of order*" (65).
The dissipative structure the System generated through a bifurcation in 1480 (the 1st FTS), in response to its increasing instability FFE during the period preceding the bifurcation, was a 'stable' structure with

lower entropy, that was maintained during the transient period (1480-1945). As I explain later, the 1st FTS was instrumental in a phase transition of the core (the European State-System) to thermodynamic equilibrium.

Kondepudi et al. explain that there are some general features of FFE-systems, which explain their behavior. According to Kondepudi et al. "The loss of stability of a nonequilibrium state can be analyzed using the general theory of stability (...)" and a basic relationship exists between the loss of stability of a FFE-system, the multiplicity of solutions and symmetry (44).

However, besides certain general features, certain special features of the system concerned and the precise conditions for instability cannot be ignored, if full understanding of the system's behavior is sought. In case of the System, and the bifurcations the System experienced, the special features include the relationship between population growth, entropy-production and KA (war and war dynamics).

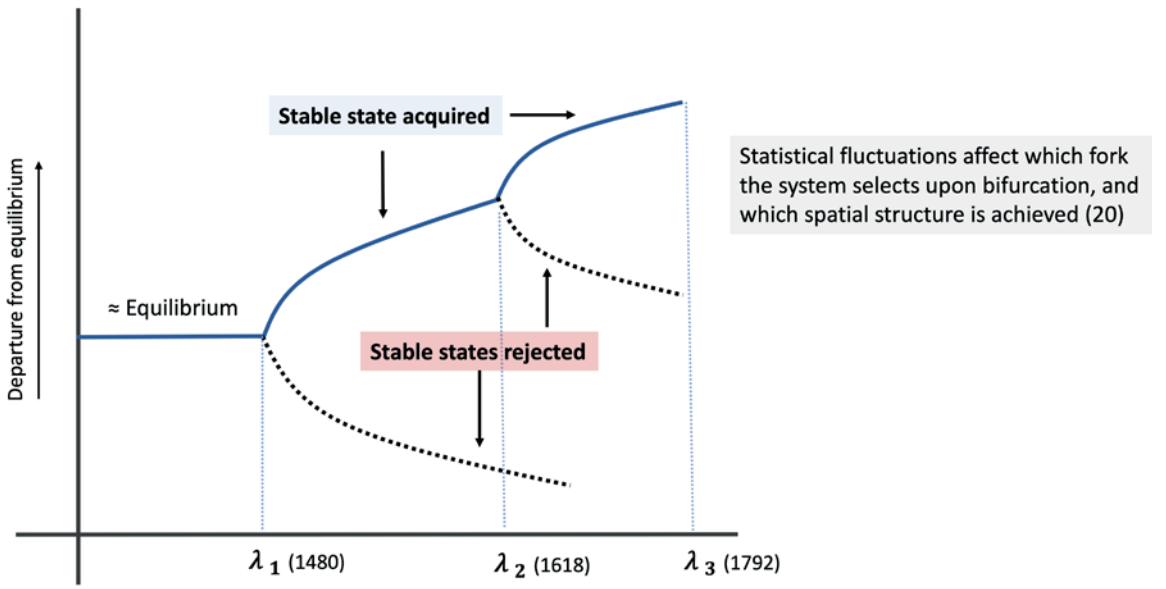


FIGURE 14.1: Bifurcation: Symmetry-breaking. In this figure, an open system is depicted in a bifurcation diagram, on its departure from equilibrium. This is a historical (evolutionary) process. λ is equivalent with the distance from equilibrium (which increases over time). At λ_1 (1480) the bifurcation point - a relatively stable - but increasingly unstable - state spontaneously breaks the System's symmetry, when a certain critical distance/threshold (λ_1) is reached. "The result is two new, possible, dynamical steady states, only one of which a given system actually selects, depending partly on the system's history and partly on environmental fluctuations at the time of bifurcation. In non-equilibrium thermodynamics, the new states can result in whole new spatial structures at each bifurcation, much as in equilibrium thermodynamics when changing temperatures cause phase changes in various states of matter" (20). This process - the emergence of a dissipative structure (the 1st FTS) - is also referred to as 'order through fluctuations', 'energy flow ordering', or 'self-organization' ("although that term is deceptive in that such ordering is actually occurring not by itself (...), but only with the introduction of energy" (20)).

14/3 Properties of bifurcations

The existence of a bifurcation point - a point when multiple solutions present themselves to a FFE system that has become increasingly unstable - is related to the general property of nonlinear equations[3] that describe the behavior of the system (44). To which of the multiple possible states the system concerned will evolve is not deterministic: it depends on the random fluctuations in the system. The loss of stability implies that a random fluctuation will grow and drive the system to one of the possible states (44). The transition of the System, from an increasingly unstable state FFE to a dissipative structure (the 1st FTS) in 1480, followed such a developmental process.

The bifurcation the System experienced seems to qualify as a Hopf bifurcation.

Kondepudi et al. explain that "instability can arise only when the system is far from thermodynamic equilibrium and, generally, when autocatalysis is present" (44). Autocatalysis is a precondition for the instability required for a FFE system to generate a bifurcation; nucleation processes also typically precede bifurcations. Autocatalysis and nucleation processes do - so to speak - the 'groundwork' for instabilities and bifurcations. These phenomena can also be observed in the System, as I already mentioned and will be discussed in more detail at a later point.

A bifurcation involves and is also referred to as symmetry-breaking. Symmetry breaking is a phenomenon in which (infinitesimally) small fluctuations (probabilistic in nature) acting on a system crossing a point decide the system's fate, by determining which branch of a bifurcation is taken. Through the transition in 1480, the System made a transition from a symmetric but disorderly state into a more organized (lower entropy) state: The System's symmetry was broken, at that point.

Once a system generates a bifurcation, there is often a sequence in the organized states, when the system is pushed increasingly farther from equilibrium by the driver of the system[4]; the primary (initial) bifurcation is then followed by successive bifurcations, and the system generates successive non-stationary but oscillating ordered states (65).

This typical behavior can also be observed in Bénard structures when "farther away from thermal equilibrium the convection flow begins to oscillate in time; as the distance from equilibrium is increased still farther, more and more oscillation frequencies appear and eventually the transition to equilibrium is complete" (65). To understand the complex behavior of the System we have to follow the bifurcation diagram of the System farther (65).

This behavior can also be observed in the System, when through population growth and increasing connectedness of societies the entropy-production in the System also further increased. This study shows that the System - the 1st FTS - also generated a series of cascading bifurcations and that 'in the process' a second layer of dynamics was imposed 'on top' of the chaotic non-systemic KA the System started generating in 1480: The network-effect (tipping point) during RSP's, caused the accumulation of

3. "This general relation between bifurcation and stability of solutions of nonlinear equations can be explained using topological degree theory, which is beyond the scope of this discussion" (44).
4. "A remarkable simple road to "chaos" (...) is the Feigenbaum sequence"."it concerns any system whose behavior is characterized by a very general feature, that is, for a determined range of parameter values the system's behavior is periodic, with a period T; beyond this range, the period becomes $2T$, and beyond yet another threshold, the system needs $4T$ in order to repeat itself. The system is thus characterized by a succession of bifurcations, with successive period doubling. This constitutes a typical route going from simple periodic behavior to the complex aperiodic behavior occurring when the period has doubled ad infinitum. This route, as Feigenbaum discovered, is characterized by universal numerical features independent of the mechanism involved as long as the system possesses the qualitative property of period doubling" (65).

entropy and eventually (after becoming critical) caused systemic KA/war. Four cycles were generated in the process (accompanied the 1st FTS (1480-1945)) and - as is the case for Bénard structures - these typical dynamics continued until the transition of the State-System (the core) to thermodynamic equilibrium was complete.

14.4. Routes to chaos

In the previous paragraph, sequences in organized states - routes to chaos (which is an organized state) - were discussed. The System started producing chaotic non-systemic KA in 1480.
Research has revealed regularities in 'routes' systems follow to chaos (66). The transition to turbulence (chaos) in fluid systems (for example) shows the emergence of flow patterns - flow regimes - that depend on e.g. the temperature of the fluid (11). The change of flow patterns means that the symmetry is broken in the system. Although it seems paradoxical, a deterministic flow can appear chaotic[5]; that is, as a consequence of the nonlinearity of the system. The equations can have exceedingly complex solutions that do not look as if they are the result of a deterministic process (as is for example also the case for the weather system).
Prigogine discusses four scenarios - routes - to chaos (66):

1. *Fragility of three (or more) dimensional tori*. In this scenario, the route to chaos is via a three-dimension torus describing quasi-periodic motion. Ruelle and Takens have shown that although a two-dimensional torus - resulting in quasi-periodic dynamics - is robust, this is not the case for tori of three or more dimensions involving at least three incommensurate (from an irrational fraction) frequencies. These are fragile objects that disappear when perturbed and give rise to a strange and structurally stable attractor, and chaotic dynamics (66).
2. *Period-doubling cascades*. In the second scenario chaos arises from an infinite sequence of bifurcations when the control parameter values are adjusted (tuned up). At well -defined parameter values which correspond with bifurcations, the periods of higher order cycles double. At a certain value of the parameter the system obtains 'infinite period' orbits that show chaotic behavior, and the entire state space of the system belongs to a single chaotic attractor displaying instability of motion and sensitivity to the initial conditions (66). Feigenbaum has revealed the existence of remarkable regularities in the approach to the chaotic region (....). The existence of these very regular period-doubling cascades is confirmed by many experiments (66, 29).
3. *Pomeau-Manneville intermittency*. In case of this scenario there is a transition to chaos due to intermittency. In dynamical systems, intermittency is the irregular alternation of phases of apparently periodic and chaotic dynamics, or different forms of chaotic dynamics (96).
4. *Homoclinic scenario*. The reinjection of departing trajectories in the vicinity of an unstable fixed point in case of a saddle-point shaped attractor, produce homoclinic orbits. Under certain conditions these homoclinic orbits leave structures which behave chaotically (66).

5. The chaos that is referred to here - "equilibrium turbulent chaos" - should not be confused with "equilibrium thermal chaos". "In thermal chaos as realized in equilibrium, all characteristic space and time scales are of molecular range, while in turbulent chaos we have such an abundance of macroscopic time and length scales that the system appears chaotic" (65).

It is problematic to determine the (exact) route to chaos of the System; accurate war-data (preceding 1480) is not available: It is not possible (at this stage?) to explore the route to chaos, that preceded '1480'. However, the scenarios presented by Prigogine offer also some insights in the war dynamics of the System, especially because what the 'switches' (bifurcations) between chaotic and quasi-periodic war dynamics (1657) and vice versa (1763), reveal.

14.5. The role of a constraint

A so-called constraint has an important function in generating and in maintaining nonequilibrium states and nonlinearities, and in producing dissipative structures (66). The constraint has a certain 'strength' and generates a certain force and flows. The S/T-field is a manifestation of the constraint of the (State-) System, as I explain in more detail later.

The term 'constraint' is related to certain limitations of a system, that define boundaries to its dynamics. A constraint drives the EMIS-flows required to generate and sustain dissipative structures. "Nonequilibrium states are associated with non-vanishing fluxes between system and environment" (66), and in case of the FTS, between the State-System and its environments (societies and the non-core).

Before elaborating on the constraint of the System and its impact on the System's dynamics, I discuss as an example, the impact - effects - of a constraint on traffic flows. This example illustrates the interplay between the constraint that is imposed on a system, and its dynamics.

Traffic flows are depended on the available infra structure that imposes constraints (on these flows). Traffic (flows) can be considered a dynamical system, and traffic flow dynamics are to a large degree determined by the width of the road, the number of available lanes, by the number of vehicles, and behavior of drivers (their velocity, distance between cars, reaction time, etc.). The width of the road constitutes a constraint for the traffic-system and can be considered an 'environmental' limit that is imposed on this dynamical system. The number of available lanes impacts on the throughput of the traffic.

Traffic can be unimpeded - that is fluid - or jammed (solid, no throughput), but there is also an intermediate 'state' of the traffic-system - between fluid and solid - when a fluid and solid traffic states alternate.

During this typical intermediate behavior - between fluid and solid - the traffic-system is so to speak 'critical'. While during a fluid situation the correlation-length of the traffic-system is short - and braking-action of a driver does not reverberate through the traffic system, because a local reduction in velocity of a car (a local perturbation) can be 'absorbed' (there is sufficient distance between cars) - in case of a critical traffic condition (close to solid), local behavior - brake-actions of cars - reverberates through the traffic system: Driving behavior is no longer 'independent' of the behavior of other drivers much farther down the road; the correlation-length is much greater - in fact there is a divergence of the correlation length - the system is tightly-coupled, and there is coherent - collective and macroscopic - behavior.

During the intermediate stage, the traffic flow behaves like a 'harmonica' and the traffic flow comes temporarily to a halt and then starts flowing again, but there are no 'obstacles' on the road; the coherent macroscopic 'harmonica' behavior is intrinsic to the traffic system, and a function of the conditions - certain parameters - of the system.

The System is also subject to a constraint; Without a constraint, the 1st FTS would not have emerged in 1480, and could not have been sustained, during the transient period (1480-1945).

The so-called collective dimension - which is related to the carrying capacity of the System (and comparable to the width of the road in traffic systems) - constitutes the constraint of the (State-)System. A remarkable feature of the FTS is that this dissipative structure can regulate the System's carrying capacity and its utilization, at least to an extent; this subject will be discussed later.

14.6. Mode-coupling

In the previous paragraphs, the emergence of long-range correlations - in which the constraint plays an important role - is mentioned.
Mode-coupling can be considered the mechanism that is responsible for the establishment of long-range correlations between interactions (66); the coupling is nonlinear. The emergence of macroscopic behavior means that the system generates and maintains reproducible relationships among its distant parts: The system shows coherent - and very regular - behavior (66).

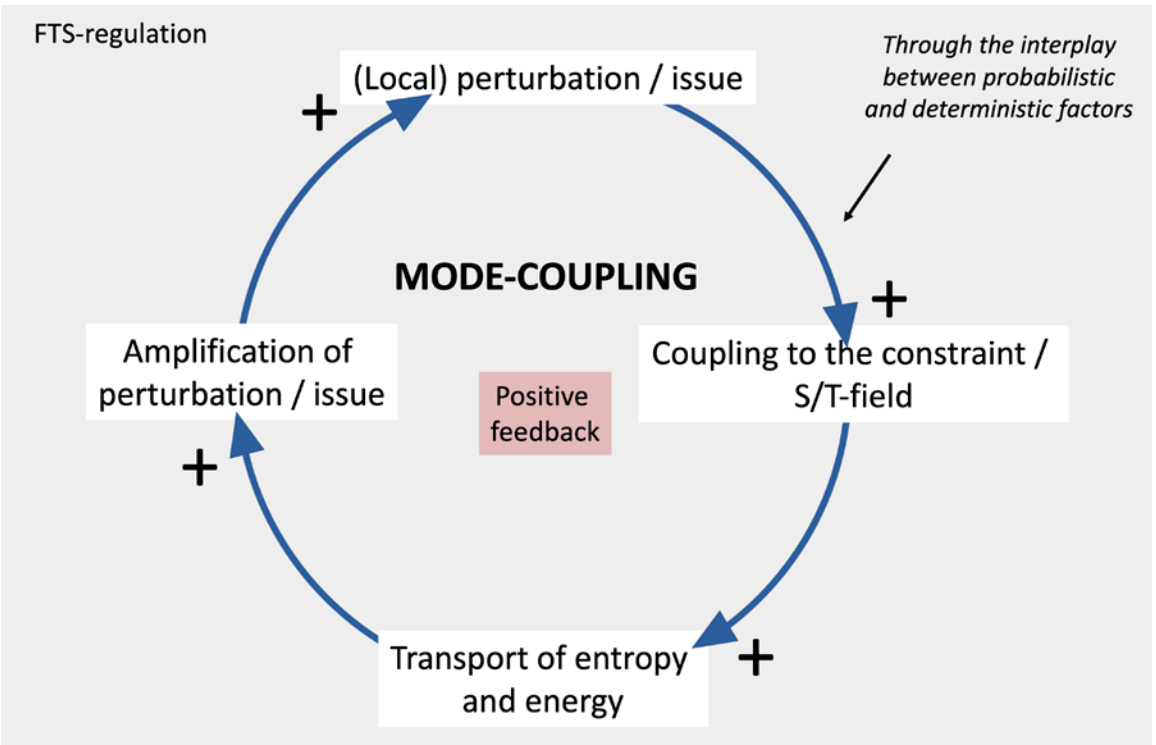


FIGURE 14.2: Mode-coupling. This figure shows the establishment of mode-coupling between a (initially) localized entropic perturbation (issue/war) and the constraint (S/T-field). The transport of entropy and energy between the issue and field causes amplification. At a certain point, the dominant feedbacks change and the perturbation/issue 'fades away'. The process is regulated by the FTS.

Near bifurcation and critical points and during the operation of dissipative structures, the two modes become (increasingly) coupled: (1) A mode concerned with localized issues and interactions, and a (2) mode concerned with the transport of (entropy) tensions and energy in the system (66), between more distant parts. Both modes are needed - and need to be coupled - to ensure that a local fluctuation (inhomogeneity) can be 'communicated' - spread and cascade - through a system. Mode-coupling is a prerequisite for coherent macroscopic behavior, i.e. for the functioning of the FTS. The FTS provides mode-coupling to the (State-)System, by coupling local entropic perturbations (issues) to the S/T-field (collective dimension) and ensuring the transport of entropy and/or kinetic energy (causing amplification of the issue).
The degree of mode-coupling is dependent on - a function of - the constraint. Until 1480, the moment of the bifurcation - the moment of the break-down of the central limit theorem (66) and the establishment of long-range correlations and a macroscopic coherent organization (the 1st FTS) - the two modes were still too weakly coupled; until 1480, the System was so to speak still in an "uncorrelated state of matter". This changed in 1480.
The sustained functioning of the 1st FTS (1480-1945) required adequate mode-coupling to enable system-behavior and EMIS-regulation. Mode-coupling and the FTS require continuous dissipation which is ensured through the constraint.

14.7. The interplay between chance and constraint

Another general feature of bifurcations is the unpredictability of the organized state - the dissipative structure - that will be 'selected' by the bifurcation: "It is curious to observe that the same system may give rise to several types of dissipative structures by only slight changes of the boundary conditions" (62). In case of a bifurcation, there is an interplay between chance and constraint; between determinism and the probabilistic nature of the system involved. The interplay between probabilistic and deterministic factors will be discussed in subsequent chapters as well; it is a recurrent theme, and important in understanding the interplay between determinism and probabilistic factors in social and historical processes as well.
The systems concerned "obey deterministic laws, such as the laws of chemical kinetics, between two bifurcations points, while in the neighborhood of the bifurcation points fluctuations play an essential role and determine the "branch" that the system will follow" (63). Prigogine shows how a bifurcation - symmetry-breaking - links dynamical and probabilistic processes (66), and how a microscopic formulation of the Second Law of thermodynamics is obtained (66).
The probability of small fluctuations that are amplified, determine the subsequent configuration and behavior of the system "by choosing one among the many possible solutions a priori available for the system". This choice, "represents the historical element which has to be added to the system to determine, together with the causal laws, its future evolution".
Thus, as a result of random fluctuations, or other random factors such as small inhomogeneities or imperfections, the system evolves to one of the many possible states. Which one of the organized states a particular system will evolve to is, in general, not predictable: It is the result of the interplay between determinism and the probabilistic nature of these systems: "(...) for a given set of nonequilibrium conditions, it is often possible to have more than one state" (62).

"The new states thus attained are often 'ordered states' that possess spatiotemporal organization. Patterns in fluid flow, inhomogeneities in concentrations exhibiting geometrical patterns with great symmetry or periodic variations of concentrations are examples of such ordered states. Because of its fundamental character, we shall refer to the general phenomenon of a nonequilibrium system evolving to an ordered state as a result of fluctuations as order through fluctuations" (44). These fluctuations are intrinsic to the system's (internal) dynamics (as is the case with the harmonica behavior of traffic flows, discussed earlier). Prigogine explains in reference to the outcome of a bifurcation: "Nothing in the description of the experimental setup (*IP: of experiments Prigogine describes*) permits the observer to assign beforehand the state that will be chosen; only chance will decide, through the dynamics of fluctuations.

"The system will in effect scan the territory and will make a few attempts, perhaps unsuccessfully at first, to stabilize. Then a particular fluctuation will take over. By stabilizing it, the system becomes a historical object in the sense that its subsequent evolution depends on the critical choice" (66). There is an "remarkable interplay between chance and constraint, between fluctuations and irreversibility": "(...) the passage toward complexity is intimately related to the bifurcation of new branches of solutions following the instability of a reference state, caused by the nonlinearities and the constraints acting on an open system" (66).

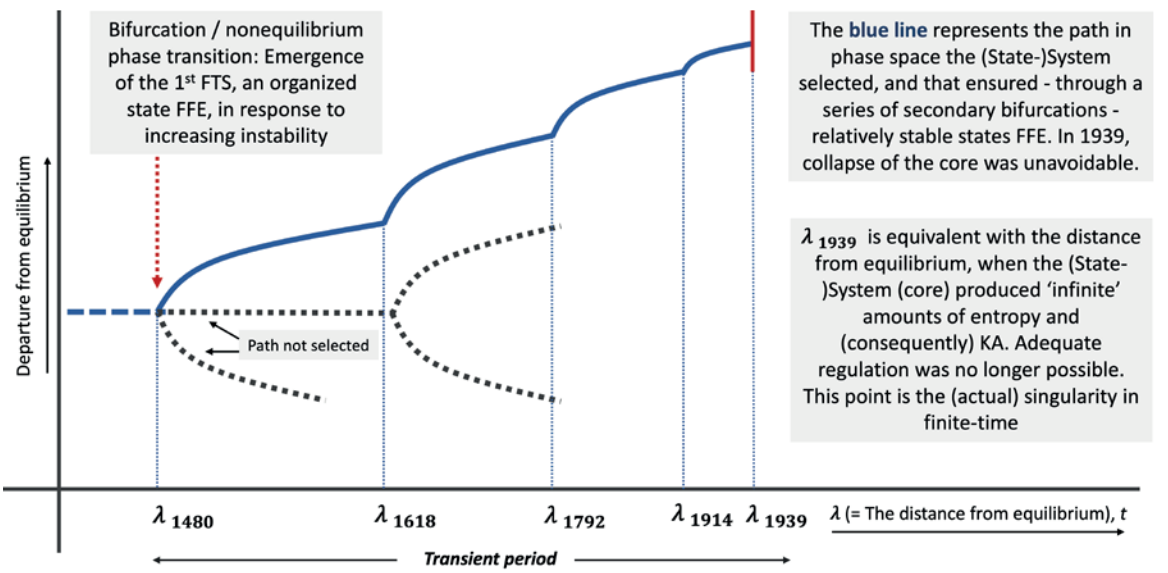


FIGURE 14.3: The path of the (State-)System. This figure is a schematic depiction of the path of the (State-)System in phase space, during the transient period (1480-1945): A period of increasing instability (< 1480) was followed by a bifurcation in 1480, when the System (core) experienced a bifurcation (nonequilibrium phase transition) and a dissipative structure - the 1st FTS - emerged. In the figure, the thermodynamic branch is shown (in blue) of the unique equilibrium states the System followed, when the System was increasingly 'pushed' FFE. The observed behavior of a system depends "crucially on the stability properties of the various states which are accessible under the changing conditions" (72). During the System's shortest past to thermodynamic equilibrium, the stationary state of the System was periodically upgraded through secondary bifurcations (1618, 1792 and 1914), which resulted in a lower free energy state (at least temporarily). In 1939, the European State-System (core) reached a critical point (critical threshold) that triggered the actual phase transition to thermodynamic equilibrium in the core. I use the symbol λ, for the 'distance from equilibrium' of the System; the parameter λ is related to the constraint of the to the System and EMIS-flows that are generated by the FTS. "When λ reaches a particular value (IP: $\lambda_{critical}$, which happened in 1480 in case of the (State-)System), the thermodynamic branch becomes unstable but at the same time new solutions now become possible; driven by fluctuations, the system makes a transition to one of the new states" (44).

14.8. Statistical aspects of the formation of dissipative structures

A poissonian - random - distribution of (for example) the sizes of fluctuations or motions of parts (elements) in a system, reflect complete disorder; random distributions (for example of motions of parts) are the property of a system at thermodynamic equilibrium (66). "In equilibrium, the probability distribution is poissonian and spatial correlations do not exist" (66). But, "the moment attractive interactions are switched on (an attractor is activated) the poissonian distribution will break down: fluctuations/motions are no longer random" (66). In case of equilibrium there is detailed balance; it only holds at equilibrium: "detailed balance precludes nonrandom behavior: 'motions' are cancelled out; in case the poissonian behavior is temporarily/locally disturbed, it will be recovered" (66). "In case of detailed balance elements/parts are distributed randomly, just as one would expect in a system of non-interacting particles.
Far from equilibrium, when a system is driven near a bifurcation- or critical point - as was the case for the System in 1480 (primary bifurcation), and in 1618, 1792, 1914 and 1939 (secondary bifurcations) - "detailed balance is not valid and the spatial correlation then acquires a long tail" - the correlation length (if 'one') spans the whole system - "reflecting the ability of the system to undergo a change encompassing the entire system" (66). Far from equilibrium, the presence of nonlinear interactions and nonequilibrium constraints "will disturb the detailed balance, and as a result a systemic deviation from the Poisson law will be sustained" (66). "Under those conditions, the system will behave like a system of elements/parts interacting through long-range correlations/forces" (66).
The fact that during the transient period (1480-1945) KA - the distribution of the sizes of wars - can be (best) described by a power-law and Zipf-distribution, is also indicative for the long-range correlations in the System and its coherent behavior (see figure below figure).

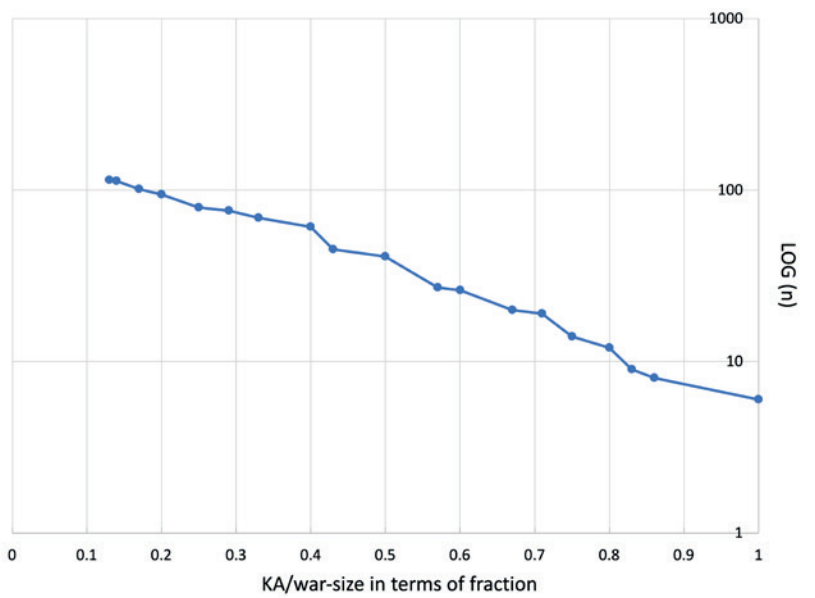


FIGURE 14.4: Zipf-distribution of the sizes of KA/wars in terms of fraction, during the period 1495-1945 (data from Levy (..)). KA/wars during the 1st exceptional period (1657-1763) and expansion wars are included.

As explained, at bifurcation points FFE-systems can experience a change in their configuration and behavior: Long-range coherent behavior - a dissipative structure - emerges. The bifurcation the System experienced in 1480 is such a fundamental change, from disordered behavior to an ordered and coherent dissipative structure, a dissipative structure (the 1st FTS).
A bifurcation can also be explained from a 'statistical perspective as the "breakdown of the conditions of validity of the law of large numbers" (63) with the result that "the distribution of reactive particles near instabilities is no more at random". When the bifurcation point is encountered (*IP: 1480 in case of the System*), "the correlation function and hence the deviation from the poissonian undergo a radical change because of the divergence of the characteristic length (66). Consequently, near bifurcation points, long-range correlations appear in the systems concerned, and "disorder gives rise to order" (63).
I argue that a similar change took place in the System in 1480 (at the initial bifurcation point), when (also) the distribution of kinetic interactions (KA) was no longer random, as was the case in the period preceding the bifurcation, I assume.

14.9. Application (1): The 1st FTS constitutes a fundamentally new social structure

The dissipative structure - the 1st FTS - that was attained through a bifurcation in 1480, also constitutes a fundamentally new social structure that was induced and sustained by a flow of free energy - KA/wars - under non-equilibrium conditions. In this new state of the System, there was a new social order 'in place', on a macroscopic level. The 1st FTS was sustained by accelerating EMIS-flows, that also involved the non-core of the System.
The processes of aggregation (of the integration of societies and states in Europe, the core of the System), expansion (colonization of the non-core, by European states), and empowerment (of societies in the core, Europe), were 'components' of the 1st FTS, and instrumental of EMIS-regulation, during the transient period (1480-1945).

14.10. Application (2): Carrying capacity of the (State-)System

The constraint of the System can also be related to the concepts of carrying capacity, metapopulation and metapopulation in ecology. The carrying capacity "of a biological species in an environment is the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment. In population biology, carrying capacity is defined as the environment's maximal load". A metapopulation is "an assemblage of local populations living in a network of habitat patches. More generally, spatially structured populations at landscape scales are often called metapopulations" (45). Metapopulation capacity "is a measure of the size of the habitat patch that takes into account the total amount of habitat as well as the influence of fragmentation on metapopulation viability" (45).
The constraint also has a certain capacity (and certain limitations) to fulfill the 'demands' of the System and the FTS, of which the constraint is an integral part. By balancing continuity and change, the FTS enabled population growth, and a process of aggregation etc.

The 'carrying capacity' of the FTS can be defined as the maximum 'size' of the System - in terms of population size, but also as a collection of interacting societies - it can effectively regulate FFE, without the System losing its coherence and macroscopic/collective behavior. During the transient period (1480-1945), the 1st FTS - of which the constraint is an integral component - enabled population growth (in Europe), from circa 83 million in 1480 to circa 544 in 1945, while the 1st FTS also accomplished a phase transition. Humans - organized in social systems - contributed to the energy supply of the 1st FTS (through the entropy that was produced), while the FTS at the same time enabled population growth and its development; these interactions constituted a positive loop.
I assume that the 'performance' of the 1st FTS during the transient period (1480-1945), is equivalent with its maximal load.
Solé et al. explain that the carrying capacity can be used as a bifurcation parameter in dynamical population models, in which also cyclic and chaotic dynamics can be observed, as is the case for the KA of the System (80). Biology and ecology offer a wide range of insights that can contribute to our understanding of the System, and social systems in general. These insights are also useful in understanding the (possible) impacts/effects of climate change on the performance of the current (2nd, global) FTS.

14.11. Application (3): The "introduction" of history

Because there are multiple solutions in case of bifurcations, "bifurcations introduce in a sense "history" into physics" (63); "history matters" (65).
The introduction of an "historical" element in physics and chemistry can be understood with the help of figure 14.5: "Suppose that observation shows us that the system whose bifurcation diagram is represented by below figure is in the state C and came there through an increase of the value of lambda. The interpretation of this state (...) implies the knowledge of the prior history of the system, which had to go through the bifurcation points A and B" (63).
Prigogine observes that historical elements are not only reserved for "sciences dealing with biological, social, and cultural phenomena", but also apply to physics and chemistry (63). History has in fact a physical basis.
As will be discussed in the next chapters, bifurcations are not only instrumental in selecting the most efficient path of the System towards thermodynamic equilibrium, but (in the contingent domain) in the selection of social and political solutions within the contingent latitude that is (still) available.
Bifurcations and choices that are involved, shape social and political processes, and are instrumental in the selection involved in social evolution. It is the combination of nonlinear dynamics and nonequilibrium constraints that enable selection in the System (66). Even if the magnitude of a perturbation (fluctuation) is initially small, "its effect may be amplified considerably due to the nonlinear nature of the system" (66).
In the terminology of Modern Thermodynamics (44, 66), there is "selection through symmetry-breaking interactions with an external field" (66). In case of the System, there is also selection - e.g. issues that will be magnified - which involves an external field; i.e. the S/T-field. The relationship between bifurcations, social evolution and the involvement of a field, will be discussed later in more detail.
As I already mentioned, the initial (primary) bifurcation of the System in 1480 and the subsequent emergence of a dissipative structure (the 1st FTS), were followed by a series of 'secondary' bifurcations,

respectively in 1618, 1792, 1914 and in 1939. The secondary bifurcations were (also) instrumental in a phase transition - a transition of the European State-System (core) to thermodynamic equilibrium - that took place during the transient period (1480-1945) and was regulated by the 1st FTS.
The System can be considered a "hierarchy of dissipative structures each one enriched further by the information content of the previous ones through the 'memory' of the initial fluctuations which created them successively" (62).

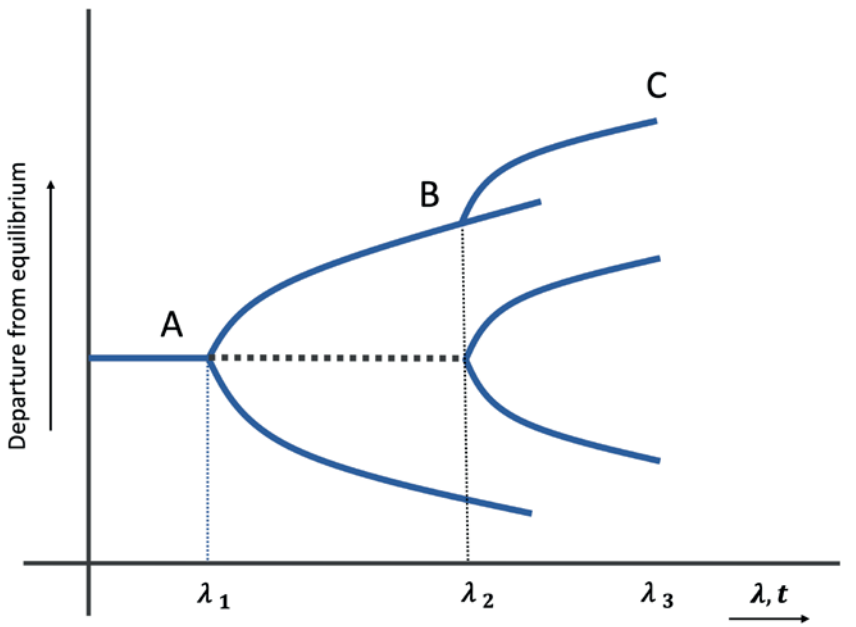


FIGURE 14.5: Successive bifurcations (based on (63)).

14.12. Application (4): Disturbed mode-coupling during the Cold War: Dominance of the transport-mode

In the preceding chapters, I have referred to the presence of abnormal non-systemic KA - abnormal war dynamics - during two periods, since the primary bifurcation of the System in 1480 that resulted in the 1st FTS.
The 1st exceptional period was from 1657-1763, during the 2nd cycle (1648-1815) of the 1st FTS (1480-1945); the 2nd exceptional period - better known as the Cold War - was from 1945 until 1989, during the 1st cycle (1945-....) of the 2nd FTS (1945-....).

The abnormal war dynamics during the two exceptional periods, have in common that in both cases, the mode-coupling of the System (of the respective FTS's) was disturbed, and that this disturbance impacted on the macroscopic behavior of the System, at that time.

As explained, mode-coupling is concerned with the coupling of local interactions (and entropy-production as a consequence of local perturbations) and their transport in the System; their linkage to the S/T-field. A proper balance must be maintained between the two modes (short-range (local) and long-range (macroscopic)), and disturbance of the balance between both modes and related processes leads to qualitative changes in the (behavior of) the System. Except for the two exceptional periods, the mode-coupling was functioning, and the FTS-regulation was effective.

I assume that during the 1st exceptional period (the Cold War, 1945-1989), through a combination of factors and conditions, the mode-coupling was disturbed and dysfunctional, and that this disturbance caused a qualitative change in the KA - war dynamics - of the System. The dysfunctional mode-coupling did undermine the functionality and efficiency of the 2nd FTS and its ability to regulate EMIS-flows. Because of the intense rivalries between the two most dominant Great Powers in the System (the United States and the Soviet Union) during the Cold War (1945/53-1989), the transport mode (process) dominated the mode-coupling and related processes, and *localized* issues and interactions - one of the two modes - did (and could) in fact not exist: All issues were connected, into one overarching and dominating issue. The collective dimension was too strong, so to speak.

Consequently, (local) fluctuations - entropic perturbations - were suppressed and could (and did) not generate kinetic responses (KA). Prigogine observed this typical condition and behavior in other systems and refers to this condition as "a 'homeostatic' fossil-like state in which fluctuations are crushed and full uniformity is imposed" (66).

The System not only had problems to generate non-systemic KA in response to localized entropic perturbations - they were not localized; all issues were magnified - but also lacked the degrees of freedom to generate *chaotic* non-systemic war dynamics.

Because of the absence of long-range correlations, the KA generated during the Cold War lacked coherence: there are no patterns. During the Cold War - the 2nd exceptional period - the System could not produce a functional (fully operational) dissipative structure (a 2nd (now global) FTS), and consequently the KA and the processes of aggregation, expansion and empowerment were (mostly) 'on hold'. The System and its dynamics were frozen, ossified; 'fossil-like' in the words of Prigogine (66).

During the Cold War - the 2nd exceptional period - the 'logic of war' - as it had evolved during the transient period (1480-1945), based on an intimate thermodynamic relationship between entropy-production and KA and regulated by the FTS - was disturbed, but was eventually re-applied - when in 1989, the Soviet Union collapsed: In 1989 'default' chaotic non-systemic KA resumed.

Abnormal war dynamics will be discussed in separate chapters in more detail.

14.13. Application (5): Bifurcations and the FTS provide a template for social development and evolution

In case of a bifurcation, a system has to perform a critical choice (66), as was the case with the System in 1480 (as well as in 1618, 1792, 1914 and 1939, which can be considered secondary bifurcations, albeit with a decreasing latitude for choice): Nonlinearity combined with nonequilibrium constraints allows for multiple solutions, and hence for the diversification of behaviors.
The possibility of having multiple solutions in a nonlinear system raises the question of choice between the different outcomes that are available (66). In case of a bifurcation, a "system will in effect scan the territory and will make a few attempts, perhaps unsuccessful at first, to stabilize (66)". It is not possible to determine beforehand the path the system will choose: Chance will decide, through the dynamics of fluctuations. In case of the System, there is also "a remarkable interplay between chance and constraint, between fluctuations and irreversibility" (66). By offering multiple solutions to reestablish stability, fluctuations involved in the bifurcation-process create diversities: The search for 'new' stability creates diversity. In 1480, the System bifurcated from an increasingly unstable state (< 1480) to an organized state FFE, a dissipative structure (the 1st FTS). Entropy-regulation was now optimized and the 1st FTS ensured that the State-System made a transition to thermodynamic equilibrium via the most efficient path. This organized state imposed four accelerating cycles on the System; bifurcations and the FTS provide a template for social development and evolution.

14.14. Application (6): Symmetry-breaking and diversification

Bifurcations are 'sources' of innovation and diversification, and present new solutions to a system. The physical laws that underpin these typical dynamics are deterministic in nature, but probabilistic factors also play a role in the solutions the system selects. The solutions the bifurcations generate display broken symmetries, symmetry-breaking transitions. Symmetry-breaking is the manifestation of intrinsic differentiation between different parts of a system, or between the system and its environment (66). The series of fluctuations - and bifurcations - the System experienced during the unfolding of the 1st FTS, involved several symmetry-breaking transitions. The increasing intrinsic differentiation between the parts of the System - the increasing degree of order, and decreasing entropy of the State-System - are manifestations of these symmetry-breakings.
Nonlinear dynamics, nonequilibrium, fluctuations, bifurcations and symmetry breaking are closely related to diversification and evolution and are a prerequisite for complex behavior. Symmetry-breaking also is a prerequisite for information (66). In case of the System and its evolution, once differentiation was accomplished, other processes were activated, which ensured further differentiation. This mechanism is also referred to as novelty by combination, which is a powerful mechanism in (especially) the contingent domain of the System.

15. Dissipative structures

15.1. Introduction

In this chapter, dissipative structures are further discussed; various aspects were already discussed in the preceding chapters.

15.2. Dissipative structures

A dissipative structure (or system) system is an open system which is operating out of, and often far from, thermodynamic equilibrium in an environment with which it exchanges energy and matter. "Dissipative structures are generated and maintained through irreversible processes that continuously generate entropy" (44).

Kondepudi et al. explain: "it can be argued that most of the 'organized' behavior we see in Nature is created by irreversible processes that dissipate energy and generate entropy. For these reasons, these structures are called dissipative structures (…). In an open system, these organized states could be maintained indefinitely, but only at the expense of exchange of energy and matter and increase of entropy outside the system" (44).

Dissipative structures come in various forms and standard rules do not apply (44). "Convection cells, hurricanes, autocatalytic chemical reactions and living systems are all examples of nonequilibrium dissipative structures which exhibit coherent behavior" (92), and for which the laws of thermodynamics are of course valid (64).

Dissipative structures are characterized by the spontaneous appearance of symmetry breaking and the formation of complex, sometimes chaotic, structures where interacting particles exhibit long-range correlations, as explained in the previous chapter. Dissipative systems (structures) are - as the name suggests - dependent on the flows of matter and energy from their environments: "a characteristic feature of dissipative structures is that consumption of energy is required to maintain the organized state" FFE (4).

Dissipative systems obey 'laws of evolution' which are different from that of equilibrium systems, involve nonlinear behavior, the existence of thresholds, the effects of fluctuations, and are both deterministic and stochastic in nature: "there are times when the system follows a stable trajectory of inevitable change and other moments of choice or bifurcation when chance plays a vital role and when a qualitative modification of structure can occur", furthermore, there are "different possible branches of solution and the particular path taken by the system through the branching type of possibilities is determined by the precise history of the system" (4, 72).

As Prigogine et al. explain (44, 63, 65), dissipative structures self-organize through fluctuations and instabilities ('order through fluctuations'), by bifurcations and generate new (intermediate) stable states. The 1st FTS also emerged through fluctuations and instabilities and involved a bifurcation in 1480, that resulted in an organized state FFE (1480-1945): A dissipative structure that was accompanied by four accelerating war-cycles and by four intermediate stable states (RSP's).

The FTS is a dissipative system which operates FFE and generated a combination of complex - chaotic - dynamics (R1-dynamics) and cyclic/periodic dynamics (R2-dynamics).

The behavior of dissipative structures is governed by a (system- and condition specific) thermodynamic potential. Entropy-production is the thermodynamic potential that governed the System/FTS: The level of entropy-production characterizes the System and FTS.

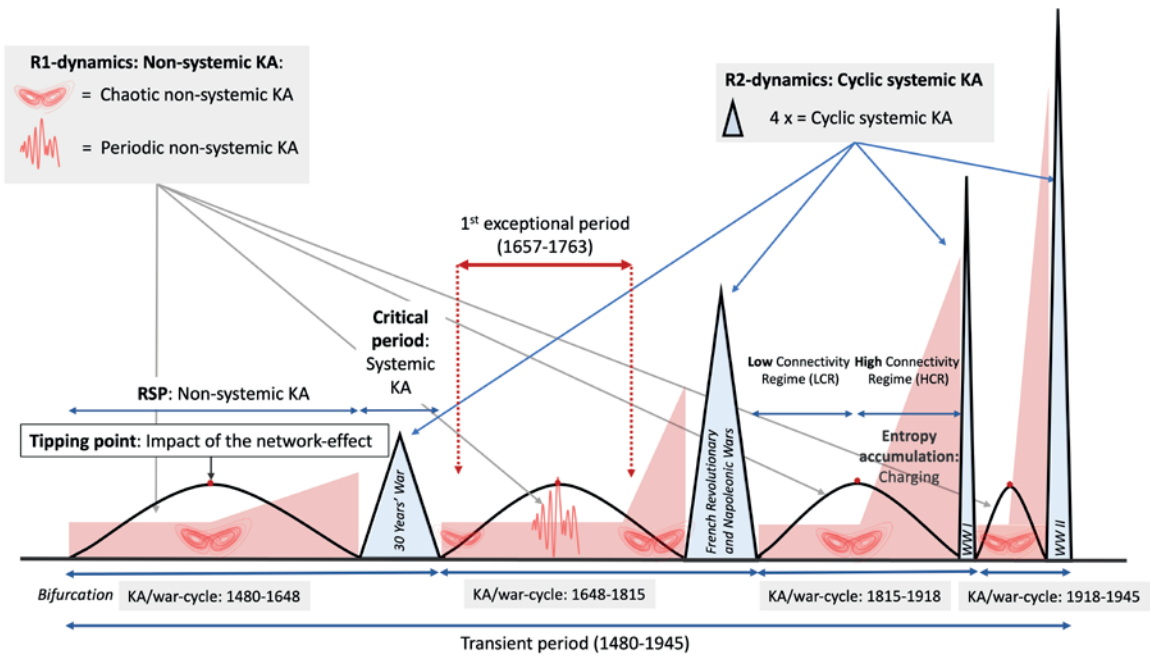


FIGURE 15.1: Schematic representation of the 1st FTS. During the period - the transient period - from 1480-1945 - entropy-production - EMIS-flows - in the (State-)System, was regulated by a dissipative structure: The 1st finite-time singularity dynamic (FTS) that was accompanied by four accelerating (KA/war) cycles, each cycle consisting of a relatively stable period (RSP), when entropic perturbations were regulated through chaotic non-systemic KA/wars, and a critical period, when accumulated entropy was put to use to upgrade the order of the System and the establishment of a new (upgraded) RSP's, that allowed for a lower energy-state of the System (albeit temporarily). The 1st FTS was instrumental in a phase transition that was accomplished in 1945, with two complementary effects: (1) thermodynamic equilibrium in the former core of the System (the European State-System), and (2) the simultaneous globalization of the State-System, and the establishment of a 1st global order (the United Nations). From 1945 onwards, the global System is regulated by a 2nd FTS, which will eventually be instrumental in the accomplishment of thermodynamic equilibrium in the global State-System, assuming the 2nd FTS can be sustained. Normally during RSP's, non-systemic KA is chaotic in nature, however, during the 1st exceptional period (1657-1763) non-systemic KA was periodic.

In case of the System FFE, entropy-production generated kinetic responses (war): Non-systemic KA in response to entropic perturbations during RSP's of war-cycles, and systemic KA during in response to the accumulation of entropy caused by a combination of autocatalytic interactions and a network-effect. Self-organization of and in dissipative structures is closely related to and dependent on "the presence of nonlinearities in the interactions between the elements" generated by autocatalytic processes taking place in these systems (64). If these autocatalytic 'reactions' are maintained (FFE), these systems exhibit a rich variety of self-organizing behaviors, and different types of coherent behavior can appear, including steady temporal oscillation (64).

These features can also be observed in the System (FTS): The 1st FTS was initiated by a primary bifurcation in 1480, and produced four secondary bifurcations during the transient period (1480-1945), in which autocatalytic processes - the self-reinforcement of entropy-production and accumulation - played a vital role: Through these autocatalytic processes a coherent structure could be sustained (the 1st FTS and the European State-System).

In case of dissipative structures - including the 1st FTS - the internal entropy spontaneously decreases when (through a bifurcation) an organized state emerges FFE. The ('local') decrease in entropy (of which the 1st FTS and the European State-System in the core are manifestations) is possible, because "the Second Law of thermodynamics merely states that the change in the entropy of a system $\boldsymbol{dS}$ can be written as the sum of two terms, $\boldsymbol{d_iS}$ the internal entropy production and $\boldsymbol{d_eS}$ the entropy flow across the boundaries of the system,

$$\boldsymbol{dS = d_iS + d_eS; d_iS \geq 0}$$

The term $\boldsymbol{d_iS}$ is either positive or zero (as discussed in chapter 2). In systems which are more than a critical distance from equilibrium, however, the flow of entropy through the boundaries can, under certain circumstances, more than compensate the entropy production within the system, in which case a spontaneous self-organization of the system occurs" (64).

Dissipative structures contain a very large number of interacting entities (individual humans, communities, societies, etc. in case of the 1st FTS), and typically interact "through the intermediary of some environmental constraint" (64). Contrary to systems in equilibrium is the length scale of dissipative structures not characterized by 'local' (for example molecular) interactions, but by a much larger scale which involve "gigantic numbers of the entities in interaction" (64).

In case of the FTS, the entities of the System interact because of the scarcity of resources for which these entities must compete in an anarchistic setting and mutual dependencies; scarcity and interdependencies contribute to environmental constraints and constitute a 'collective dimension'.

"Nonequilibrium constraints induce long-range correlations" (66), as I explained in the previous chapter. Through the parameters of the FTS, the environmental constraints act on societies and states, and vice versa.

The long-range correlations ensure that the different parts of the dissipative structure - societies/states for example in case of the FTS - "can act in a concerted and coherent fashion by maintaining well-defined relationships between each other" (66). Through the FTS (mode-coupling), spatial coherence was established over a macroscopic range; diffusion had to be maintained to ensure these long-range correlations (66).

If these long-range correlations would not exist or would not be maintained in a dissipative structure producing oscillatory behavior, perturbations would destroy these regular oscillations (66): Long-range

correlations must be maintained to ensure macro-coherence (66). The absence of a constraint would have destroyed the regular oscillations - the four accelerating KA/war-cycles - that accompanied the 1st FTS during the transient period (1480-1945).

This study shows that the 1st FTS was instrumental in producing regulated EMIS-flows (that contributed to processes of KA, aggregation, expansion and empowerment), but was also dependent on these same flows to maintain its coherence and sustain its operation.

The maintenance of a certain organization required constant work: Energy had to be continuously 'consumed' (transformed).

In order to maintain constant and coherent flows, the 1st FTS had to sustain a gradient (during the transient period), which required the constant interplay between competing thermodynamic potentials and their extremization in the (State-)System. The presence of a gradient not only generates flows, but also involve forces; Through the 1st FTS a constant force was applied to the (State-)System.

The growing System and the maintenance of the FTS initiated the same developments that can be observed in growing and developing biosystems: An increase of the total dissipation, the development of more complex structures with more energy flow, an increase in cyclic activity, and the development of greater diversity and more hierarchical levels (92).

From a thermodynamic perspective, dissipative systems emerge FFE - in accord with the Second Law and related principles that apply FFE - to reduce the effect of the gradient that is applied (92), and to 'find' the most efficient path to thermodynamic equilibrium.

A 'paradox' of the FTS is that it could only eventually eradicate the gradient (achieve thermodynamic equilibrium), by (four times) upgrading its macroscopic organization (order), during the transient period (1480-1945), which in each case reinforced the gradient (that powered the 1st FTS): Efforts to minimize entropy-production in the State-System contributed to the accelerating production of entropy of the System, and the accelerating entropy-production caused an acceleration of the 1st FTS until in 1939, the 1st FTS (the European State-System) produced infinite amounts of entropy, and consequently collapsed. At that point the last stage of the phase transition could be accomplished through the 4th systemic KA/war (the Second World War, 1939-1945). As mentioned, the interplay between competing thermodynamic potentials and their extremization is at the heart of the (State-)System and drives/powers the FTS.

The generation and sustainment of the FTS - a coherent self-organized macroscopic organization - during the transient period (1480-1945), is not only characterized by a macroscopic organization, but also by a very specific and coherent pattern of KA, of war dynamics. The scale of the macroscopic organization and patterns is on a scale much larger than that of 'individual' and local interactions of communities and societies (states). The properties of the (State-)System and FTS, and of the KA (war dynamics) and processes of aggregation, expansion and empowerment the FTS generates "are a property of the collectivity and cannot be inferred from a study of the individual elements in isolation" (64). In case of the (State-)System and FTS, the whole is obviously much more than sum of their parts.

15.3. "Archetypes of complexity"

Prigogine observes that there are - what he names - "archetypes of complexity" (66): Different attractors can exist in dissipative structures, each attractor produces a typical dynamic; the number of degrees of freedom (DoF, ***n***) of a system (dissipative structure), is a defining condition. The degree of freedom of a system is defined as the number of parameters of the system that may vary independently.
In case a system has more than two DoF (***n*** > 2) it can produce combinations of behaviors.
In below table, the relationship between the number of DoF (***n***), the type of dynamic, and typical behavior (dynamic) is shown (66).

TABLE 15.1: Archetypes of complexity. An increase in the number of DoF results in (increased) flexibility and an enhanced capability of the system to innovate.

DoF (n)	Attractor	Corresponding behavior/dynamic	'Application' in case of the System (1480-1945)
n = 1	Limit point.	Development toward a steady state; convergence toward a fixed point in phase space; involvement of a singularity.	Development toward a steady equilibrium state at System-level, involves a singularity and a phase transition (1939-1945).
n = 2	Periodic attractor, limit cycle.	Oscillations, damped oscillations.	Damped oscillations at orbit level during RSP 1 (1480-1618); at system-level, the FTS can be considered an 'accelerating' oscillator.
n > 2	Torus (a bounded surface in 3D).	Quasi-periodic oscillations.	The abnormal war dynamics during the 1st exceptional period (1657-1763) qualify as quasi-periodic oscillations.
n > 2	A fractal (self-similar structure in 3D).	Chaotic dynamics.	'Default' R1-dynamics (non-systemic KA/ wars) during RSP's are chaotic in nature.

The number of degrees of freedom of the (State-)System determines the behaviors (solutions) that are available to the System. According to Prigogine: "... in all systems where dynamics is reducible to a one- or two dimensional phase space *(IP: A phase space with* ***n*** *= 1 or* ***n*** *= 2*), the behavior is severely limited by the topological constraints imposed on any low-dimensional motion. In particular, the only possible attractors turn out to be fixed points and limit cycles" (66).
The dissipative structure - the 1st FTS - the (State-)System produced through a bifurcation in 1480, was a more-dimensional structure that gave rise to intricate and coherent transition phenomena: Chaotic and regular - respectively chaotic non-systemic KA (R1-dynamics) and cyclic/periodic systemic KA (R2-dynamics) - coexisted in the (State-)System during the transient period (1480-1945), as I explain later.

15.4. Application (1): The FTS constitutes a war-trap

The properties of the System and FTS - including of the KA (war dynamics) and processes of aggregation, expansion and empowerment the FTS generates - "are a property of the collectivity and cannot be

inferred from a study of the individual elements in isolation" (64), also means that "the collective structure of the system and its evolution do not necessarily correspond to the individual desires of the elements of the system. The collective structure simply reflects the nonlinearities of the interactions and, therefore, can give rise to unexpected, and often undesirable, aspects of progress" (64).
Wars that were (and still are) fought are the contingent - real world - manifestations of the KA the FTS generates in response to entropic perturbations and accumulation of entropy in the (State-)System. War and war dynamics are generated by the System and are a 'property of the collectively'; the social innovations we have introduced over time - including state-structures that represent societies - are products of and fully conditioned to the thermodynamic features of the (State-)System.
Humans are 'parts' of the (now global) FTS, which is instrumental in maintaining the coherence of the (State-)System and in the (collective) fulfillment of basic requirements, but the FTS can also cause collective self-destruction, because of the acceleration of entropy-production and KA it causes: The emergent dynamics of the System show how the "the collective dimension of individual actions" impacts on the evolution of societies and the System, and how "individuals acting according to their own particular criteria may find that the resulting collective vector may sweep them in an entirely unexpected direction (...)" (64).

15.5. Application (2): Europe is torn apart

The constraint - the collective dimension - is an essential component of the FTS, of dissipative structures in general. The constraint - which is equivalent with a gradient that generates flows and involves forces - 'drives' and shapes the EMIS-flows necessary to generate and sustain the FTS.
A constraint induces long-range correlations in the System, assuming a certain 'tuning' (e.g. mode-coupling) is achieved. Scarce resources - societies/states have to compete for to ensure their well-being and survival - contribute to the (sustainment of the) constraint of the System.
I assume that (perceived) threats constitute an integral part of the constraint of the System: Security is also a scarce 'commodity' in the System, societies must compete for.
The function of a constraint also sheds some light on the now faltering process of unification (the accomplishment of aggregation stage 3B) in Europe (the former core of the System).
The 1st FTS was also instrumental in a process of aggregation in the core of the System (Europe), during the transient period (1480-1945): The core reached the conditions for full aggregation stage 3A ('aggregation enabled') following the 4th systemic war (1939-1945, the Second World War), a response to the collapse of the core in 1939 (however, the process of actual unification was delayed until 1989, when the Soviet Union collapsed and the second exceptional period (1945-1989, the Cold War) came to an end).
Because of the disappearance of the constraint that drove the 1st FTS (1480-1945) - which included a force (generated by the 1st FTS) that was solely applied to the core (the European State-System) - the process of aggregation in/of the core (Europe), which is still not yet fully accomplished, is now faltering.
The constraint that now drives the 2nd (global) FTS (1945-....) and applies a force to the global State-System and drives a process of global aggregation, undermines the still fragile European structures that are still not yet fully developed and implemented.

Furthermore, the chaotic non-systemic KA the 2nd FTS since 1989 generates (at a global level) has the effect of a centrifugal force on the European structures and adds to the process of fragmentation (disaggregation) in the former core (Europe).
At present, Europe and European states are "stuck in the middle" so to speak and are consequently vulnerable: European structures are not yet fully developed and implemented, while states have already transferred certain authority (to these structures); European and state-structures increasingly work at cross purposes, and competition and rivalries between states intensify. Europe is vulnerable; aggregation (unification) that was accomplished (stage 3A) is now undermined and challenged: At the same time when the 2nd FTS is gathering pace, chaotic non-systemic KA cause (more) unpredictability.
A further 'complication' is that the 1st KA/war-cycle of the 2nd FTS, is now - analysis of war data suggests - in its HCR (the tipping point of the cycle was reached in 2011), and entropy (issues and tensions) is accumulating in the (State-)system. This condition adds to the social and political volatility of the System. Europe is torn apart by the 2nd FTS.

15.6. Application (3): Internalization of and social conditioning to thermodynamic principles

The 1st FTS is a dissipative structure that was produced by the System through a bifurcation in 1480. The purpose of the FTS - from a thermodynamic perspective - is to establish thermodynamic equilibrium in the core of the System, via the most efficient path.
Thermodynamic equilibrium of the core - social equilibrium - requires (in practical terms) the eradication of state-structures, and the establishment of homeostatic-control, which ensures that entropy-production is contained, and can be dealt with without KA.
In case of thermodynamic equilibrium of the System, the entropy is maximum, while the free energy is minimum; the stability condition $\boldsymbol{d_i S < 0}$ applies.
In case of social equilibrium, the minimization of free energy (i.e. minimization of military capabilities in the contingent domain) serves as a thermodynamic potential that is minimized: The minimization of free energy ensures the maximization of entropy, in case of equilibrium.
The minimum of this thermodynamic potential - of the free energy (military capabilities in the contingent domain) - constitutes the point of equilibrium, in case of thermodynamic equilibrium in social systems.
These thermodynamic principles are embedded in social systems, e.g. through the institutionalization of matching social behavior.
The tendency - drive - of social systems in social equilibrium to minimize kinetic energy (e.g. military capabilities), is a manifestation of the internalization of - and social conditioning to - thermodynamic principles that apply in those conditions.

16. Chaotic and periodic dynamics

16.1. Introduction

In this chapter, I discuss chaotic and quasi-periodic dynamics. As I already mentioned, in 1480, when the System experienced a bifurcation and adopted an organized state FFE, non-systemic KA - non-systemic war dynamics - became 'chaotic'. According to Prigogine et al. (44), this type of behavior can be observed in dissipative structures.

Although, during the transient period (1480-1945), non-systemic KA (KA during RSP's of cycles) was chaotic 'by default', there was a temporary distortion during the period 1657-1763, when non-systemic KA was periodic in nature. I refer to the period 1657-1763, as the '1st exceptional period'; a second exceptional period occurred from 1945-1989, during the 1st war-cycle of the 2nd (global) FTS (1945-....).

16.2. Chaotic dynamics

"Chaos is a phenomenon encountered in science and mathematics wherein a deterministic rule-based system behaves unpredictably. That is, a system, which is governed by fixed, precise rules, nevertheless behaves in a way that is, for all practical purposes, unpredictable in the long run" (30). Despite the seemingly unstructured nature of chaotic (war) dynamics, these dynamics have an "abundance of macroscopic time and length scales" (65); chaotic dynamics are highly organized at a microscopic scale. Chaotic systems are deterministic systems that appear to be random. However, they actually follow precise (mathematical) rules (61). Thus, "behind the veil of apparent randomness, though, many processes are highly ordered, following simple rules" (23). "Mathematically chaotic systems are, in a sense perfectly ordered, despite their apparent randomness." "The study of chaos shows that simple systems can exhibit complex and unpredictable behavior. "In chaotic systems arbitrarily close initial conditions diverge exponentially; the system exhibits aperiodic behavior" (44). This realization both suggests limits on our ability to predict certain phenomena and that complex behavior may have a simple explanation" (30).

A dynamical system is chaotic if it possesses each of the following properties (30):

- The dynamical rule is deterministic.
- The orbits are aperiodic, i.e., they never repeat.
- The orbits are bounded and thus remain between an upper and lower limit.

- The dynamical system has sensitive dependence for initial conditions. A system that has sensitive dependence for initial conditions has the property that a very small change in its initial conditions will lead to a very large change in orbit in the phase state.

Chaos requires a system with only a few - but more than two - degrees of freedom or variables, but not too many. Chaotic dynamics rely on the assumption that only a few major variables interact nonlinearly and create complicated trajectories (83). From a mathematical perspective, the fact that chaotic dynamics are deterministic implies that the output of a deterministic function that describes the behavior of the chaotic dynamics is used as the input for the next step, which can be thought of as a feedback process in which output is used as input.
Sterman (87) defines chaotic dynamics from a system dynamics perspective as follows: "Chaos, like damped fluctuations and limit cycles, is a form of oscillation. However, unlike limit cycles, a chaotic system fluctuates irregularly, never exactly repeating, even though its motion is completely deterministic." "The irregularity arises endogenously and is not created by external, random shocks. Like a limit cycle, the path of a chaotic system is bounded to a certain region in state space. Because chaotic systems are bounded, chaos, like limit cycles, can only arise in nonlinear systems. However, unlike linear systems or limit cycles, chaotic dynamics do not have a well-defined period. The motion of a chaotic system never repeats; instead, the orbits of the system approach what is known as strange attractor, a set of closely related but slightly different orbits rather than a single closed curve. Furthermore, chaotic systems have the property known as sensitive dependence on initial conditions. Two nearby trajectories, no matter how close, will diverge exponentially until the state of one provides no more information about the state of the other than any randomly chosen trajectory. Sensitive dependence means that the prediction horizon for chaotic systems, the length of time over which forecasts of future behavior are accurate, is likely to be short even if our model of the system structure and parameter estimates are perfect."
This study shows that two types of non-systemic KA/war dynamics can be distinguished: chaotic and non-chaotic non-systemic KA/war dynamics. 'Normally' - I argue - non-systemic KA is chaotic in nature; however, it is not possible to scientifically prove that war dynamics are chaotic in this mathematical sense, since (for one reason) insufficient data is available.

16.3. Periodic dynamics

Contrary to chaotic dynamics, are periodic dynamics very regular; the system concerned has 'only' two degrees of freedom.
According to Sterman, are oscillations "the third fundamental mode of behavior observed in dynamic systems", besides exponential growth and goal seeking (87).
"Like goal-seeking behavior, oscillations are caused by negative feedback loops" (87). "The state of the system is compared to its goal, and corrective actions are taken to eliminate any discrepancies. In an oscillatory system, the state of the system constantly overshoots its goal or equilibrium state, reverses, then undershoots, and so on. The overshooting arises from the presence of significant time delays in the negative loop. The time delays cause corrective actions to continue even after the state of the system reaches its goal, forcing the system to adjust too much, and triggering a new correction in the opposite direction."

Sterman explains: "Oscillations are among the most common modes of behavior in dynamic systems. There are many types of oscillations, including damped oscillations (*IP: as can be observed during the 1st RSP (1480-1618), at orbital level, to be discussed later*), limit cycles, and chaos (*IP: oscillations are aperiodic and very sensitive to the initial conditions if these systems, and consequently intrinsically unpredictable*). Each variant is caused by a particular feedback structure and the set of parameters determining the strengths of the loops and the lengths of the delays. But every type of oscillation has, at its core, a negative feedback loop with delays" (87).

16.4. Optimization between order and disorder and the role of chaotic dynamics

As mentioned before, life - including the sustainment of a dissipative structure as the FTS - requires an intermediary level of entropy: Not too much entropy - too much disorder - and not a too low level entropy (too much order). Survival - continuation of operation, and thus the ability to maintain a certain order (intermediate level of entropy) FFE - requires adaptability: The conditions continuously change, and survival requires that change cannot be left unanswered. The increased ability of rival states to compete for scarce resources cannot be ignored. Change contributes to and stimulates more change, including by novelty by combination: the complexity of these systems FFE constantly increases.

Georgescu-Roegen formulates the requirement for an intermediate level of entropy to sustain life, as follows: "life is compatible only with a moderate entropy. In an environment of very low entropy, a living organism would not be able to resist the onslaught of the free energy hitting it from all parts. On the other hand, in an environment of very high entropy there would not be enough free energy going around for the sorting to be successful in the short run" (34).

Because of the generation of complexity in the region between order and disorder, this region is sometimes also referred to as the complex state or complex region. The complex state or region of the System is the region with an intermediate level of entropy, between order and disorder where the FTS can be sustained.

Living systems must constantly adapt to ensure optimization (of operation), and to ensure a certain efficiency in a constantly evolving environment. The homeostatic imperative provides guidance and serves as a reference and ensures a certain stability.

Chaotic dynamics are highly instrumental in selecting - 'finding' - optimal solutions in FFE-conditions; in selecting innovations that can contribute to the sustainment of the operation and functioning of the FTS, and its components**.** In case of chaotic dynamics - between order and disorder - there is a combination of randomness and large-scale regularities. Chaotic war dynamics and the complex state of the (State-)System are related. Through chaotic dynamics new microstates can be explored. The KA of the (State-)System - war dynamics - are instrumental in a process of exploration - finding new solutions and opportunities - and in their selection.

Periodic dynamics on the other hand, are much more limited in their ability to explore. Periodic dynamics are less restrained in their magnitude: Periodic dynamics lack a third - restraining - degree of freedom. This - the absence of a third degree of freedom - explains why the (State-)System produced a series of "unrestrained" non-systemic KA/wars with a large size and magnitude, during the 1st exceptional period.

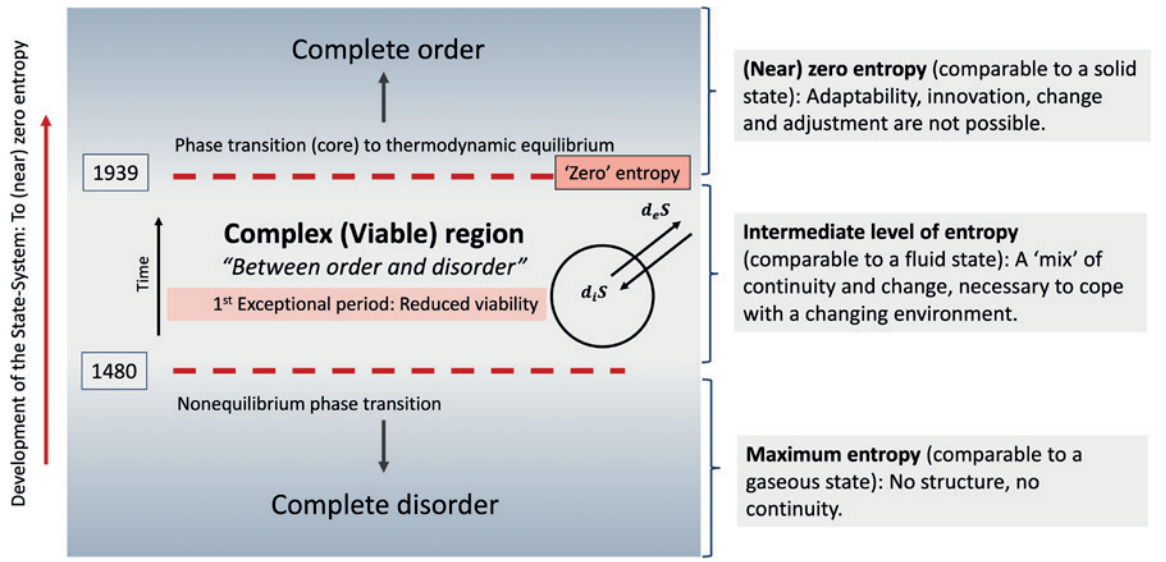


FIGURE 16.1: This is a schematic representation of the complex region, between order and disorder. In the complex region there is an intermediate level of entropy. Entropy is equivalent with disorder, new possibilities and uncertainty, generated through irreversible processes in the System. The FTS regulates EMIS-flows in the System and with its environment. During the transient period (1480-1945), the 1st FTS ensured that the (State-)System was maintained in the complex (viable) region, between order and disorder; however, the viability and efficiency of the System were temporarily diminished during the 1st exceptional period (1657-1763), when the non-systemic KA was not chaotic but periodic in nature.

The chaotic nature of non-systemic KA not only introduces an important element of unpredictability (because of the high sensitivity for initial conditions), but also the 'ability' of the System to explore new micro states and configurations, and to innovate (66). New configurations - the periodic upgrading of the order of the System - require innovation and chaotic war dynamics. The instability of motion associated with chaos allows the System to continuously explore its phase space, "thereby creating information and complexity" (66).

Innovations in this context, must not be understood as very specific - for example - technological innovations. The innovations in this context concern solutions that satisfy the demands - the specific constraints - imposed by the Second Law and related principles that apply FFE, on the (State-)System.

KA (non-systemic wars) - but also for example terrorist attacks - are triggered in responses to entropic perturbations (and resulting gradients). The KA is also part of the explorative activity of the System, to find solutions for 'discrepancies' in the physical domain. The KA provides a 'template' for social development and evolution (in the contingent domain). The solutions that are found and 'implemented', include modifications to the RSP's configuration (within the existing stability domain), and are embedded in the VC's of the RSP.

Chaotic war dynamics generate solutions and innovations that feed the process of nucleation of VC's in the System. The configuration of the network of VC's is important for the generation of a network-effect. VC-clusters can be considered a 'map' - a blueprint - that 'emerges' from the exploration of state space during RSP's through chaotic dynamics. The accumulation of tensions, and such a blueprint are

prerequisites for the System to become critical and produce a systemic response (a systemic war) with the right properties to allow the System to search for and find a new stable state (RSP). The nucleated VC-clusters contain the solutions for the upgrade of the order and can be considered a gateway to the next RSP.
Without chaotic war dynamics, there is no suitable nucleation of VC's and consequently no network-effect and accumulation of entropy necessary for the System to become critical and be able to upgrade to the next level of organization and continue the most efficient path to thermodynamic equilibrium.

16.5. Compression of phase space at two levels

An order (implemented during the systemic KA/war that precedes a RSP) is equivalent with a macrostate of the System. Within an order, the System can adopt different microstates; the degree of entropy determines the available number of microstates (configurations).
An order (RSP) has a certain ability to generate KA, which is instrumental in the process of rebalancing (maintaining the status quo, the existing RSP), and finding configurations that still fit within the existing order. During successive RSP's - orders - non-systemic KA decreases (once the TP is reached), and the available microstates (within the existing order) decrease also: Successive orders - RSP's - were increasingly organized and contained less entropy (possible microstates); the State-System was pushed to 'zero entropy', under 'direction' of the MEP-Principle.
During the transient period (1480-1945) - during the four successive and accelerating cycles (and RSP's) - phase space of the State-System 'shrank', so to speak. Shrinking of phase space is also referred to as phase space compression. "Phase space compression is related to the loss of the system's dimensionality, and is facilitated by a continuous flow of entropy, which is transferred from the system to its surroundings. In other words, as the system organizes itself, the phase space available to its components becomes smaller, and the larger the change in the degree of system's ordering (per unit time), the more entropy is produced and transferred to the environment" (31).
The shrinking (compression) of phase space of the System can be observed at two levels of organization: At the level of the System (as just described), and also at the level of cycles (RSP's).
At the level of cycles/RSP's, during HCR's (once the tipping point of a RSP is reached), the network-effect reduces the effectiveness of entropy-regulation through non-systemic KA, and issues and tensions (entropy) start accumulating in the System. The accumulating entropy results in the increased nucleation and organization of VC's (vulnerable clusters), that (increasingly) percolate - and suffocate - the System. Increased political and social volatility during HCR's are indicative of (and contribute to) this process.
Because KA (non-systemic war) is suppressed through the network-effect (issues have become too connected) and entropy-regulation is problematic, the exploration of phase space through KA is also increasingly limited, and the System can no longer find solutions (new configurations) within the existing order (RSP). The moment the VC's percolate the System, non-systemic KA is completely suppressed and the order (RSP) consequently collapses; the System is now critical and produces a systemic response.
In both cases, when phase space was compressed at respectively System-level and at the level of cycles/RSP's, the System ran out of options (viable microstates, latitude), because of a decrease in entropy, and the suffocating effect of percolating VC's.

To ensure compliance with the Second Law and related principles that apply FFE, changes were required. Three times, the System could upgrade at cycle/RSP-level (1618, 1792 and 1914), before a more fundamental change was required at System-level in 1939, when the System was ultimately forced into another thermodynamic state (thermodynamic equilibrium in the core).

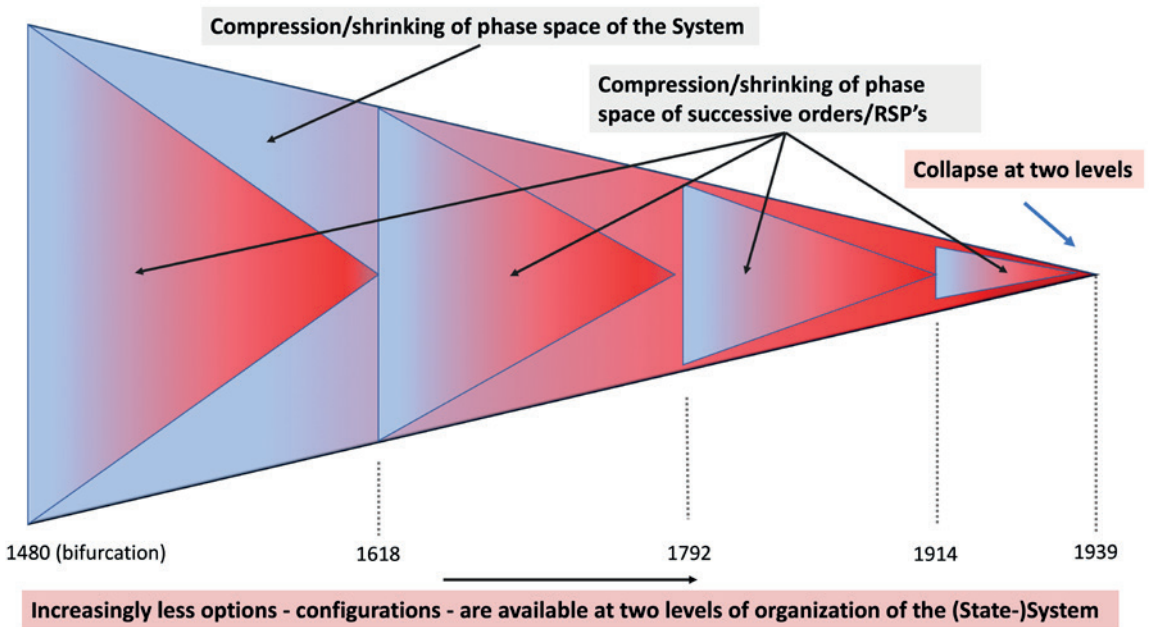


FIGURE 16.2: Compression - shrinking - of phase space at two levels of organization of the System. The triangles represent compressed phases spaces in time, at two levels of organization, during the transient period (1480-1945).

16.6. Application (1): Exploration during critical periods

In this chapter, I have explained the compression/shrinking of phase space, at two levels of organization of the System; at System- and at RSP-level. I have also explained the importance of *chaotic* non-systemic KA in the exploration of phase space during RSP's. Chaotic KA ensures optimal exploration and utilization of available configurations (microstates). Chaotic non-systemic KA is also a prerequisite for the System to upgrade its order (as I explain later).

However, also during systemic KA/war - during critical periods - processes of exploration and nucleation are required; respectively to find viable new (upgraded) orders and to ensure the critical and 'fluid' System 're-solidifies' (in a viable configuration). During systemic KA, phase space also shrinks, until an upgraded order is selected and implemented that complies with the Second Law and related principles that apply

FFE and reflects the actual power-relationships between states in the System (at least at that point in time). It is also important that mechanisms are embedded in the (upgraded) order - institutionalized - that can guarantee a certain (dynamic) steady state and relative stability.

The process during systemic KA is as follows: The VC's that were instrumental in the collapse of the (preceding) RSP, constitute the initial/start-condition for the systemic kinetic response that follows the collapse (as was the case in 1618, 1792, 1914 and 1939). Whereas non-systemic KA during RSP's is about maintaining the existing order, by neutralizing and redistributing entropy - which includes a process of nucleation of VC's in which also solutions, and innovations are embedded - systemic KA during critical periods is about the selection and implementation of a next order that is supposed to provide a certain stability during the next RSP and can ensure further growth and development.

Also, during systemic KA (systemic wars) there is selection. The Second Law and related principles that apply FFE are instrumental in ensuring that the most efficient path to thermodynamic equilibrium is still pursued by the FTS.

In the contingent domain, systemic KA (systemic war) manifests itself as a struggle - "a violent clash of energies" (...) - between societies and states. States employ kinetic energy - military capabilities - which is the KA, generated by the FTS - but provided with a social and political context and purpose.

The most powerful and influential societies/states are able to impose the rules that will apply to the next order (during the next RSP). Typically, these states (Great Powers) use their position of dominance and influence - determined by their ability to develop, produce and deploy military capabilities and put them to use in the social and political context - to 'design' and implement the next order. The process of nucleation that at a certain point starts during systemic KA, I also refer to as the process of resolidification.

During systemic KA, powerful and influential Great Powers exploit their dominant positions and grant themselves certain privileges that are embedded in the upgraded order and ensure they can (further) exploit their position of dominance during the next RSP. This mechanism, I refer to as the Powerful-Become-More-Powerful (PBMP-) mechanism.

During the transient period (1480-1945), the United Kingdom (Great Britain) exploited the PBMP-mechanism most effectively and was the most successful state in creating favorable orders (that served its particular interests).

In the contingent domain, phase space was compressed by the PBMP- mechanism, during the transient period. Anther - related mechanism - also contributed to the shrinking of phase space of the System: The PDLI-mechanism (the path-dependence-lock-in-mechanism). The 1st FTS became increasingly locked in on the most efficient path to thermodynamic equilibrium, as dictated by the Second Law laws and related principles that apply FFE.

Sterman (87) defines path-dependence and lock-in as follows: "Path-dependence is a pattern of behavior in which small, random events early in the history of a system determine the ultimate end state, even when all end states are equally likely at the beginning. Path dependence arises in systems whose dynamics are dominated by positive feedback." "Microscopic differences in initial conditions lead to macroscopic differences in outcomes." Lock-in is another feature of path dependence. Initially, the trajectory, or direction of development, of the system is relatively flexible and can still change direction; multiple microstates (configurations) are still available. However, it is a matter of time and the system becomes progressively locked in. The measure of lock-in of system determines the costs (e.g., energy)

that are required to change its path (87). During the transient period (1480-1945), the PDLI-mechanism was instrumental in reducing the microstates that were available to the System, until the System ran out of options and collapsed in 1939.
Both mechanism - PBMP and PDLI - are also instrumental in shaping the competition between societies and states and the (accompanying) process of selection. The mechanisms can also be used to explain why the Great Power status dynamics decreased, and why BREXIT is a 'reflex' of the United Kingdom, in their efforts to maintain power, influence and a Great Power status; these subjects will be discussed later in more detail.

TABLE 16.1: Exploration of phase space at two levels of organization: differences and similarities.

	RSP-level	System-level
Macrostate	(Successive) orders.	The organized state FFE: The FTS.
Microstates	Various combinations of non-kinetic and kinetic activity, 'within' a certain order (RSP).	(Successive) orders, within the framework of the FTS. During the transient period (1480-1945), four orders were selected and implemented.
Attractor	A chaotic/strange attractor.	Thermodynamic equilibrium.
Related dynamics	R-1 chaotic non-systemic KA.	R-2 cyclic/periodic systemic KA.
'Out of options' (microstates): Zero entropy	When the VC-clusters percolate the System, and the System consequently reaches the critical point of the RSP (respectively: 1618, 1792, 11914, 1939).	When the System produces infinite amounts of entropy/KA (1939).
Process of nucleation	Nucleation/formation of VC's during RSP's. The (percolated) VC's serve as a gateway - a bridge - to the next (upgraded) order. The VC's contain possible solutions that are (further) explored during the critical period, when selection takes place.	The process of aggregation: the forming (nucleation/formation) of increasingly large societies/states, during the transient period.

16.7. Application (2): Insights provided by abnormal - periodic - war dynamics, during the 1st exceptional period (1657-1763)

In this paragraph, ahead of a more extensive discussion of this subject in a next chapter, I point to the significance of the occurrence of abnormal - periodic - non-systemic KA, during the 1st exceptional period (1657-1763).
During the 1st exceptional period, the System produced very consistent *periodic* non-systemic KA (war dynamics): The System produced two highly consistent (sub-)cycles. Their regularity and consistency are remarkable.
Feigenbaum shows that periodic and chaotic dynamics are closely related (29). Prigogine explains that cyclic (periodic) dynamics can often be observed in dissipative structures and 'on the road to chaos' (65). The 'emergence of periodic war dynamics is indicative for the consistency of the dynamics of the System.

The 1st exceptional period (1657-1763) can be considered a so-called periodic window. The term periodic window is associated with the transition (of systems) to chaos (chaotic dynamics). Systems/dynamics that make a transition to chaos show that chaos does not continue uninterrupted, but that various periodic windows can emerge (30). During 'periodic windows' dynamics are periodic in nature.
The emergence of the periodic window in the war dynamics of the System during the 1st exceptional period - but also of the abnormal war dynamics during the 2nd exceptional period (the Cold War, 1945-1989) - was caused by a temporary change in the parameters of the System (involving the degrees of freedom), that determined the strength of certain feedback loops and of the mode-coupling of the (State-)System and FTS: During both exceptional periods, the intense rivalries between two powerful Great Powers - Britain and France, and the United States and the Soviet Union, respectively during the 1st and 2nd exceptional periods - dominated the dynamics of the System, and disturbed the otherwise smooth and efficient operation of the 1st (1480-1945) and 2nd (1945-....) FTS.

16.8. Application (3): Chaotic non-systemic wars are more restrained

The periodic war dynamics during the 1st exceptional period lacked the restraint of (default) chaotic war dynamics: A third degree of freedom - the presence of at least a third Great Power that is taken into consideration in case of war decisions - has a restraining effect on the System's dynamics (severity/size).
In case of $\boldsymbol{n} = 2$ - two Great Powers that dominate the System's dynamics - wars tend to escalate during RSP's, the abnormal (periodic) war dynamics during the 1st exceptional period show. During the 1st exceptional period, several non-systemic wars even reached a size (fraction) of one; meaning that all Great Powers in the System participated in the non-systemic war. However, despite their size of 'one', these 'size-one' wars did not qualify as systemic wars; it was also not possible to impose a new order (RSP) through these wars.

16.9. Application (4): Reduced efficiency of the 1st FTS as a consequence of non-chaotic (abnormal) war dynamics

As explained, the optimal functioning of the FTS, requires the sustainment of an intermediate level of entropy, continuous adaptation, chaotic non-systemic KA to explore new configurations, and a process of VC-nucleation to generate a systemic kinetic response to upgrade the order of the System, and to establish a new RSP that allows for further growth and development.
The moment chaotic non-systemic kinetic activity is disturbed - as was the case during the 1st exceptional period (1657-1763), when the war dynamics were temporarily 'downgraded' to periodic dynamics - the exploration of phase state and the formation of VC-stopped. Although the tensions - entropy-production - increased significantly during the exceptional period (to be explained later), they could not be put to productive use: The selection process - which requires full exploration of phase space and thus chaotic dynamics - was no longer optimized. In case of abnormal (non-chaotic) non-systemic war dynamics the System lacks its intrinsic exploratory capabilities.
Analysis of the war-data reveals that the 1st exceptional period (1657-1763), during the 2nd cycle (1648-1815), had a detrimental impact on the functioning and efficiency of the 1st FTS. Analysis of the war data

shows that during the 2nd cycle (1648-1815), (1) more entropy was produced, (2) more KA was generated by the 1st FTS, and that (3) the development of the 2nd cycle - and consequently of the 1st FTS - was somewhat delayed (13 years), as a consequence of the intense rivalries between Britain and France. It seems that because of the intense rivalries, and the distortion it caused, the System was no longer on the most efficient path to thermodynamic equilibrium: The 1st FTS was temporarily (for the duration of the 1st exceptional period) 'derailed', so to speak.

Analysis shows that the 1st exceptional period took place before the 2nd RSP/cycle had reached the tipping point; consequently, the network-effect did not occur, entropy could not accumulate, VC's could not nucleate and percolate, and the System could not become critical, while criticality (systemic KA/war) is required for the implementation of upgraded orders. I argue that the (State-)System requires *chaotic* non-systemic KA - which is more restrained - to develop its structure and to be able to continue its path to thermodynamic equilibrium: Thermodynamic equilibrium - social homeostasis - cannot be accomplished without *chaotic* non-systemic KA.

17. Phase transitions

17.1. Introduction

In case of phase transitions, systems make a transition to fundamentally different (thermodynamic) states. During a phase transition, certain properties of a system change, continuously of discontinuously, as the result of the change of some external condition.
I argue that during the transient period (1480-1945), the (State-)System accomplished a phase transition through the 1st FTS, with two closely related - complementary - effects: (1) thermodynamic equilibrium in the core of the System (the European State-System) and (2) globalization of the State-System.
The dissipative structure - the 1st FTS accompanied by four accelerating war-cycles - was instrumental in the phase transition; Entropy-production - of which population growth was the underlying *basic* driver - constituted the external condition that 'powered' the process.

17.2. Phase transitions

This explanation of phase transitions is mainly based on a study by Richard V. Solé titled: '*Phase Transitions*' (81). Solé explains that "many important problems of complexity are related in one way or another with the presence of phase transitions. Most complex systems are known to potentially display a number of different patterns of qualitative behavior or phases." "Such phases correspond to different forms of internal organization and two given phases are usually separated by a sharp boundary and crossing such a frontier implies a change in system-level behavior."
A change in system-level behavior was also the case for the (State-)System: The internal organization of the core (Europe), changed fundamentally from (increasingly) unstable (until 1480) to thermodynamic equilibrium (in 1945, albeit with a delay until 1989).
Phase transitions occur because systems can lower their free energy by introducing a 'new' order.
"In physics, phase changes are often tied to changes between order and disorder as a control parameter (e.g., temperature) of the system is tuned. Such phase transitions cause at a certain point a change in an order parameter in the internal symmetry of the components. A transition from liquid (water) to a solid structure (ice) is an example of a change in the order parameter of the system" (81).
A phase transition is a system-wide change that requires collective action by the components of the system to be accomplished: "Transition phenomena are collective by nature and result from interactions taking place among many interacting units" (81). Typically, the basic properties of a system near a phase transition have nothing to do with the microscopic details of the system, a phenomenon also referred

to as universality: "It doesn't matter whether we are dealing with a liquid- gas transition, a structural transition where a crystal deforms, or a magnetic transition where the little magnets or spins start pointing in the same direction".
A distinction can be made between discontinuous - abrupt and more drastic - and continuous phase transitions (44, 76, 81); the transition from fluid (water) to ice (solid) is an example of an abrupt phase transition. Other phase transitions are continuous: the system in question cannot 'decide' between different phases that present themselves, so it fluctuates on all scales, exhibiting critical phenomena. During the transient period (1480-1945) the System experienced a discontinuous phase transition, when a transition was eventually accomplished through four accelerating and increasingly forceful fluctuations (systemic instabilities during critical periods).
Another distinction that can be made is between equilibrium and nonequilibrium phase transitions: In case of continuous phase transitions - contrary to nonequilibrium phase transitions - the fluctuations near the critical point have a large amplitude and extend over large distances (44). The term nonequilibrium phase transition is sometimes used in connection with self-organization phenomena leading to complex behavior (66). The bifurcation of the System in 1480, qualifies as a nonequilibrium phase transition.

17.3. A conflict between order and disorder

A phase transition always involves a "conflict" between order and disorder; as was the case for the (State-) System during the transient period (1480-1945).
In phase transitions, a critical point is involved; at the critical point, a system shows particular behavior. According to Jensen (41) "The nature of the critical state is described by the response of a system to external perturbation. For systems exhibiting noncritical behavior, the reaction of the system is described by a characteristic response time and characteristic length scale over which the perturbation is felt spatially. Although the response of a noncritical system may differ in detail as the system is perturbed at different positions and at different times, the distributions of responses is narrow and well described by the average response. For a critical system, the same perturbation applied at different positions or at the same position at different times can lead to a response of any size. The average may not be a useful measure of the response; in fact, the average might not even exist."
To explain and understand phase transitions, the so-called Ising model is often used as an example.
"Real systems, and simulations with the Ising model[6], show that systems at critical points exhibit wide fluctuations in its order parameter which are more 'extreme' than would be expected from a system at or close to equilibrium" (81). Fluctuations in macroscopic systems become increasingly large near critical points and are no longer extremely small (44). Increasingly 'extreme' fluctuations can also be observed in the R2-dynamics of the System, when the System 'approached' the critical point/threshold ('1939'); the R2-dynamics (as I will explain later) concern the four accelerating cycles that accompanied the 1st FTS.

6. The Ising model is a simple model of critical behavior, and it was soon realized that it provides a powerful framework for understanding different phase transitions using a few fundamental features. "Iron atoms have a natural tendency to align their spin - having just two possible states: -1 (down) and +1 (up) - with their neighboring atoms in the same direction. If a 'down' atom is surrounded by 'up' neighbors, it will tend to adopt the same 'up' state. The final state would be a lattice with only 'up' or 'down' units. This defines the ordered phase, where the magnetization either takes the value M = 1 or M = -1" (81).

"The Ising model is based on the observation, that if we heat a piece of iron (implying, that in this case temperature is the control parameter) to high temperatures, then no magnetic attraction is observed. This is due to the fact that thermal perturbations disrupt atomic interactions by flipping single atoms irrespective of the state of their neighbors. If the applied temperature is high enough, in other words, then the atoms will acquire random configurations, and the global magnetization will be zero. This defines the so-called disordered phase." Solé explains that "the 'problem' involves a conflict between two tendencies: the first toward order, associated to the coupling between nearest atoms, and the second toward disorder, due to external noise. (81)"

At high temperatures thermal fluctuations dominate over nearest neighbor interactions, while at low temperatures the situation is reversed, respectively producing a disordered and an ordered state. At the critical point, the tendency for the spins to align is exactly counterbalanced by the disorder caused by the heat. At that stage, there is no longer global order. Instead, there will be local domains where a group of spins are pointed up, and other domains where the spins are pointed down. The sizes of these domains vary widely at this temperature; many are small, but a few are quite large. So, this state is an interesting mix of order and disorder, and constantly changing over time (81).

"Through a transition to another more ordered state, the system reduces its free energy. An important 'law' is that systems strive to decrease free energy. Systems can reduce their free energy, by introducing order" (81).

17.4. A closer look at the critical point

The critical point describes a condition when there is in fact no longer a distinction between two phases (between order and disorder). During the transient period (1480-1945), this was also the case for the European State-System (the core of the System); there was not a clear distinction between disorder and order in the core.

Such a condition is reached when the control parameters of the system (temperature and pressure in case of water, entropy in case of the System) have specific values. "The presence of this point has a crucial relevance in understanding the nature and dynamics of many natural and social phenomena," according to Solé (81).

"A critical point is used to describe the presence of a very narrow transition domain separating two well-defined phases, which are characterized by distinct macroscopic properties that are ultimately linked to changes in the nature of microscopic interactions among the basic units. The lack of a boundary beyond the critical point makes possible a continuous movement from one phase to the other, provided that we follow the appropriate path; the critical curve (boundary) does not have to be crossed."

If the size of clusters at the critical point (composed of collections of atoms with the same spin direction in the Ising model or, in the context of this study, composed of collections of states engaged in war activity) is measured, we find that the shape of the distribution of cluster sizes is a power law.

Power laws are associated with dynamics close to a critical point and indicate the presence of large fluctuations. Near the critical point, the system displays scale invariance. "If we observe such a system at different spatial scales, it actually looks the same; the system has self-similar characteristics" (81).

However, although the presence of power laws is a hallmark of criticality; power laws can also be produced by other mechanisms unrelated to criticality.

17.5. Nucleation

A phase transition involves a process of nucleation. During the transient period (1480-1945), there was nucleation at various levels of the (State-)System: During (especially) HCR's of RSP's and during critical periods of KA/war-cycles (as discussed in the previous chapter); I also refer to as respectively RSP-nucleation and a process of resolidification.

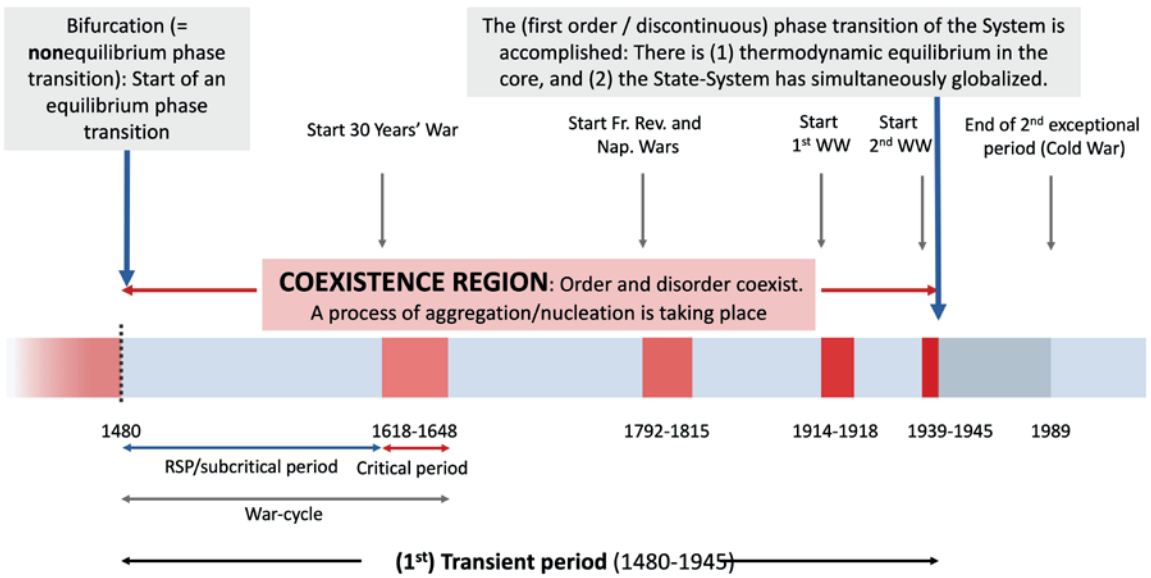


FIGURE 17.1: The coexistence region. During the transient period (1480-1945), the System accomplished a phase transition, in which the 1st FTS, accompanied by four accelerating cycles, was instrumental. During the transient period, the System was in a coexistence region, when in the core (Europe) order and disorder coexisted, and a process of nucleation - aggregation - was taking place.

The process of aggregation - the 'merging' of societies and states - during the transient period (1480-1945), constitutes the process of nucleation, associated with the phase transition taking place at System-level. This process was autocatalytic - self-reinforcing - in nature, in which the PBMP-mechanism played an important role: During the transition, through the PBMP-mechanism, powerful states could establish favorable orders that further enhanced their interests and positions of power and influence. (Increasingly) dominant states (and their structures, values, etc.) and the overarching order of the (European) State-System increasingly converged, so to speak.

During the transient period, a system of circa 300 loosely connected states in 1480, made a transition to a single 'state' (aggregation stage 3A) in 1945 (however, its implementation was delayed until 1989, as I explain later). The single "state" (the European Union, still in the process of being institutionalized), is equivalent with thermodynamic equilibrium; an uncompartmentalized homogenous state.

During the transient period, order coexisted with disorder in the European State-System: There were clusters - societies/states - that had achieved thermodynamic equilibrium and homeostatic control,

whereas the European State-System was still (increasingly) FFE and required KA - the use of kinetic energy - to be regulated. As mentioned, phase transitions always involve a 'conflict' between order and disorder; between contradicting tendencies. Because order and disorder coexisted during the transient period, this period is also referred to as the coexistence region, a phenomenon also closely related to first order phase transitions.

17.6. Metastability

During the transient period (1480-1945), the System was increasingly FFE, and not in a state of least energy; such a state is also referred to as a metastable state. Metastability and the phenomenon of first order phase transitions are closely related.
During the transient period (1480-1945) the 'level' of metastability of the System increased: During successive RSP's the orders that were implemented were increasingly able to 'contain' - to store - free energy, but through the accelerating production of entropy, their lifespans acceleratingly shortened, at the same time. The network-effect contributed to the (local) stability of the System during RSP's.
The network-effect, the ability to store (accumulate) entropy and metastability are related phenomenon: through the storage capacity of entropy in the System, the System could produce oscillatory behavior (Sterman). The accelerating production rate of entropy caused the oscillations to accelerate and their magnitude to increase.
However, the upgrades produced by the 1st FTS could not keep pace with the accelerating production of entropy, and the European State-System and FTS eventually collapsed in 1939. The (actual) collapse of the core, triggered the last step in the phase transition, the 4th systemic KA/war (The Second World War, 1939-1945).

17.7. Thermodynamic equilibrium

During the transient period (1480-1993), the System made a phase transition from an organized state FFE to thermodynamic equilibrium in the core (Europe); the 'accompanying' process of aggregation (nucleation) was instrumental in achieving thermodynamic equilibrium in the core. "The state of thermodynamic equilibrium is static, devoid of processes; in this state there is no flow of energy or matter from one point to another and no chemical change (*IP: or social change in case of societies and the System*) takes place"; it is a homogeneous state (44). In case of thermodynamic equilibrium, the entropy is maximum, and the (Gibbs) free energy at a minimum level; there are no constraints, and the variety is (thus) maximum (5).
Contrary to the organized state FFE of the System during the transient period (1480-1945), there are no long-range correlations in case of thermodynamic equilibrium: "In case of thermodynamic equilibrium, the characteristic space scales of the system are microscopic; there are no correlations of macroscopic range and consequently no transition phenomena arise FFE" (66).

17.8. Application (1): The global (State-)System is in a coexistence region

At present, a second - global - phase transition is in progress, in which the 2nd (global) FTS is instrumental. The global (State-)System is in a coexistence region, and a process of aggregation/nucleation is taking place: Order and disorder compete. The process is determined and shaped by the Second Law and related principles that apply FFE, as was the case during the preceding (1st FTS).
The global State-System is on a path to global thermodynamic equilibrium, and (global) EMIS-flows are regulated by the 2nd FTS.

17.9. Application (2): A discontinuous phase transition

As mentioned in this chapter, "Through a transition to another more ordered state, the system reduces its free energy. An important 'law' is that systems strive to decrease free energy. Systems can reduce their free energy, by introducing order" (81). This observation is also valid for the System FFE; however, a distinction must be made between the behavior of the System when the actual - - "final" - critical point was reached in 1939, and the three preceding - precursory - critical points (secondary bifurcations), reached in respectively 1618, 1792 and 1815.
During the transient period (1480-1945), there was a close relationship between entropy(-production) and Gibbs free energy(-production). The entropy/KA-relationship is the hallmark of the FTS: Entropy is "equivalent" with KA, in case of the (State-)System FFE.
When the three precursory critical points were reached, systemic KA (systemic) was generated and used to upgrade the order of the System, to ensure a next stationary state (RSP, with an upgraded order) was implemented, which allowed for (further) growth and development.
In each case, the entropy of the upgraded order was reduced, as well as the free energy in the (State-) System. When the final critical point was reached in 1939, and the final (4th) systemic KA was triggered (1939-1945), the core (The European State-System) made a transition from a state FFE to thermodynamic equilibrium, and consequently the entropy became maximum and the free energy minimum.
At that point (following the final step in the phase transition, 1939-1945, the Second World War), entropy-regulation in the core was no longer accomplished through the 1st FTS, but through homeostatic control (as I explain later, the 2nd exceptional period (1945-1989, the Cold War), caused a delay in reaching 'full' thermodynamic equilibrium (aggregation stage 3B) in the core): In case of the phase transition of the core of the System (the European State-System), there was a discontinuous change of entropy, from near zero (minimum) in 1939, to maximum entropy after the phase transition, and a discontinuous change of maximum free energy in 1939, to minimum free energy following the phase transition (albeit with a delay until 1989, caused by the 2nd exceptional period).
Because of the drastic and abrupt change in thermodynamic quantities, the phase transition of the core of the System qualifies as a first order - discontinuous - phase transition. In case of second order - continuous - phase transitions, the changes in thermodynamic quantities are not so drastic and abrupt (44).

17.10. Application (3): The dual nature of the phase transition (1480-1945)

This chapter was concerned with the effect of the phase transition on the core of the System; from an organized state FFE (1480) to thermodynamic equilibrium in 1945 (in fact in 1989, because of a delay caused by the 2nd exceptional period, the Cold War, 1945-1989). However, there was a second - other - closely related effect: The phase transition produced by the 1st FTS, was not only instrumental in achieving thermodynamic equilibrium - full aggregation stage 3A ('aggregation enabled') - in the core (Europe), but was also responsible for the expansion of the core to the non-core, and the 'merging' of core and non-core during the actual phase transition, during the 4th systemic KA/war (1939-1945, the Second World War).

The process of aggregation in the core and expansion to the non-core was regulated by the 1st FTS. The result of phase transition was a unified/homeostatic core, the merging of core and non-core, and upscaling of the System to a globalized System.

Analysis of war-data (1945-present) shows that the System is now producing a second - global - FTS, to eventually establish thermodynamic equilibrium - homeostatic - at a global level of the (State-)System, assuming the 2nd FTS is sustained, by sufficient entropy-production and KA.

18. Self-assembly

18.1. Introduction

In this chapter, I discuss self- or auto-assembly, a phenomenon that can also be observed in the System, albeit at a higher level of organization. The following subjects will be discussed: A definition and various aspects of self-assembly, its relevance for understanding the System, and possible applications.

18.2. Self-assembly

According to Fialkowski et al. self-assembly is "the process by which isolated components organize autonomously and spontaneously into ordered and/or functional structures" and is "nature's preferred way of building its animate creations on various length scales" (31). Fialkowski et al. study self-assembly above all at a molecular level, however arguably, the principles of self-assembly also apply to systems at a higher level of organization.

In addition to local interactions and EMIS-exchanges (in case of the System), "the assembling components may also be subject to various global (confining) potentials such as externally imposed electromagnetic fields or chemical gradients" (31). Processes in the System - including the emergence of the 1st FTS (in 1480) and its operation - can also be considered as processes of self-assembly, that also involve a global potential; the S/T-field and constraint.

Two major classes of self-assembly (SA exist: Static self-assembly (SSA) and dynamic self-assembly (DySA) (31). "The distinction between SSA and DySA refers to the thermodynamic description of the resulting assemblies, the former being equilibrium structures (in either global or local equilibrium) and the latter, stable nonequilibrium structures maintained in a steady state by a constant supply of energy, which is subsequently dissipated via the entropy producing (i.e., irreversible) processes associated with the interactions of the system's components" (31). In SSA, the ordered state forms - for example a crystal - as the system approaches equilibrium, and its free energy is reduced in the process.

Fialkowski et al. observe: "In real cells, tissues, and organisms, (*IP: and social systems, I argue*), self-assembly builds dynamic aggregates that change and function only if energy is delivered to them, either chemically or by external fields" (31).

The System, the State-System and states/societies also qualify as DySa-systems: The State-System for example, is a nonequilibrium system that is maintained in a dynamic steady state by a constant supply of energy (regulated by the FTS), which is subsequently dissipated through entropy-producing (that is irreversible) processes - including the processes of KA, aggregation, expansion and empowerment - that are related to and involve the interactions between the State-System's components (i.e. states and societies, etc.).

DySa processes "underlie many forms of adaptive and intelligent behaviors in natural systems" and "can be observed 'on a variety of suitable interactions/potentials on length scales from nanoscopic to macroscopic', in nonequilibrium systems" (31).
DySa can be understood from a combined thermodynamic and dynamical system perspective, and research is conducted to put DySA to practical use by programming "individual particles and let nature do the difficult rest rather than to position very small components (...) or modify tiny structures" (31).
In case of directed self-assembly, an external force is applied on a system "to change the potential landscape around elements in a system or change the elements itself to make it energetically favorable to self-assemble. This self-assembly might hold for as long as the force is applied in which case it is known as dissipative or reversible self-assembly. Another option is that the self-assembled system might find itself kinetically trapped in the new state. In either case the external force is the driving force of the self-assembly. This force can be a different force for different systems".
Various conditions impact on the process of DySa. "To form dynamic SA structures, one must drive the system away from equilibrium by supplying energy, which sets up and/or modifies the interactions of the building blocks with each other and with the environment". "These dynamic structures rely on a constant energy supply for survival and collapse ("die") when the flow of energy ceases (31). "The mode of organization (*IP: of the self-assembled system*) depends on the amount of energy delivered to the system" (31), as is also the case for the System, and the organized state that emerged through a bifurcation in 1480.
"In terms of fundamental thermodynamic characteristics, DySA structures belong to a broad class of nonequilibrium steady state systems" and "since the fundamental law of entropy maximization is not valid in the nonequilibrium regime, DySA systems can "reside" in low entropy states and are able to organize themselves into complex spatial or coherent spatio-temporal structures, which can be maintained only by dissipating energy into the environment and thus increasing its entropy" (31). "DySA structures represent a subset of a broader class of "dissipative" structures, in which the production of entropy directs the emergence of order" (31).

18.3. Relevance of self-assembly for (understanding) the System

As I already remarked, the System and its components qualify as a DySa system, and the knowledge of and experience with these systems at a nanoscale - where research is focused on - could also be useful to improve our understanding of the System, of war-dynamics and the process of social evolution. As England remarks, research results "imply a general thermodynamic mechanism for self-organization via dissipation of absorbed work that may be applicable in a broad class of driven many-body systems" (28). This study confirms this assumption.
The emergence and operation of the 1st FTS - the dissipative structure the System produced in 1480 - can be understood as an example of macroscopic DySa. The self-assembly of the European State-System, was accomplished by organizing energy- and entropy-flows in the System, and by organizing and sustaining EMIS-exchanges of the System with its environment, as is the case with microscopic systems discussed by Fialkowski et al. and England (28, 31).
The 1st FTS was the product of a DySa-dynamic, and the FTS was (thereafter) instrumental in regulating EMIS-flows, to ensure that its operation could be sustained.

As I explain later, as is the case for DySa-systems (dissipative structures) in general, the (State-)System had to process and put to use increasing amounts of energy and entropy to sustain the 1st FTS and ensure its coherence. The System and the processes it supported, became increasingly irreversible and consequently increasingly more energy had to be put to work on the FTS (28), and the successive RSP's (steady states).

18.4. Practical benefits of DySA

According to Fialkowski, DySA offers from an experimental and practical point of view "several unique advantages over static SA. Structures based on DySA can exhibit adaptive/smart behaviors, can be robust in the face of large perturbations, are capable of self-healing, and can potentially self-replicate" (31).

- *Adaptability*. "Like all self-assembling systems, structures based on DySA are 'smart', in the sense that they build themselves spontaneously from well-engineered components placed in an appropriate environment. DySA, however, has the added advantage of adaptability, e.g., the ability to respond to changes in the environment and to transition controllably between various modes of assembly. This adaptability is a direct result of the dynamic nature of DySA. In contrast to static assemblies, structures based on DySA live far from equilibrium and are continuously maintaining themselves" (31).
- *Self-healing*. "Closely related to the adaptability of DySA is its ability to self-heal. While structures created by DySA are surrounded in phase space by other basins of attraction, a perturbed ('wounded') system will return ('heal') to its stable configuration, provided that the perturbation does not bring it beyond the basin's limits. If the perturbation is so large that the system leaves its current basin, it will evolve to a different attractor and another mode of assembly. In other words, the system will heal small wounds and will adapt to large ones. We see that adaptability and self-healing are opposing characteristics: if one would like to prepare a structure that heals from arbitrarily large wounds, this structure should be globally attracting and thus not adaptable; vice versa, if one desired to have a system that can adapt easily to small parameter changes, it would be able to heal itself only from very small wounds" (31).
- *Self-replication*. "Structures based on DySA have the potential to self-replicate" (31).

18.5. Application (1): An informational perspective on self-assembly

Avery also discusses self-assembly and focuses on the informational aspects of these processes (6). Avery discusses the concept of "molecular complementarity" and explains that "biological molecules have physical shapes and patterns of excess charge which are recognized by complementary molecules because they fit together, just as a key fits the shape of a lock" and that "the language of molecular complementarity is the chief mechanism by which information is stored and transferred in biological systems" (6).

The "lock and key-metaphor", can also be used to better understand human and social dynamics, in which human and social complementarity are the chief mechanisms by which information is stored and transferred in social systems. Social auto-assembly requires a certain human and social complementarity.

During the transient period (1480-1945), through the 1st FTS, incomplementarities that hindered the process of aggregation were 'neutralized' or eradicated (i.e. with the help of KA).
Complementarity of social systems, (also) concerns the respective basic requirements of these systems, including values and interests, of social systems, and how complementarity contributes to increased survival chances and well-being, and also to (new) opportunities for self-realization. Social complementarity can be considered a mechanism by which information is created ("novelty by combination"), information is transferred and stored, and how - in other words - social order is created.
According to Avery, the mechanism for spontaneous molecular auto-assembly is "a random motion of the molecules through the solvent until they approach each other in such a way that a fit is formed. When two molecules fit closely together, with their physical contours matching, and with complementary patterns of excess charge also matching, the Gibbs free energy of the total system is minimized" (6). This is an example of SSA, as discussed in the previous paragraphs: SSA can take place when the change in Gibbs free energy caused by the (static) assembly is negative (is reduced) and the assembly process "takes place in such a direction that the entropy of the universe increases" increases, in accord with the Second Law of thermodynamics and related principles that apply FFE.

18.6. Application (2): The loss of force and the impact on the process of DySa in Europe

As mentioned in above text, "In case of directed self-assembly, an external force is applied on a system "to change the potential landscape around elements in a system or change the elements itself to make it energetically favorable to self-assemble. This self-assembly might hold for as long as the force is applied in which case it is known as dissipative or reversible self-assembly. Another option is that the self-assembled system might find itself kinetically trapped in the new state. In either case the external force is the driving force of the self-assembly. This force can be a different force for different systems".
In case of the System - the FTS - there is also an external force (related to the constraint and S/T-field of the System/FTS) involved, which impacts on the process of self-assembly. Through the 1st FTS, a dedicated - directed - force was applied on the European State-System (the core of the System), during the transient period (1480-1945). This force was instrumental in accomplishing a phase transition, and in a process of aggregation (stage 3A) in the core.
When the phase transition was accomplished in 1945, the System simultaneously globalized and a 2nd global FTS (1945-...) thereafter regulated (and still regulates) EMIS-flows in the global system. The 2nd (global) FTS, now applies a force at a global scale, that drives - must drive - the global State-System to thermodynamic equilibrium.
Since 1989, when the 2nd exceptional period, the cold War (1945-1991) came to an end, the global State-System produces chaotic non-systemic KA. Although Europe (the erstwhile core) had achieved aggregation stage 3A, during the transient period 1480-1945, full aggregation (stage 3B) is still not accomplished; the aggregated structures are not yet (?) institutionalized in an effective European Union. *The (now) global force, in combination with the chaotic non-systemic KA, tears the still vulnerable structures in Europe apart.* The fact that we are presently in the HCR of the 1st cycle of the 2nd FTS, also contributes the challenges in and of Europe and the European Union. Further fragmentation - disaggregation - of Europe seems unavoidable, and the process that took place during the transient period, suggests that a next critical period is probably required to reinforce the process of aggregation, not only at a global scale, but also in Europe.

Part V

Introduction

In Part IV, several new concepts were introduced, including the fundamental differences and behaviors of different thermodynamic states, bifurcations, dissipative structures, chaotic and periodic dynamics, phase transitions and self-assembly.
In this part, the focus is on the 1st FTS (1480-1945).

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19. (Sub)systems and domains

19.1. Introduction

In the previous chapters I have discussed various subjects, including: the laws of thermodynamics, entropy, general properties of living systems, the homeostatic imperative and the role of the state. Before elaborating on the thermodynamic - especially entropic - aspects of (the functioning of) societies and the (State-) System, I discuss in this chapter, some terminology related to the (State-)System, in this chapter. I also explain, the distinction that can be made between 'domains' in the (State-)System.

19.2. Subsystems and components

The System consist of interacting communities and societies, and of their interactions with their respective environments on which they also depend. State-structures represent and regulate societies in the State-System and System. Humans can be considered the 'elementary parts' of the System. The environment of the System is more than just physical and also contains a virtual 'component'. The System has a hierarchical structure as defined by Simon (77). The System is an open system.
The following subsystems and components can be distinguished in the System:

- *Individual humans* constitute the elementary parts of the System.
- *Communities* are collections of humans that serve certain purposes, like tribes and businesses.
- *Societies*, consisting of individual humans, groups, communities, etc.
- *States* (also referred to as state-structures): States are organizational structures that regulate societies and represent societies in the (State-)System; societies constitute the internal environment of states, while the State-System constitutes the external environment.
- *The State-System*: The State-System consists of a network of states. Interactions between states in the State-System, are regulated by formal and informal rules. During the transient period (1480-1945), the core of the System (Europe) constitutes the State-System, I also refer to as the European State-System. Although in 1898 and 1905 the United States and Japan acquired Great Power status (48), the non-core did not constitute a coherent (non-core) State-System (until after 1945) and was mainly controlled by European (core states). The State-System is the structural appearance of the FTS.
- *State/society-specific environments*: Each state/society has its own environment on which it depends; The society can be considered the internal environment of a state.
- *A shared (physical) environment*: All systems share a (physical) environment on which they depend (the 'climate' is part of the physical environment).

- *The System*: The System consists of interacting states and societies and of the environment on which they depend.
- *The core of the System*: During the transient period 1480-1945, Europe constituted the core of the System.
- *The non-core of the System*: During the transient period 1480-1945, the 'rest of the world' (non-European states, societies and communities) constituted the non-core of the System.

The System is a nonequilibrium System that is pushed and sustained FFE (by the FTS): Societies (states) are social systems (networks of communities) in local equilibrium in the otherwise nonequilibrium System. Social systems - the FTS, State-System as well as societies and communities - require EMIS-regulation, to ensure their viability.

The State-System can be considered a subsystem of the System. Sometimes, I use the term (State-)System when there is some ambivalence; for example, when it is not clear if an issue or property that is discussed applies to both. The use of the term 'State-System' always concerns the core of the System (Europe) if not stated otherwise.

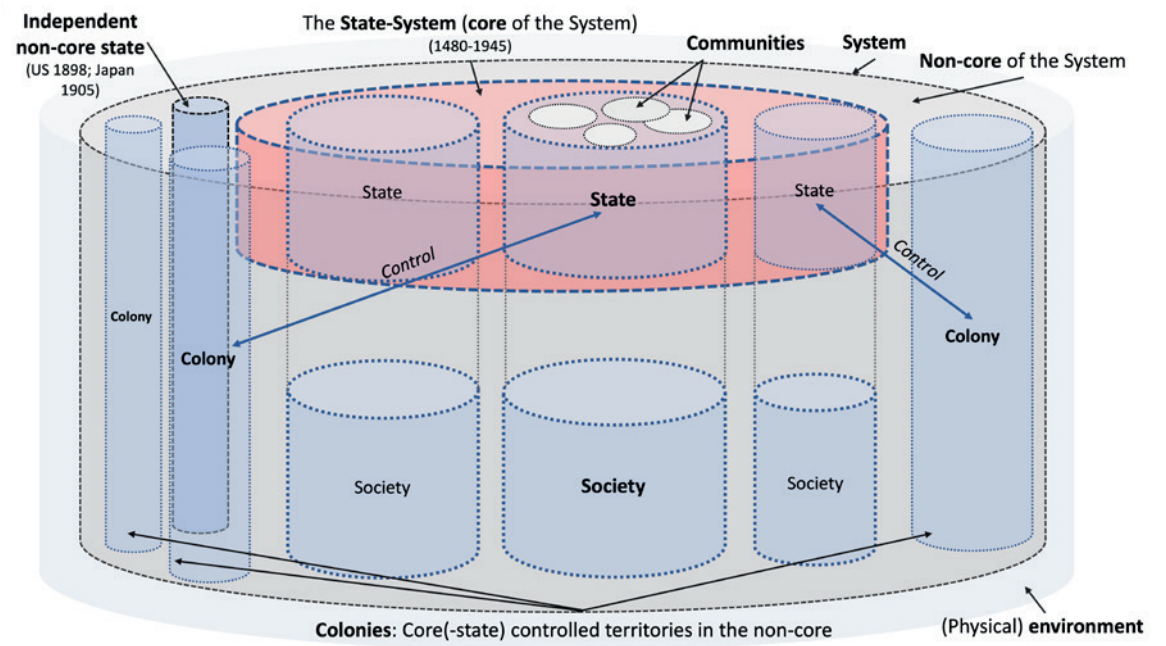


FIGURE 19.1: Anatomy of the System (1).

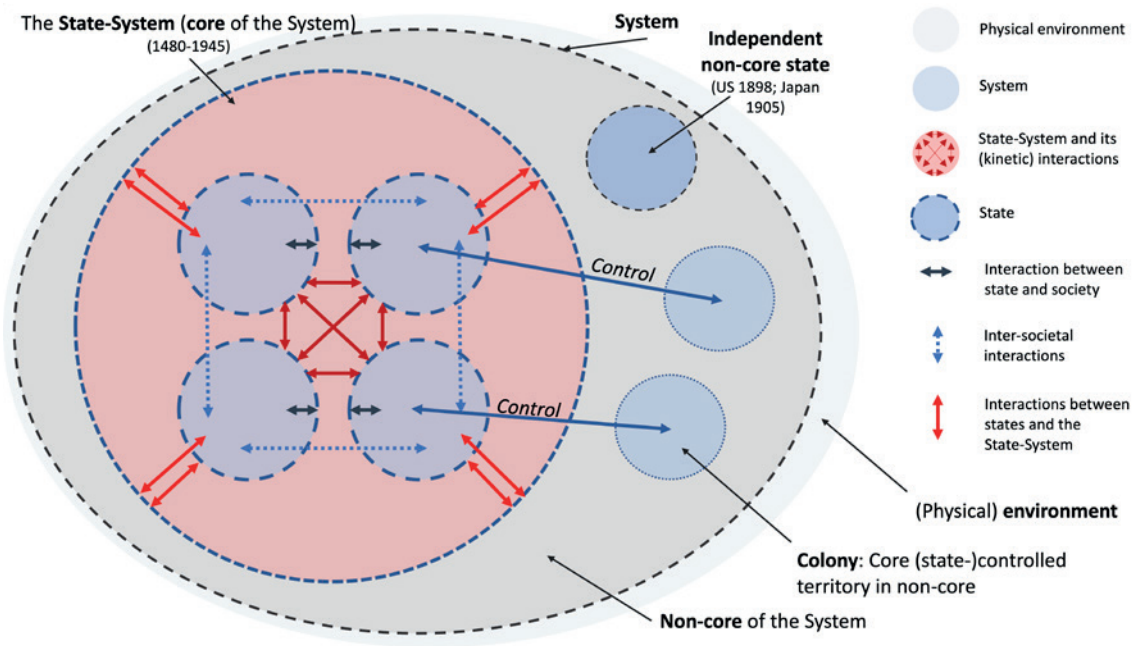


FIGURE 19.2: Anatomy of the System (2).

19.3. Domains

In this study, I make an (analytical) distinction between the so-called deterministic and contingent domains. The deterministic domain consists of the 'body' of laws of physics and nature. The contingent domain is the 'real world' as we know it; there is an interplay between the contingent and deterministic domains: The contingent domain is also subject to laws of physics, for example.

From a somewhat different perspective, it is also possible to make a distinction between a physical and an abstract domain. Information is the main source - content - of the abstract domain (although it has physical properties): Humans have developed the ability through communication and learning to collectively 'model' the presence, past and future in abstract terms. The mental constructs are the building blocks of social orders. Humans and social systems have the potential to shape their environment and to create their own reality, at an individual as well as collective level. These abstract and their physical representations need constant interaction and communication between humans to be sustained (6).

The physical domain is the domain of energy and matter, and of their exchanges and transformations.

The distinction between domains is often somewhat 'blurred', for example energy also contains information. Furthermore, each bit of information equivalent with a certain (very specific) amount of energy; a lack of information can be understood as entropy (disorder), entropy is a physical property accurately defined in the deterministic domain (i.e. in terms of degraded energy).

While thermodynamic information is a very specific (physical) property, cybernetic information can be freely (re)combined in new ideas and concepts in the abstract domain. The practicality and feasibility of these new ideas in the physical domain are another matter[1].

It is also important to note that physical structures in the contingent domain - the real world - always have an abstract 'counterpart': All physical exchanges and (inter)actions by humans and social systems - including the application of military capabilities (kinetic energy) - also involve the exchange of information. Norms and values underpin societies and communities, but they (often) also have physical appearances.

What seems to characterize the human species, is its ability to decouple information from the physical domain (energy and matter, and also from the here and now), to process and exchange (communicate) information, and 'recouple' information (ideas) to the physical domain. Through the human species, entropy- and information manipulation have reached a new level. I discuss the decoupling of information - and the availability of an 'autonomous' abstract domain - at a later point in more detail.

Another domain relevant for this study is the cyber domain, sometimes referred to as cyber space. The cyber domain is part of the abstract domain. The word 'cyber' has become closely related to information, information and computer technology and their applications, and communication (the exchange of information). In the cyber domain, communication (information exchange) occurs over computer networks. In case of cyber warfare, the cyber domain is put to use to influence users and to exploit computer and information networks to perform acts sabotage and cause physical destruction in support of political and military objectives.

19.4. Contingent latitude

The question now is: Where do humans and social systems reside, in relation to the various domains? As I mentioned, humans and social systems - including societies and the System, etc. - operate in the contingent domain. The contingent domain has a deterministic component: Laws of physics also apply to social dynamics, however (a subject to be discussed later) laws of physics - and physical phenomena - are also probabilistic in nature and leave room for chance.

Although, the deterministic domain imposes constraints on the contingent domain, the laws of physics do not (noticeable) impact on all social dynamics.

How the laws of physics (including the laws of thermodynamics) manifest themselves in the contingent domain is another matter: We are (mostly) used to and fully conditioned to these laws, and are able to put them to use; after all, we are products of these laws, and the processes of biological evolution - and also social evolution, I argue - are determined and shaped by these laws.

1. Miller (53) makes a distinction between conceptual, concrete and abstracted systems. A concrete system "is a nonrandom accumulation of matter-energy, in a region in physical space-time, which is organized into interacting interrelated subsystems or components". The deterministic domain is concerned with the 'concrete' manifestation of the System, "in a region in physical space-time, which is organized into interacting interrelated subsystems or components". According to Miller: "Relationships in concrete systems are of various sorts, including spatial, temporal, spatiotemporal, and causal." And: "The state of a concrete system at a given moment is its structure. It is represented by the set of values on some scale which its variables have at that instant. This state always changes over time slowly or rapidly" (53).

We mostly take for granted - and we can take for granted - the fact that laws of physics govern our existence. However, the fact that we are products of these laws also seems to hinder us to recognize their presence and effects. In case of for example the war dynamics of the System - an example of laws of physics in action - physical laws are just taken for granted, and until now, there existence and impact are not yet fully recognized and understood.
The contingent domain not only has a deterministic component, but also includes the abstract domain; the abstract domain is 'man-made'.
Because the contingent domain is not entirely subject to the laws of physics, the laws of physics leave also room for chance, and because cybernetic information can be freely (re-)combined, humans and social systems have a certain contingent latitude; that is, a certain latitude to determine - without causing conflicts with constraints - to make choices. Entropy - new possibilities - is the source of contingent latitude. The 'amount' of contingent latitude - entropy we can effectively put to use - determines the degrees of freedom of humans and social systems.

19.5. Interaction between domains

There is extensive interaction between domains; domains are fully 'integrated', the distinction between domains serves above all analytical purposes.
For example, in the abstract domain information used is by humans and social systems to (collectively) 'construct' ideas, concepts, ideologies and doctrines, etc. that underpin social orders, and are used as blueprints to shape the physical and contingent domains, within the contingent latitude that is available. The use of information (in the abstract domain) is not constrained by laws of physics like energy and matter.
Abstract orders (ideologies, etc.) are not only constructed to serve as blueprints and as guidance, but also as justifications for (inter)actions with other humans and social systems.
Information can be communicated over long distances; ideas and ideologies etc. can serve as 'attractors' for humans and social systems; they serve as a source of inspiration and have a certain action potential.

19.6. Application (1): Dominance of the deterministic domain

Some observations regarding the interplay between domains: During the transient period (1480-1945), the (State-)System produced accelerating amounts of entropy, and consequently generated increasingly intense kinetic responses. This dynamic - dictated by the Second Law of thermodynamics ('in' the deterministic domain) - eventually (and very predictably) - resulted in the collapse of the core in 1939.
During the transient period, the State-System (its structure) itself was pushed toward zero entropy (a state it reached in 1939), and all variety was pushed out of the State-System. Consequently, the contingent latitude in the State-System was reduced to (near) zero and the constraints were "absolute" at that point: Zero entropy is equivalent with maximum constraints and zero contingent latitude.
In 1939, the System generated a massive kinetic response (the 4th systemic war, 1939-1945, the Second World War) to the entropy that was produced at an 'infinite' rate: The 1st FTS consequently 'demanded' systemic KA at an infinite frequency and with an infinite intensity.

The collapse of the core of the System (Europe) in 1939, triggered the actual phase transition of the (State-) System, with two effects: Thermodynamic equilibrium (full aggregation, stage 3A) was accomplished in the core (albeit with a delay until 1989), and the State-System globalized, and a first global order (the United Nations) was established. In the core, EMIS-regulation by the 1st FTS was replaced by homeostasis. However, the political motives that triggered the 4th systemic war (The Second World War, 1939-1945), the political ideologies and other justifications that were formulated, how this systemic war was fought (with what technology, strategies, etc.), and what political order eventually was imposed (the United Nations order), etc. were of no concern for the deterministic domain. 'Every' European order - be it fascist, communist or based on democratic governance - would do, as long as the demands of the deterministic domain (the laws of physics) were obeyed. The 'choice' of the (political) order is up to the contingent domain.

When we try to explain war(s), we always ignore the impact of the deterministic domain, of the laws that actually generate the KA, in response to entropy(-production). We were not aware of the existence of the 1st FTS - a dissipative structure - that emerged in 1480 in response to increasing instability of the System. The FTS regulates EMIS-flows in accordance with thermodynamic laws and principles that apply to systems FFE. KA is generated - energy is put to use - to regulate entropy-production and to utilize new possibilities that present themselves through a multitude of irreversible processes in the System. KA, the use of kinetic energy in the deterministic domain, is equivalent with war - the use of military capabilities - in the contingent domain.

Although, we are aware of the existence of energy and its purpose - work requires energy - entropy and its effects are ignored. We are not aware that tensions, uncertainty, variety, disorder, etc. are manifestations of entropy, that entropy is a physical property, and that the System - in accordance with thermodynamic laws and related principles that apply FFE - responds to entropy accumulation and production with KA.

War is not what it seems: As will be discussed later, the timing, duration, size, location of kinetic activity (wars) are determined by the FTS (the laws that apply to the System and its dynamics), and not by social dynamics/issues between societies/states. The four highly deterministic and regular war-cycles that accompanied the 1st FTS, were imposed on the System and its components (societies and states): Dynamics in the contingent domain - the 'real world' - are determined and shaped by the deterministic domain.

19.7. Application (2): Imposition of a deterministic template

Laws of physics to a high degree determine and shape contingent - real world - dynamics in the System. Social and political developments - historical processes - are a function of laws of physics and contingent latitude. The 1st FTS regulated entropy(-production) in the System through KA and through the processes of aggregation, expansion and empowerment. The entropy - variety, disorder, new possibilities, tensions - was input for social innovation (evolution) and political processes in the contingent domain.

The 1st FTS followed a very regular and predictable - the most efficient - path to thermodynamic equilibrium in the core. This path provided a 'template' for social and political dynamics in the contingent domain. Through the FTS - and through the interplay between domains - dynamics and developments in the physical and contingent domains became 'locked' and synchronized. The 1st FTS set the pace and direction for social and political dynamics and developments in the contingent domain. Societies/states

had to respond to the accelerating frequency of systemic KA, that was imposed by the 1st FTS: All four systemic KA/wars were accurately timed, and their magnitudes (in terms of BCD) were predetermined; social and political dynamics had to 'fit' - to match - the dynamic template the FTS imposed.

19.8. Application (3): Different types of regulation

Two (main) types of EMIS-regulation can be distinguished in the (State-)System: Homeostatic- and FTS-regulation. In case of homeostatic regulation an intricate set of negative feedbacks - goal seeking behavior - dominates the dynamics of the social system, as is for example the case for societies. Through homeostatic control, certain key-variables of the social system are maintained within certain ranges, to ensure its (efficient) operation.
In case of FTS-regulation, a dissipative structure - and positive (self-reinforcing) loops - dominate a system's behavior, as is the case for the State-System; in case of the State-System, the dissipative structure (the FTS) drives a process of accelerating entropy- (and consequently KA-) production; because accelerating growth is unsustainable, collapse is unavoidable, and a matter of time. During the transient period (1480-1945), the System coped with this acceleration through the processes of aggregation, expansion and empowerment.
From a thermodynamic perspective, the function of a dissipative structure is to 'eradicate' a gradient as efficient as possible, and by doing so, to restore (thermodynamic) equilibrium. In case of the 1st FTS, the dissipative structure was able to power itself (through self-reinforcement), during the transient period (1480-1945), and by intensifying and accelerating its operation, it could eventually establish thermodynamic equilibrium in the core.

19.9. Application (4): The European State-System was carved out by the 1st FTS

EMIS-flows in the (State-)System were regulated by the 1st FTS (1480-1945), a highly optimized dissipative structure that ensured the most efficient path of the (European) State-System to thermodynamic equilibrium. The 1st FTS produced four accelerating war-cycles; each cycle consisting of a RSP, followed by a critical period (systemic KA/war) when the order of the System was upgraded.
Two layers of dynamics can be distinguished: R1- and R2 dynamics (as I explain later), respectively chaotic non-systemic KA during RSP's and four periodic fluctuations (systemic KA) generated in response to accumulated entropy in the (State-)System.
A close relationship exists between the KA generated and regulated by the 1st FTS and the processes of aggregation, expansion and empowerment. These processes 'defined' and configured also the structure of the State-System, not only from an organizational perspective, but also in a physical sense: Each state controlled (and still controls) a society and a well-defined territory.
The configuration of the State-System is also about EMIS-regulation. The State-System was carved out by the 1st FTS: The physical configuration of the State-System was determined and shaped by the processes generated by the 1st FTS; the spatial regularities (the physical aspect of the State-System) reflect the operation of the 1st FTS. The 1st FTS and the configuration of the State-System are highly optimized by laws of thermodynamics and related principles that apply FFE. During the transient period (1480-1945),

the State-System was continuously reconfigured to optimize EMIS-regulation. The size distribution of states in the State-System can be best described by a power law (50). That is no coincidence, but a reflection of the highly optimized operation of the 1st FTS and State-System.

19.10. Application (5): What is the international order?

In international relations theory, the international order is concerned with (global) issues among states within the international system. The current international order is the United Nations order (1945-....). The purposes of the United Nations are:

- To maintain international peace and security, and to that end: to take effective collective measures for the prevention and removal of threats to the peace, and for the suppression of acts of aggression or other breaches of the peace, and to bring about by peaceful means, and in conformity with the principles of justice and international law, adjustment or settlement of international disputes or situations which might lead to a breach of the peace;
- To develop friendly relations among nations based on respect for the principle of equal rights and self-determination of peoples, and to take other appropriate measures to strengthen universal peace;
- To achieve international co-operation in solving international problems of an economic, social, cultural, or humanitarian character, and in promoting and encouraging respect for human rights and for fundamental freedoms for all without distinction as to race, sex, language, or religion; and
- To be a center for harmonizing the actions of nations in the attainment of these common ends (Charter of the United Nations).

The Organization is based on the principle of the sovereign equality of all its members and membership is open to peace-loving states (Source: Charter of the United Nations).
In fact, the international order is concerned with - what could be named - the public domain of the State-System; it is a highly demarcated and well-defined 'domain'.
I consider the international order, a too limited perspective, that has no relationship with the actual structure and dynamics of the (State-)System.
However, I use the term order in this study, order 'is' much more than 'international order: The order of the System refers to the System's organization, not only its (organizational structure), but for example also to the rules that apply.

19.11. Application (6): A close relationship exists between the FTS and developments in the abstract domain

During the transient period (1480-1945), the 1st FTS can be considered the 'engine' of the (State-)System, that generated and regulated KA and the processes of aggregation, expansion and empowerment. The 1st FTS was powered by population growth and by the (just mentioned) self-reinforcing processes it generated. The 1st FTS can be considered an accelerating treadmill - a succession of accelerating war-cycles - toward thermodynamic equilibrium of the core. The 1st FTS consisted of a deterministic, physical, abstract and contingent domain, and possessed a certain contingent latitude. The 1st FTS generated

accelerating processes of development and (social) evolution in the contingent domains, which also - directly or indirectly - involved all the other domains. The processes of aggregation, expansion and empowerment also impacted on developments in the abstract domain (and vice versa) that had to be synchronized with developments in the other domains.
The processes and developments that marked the emergence of modern science - like the scientific revolution and the Enlightenment - were spin-offs (integral components) of the 1st FTS, and vice versa. The acceleration of science and cultural innovations (including social and political innovations) are closely related to - and enablers of - the acceleration of the 1st FTS and accompanying war-cycles, during the transient period, 1480-1945.

19.12. Application (7): Mode-coupling in the contingent domain

In this paragraph, I discuss mode-coupling in the contingent domain of the System.
Besides the exchange of energy and matter, mode-coupling involves also the exchange of information between 'localized' issues and a collective dimension (the constraint) at system-level. Mode-coupling in the deterministic domain of the System, also has its 'equivalent' in the contingent domain of the System; these two perspectives are complimentary and in fact constitute a single and unified mechanism.
Mode-coupling in the System - the phenomenon that localized issues acquired a collective dimension - emerged in the 14th and the 15th century. In the second half of the 15th century, it became common practice in Europe to send diplomatic representatives - ambassadors - to other states in Europe, in order to improve (more regular) communication and coordination between states. This communication structure contributed to the establishment of mode-coupling.
Also, at about the same time, interests of states - and the competition between these interests - became increasingly entangled and organized through arranged marriages and relationships between those in power. Through arranged marriages interests of states were secured and enhanced, however, these arrangements also contributed to rivalries and competition in Europe.
These developments not only contributed to the connectedness of Europe (the core of the System), but also to the process of aggregation and expansion.
I assume that during the 14th and 15th centuries, the network of relations and interactions between communities and states in Europe, increasingly acquired small-world network characteristics, and that a relationship emerged between the small-world network properties of the System, an emerging collective dimension that could serve as a constraint, mode-coupling, and the emergence of the 1st FTS in 1480 through a bifurcation.

20. The entropy/tension-field

20.1. Introduction

In the preceding chapters, I have introduced various terms and concepts, including: Constraint(s), gradients, VC's and the S/T-field.
In this chapter, I explain the significance of the S/T-field and the relationship between various terms and concepts; there is a certain overlap between these concepts. That should not come as a surprise: These concepts originate in different scientific disciplines, but concern (more or less) the same phenomena.
These different - but often also complementary - perspectives, can cause some confusion. In this chapter I discuss these different - but complimentary - perspectives and define the entropy-tension-field (S/T-field).

20.2. Different perspectives

In the previous chapters, the following concepts and terminology were introduced; they are related to the (concept of) S/T-field. See table 20.1.

20.3. The entropy-/tension-Field (S/T-field)

Based on these different concepts and ideas, I introduce the concept of the entropy/tension-field, the S/T-field, of the (State-)System.
The reasoning is as follows: Social processes and interactions - all natural processes - are irreversible processes that generate entropy. Tensions in the System constitute (social) entropy, as explained in e.g. chapters 2.
In 1480, through a bifurcation, the (State-)System generated an organized state FFE, the 1st FTS. The FTS regulated EMIS-flows, including entropy(-production). The entropy/tension-field (S/T-field) is an integral component of the FTS.
The S/T-field is a manifestation of the constraint (collective dimension) of the System, works/functions as a gradient, is instrumental in maintaining the carrying capacity of the System - by driving/powering the FTS - and contains networks of VC's. The S/T-field has a certain capacity to sustain the operation of the FTS. The S/T-field contains a certain amount of entropy (tensions) and has a certain configuration. The S/T-field is a dynamical non-homogeneous field.

TABLE 20.1: Different- but related - concepts.

Concept	Perspective	Definition	Function/role
Constraint	Thermodynamics perspective	A constraint (at macroscopic/ System level) sets (physical, thermodynamic) limits that impact on the System's dynamics and drives the EMIS-flows required to generate and sustain dissipative structures. Not only drives the constraint the FTS, it also stabilizes the FTS.	The constraint of the System can be considered a collective dimension, that interacts with the (State-)System and its components. Mode-coupling is required for the constraint, to function. The macroscopic coherent behavior of the System (FTS), is produced by the interplay between short-range ('local') interactions and long-range correlations related to the constraint. The scarcity of resources - and the competition and (perceived) threats this generates - contribute to the constraint of the System.
Gradient	Thermodynamics perspective	The strength of a (local) gradient is determined by the inhomogeneity - the 'local' slope - of a field. A gradient is a function of multiple variables. The strength of a gradient determines the force that is (locally) applied.	The gradient determines the force that is applied, and the flows and momentum that are (consequently) generated. During the transient period (1480-1945), the distance from equilibrium - the gradient - of the State-System increased, and consequently the EMIS-flows that were generated and the force that was applied on the core (Europe).
Carrying capacity	Ecological perspective	Carrying capacity in ecology is defined as the number or weight of animals of a single or mixed population that can be supported permanently on a given area (J2). The carrying capacity can be defined as the maximum 'size' of the population, that can be supported by the (State-) System in terms of basic requirements and well-being.	The concept of carrying capacity points to the limitations of the FTS: The FTS requires inputs and exchanges with its environment to sustain its operation.
Vulnerable clusters (VC's)	Network perspective	VC's are networks of issues, accompanying tensions (entropy) and their relationships. States and societies are parts (nodes) of these networks. These networks have a certain topology and generate certain dynamics.	A distinction can be made between the dynamics *of* the network (e.g. in terms of nodes and their relationships) and the dynamics *on* the network of VC's: e.g. KA. The connectedness of the network of VC's and the (decision) thresholds states apply to the use of KA (war) in response to issues, determine the dynamics on the network of VC's (KA/war dynamics). Increasing connectedness (interdependencies) of societies/states and VC's reinforce the constraint and collective dimension. Solutions to non-systemic KA (during RSP's) and 'innovations' are embedded in the network of VC's. The VC's constitute a gateway to the next systemic KA/war, and to the next (upgraded) order.
Phase (or solution) space	Dynamical systems perspective	Phase space is a 'space' defined by a set of parameters, in which all possible states of a system are represented.	Phase space contains a number of microstates, states of the System that are possible within a certain space - a certain set - of parameters. The number of possible microstates determines the solutions that are available to the System. During the transient period (1480-1945), phase space of the System shrunk to near zero, when in 1939, the core reached near zero-entropy, and consequently collapsed.

20.4. The working of the S/T-field and constraint

As explained, entropy is contained in the S/T-field, and the field is an integral component of the (State-) System and FTS.
The S/T-field works as a nonequilibrium constraint and ensures that the (State-)System is maintained in a nonequilibrium state. The S/T-field powers - so to speak - the FTS and ensures that the coherent long-range order is maintained. The S/T-field also generates (kinetic) energy fluxes (flows and forces).
The S/T-field requires the (constant) input of entropy. As I mentioned, the influx of entropy (in the field) is ensured through the entropy produced by irreversible processes in the (State-)System and is regulated by the FTS. Population growth and increasing connectedness of societies and states (resulting in rivalries) are the main sources of entropy influx in the S/T-field.
Through the S/T-field - mediated by the FTS - a continuous force is applied on the State-System; this force generated the momentum - accelerating war-cycles - of the 1st FTS.
The entropy/tension field can - at least in some respects - be compared to the atmosphere with its constant fluxes and dynamics, or as is shown in below figure, with the tangled magnetic field of the Sun.

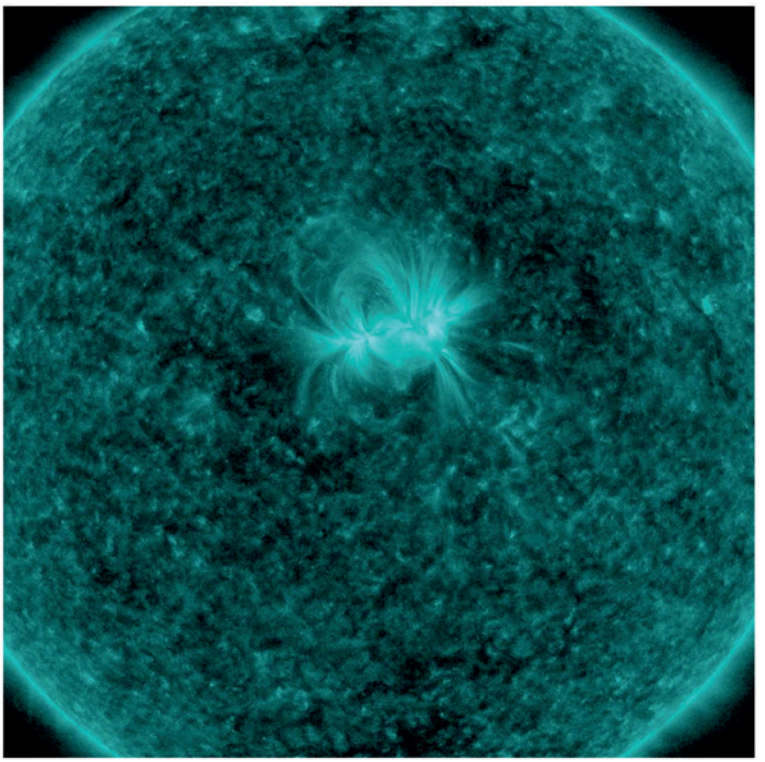


FIGURE 20.1: Interaction between local perturbations and a field. Other systems can also contain a field. This figure shows local activity of the magnetic field that envelops the sun: a "lone active region visible on our Sun put on a fine display with its tangled magnetic field lines swaying and twisting above it when viewed in a wavelength of extreme ultraviolet light. The charged particles spinning along these field lines illuminate them. The region did not erupt with any significant solar storms, although it still might." (Source: NASA/GSFC/Solar Dynamics Observatory).

The 'tangled magnetic field' and its dynamics (see above figure), can be considered (at least in some respects) a depiction of the dynamics of the tangled S/T-field when entropy of various sources is attracted to an entropic perturbation. The moment a certain threshold value is reached, a non-systemic kinetic response will follow. This response itself will generate entropy and attract (even) more entropy. As long as this self-reinforcing dynamic - which includes influx from the S/T-field and the kinetic response - is sustained the non-systemic KA it powers and sustains (the non-systemic war) will not stop.

20.5. Properties of the S/T-field

Some properties of the S/T-field include:

- *The S/T-field works as a constraint*. The constraint - the S/T-field - ensures that the (State-)System is maintained in a nonequilibrium state.
- *The S/T-field is an integral component of the FTS*. The 1st FTS - a dissipative structure that emerged through a bifurcation in 1480 - was responsible for EMIS-regulation of the (State-)System, during the transient period (1480-1945), including the regulation of entropy influxes to the S/T-field, and the generation of systemic and non-systemic kinetic responses, respectively in response to the accumulation of entropy and entropic-perturbations during RSP's.
- *The S/T-field can be considered a manifestation of the collective dimension of the System*. During the transient period, the connectedness and interdependence of/in the (State-)System increased and consequently, the collective dimension became increasingly strong: Through the mediation of the S/T-field the collective dimension impacted on (individual) behavior of actors, and at the same time these actors - through their interactions - contributed to the strengthening of the collective dimension and S/T-field. As Allen observes (4): "(...) a self-organizing system takes into account the collective dimension of individual actions" and this "emphasizes the possibility that individuals acting according to their own particular criteria may find that the resulting collective vector may sweep them in an entirely unexpected direction, involving perhaps qualitative changes in the state of the system". "In a nonlinear system the whole is not given trivially by the sum of the parts" (4).
- *The S/T-field has a (local) gradient*. The S/T-field is a non-homogeneous dynamical field, with a certain 'overall' gradient. However, the gradient differs locally. The S/T-field has a certain configuration (contained in the network of VC's). The strength of a (local) gradient is determined by the inhomogeneity - the 'local' slope - of the S/T-field. The gradient is a function of multiple variables. The strength of the gradient determines the force that is (locally) applied to the System by the S/T-field. Provided that an energy difference (a gradient) exists (e.g. in case of the State-System, differences in kinetic potential (military capabilities) of states), then useful work can occur (20). See figure 20.2.
- *The (overall) gradient of the S/T-field is indicative for the distance from equilibrium of the System*. During the transient period (1480-1945), the (State-)System was maintained in a non-equilibrium state FFE through the 1st FTS. During the transient period, the KA/war-cycles the 1st FTS produced, continuously accelerated. During the transient period, the distance from equilibrium and consequently the gradient and force applied on the (State-)System also continuously increased.
- *The S/T-field generates a force and momentum in/on the (State-)System*. The gradients of the S/T-field generate flows and forces.

- *Vulnerable clusters are embedded in the S/T-field*. Vulnerable clusters are embedded in the S/T-field and determine the configuration of the S/T-field, including the strength of the overall and local gradients. VC's contain (stored) information.
- *Entropy is stored in the S/T-field*. Entropy - and information - is stored in the VC-clusters contained in the S/T-field; the capacity of entropy storage is a function of the connectedness of VC's and the System. Once the tipping point of RSP's is reached, the entropy storage capacity of the System increases temporarily through the network-effect, until the critical point of the RSP is reached and the existing order collapses.

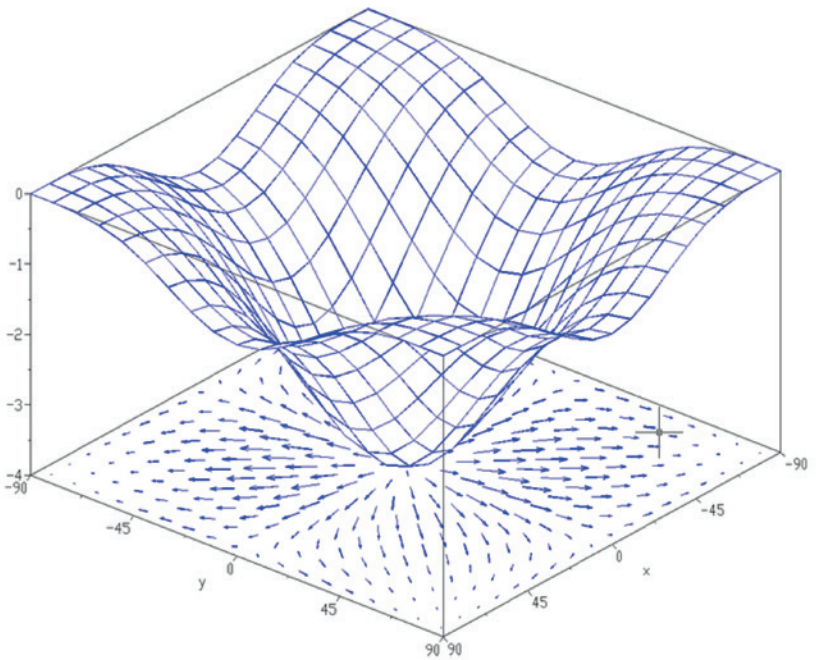


FIGURE 20.2: The gradient of the S/T-field projected as a vector-field. This figure can be considered the depiction of a specific segment of the S/T-field. The gradient is projected as a vector field on the bottom plane (96). The S/T-field can be projected as a two dimensional vector-field. Each vector in this vector-field points in the direction of the greatest rate of increase of the entropy-function, while the slope of the graph represents the magnitude of the function at that point in the S/T-field.

20.6. Systemic and non-systemic KA are kinetic responses regulated by the FTS

Although an entropic perturbation in the System - an issue between states for example - is (initially) localized, the KA that is generated - systemic as well as non-systemic - is a system-response, under control of - regulated by - the FTS. Entropic perturbations - issues - are selected, so to speak; a process that involves the FTS, and a combination of probabilistic and deterministic factors.

The total entropy and energy produced and used in an entropic perturbation (issue) consists of a combination of locally generated entropy and the entropy contained in - and 'sucked in' - from the S/T-field. The FTS regulates the amount of entropy that is contributed to a local entropic perturbation by the S/T-field, as well as the 'size' of the kinetic response that is generated, in accordance with the Second Law and related principles that apply FFE. Although, the immediate effects of KA - of non-systemic wars in the contingent domain - are local, non-systemic KA is a demonstration of system-behavior, regulated and controlled by the FTS.

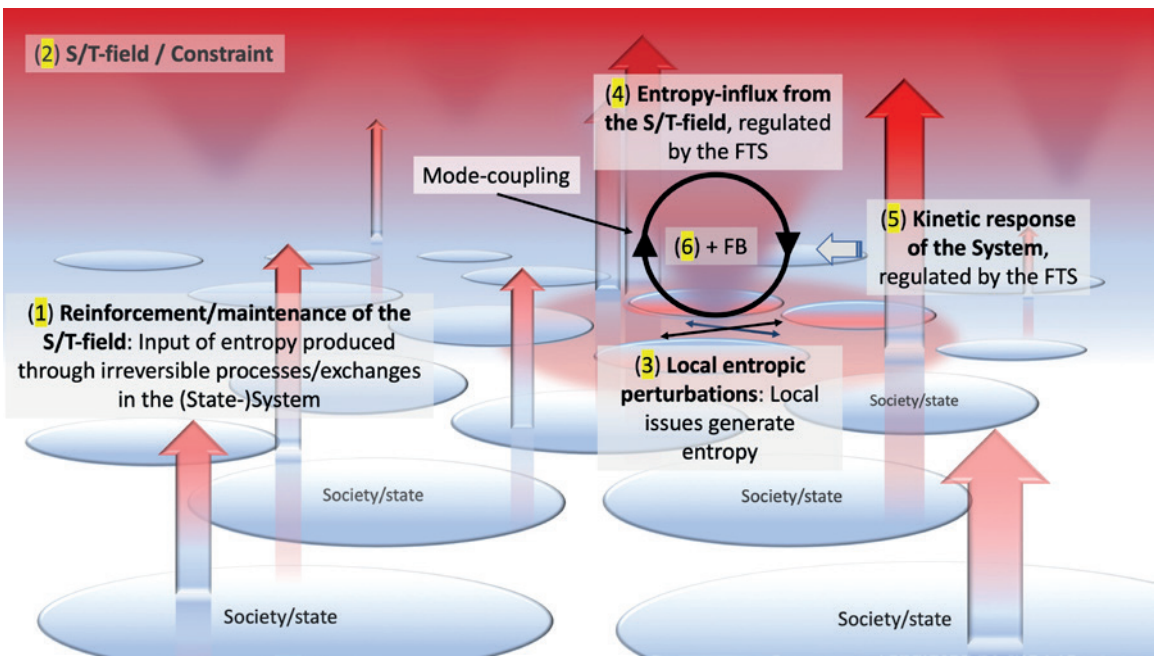


FIGURE 20.3: Interaction between issues and the S/T-field. The S/T-field is an integral component of the FTS. Although many - most - entropic perturbations in the (State-)System (issues in the contingent domain) stay isolated, are not amplified and just fade away, some entropic perturbations - selected through a combination of probabilistic and deterministic factors (a combination of chance and constraint) - are amplified and start interacting with the S/T-field. Consequently, these perturbations/issues are amplified (escalate) and become subject to further FTS-regulation; the FTS ensures compliance with the Second Law and related principles that apply FFE. These issues are part of the process of KA and are 'selected' with the help of the FTS. Through this process and the KA that is generated, the (State-)System - and the FTS - are able to maintain their coherence and operation. Although, the issue - the war that follows - does not (always) have the intended effect/ result in the contingent domain of the (State-)System - the Vietnam War is a good example - the KA always serves a 'constructive' role in the (State-)System, from a thermodynamic perspective.

Above figure, is a schematic depiction of the S/T-field and its interactions with entropic perturbations: (1) Through regular (irreversible) interactions between components/parts entropy is continuously produced in the System; (2) This entropy feeds the S/T-field; (3) Entropic perturbations - inhomogeneities - always occur, and local perturbations contribute to (further) entropy-production; (4) Through a combination of probabilistic and deterministic factors, certain perturbations (issues) are selected, and an interplay - through the mechanism of mode-coupling - starts between the (initially) local perturbation/ issue and the S/T-field; (5) Through the S/T-field, an influx of entropy (4) and kinetic energy/KA is generated, causing further amplification (escalation). The process is regulated by the FTS, although the entropic perturbation and KA are (and stay) localized (in case of non-systemic KA/wars), the response qualifies as a system-response, that serves the FTS and the coherence of the (State-)System. The deterministic domain - the laws of physics - is indifferent what results the issue produces in the contingent domain (from a social and political point of view). For a certain time, the 'local perturbation (issue) and the S/T-field reinforce each other (6), when a solution is found, KA dies out, and the solution is embedded in the network of VC's.

20.7. Application (1): 'Calculation' of the force that was applied by the FTS, and the momentum that was generated

During the transient period (1480-1945), an increasingly strong force was applied on the (State-)System, involving the S/T-field; the force was mediated by the 1st FTS. This force generated the momentum of the (State-)system toward thermodynamic equilibrium, of which the accelerating KA/war-cycles that accompanied the 1st FTS, are indicative.

The concepts of force and momentum as defined in physics, can also be applied to the (State-)System. In physics force is defined as any interaction that can change the motion of an object and causes an object with mass to change its velocity (to accelerate/decelerate). A force is the product of mass and acceleration: $\boldsymbol{F} = \boldsymbol{m}$; momentum ($\boldsymbol{p}$) is defined as the product of mass and velocity: $\boldsymbol{p} = \boldsymbol{mv}$.

The (State-)System also has a physical mass (population, flows of matter, etc.), and a physical configuration. During the transient period (1480-1945), processes in the System accelerated, including the System's KA/war dynamics: Accelerating amounts of KA were applied during successive cycles. The flows accelerated and (thus) the related forces.

The acceleration of the 1st FTS can be attributed to a force that was applied through the S/T-field; the momentum of the (State-)System also accelerated. Both the force applied to the (State-)System and the momentum generated by the FTS can be 'calculated'.

The acceleration of the 1st FTS can be calculated by using the shortening of war-cycles the 1st FTS produced (actual: 153, 167, 103 and 27 years, and corrected: 168, 154, 103 and 22.5 years, see also 59). During successive cycles, the 1st FTS covered - so to speak - the same 'distance', but in a shorter time span. The 1st FTS pushed the State-System toward thermodynamic equilibrium by applying an increasingly strong force; and the (State-)System consequently gathered momentum (while its mass increased through (exponential) population growth).

In 1939, the (State-)System produced infinite flows of entropy, and the force the 1st FTS applied to the State-System, caused its collapse.

20.8. Application (2): Loss of force and momentum to accomplish full aggregation in Europe

The force and momentum generated by the 1st FTS were instrumental in the process of aggregation in/of the European (State-)System, during the transient period (1480-1945): The aggregation that was accomplished during the transient period (1480-1945) - from circa 300 loosely connected communities with a total population (in Europe) of 83 million in 1480, to a tightly coupled network of circa 25 societies/states with a total population of 544 million in 1939 - was accomplished by the increasing force that was applied and the momentum that was generated.

In 1939, the European State-System (the core) and the 1st FTS collapsed, and during the 4th systemic war (1939-1945, the Second World War) the final step was made in the phase transition, with two complementary effects: (1) The final step was made to full aggregation stage 3A ('aggregation enabled') and (2) the (State-)System simultaneously globalized (core and non-core 'merged'), and a 1st global order was established (the United Nations).

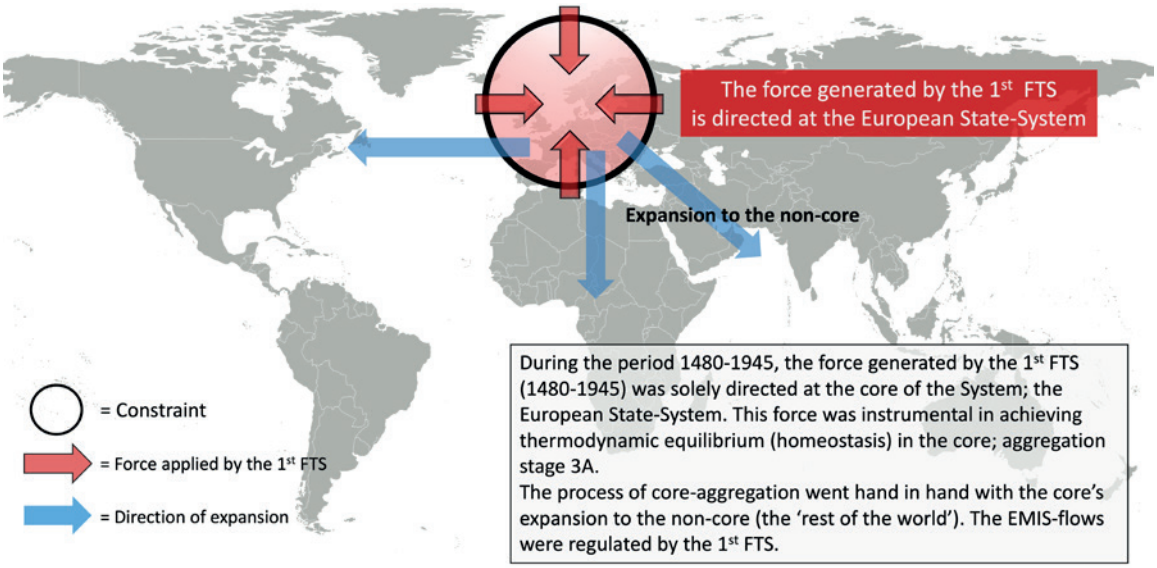


FIGURE 20.4: A directed force at the European State-System (1480-1945). Through the 1st FTS (1480-1945), a force was directed at the core of the System (Europe).

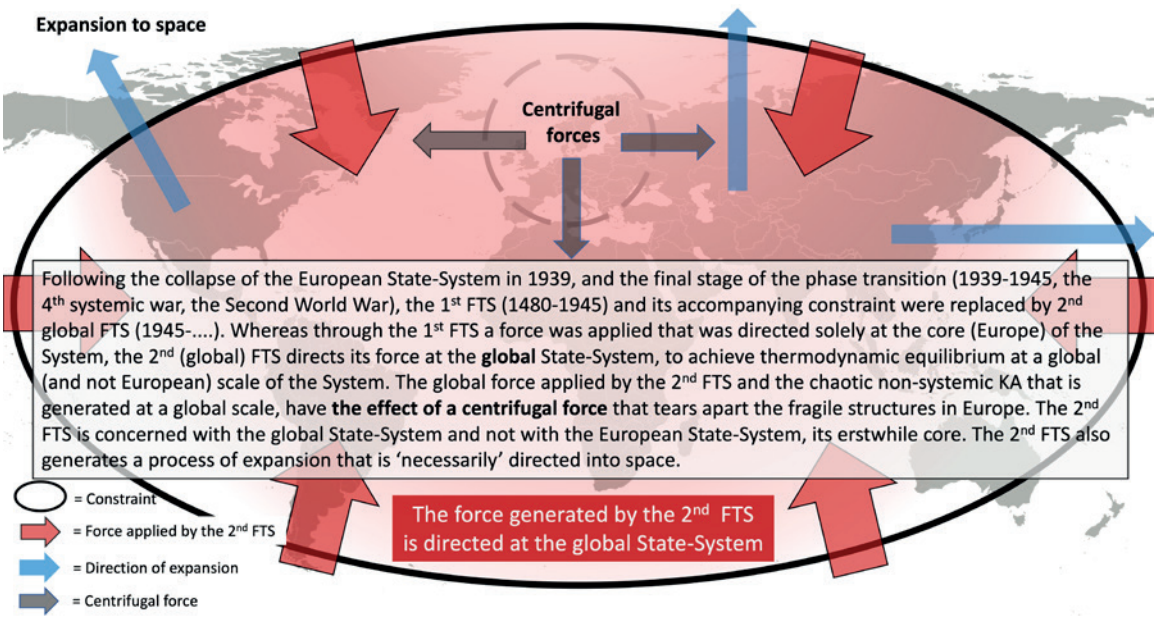


FIGURE 20.5: A directed force at the global State-System (1945-....). Through the 2nd (global) FTS, a force is directed at a global scale. the globalized System.

Although - as I will explain later - the abnormal KA/war dynamics during the 2nd exceptional period (1945-1989), caused some delays in the development of the (now global) (State-System, in 1989, the 2nd FTS became fully operational and chaotic non-systemic KA resumed, but now at a global scale.
The transition from a 1st FTS with a regional (European) scope to a 2nd FTS with a global scope, had a significant impact on the process of aggregation (unification) that was taking place in Europe: Albeit there was some initial progress in the (further) institutionalization of aggregated structures in Europe (in the process from aggregation stage 3A to 3B), when the 2nd FTS became operational in 1989, it seems that the forces of fragmentation (disaggregation), are now much stronger, and that 'Europe' - the European Union - is 'torn apart.
The 2nd FTS has two detrimental impacts on the process of aggregation in the former core, Europe:
A force is now applied on the global State-System. Whereas during the period 1480-1945, the 1st FTS applied a directed force on the European State-System - to ensure the European State-System was pushed to thermodynamic equilibrium via the most efficient path - the 2nd FTS (1945-....) applies a directed force at the global State-System, to ensure thermodynamic equilibrium is achieved, at a global scale.
The chaotic non-systemic KA have the effect of a centrifugal force. The chaotic non-systemic KA/wars the 2nd FTS generates since 1989 also operate at a global scale of the State-System.
These 'global' forces have the effect of centrifugal forces on the erstwhile core and still vulnerable (not yet fully developed) institutions in the former core (i.e. the European Union). These centrifugal forces find 'points of application' at state-level, and consequently stimulate processes of renationalization in Europe, that undermine efforts for unification, and tore apart Europe's fragile social and institutional fabric.
Europe is torn apart, by the forces and flows generated by the 2nd - global - FTS.

21.9. Application (3): No human control

In the (State-)System, entropy and KA are regulated by the FTS, in accordance with the laws of thermodynamics and related principles that apply FFE. Whether a local issue (entropic perturbation) is amplified, is determined by a combination of probabilistic and deterministic factors, mediated by the FTS; all issues start local.
As the war-data shows (48), during the 1st RSP (1480-1618), the (State-)System (through the 1st FTS) generated 45 non-systemic wars (kinetic events), during the period 1495-1945. That means that 45 times, a local issue escalated into a Great Power War (as defined by Levy). From the perspective of this study, this means that 45 times an (initially local) entropic perturbation was amplified through the interaction between an (initially local) perturbation and the S/T-field.
Humans, societies, states, etc. play a role in the KA (wars) of the System, but do not determine and shape its main properties, like size and duration; their involvement is limited to the contingent domain; to social and political aspects, that do not conflict with the demands of the Second Law and related principles that apply FFE.
Although we think we are in control, that is to a large extent just an illusion, which we like to maintain. Societies and states (we, in other words) react to the highly autonomous dynamics of the (State-)System/FTS: We always obey - and must obey - the S-imperative: The Second Law and related principles that apply FFE - of which the FTS is a product - determine the shortest path to thermodynamic equilibrium of the (State-)System.

The fact that we do not recognize this obvious and very basic fact - the fact that laws of physics also apply to social systems and dynamics - is a manifestation of our ability for (collective) self-deception and justification. However, these human characteristics are also integral to the homeostatic imperative, the process of social evolution, and to the FTS itself, as I explain in Part VII.

21. Drivers of the system

21.1. Introduction

As discussed, entropy(-production) powered the 1st FTS during the transient period (1480-1945), and powers the 2nd (global) FTS (1945-....): Entropy can be considered a source of energy - because it serves as a catalyzer for the exchange of societal energies in military capabilities - and a source of order FFE.
Entropy is produced in the (State-)System through interactions and exchanges between its components. The constraint - an integral component of the FTS - drives the (State-)System. In this chapter, I discuss the underlying drivers.

21.2 .Basic drivers: Population growth and rivalries between societies

From a thermodynamic point of view, entropy(-production) and free energy are the main drivers of the (State-)System. The production of entropy in the System is directly related to (the rate of) irreversible processes in the System; all social (natural) processes are irreversible. Population growth and the increasing connectedness of societies - and their 'clustering' - determine these irreversible processes and the entropy that is produced: Population size and the connectedness of the System (the degree of decomposability of societies and states) are the main state variables of the System (66). Free energy is required and used to utilize the opportunities - new possibilities - entropy contains.
Individual humans and social systems must obey the H-imperative. The H-imperative demands the fulfilment of a set basic requirements and requires that certain variables - of the living system itself and in their environments - are maintained within certain ranges.
Following the Black Death (1351), the population of Europe started growing acceleratingly. The H-imperative of individuals and communities etc. was served through social cooperation. Through cooperation and integration more economies of scale and scope could be explored and exploited. Individual humans and social systems (societies) also had to compete for scarce resources. These developments resulted in (increasing) instability and increase in entropy (-production). In 1480, through a bifurcation, a dissipative structure - the FTS - was imposed on the System FFE.
EMIS- and especially entropy-regulation, was/is the main purpose of the FTS, in accordance with the Second Law and related principles that apply FFE. During the transient period (1480-1945), the 1st FTS regulated the accelerating entropy-production, until - in 1939 - collapse of the (State-)System was unavoidable. In 1939, the entropy (production) was 'infinite' and required infinite amounts of KA (in accordance with thermodynamic principles) to be regulated. In 1939, the (State-)System had reached the singularity in finite time: The critical population threshold. The basic drivers - population growth and competition/rivalries - underlie these processes.

21.3. Secondary drivers

The need for entropy-regulation, initiated, reinforced and shaped various processes in the (State-)System, as integral components of the FTS. The FTS generated coherent KA, and reinforced and shaped processes of aggregation, expansion and empowerment. These processes contributed to the neutralization, transformation, redistribution and storage of entropy. These processes reinforced each other through various positive feedback loops and can be considered secondary drivers.
However, these four processes were not only instrumental in the neutralization, transformation and redistribution of entropy; these processes themselves also contributed to the production of 'new' - more - entropy.
Furthermore - and that is the relentless 'power' of the FTS - the processes the FTS generated, constituted a self-reinforcing mechanism: The FTS - by regulating EMIS-flows and entropy-production - ensured that more entropy was produced to power its accelerating operation and the State-System's transition to thermodynamic equilibrium. The FTS generated and maintained its own momentum, by facilitating and reinforcing further population growth - through the balancing of continuity and change - and through intensifying rivalries between societies.
The drivers - basic and secondary - constitute a powerful positive feedback structure.

21.4. Relationships between drivers and the constraint of the FTS

In below figure, the relationships between basic and secondary drivers of the System, entropy-production (through irreversible processes in the System), the constraint, and EMIS-regulation through the FTS, are visualized.

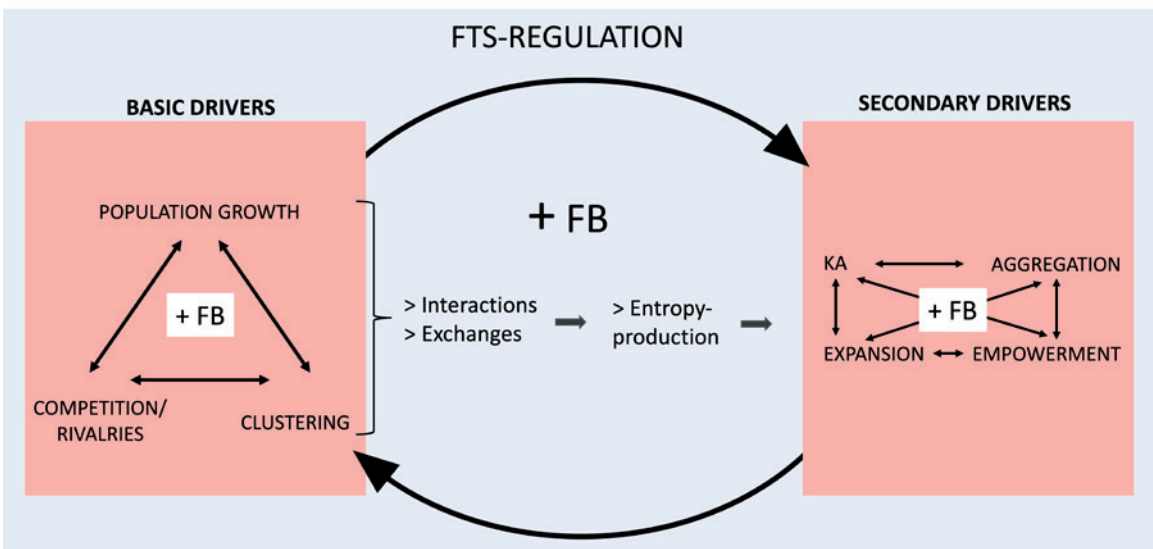


FIGURE 21.1: The relationship between basic and secondary drivers.

The 1st FTS consisted of a coherent 'set' of multiple positive feedback structures, that pushed the State-System to thermodynamic equilibrium via the most efficient path, in accord with the Second Law and related principles that apply FFE. These processes constitute a platform - a template - for social development and evolution.

21.5. Application (1): The synthesis of some observations

In this paragraph, I further explore some observations, that are indirectly related to the drivers of the System.

Although entropy is a well-defined physical quantity (like for example) energy, entropy is sometimes somewhat difficult to conceptualize: Entropy has multiple "appearances", characteristics and applications. Entropy is used as a measure for (dis)order in a system, for (the amount of) degraded energy, (a lack of) information, and a measure for new possibilities and possible microstates a system can adopt.

In this paragraph, I discuss a number of aspects of entropy, relevant for this study.

Maximum entropy - the state of a system in thermodynamic equilibrium, when the free energy in the system is at a minimum - is a state of maximum disorder, there is an absence of (all forms of) organization (including flows, processes and other regularities) and there is maximum variety: There is 'total' mixing and 'total' uniformity (from a macroscopic perspective).

The existence of clusters of mass in the universe - e.g. stars and planets - but also of differences in information (content) in social systems, point to order and organization - a lack of uniformity - and (low) er (than maximum) entropy. The systems concerned are not in thermodynamic equilibrium.

Through irreversible processes some energy that is not transformed into work, always 'leaks' to the system's environment; hence the indication *degraded* energy. A process can be optimized, but a certain leakage - production of entropy - is always unavoidable, as I explained.

The "leaked" energy can however (potentially) be put to use by/in other processes and contribute to the creation of ('new') order; entropy contains new possibilities and constitutes a potential for new order. The qualification 'degraded' is subjective, and misleading. Although the 'degraded' energy was and could not be put to use in a particular (irreversible) process, it can potentially serve as free energy for other processes, and new sources of order.

In the System there is novelty through combination; order and novelty are also created through the (re-)utilization of entropy. Waste - degraded energy - can be recycled - reprocessed - by finding new applications. The ability of social systems to re-utilize entropy determines their adaptability and survivability.

Entropy can also be considered a 'glue' that 'connects' processes to their environment through the exchange of 'degraded' energy and the new possibilities it provides. Entropy 'connects' and can be a source of order. Entropy-production and expansion are closely related.

The bifurcation the System experienced in 1480, demonstrates that the order that was imposed FFE - the spatial/temporal structures that emerged - had its own intrinsic 'logic'. This logic was the resultant of the combination of the laws of physics/thermodynamics and the specific characteristics of the components of the social system; e.g. the requirement for societies and states to fulfill a set of basic requirements to ensure their well-being and survival (satisfy the H-imperative).

Irreversibility of processes means that there is an 'arrow of time'; time has a forward direction. Through symmetry-breaking (the bifurcation in 1480), spatial and temporal structures emerged. The 1st FTS was accompanied by four accelerating cycles, with their own logic, including their own temporal structures. Humans have introduced a unit for time: the second. A second is equivalent with a certain change (in the position) of the second-hand of a watch. However, the System has its own temporal structure, its own internal clock so to speak. The duration of the four identical cycles can be considered the typical 'time-unit' of the State-System, during the period 1480-1945. During a time-unit of the (State-)System - a cycle - a certain process is accomplished: An upgrade of the order, after a period of relative stability (RSP). Through the bifurcation in 1480, another layer of organization was imposed on interacting societies and states that continuously produced and exchanged entropy. Entropy - the new possibilities it presented - served as a source of order and innovation, and the behavior of the System - the 1st FTS - became increasingly coherent. Complexity generated more complexity, and through the constraint - the collective dimension - a force was applied to the System that generated an accelerating momentum of the State-System toward a state of thermodynamic equilibrium. In the process, the components of the System and 1st FTS - states and societies - were increasingly "harnessed" (constrained) and pushed towards uniformity.

It is possible, to distinguish three types of expansion/growth in the State-System: (1) Intrinsic (or organic) expansion/growth: Expansion (growth) of a system through the utilization of entropy - new possibilities - the system itself 'exported' to its environment, and by applying (extending) its own intrinsic logic to the environment, (2) Non-organic expansion/growth: by expansion/growth of a system through imposing a 'new' logic on other 'autonomous' structures and systems that already developed - at least partially - an own intrinsic logic, and produced structures and processes that are consistent with this logic, and (3) A combination of organic and non-organic growth: Through the constraint - the collective dimension - autonomous social systems converge (their future is increasingly shared), while at the same time one social system absorbs another.

In case of the second type of expansion/growth, there are incomplementarities that must be overcome/eradicated - work must be accomplished - before a single logic (and structures and processed based on this logic) can be implemented and maximum efficiency can be achieved. These adjustments require that energy is put to use, that work is accomplished and that a force is applied. There are limits to non-organic growth: In some cases, certain incomplementarities cannot be solved, without physical destruction of (parts) of the system(s).

The process of aggregation during the transient period (1480-1945) that was regulated by the 1st FTS, is an example of the third type of expansion/growth, in which the constraint - the collective dimension - played a constructive and essential role: At the same time when incomplementarities were solved through a combination of organic and non-organic growth - a process that also included the application of KA (free energy) - the collective dimension (constraint) and the mechanism of PDLI pushed all states toward the same collective end-state. Through the constraint, the 1st FTS applied an increasing force on the System, during the transient period (1480-1945). Through the increasing constraint (collective dimension), the 'futures' of societies and states became increasingly connected and shared, and their development consequently increasingly converged. In other words, the processes of expansion and growth of societies and states were aided and shaped by the constraint - the collective dimension - that forced these societies and states in the same straitjacket/framework, toward a single - shared - future.

Furthermore, a closer look at the final stage of the process of aggregation of the core reveals that aggregation was not accomplished by means of acquisition (only); it was a much subtler process: The process of aggregation was accomplished through a long-term process of synchronization and 'tweaking' of values and norms and EMIS-flows at all hierarchical levels, during the transient period. The process of aggregation is necessarily a very gradual process. Homeostatic control is a prerequisite for thermodynamic equilibrium in the State-System and cannot be imposed or enforced: Fine-tuning is required.

At a certain point, the 1st FTS collapsed (1939), including the accompanying collective dimension - the constraint - and 'merged' with the homeostatic structures of (aggregated) societies/states into a single more or less integrated homeostatic structure at the level off the core (Europe). At that point, the gradient was 'neutralized' and the State-System reached thermodynamic equilibrium: Uniformity was accomplished, entropy(-production) and KA (free energy) were no longer "equivalent" (as was the case under FFE-conditions), and minimization of free energy now served/acted as the thermodynamic potential for a unified core (Europe): Interactions (EMIS-flows) in Europe (the erstwhile core) could and were no longer regulated through KA by an FTS (a dissipative structure), military capabilities had become obsolete and dysfunctional for internal use, and were (and could) no longer be 'directed' at other European states, that were now subject to the same homeostatic control structures. The 'focus' - (potential) utilization - of free energy (KA, military capabilities), was now (and still is) exclusively external. These processes were accomplished through the (subtle) interplay between basic and secondary drivers, directed by the 1st FTS.

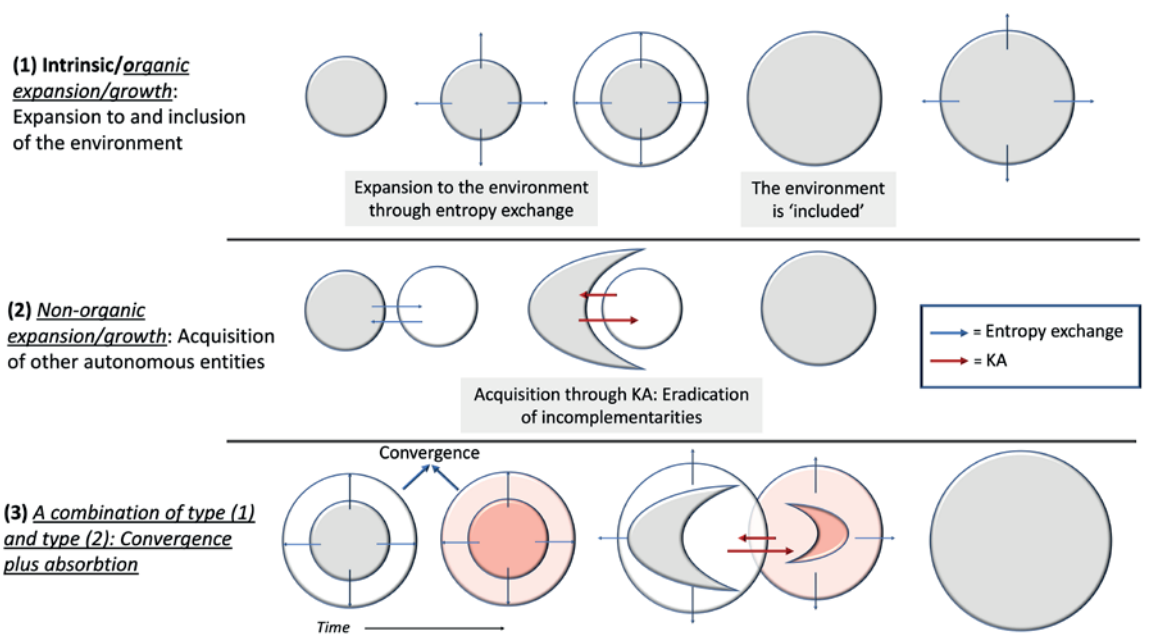


FIGURE 21.2: Three types of expansion/growth.

22. Three phases in the development of the system (1480-1945)

22.1. Introduction

Based on analysis of war-data and the concepts discussed so far, it is possible to distinguish three phases in the development of the System (1480-1945): (1) an unstable, unstructured phase (< 1480), (2) an organized phase FFE - the transient period 1480-1945- when a dissipative structure - the 1st FTS - regulated entropy-production (EMIS-flows), and (3) a phase (> 1945), when the core of the (State-)System (Europe) was (is) in thermodynamic equilibrium, and the System no longer consists of a core and non-core, but is globalized. From 1945 onwards, EMIS-flows are regulated by a 2nd (global) FTS.
The second and third phase - respectively from 1480-1945 and from 1945 onwards - were interrupted by abnormal war dynamics, respectively during the 1st exceptional period (1657-1763) and 2nd exceptional period (1945-1991, better known as the Cold War).
The characteristics of these phase will be discussed in this chapter; however, before elaborating on the three phases that can be distinguished, I provide some information about basic regularities in KA/war-data, which were (also) used to identify the three phases.

22.2. War-data

Before elaborating on distinctive phases in the development of the (State-)System, in this paragraph, I show some regularities that can be identified in the KA/war-dynamics of the (State-)System, during the period 1495-2018 (data from the period 1480-1495 is not available). This paragraph also serves as a preview, to provide some perspective to the reader.
The data used is from Levy (48) for the period 1495-1975 and is augmented from data from other sources for the period 1975-2018.
I have defined the size of KA/wars in terms of fraction, a new procedure, not used by historians, but a method that ensures better affiliation with the thermodynamic perspective used/developed in this study.
In figure 22.2, the size-development of KA/wars during the period 1495-2018 is shown. This figure includes some phenomena (including: damped oscillations, the 1st and 2nd exceptional period (EP), which will be discussed at a later stage.

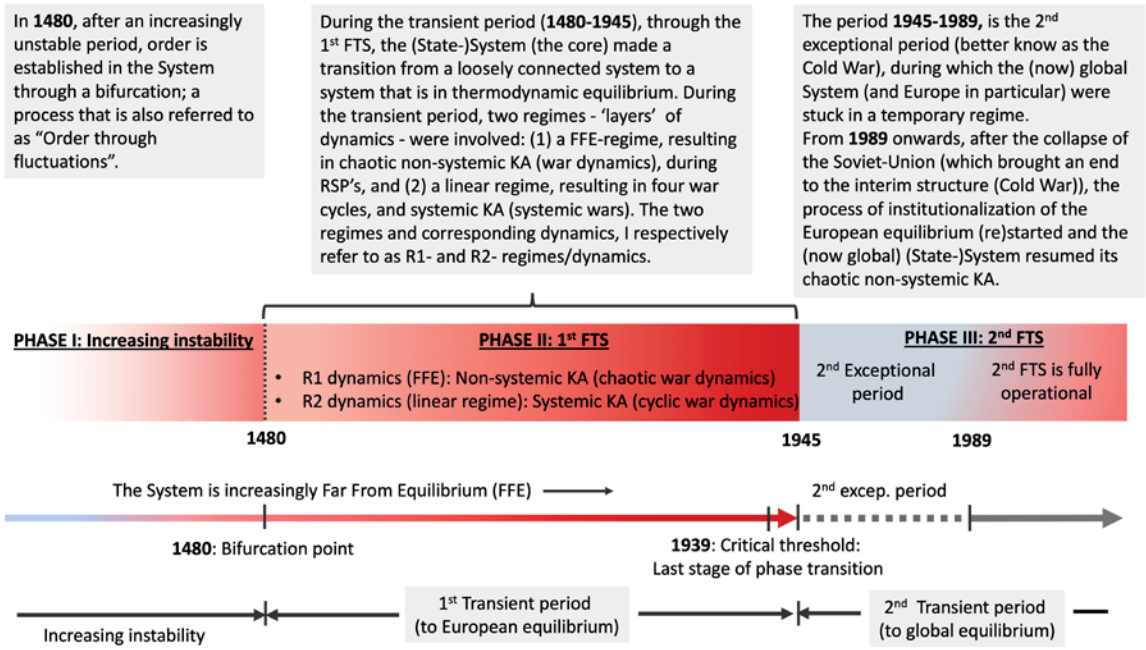


FIGURE 22.1: Three phases in the development of the (State-)System.

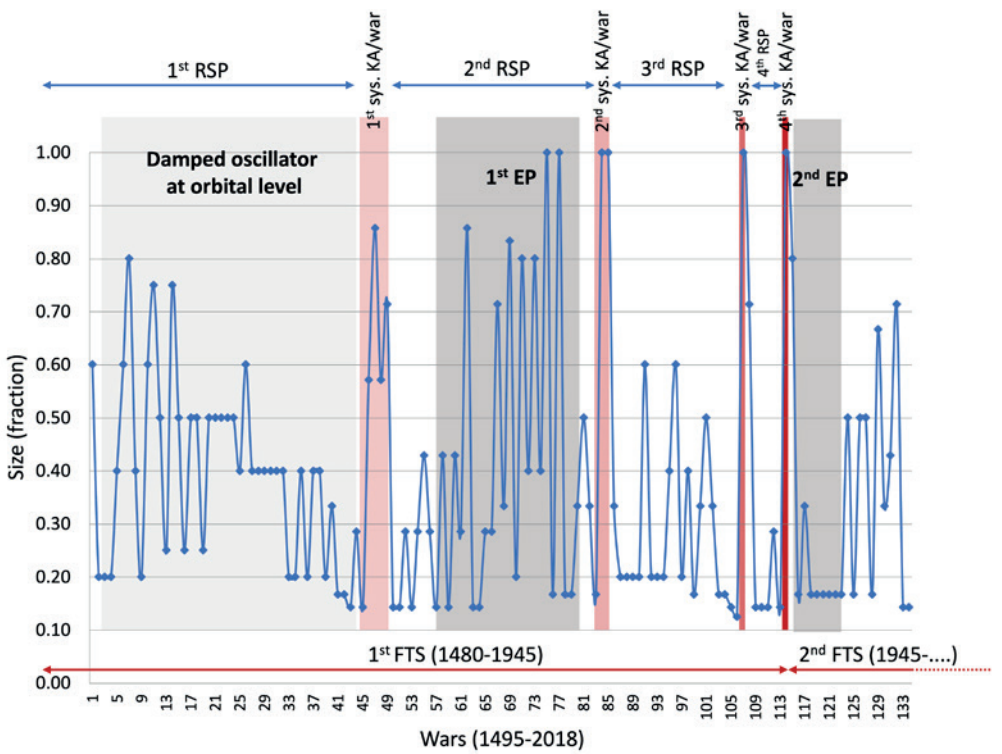


FIGURE 22.2: The size-development of KA/wars, during the period 1495-2018.

In order to be able to identify and better understand underlying patterns that are "hidden" in these size-dynamics, I have calculated the average size of five successive KA/wars and determined the development of the moving average over time. The moving average procedure produces a lag- and a "damping" effect, which must be taken into consideration.

Despite the seemingly volatile size-dynamics, the size-distribution of KA/wars obeys a Zipf-distribution; at least for the period (1495-1945, the life-span of the 1st FTS); see figure 22.3.

Although, at first sight, it is probably difficult to identify (underlying) patterns and regularities, it is possible to identify four accelerating KA/war-cycles, during the period 1480-1945, which accompanied a dissipative structure, the 1st finite-time singularity dynamic (1st FTS). In figure 22.5 some features of the KA/war-dynamics and KA/war-cycles are shown: including: Tipping points of KA/war-cycles (1514, 1774, 1856, and 2011), and so-called HCR's (high-connectivity regimes), when the (State-)System is accumulating entropy and is pushed toward a critical state. The term "critical fraction" refers to the fraction of HCR's of RSP's, when the (State0System becomes critical. These phenomena will be discussed later.

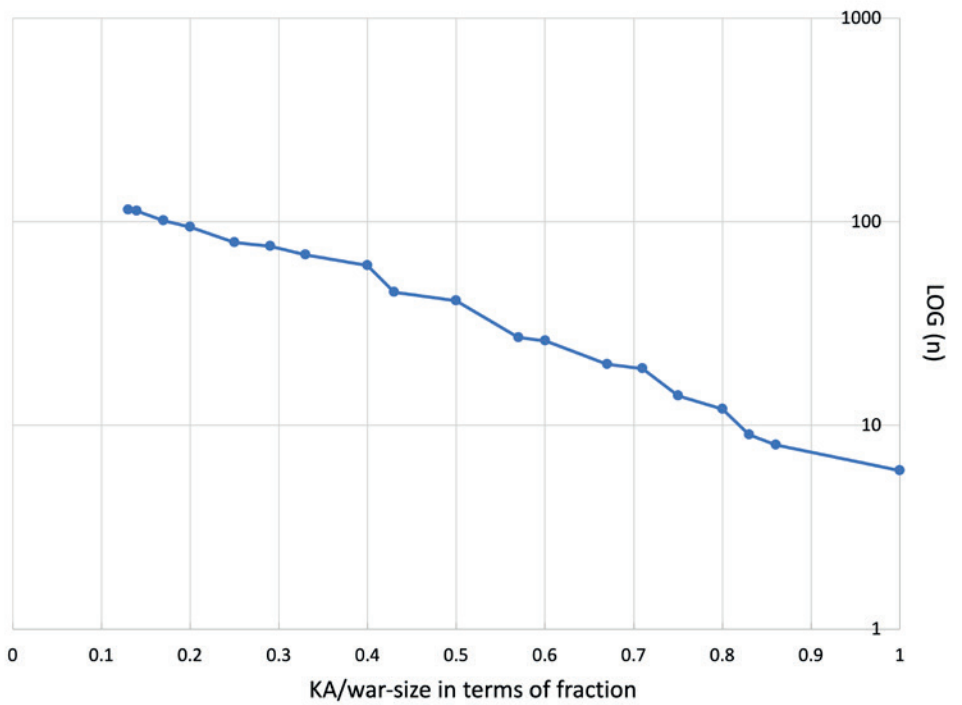


FIGURE 22.3: Zipf-distribution of the sizes of KA/wars in terms of fraction, during the period 1495-1945 (data from Levy (48)). KA/wars during the 1st exceptional period (1657-1763) and expansion wars are included.

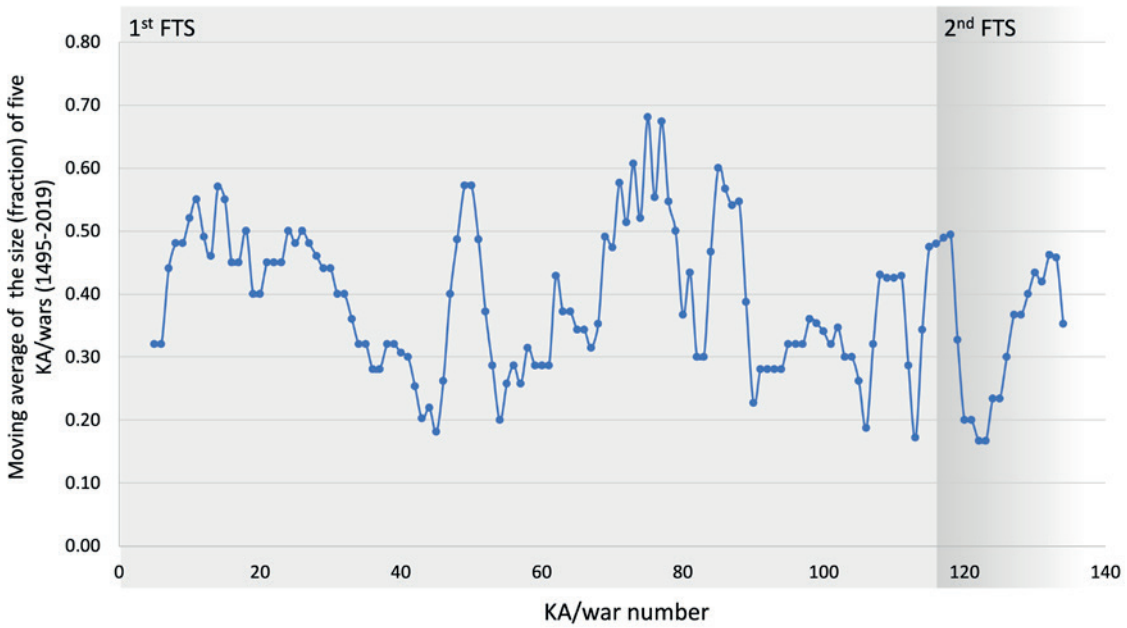


FIGURE 22.4: The development of the moving average of five (KA/wars), during the period 1495-2018.

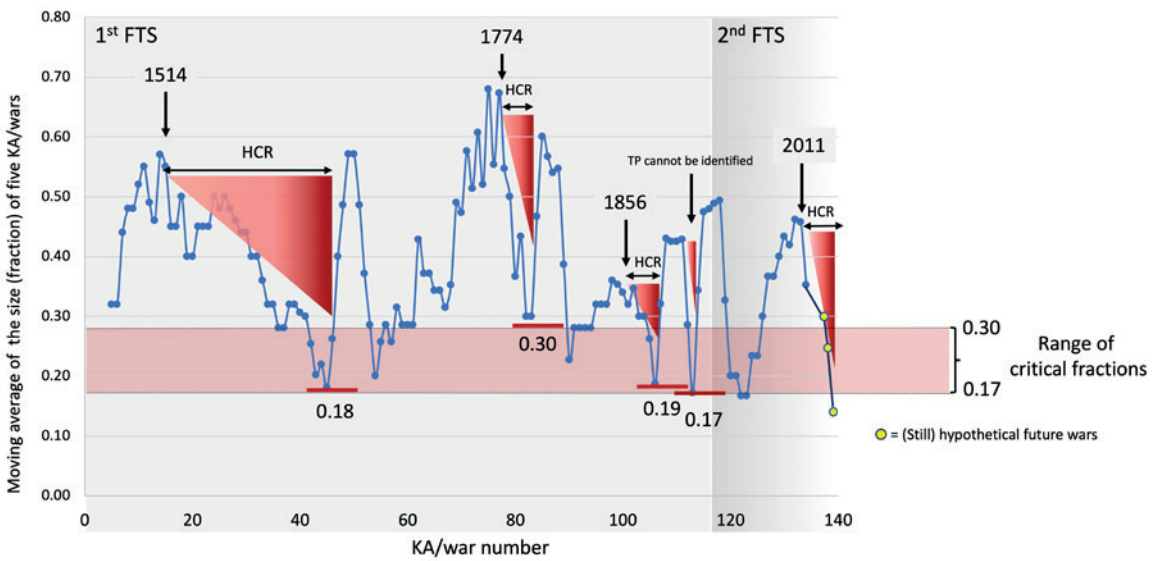


FIGURE 22.5: Features of KA/war-dynamics and KA/war-cycles.

22.3. Unstable and unstructured phase < 1480

The period until 1480 was unstructured (unorganized), but societies (state-structures and their precursors) became increasingly connected (increasingly non-decomposable; increasingly interdependent), EMIS-flows intensified, the System was pushed increasingly FFE and became increasingly unstable. Population growth was the underlying driver of these dynamics. There were however no long-range correlations (no functional constraint, no mode-coupling) at that stage, and the System's behavior lacked coherence. This changed when the System experienced a bifurcation - a nonequilibrium phase transition - in 1480, and the System consequently made a switch from an unorganized state to an organized state FFE; in 1480 the behavior of societies and states was no longer 'individual' but became collective (62); EMIS-flows were regulated by a dissipative structure. From 1480 onwards EMIS-flows - including entropy(-production) - became regulated; directed by the 1st FTS.

22.4. The transient period 1480-1945

Through the bifurcation in 1480, an organized state FFE, a dissipative structure - the 1st FTS - emerged, a phenomenon that can also be observed in other systems FFE that in response to increasing instability, 'adopt' a completely different type of behavior, enforced by the Second Law and related principles that apply FFE (62).

The 1st FTS was - so to speak - imposed on the System and ensured macroscopic coherence, which involved the use of KA (war).

The 1st FTS was accompanied by four accelerating oscillations, war-cycles. The emergence of the dissipative structure (the FTS) is an example of 'order through fluctuations' (44). During the transient period (1480-1945), EMIS-flows were regulated by the 1st FTS, and a thermodynamic relationship existed between entropy(-production) and free energy (KA of the System). Through KA (and the processes of aggregation, expansion and empowerment), entropy was neutralized and redistributed. The 1st FTS 'pushed' the European State-System - the core - of the System via the most efficient path to thermodynamic equilibrium and was instrumental in achieving a phase transition from a highly unstable state FFE (< 1480) to thermodynamic equilibrium in 1945.

The process was powered by population growth, and the 'supporting' processes the 1st FTS generated (the processes of KA, aggregation, expansion and empowerment); these processes enabled further population growth and development. During the period 1480-1945, the 1st FTS constituted an accelerating self-reinforcing dynamic.

Two 'layers' of mutual supporting dynamics can be distinguished in the 1st FTS: (1) Chaotic non-systemic (war) dynamics (also referred to as R1-dynamics) during RSP's of cycles, that were periodically punctuated by (2) periodic/cyclic systemic dynamics (also referred to as R2-dynamics), during critical periods.

Entropy(-production) during RSP's, was regulated through chaotic non-systemic KA (R1-dynamics); through the chaotic non-systemic KA/wars the (State-)System tried to preserve the existing order and stability. However, because of a network-effect - the fact that at a certain point (the tipping point of the RSP), the entropy-regulation through non-systemic KA was no longer adequate - entropy started accumulating and triggered an autocatalytic process.

The accumulated entropy - issues and tensions - were embedded in VC's through a process of nucleation. However, the accumulated issues and tensions - entropy - caused the System to become critical and generate a systemic kinetic response (KA), at certain points in time (1618, 1792, 1914 and 1939). The systemic KA during criticality was put to use to upgrade the order of the (State-)System to accommodate a next RSP, that allowed for further growth and development.

During the transient period (1480-1945), the System became four times critical, and produced four systemic KA/wars: In 1618, 1792, 1815 and in 1939. The systemic KA defines the four (accelerating) cycles that accompanied the 1st FTS.

In 1939, the core of the System had reached a critical threshold, and the 1st FTS could no longer regulate the (State-)System: At that point the core produced infinite amounts of entropy that required an infinite kinetic response; collapse of the System and the last 'step' in the phase transition were now unavoidable.

TABLE 22.1: Characteristics of the three phases of development.

PHASE I: < 1480: Increasing instability	**PHASE II: 1480-1945: Dissipative structure (order through fluctuations) With three 'levels' of dynamics.**			**PHASE III: > 1945: 2nd EP, Thermodynamic equilibrium (Europe) + globalization, 2nd FTS**
	R1-regime	**R2-regime**	**FTS**	
• Increasing instability: Fluctuations are not damped; • No long-range correlations; • No collective (macroscopic) behavior • Increasing production of entropy; • Entropy has a disruptive role.	• An organized state FFE: Fluctuations are damped; • Long-range correlations and macroscopic (collective) behavior; • General extremum principles do not apply; • Entropic perturbations are regulated by chaotic non-systemic KA generated by the dissipative structure (1st FTS); • Entropy(-production) has a constructive role.	• Near equilibrium: Linear regime; • Extremum principles apply; • The MEP-Principle applies; • The State-System is pushed to zero entropy; • Four accelerating cycles are produced; • Entropy(-production) has a constructive role.	• Integration of R1- and R2-dynamics, with synergetic effects; • The most efficient path to thermodynamic equilibrium in the core (the European State-System) is selected; • The FTS constitutes a phase transition; • Entropy(-production) has a constructive role.	• During the 2nd EP, mode-coupling is disturbed, the System is ossified. • From 1991 onwards, chaotic non-systemic KA resumes, but now at a global level; • In the erstwhile core (the European State-System), there is maximum entropy, and minimum free energy; • FTS regulation is replaced with homeostatic control; • At a global scale EMIS-flows are regulated by a 2nd FTS, and the (now global) System is experiencing a 2nd phase transition to thermodynamic equilibrium at a global scale.

22.5. Thermodynamic equilibrium

The actual phase transition of the European State-System - that was preceded by three precursory critical events (1618-1648, The Thirty Years' War, 1792-1815, The French Revolutionary and Napoleonic Wars, and 1914-1918, The First World War) - took place during the 4th systemic KA/war (1939-1945, the Second World War).
The phase transition had two closely related - complementary - effects: (1) The core of the System (European State-System) reached thermodynamic equilibrium, and (2) the core (Europe) and non-core of the System 'merged' - linked - into a global State-System.
The implementation of the equilibrium state in the former core (Europe) was delayed until 1989, because of the abnormal dynamics during the period 1945-1989 (the 2nd exceptional period, the Cold War), a phenomenon I discuss later in more detail.
The distinction between core and non-core was now obsolete. The 4th systemic war - in fact the first systemic war at a global scale - also resulted in the implementation of a 1st global order (the United Nations, 1945-....), which is instrumental in regulating the status quo - the RSP - that is now in place.

22.6. The interplay between competing thermodynamic potentials (and their extremization) and stability principles, during the transient period (1480-1945)

Two layers - types - of dynamics can be distinguished in the 1st FTS; respectively R1- and R-2 dynamics. Whereas the chaotic non-systemic KA - the R1-dynamics - were related to the FFE thermodynamic state of the (State-)System, the cyclic (periodic) systemic KA - the R2-dynamics - obeyed near-equilibrium principles. These dynamics were complementary: The R2-dynamics were generated by the R1-dynamics, through the network-effect that was activated when the tipping point of the RSP was reached in 1618, 1792, 1914 and 1939). The network-effect caused the accumulation of entropy and caused the (State-) System to become critical. During criticality the R2-dynamics (systemic KA) ensured that the order of the (State-)System was upgraded (again). Through the upgrade - the R2-dynamics - the R1-dynamics could continue. The combination of - the interplay between - both types of dynamics - the 1st FTS - was instrumental in accomplishing a phase transition.
The respective thermodynamic potentials that directed both types of dynamics competed - so to speak - and resulted in the maximization of entropy-production by the System, and the simultaneous push to zero entropy of the (structure of the) State-System, through the application of the MEP-Principle.
The purpose - from a thermodynamic perspective - of periodic upgrades of the order of the (State-) System (through cyclic systemic KA, R2-dynamics) during critical periods - in response to accumulated entropy (excess entropy, that could not me neutralized or redistributed) - was to decrease the entropy(-production) and energy state of the System, and to optimize - update - the regulatory-capabilities of the State-System/FTS.
As I already explained, the paradox of the (State-)System is that whereas the principal of *minimum* entropy-production applied to the State-System and determined and shaped the R1- and R2-dynamics of the System, the principal of *maximization* of entropy-production applied to the System (FFE): By sustaining the FTS, continuity and change were balanced in the System and population growth and thus entropy-production - the basic driver of the (State-)System - were consequently maximized.

The principle of *minimization* of entropy-production that applied to the State-System, and the principle of the *maximization* of entropy that applied to the System, play the same role as thermodynamic potentials in equilibrium theory (62).

The combination of R1- and R2- dynamics ensured that the 1st FTS was (and stayed) optimized, and that continuity and change were optimally balanced in the (State-)System. The 1st FTS ensured that exponential population growth - the underlying driver of the FTS and the related processes of aggregation, expansion and empowerment - could also be sustained. The related processes were not only instrumental in the redistribution of entropy, but also supported the maximization of entropy-production of the System.

From a thermodynamic perspective, these dynamics and processes ultimately served only a singular objective: To achieve thermodynamic equilibrium in the European State-System (the core), via the most efficient path, in accordance with laws of thermodynamics and related principles that apply FFE. The population growth that was accomplished not only ensured the continuous acceleration of the 1st FTS, but also that a phase transition could be accomplished.

TABLE 22.2: Extremization of thermodynamic potentials during (sub)phases.

(Sub)system	Corresponding dynamic	Entropy		Free energy/KA	Remarks
		Production	Level/amount		
State-System during RSP's, stationary states	A stationary state is maintained through chaotic non-systemic KA (R1-dynamics) regulated by the FTS (an organized structure FFE).	Minimization (= thermodynamic potential); MEP-principle.	Maintain within certain range.	Minimization, but selective use to neutralize entropic perturbations (issues in the contingent domain).	Entropic perturbations trigger KA, to neutralize the perturbations.
State-System	Cyclic systemic KA (R2-dynamics) Near equilibrium dynamics, instrumental in the lowering of the entropy/energy-state and eventually in a phase transition, regulated by the FTS.	Minimization (= thermodynamic potential); MEP-principle.	Minimization to zero entropy.	Minimization.	The four upgrades constitute steps in a phase transition.
System (1480-1945)	A dissipative structure dynamic FFE; including processes of KA, aggregation (core), expansion to non-core and empowerment in core; regulated by the FTS.	Maximization (= thermodynamic potential).			It is a process of growth, contained by the carry capacity of the System, the System itself enhances with the support of the FTS.
The European State-System erstwhile core (>1945)	Thermodynamic equilibrium (following the phase transition.	No entropy-production.	Maximum.	Minimum.	

22/7 Application (1): A 2nd (global) FTS

Analysis of war-data shows that the global System is now producing a first KA/war-cycle, that accompanies 2nd FTS. The purpose of the 2nd FTS is the same as of its predecessor, I assume: To accomplish thermodynamic equilibrium in the global State-System (to enable global homeostasis), via the most efficient path.
It seems (at this stage) that the same four processes are instrumental in achieving thermodynamic equilibrium: Cycles of KA (war-cycles), a process of aggregation, a process of expansion (also into space), and a process of empowerment (including expansion into the abstract domain, and utilization of this domain).
The 1st FTS (1480-1945), only produced an intermediate result: Thermodynamic in the European State-System (core), assuming this state can be sustained.

22.8. Application (2): 1480: A fundamental change in the purpose of KA (war)

The moment a dissipative structure - the 1st FTS, an organized state FFE - emerged in 1480, - the nature of war (dynamics) changed fundamentally: KA/war dynamics were no longer without structure and without a clear 'overarching' purpose, but became instrumental in sustaining the 1st FTS, to ensure thermodynamic equilibrium of the European State-System was accomplished via the most efficient path. In 1480, KA had become system-behavior, to which societies and states were subjugated.
The (superimposed) FTS had its own purpose (logic): To find the most efficient path to thermodynamic equilibrium in the core (European State-System) and the 1st FTS consequently imposed a template for social development and evolution on societies. The 'template' shaped the processes of KA (war), aggregation, expansion and empowerment.
The FTS - the template - also 'shaped', which entropic perturbations (issues in the contingent domain), would be amplified (involving interaction between the perturbation/issue and the S/T-field), involving a combination of probabilistic and deterministic factors. The 1st FTS was - and the 2nd FTS now is - the ultimate arbiter in the System.

22.9. Application (3): The interplay between competing thermodynamic potentials and their extremization produce synergetic effects

It seems paradoxical that during the transient period (1480-1945) - but also at this stage, during the 2nd transient period (1945-....) - that parts (subsystems) of the System were simultaneously in two 'regimes' (FFE and near equilibrium). But it was the interplay between the (competing) thermodynamic potentials, and the respective dynamics generated by the two regimes (R1- and R2-dynamics) that powered the 1st (and now 2nd) FTS.
A closer look reveals that these regimes - the corresponding dynamics - are mutually reinforcing and enabling. The FTS - with its two layers - is a highly optimized structure, that ensures the most efficient path

to thermodynamic equilibrium (equivalent with homeostasis in social systems), during which continuity and change must be (continuously) balanced. Each layer of dynamics is shaped by (fundamentally) different thermodynamic potentials that apply to the respective regimes.
The FFE-regime applies to the first layer of chaotic non-systemic KA (R1-dynamics), while the near-equilibrium - the linear - regime applies to the second layer of cyclic/periodic systemic KA (R2 dynamics). The R2-regime and dynamics were responsible for the phase transition that was accomplished during the transient period (1480-1945).
The cyclic/periodic R2-dynamics - the four accelerating war-cycles that accompanied the 1st FTS - were generated by the network-effect that 'kicked in', when the tipping points of the respective RSP's were reached. Through the network-effect, entropy (issues and tensions) could accumulate in the (State-) System, and an autocatalytic process was triggered. Consequently, sufficient entropy was transformed into free energy (military capabilities), to drive the core of the System to thermodynamic equilibrium.

22.10. Application (4): Institutionalization of competing thermodynamic potentials and their extremization tendencies

The contingent - 'real world' - domain is submitted to the deterministic domain of the System, of which the FTS is a manifestation. The FTS imposes a 'template' - a straitjacket - on social and political developments. However, the deterministic domain - the Second Law and related principles that apply FFE - is indifferent to contingent dynamics, as long as its demands are obeyed.
The System and FTS are products of laws of physics, and the interactions of and in the System - including of societies and states, and individual humans - are necessarily conditioned to the Second Law and related principles that apply FFE.
Thermodynamic potentials - and related stability principles - that determine and shape dynamics during RSP's, critical periods, and thermodynamic equilibrium, are (necessarily) embedded in social and political structures in the contingent domain; these structures represent the thermodynamic potentials and stability principles and are 'activated' under certain conditions (e.g. as too much entropy is produced, that requires redistribution).
For example, social and political structures and mechanisms - like the United Nations, and its coordinating structures (like the Security Council) - that regulate interactions between societies/states, can be considered institutionalized thermodynamic potentials, that e.g. strive to reduce and contain entropy-production (issues and tensions), and regulate the application of free energy to restore - or upgrade - the existing order (status quo), in accordance with the deterministic template that is imposed.
The continuous efforts of the European Union to prevent and contain tensions (entropy-production) between its member-states, is consistent with the thermodynamic principle that applies in an equilibrium state; Kondepudi et al. explain: "at equilibrium, the entropy-production due to every irreversible process must vanish" (44).

23. The pre-organized phase

23.1. Introduction

A period of increasing instability preceded the bifurcation in 1480. In this chapter, I have a closer look at developments in the System that preceded the bifurcation in 1480, and the emergence of a dissipative structure (the 1st FTS).

23.2. The System was pushed increasingly farther from equilibrium (FFE)

When Europe recovered from the Black Death - that had ravaged the continent - Europe became increasingly unstable through a combination of developments and factors. Through these developments and dynamics, Europe was pushed increasingly farther from equilibrium.
The Black Death peaked in Europe from 1347-1351. The Black Death is estimated to have killed a third of Europe's population, and caused a severe economic crisis. Total production and trade were lower in 1400 than they had been a century earlier and it took roughly 200 years for Europe's population to regain its 1340 level.
The Black Death was followed by a period of accelerating population growth, that was accompanied by economic recovery, state-building and the initial (still restricted and also 'unorganized') expansion of Europe (the core of the System) to the non-core (a process that started around 1500 in earnest, as I explain later).
Numerous factors contributed to these (closely related) developments, including:

- *Technological advances*. A shift in power through scientific and technological advances, including the invention of printing (1455), which empowered secular elites, and contributed to the creation of a new political environment (56).
- *Avoidance of fragmentation*. The strengthening of the principle of male primogeniture, under which only the eldest son inherited his father's property, thus keeping estates intact (56).
- *Introduction of the national state*. City-states, leagues and empires, were increasingly 'replaced' by national states: "relatively autonomous, centralized, and differentiated organizations exerting close control over the population within several sharply-bounded contiguous regions" (91).
- *Enhanced capacity to wage war*. An increase of the tax base of European states gained rulers greater access to credit and enabled them to afford new military technologies (like artillery) and to scale-up military operations. Artillery made reinforced structures like castles, more vulnerable, and established power structures could be challenged (56).

- *The establishment of regular diplomatic missions*. During the end of the fifteenth century, regular diplomatic missions were established in Europe. Tilly (91) Explains: "With the institution of embassies came extended information-gathering, widened alliances, multilateral negotiations over royal marriages, greater investment of each individual state in the recognition of other states, and a generalization of war". This development contributed to the creation of a European state-system.
- *The creation of a European state-system*. Various developments contributed to the development of an European state-system, including (91): (1) "a system of interconnected states linked by treaties, embassies (*IP: see above point*), marriages, and extensive communications", (2) "declared wars fought by large, disciplined military forces and ended by formal peace settlements, and (3) the practice at the ends of wars to realign boundaries and sovereigns in Europe, "under the terms of agreements joined by multiple states".

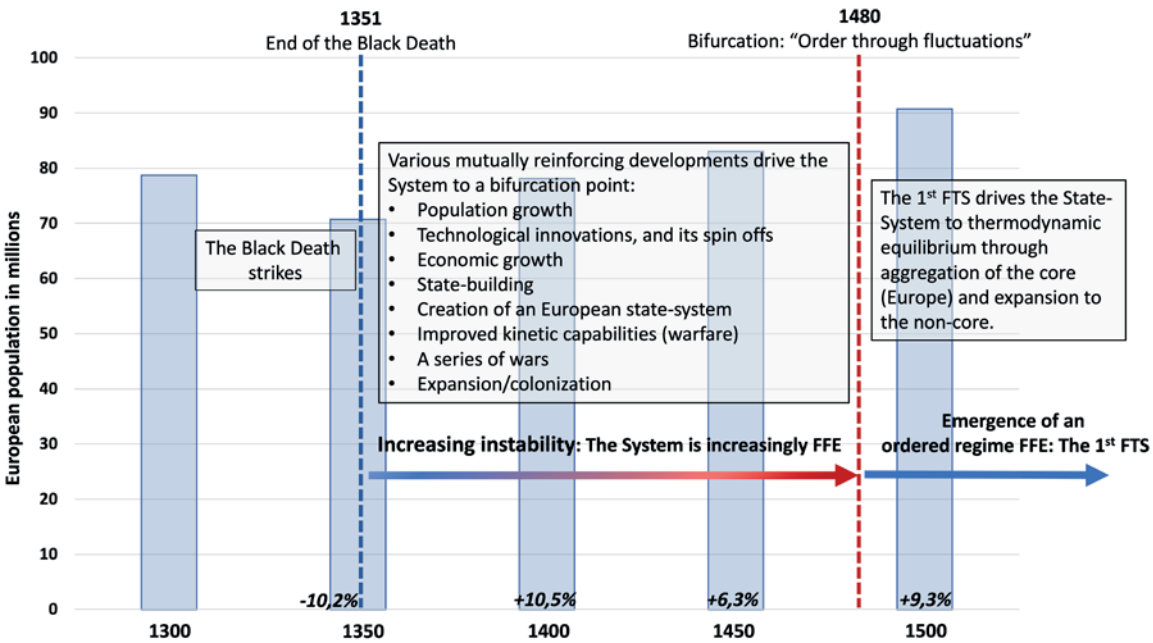


FIGURE 23.1: Increasing instability preceding the bifurcation in 1480. In this figure the run-up to the bifurcation in 1480 is shown. In the period preceding the bifurcation, various factors and developments pushed Europe - what would become the core of the System - increasingly farther from equilibrium. Under those FFE-conditions a system can generate order - a dissipative structure - which is instrumental (in case of the System) in EMIS-regulation. The dissipative structure (1480-1945), the 1st FTS, not only provided a vehicle toward thermodynamic equilibrium of the European State-System (in accordance with the Second Law and related principles that apply FFE), but also a vehicle - a platform - for social and political developments and social evolution.

23.3. Kinetic activity (KA)

In the period leading to the bifurcation point (1480), the first four factors resulted in a series of large-scale dynastic and territorial wars (KA), in which rulers sought to define frontiers, expanded their power and influence, and developed centralized bureaucracies. Through the arrangements that were introduced, the European State-System (the core of the System) took shape but became also increasingly unstable. The System was pushed increasingly farther from equilibrium, and a bifurcation was triggered in 1480, resulting in the emergence of a dissipative structure, the 1st FTS.
However, the fact that the System became increasingly unstable, does not alter the fact that the System already possessed a certain organization - I refer to the Holy Roman Empire - which was however not able to adequately contain the increasing entropy-production and KA in the System, and could - so to speak - not prevent an intervention by the Second Law, to ensure compliance with this law and related principles that apply FFE.

23.4. Application (1): Pre-1480 colonization served as a kick-starter for the 1st FTS

During the transient period (1480-1945), the 1st FTS regulated EMIS-flows in the (State-)System and ensured that the European State-System followed the most efficient path to thermodynamic equilibrium. The 1st FTS - through the relationship between entropy(-production) and KA(-production) - shaped various secondary processes, including the processes of aggregation, expansion and a process of empowerment. These processes were (and still are, but now at a global level) also instrumental in EMIS - and especially - entropy-regulation.
However, these processes were not new, but became organized and subject to FTS-regulation from 1480 onwards, which explains their (increasing) consistency and their acceleration, during the transient period. In fact, for the 1st FTS to emerge in 1480 - for the System to accomplish a bifurcation - the processes of aggregation and expansion had to be initiated already: For a dissipative structure to emerge, entropy-exchanges with a suitable environment (to dump entropy, so to speak) are a prerequisite (44). Societies and the non-core (the rest of the world), constituted the environments of the European State-System. Before 1480, colonization - expansion from the core (Europe) to the non-core already took place, albeit at a different scale and tempo, then during the transient period: Pre-1480 colonization served as a kick-starter for the 1st FTS.

24. Bifurcation in 1480

24.1. Introduction

In chapter 14, bifurcations were explained: "Far-from-equilibrium (FFE) states can lose their stability and evolve to one of the many states available to the system. Irreversible processes and the boundary conditions do not uniquely specify the nonequilibrium state to which the system will evolve; driven by internal fluctuations or other small external influences, the system leaves the unstable state and evolves to one of the many possible new states. These new states can be highly organized and are called dissipative structures" (44).
The 'switch' to the organized state FFE is a so-called bifurcation. To which of the multiple possible states the system concerned will evolve is not deterministic: It depends on the random fluctuations in the system; bifurcations involve both deterministic and probabilistic elements. Prigogine (44) refers to this behavior as 'order through fluctuations', causing new spatial and time-dependent phenomena arise (66). Bifurcations involve a constraint, symmetry-breaking, long-range correlations, mode-coupling, the emergence of coherent macroscopic (collective) behavior, and through bifurcations, 'history' is introduced: Successive adaptations to the emergent dissipative structures - the FTS, in case of the System - build on previously introduced structures.
The 1480-bifurcation is discussed in this chapter, in more detail.

24.2. The stage is set for a bifurcation

In the preceding chapters, "We have discussed the concepts that allow us to describe the formation of dissipative structures, such as the theory of bifurcations. It is remarkable that near-bifurcations systems present large fluctuations. Such systems seem to "hesitate" among various possible directions of evolution, and the famous law of large numbers in its usual sense breaks down. A small fluctuation may start an entirely new evolution that will drastically change the whole behavior of the macroscopic system. The analogy with social phenomena, even with history, is inescapable. Far from opposing "chance" and "necessity", we now see both aspects as essential in the description of non-linear systems far from equilibrium" (65).
According to Turner, who discusses self-organization in nonequilibrium chemistry and in biology (72): "(...) open systems undergoing nonlinear chemical reactions and transport far from thermodynamic equilibrium are subject to instabilities in the thermodynamic branch of solutions and may evolve subsequently to other operating regimes characterized by new types of behavior" (72).
I argue that this typical behavior is not restricted to nonequilibrium chemistry but can also be observed in the System (see also preceding chapters).

Turner explains, that "The class of chemical systems that may exhibit such behavior is characterized by two essential features. On one hand, certain types of nonlinearities are required both to permit the existence of more than one macroscopic state and to provide an appropriate chemical mechanism by which instabilities may appear. On the other hand, it is necessary that the system operates in the far-from-equilibrium (i.e. nonlinear) domain of irreversible thermodynamics. That is, a minimum level of dissipation is essential to both creation and maintenance of the "dissipative structures" which may arise beyond instability. In the coupling of chemical kinetics with transport, it is well understood now that the types of nonlinearities which can lead to instabilities and dissipative structures are provided by auto-and cross-catalytic processes, by chemical steps which by positive or negative feedback influence their own rates of reaction" (72).
During the period preceding the 1480-bifurcation, the conditions in the System arose (grew) to satisfy the three requirements mentioned by Turner: (1) nonlinearity (non-linear interactions), (2) a state FFE, and (3) the availability of a suitable environment.

- *Nonlinearity*. The social variety of the System (in 1480, the System was organized in a system of circa 300 loosely coupled and divers state-like structures) and intensifying (kinetic) interactions, provided the nonlinearities that permitted more than one macroscopic state (of the System) and provided the mechanisms to provide increasing instabilities.
- *FFE*. Increasing amounts of entropy were produced at an increasing rate, through intensifying interactions and exchanges, as a consequence of e.g. population growth, increasing interdependencies and increasing competition for scarce resources: The System was consequently - through accelerating entropy-production, and the interplay with KA - driven increasingly farther from equilibrium. This process was dominated by positive feedbacks and was autocatalytic in nature (issues/tensions (entropy) produced more issues/tensions (entropy)). Prigogine refers to this condition for the appearance of organized behavior FFE, as the "existence of catalytic effects" (65), in these systems. In case of autocatalysis in the System, the presence of entropy accelerates its own syntheses: "issues and tensions produce more issues and tensions". FFE entropy can serve as a source for order.
- *A suitable environment*. At that stage, the dissipation of energy and entropy to the non-core also intensified - interactions with the non-core were already established (well) before 1480 - which enabled the dissipation of energy and entropy by the European State-System (the core), that was now taking shape, to a suitable environment.

When in 1480, a critical threshold was reached, long-range correlations were established, long-range energy and entropy transport were enabled, the necessary mechanisms and processes were coupled, dissipation to a suitable environment (from the European State-System to the non-core and societies) was enabled, and a coherent structure - the 1st FTS - could emerge.
Historians also observe that the war dynamics of the System were fundamentally different before - in the terminology of Levy - a Great Power System was established in 1495 (48).
The basic drivers - now regulated and reinforced by the 1st FTS - ensured that the 1st FTS could be sustained, until it had accomplished its purpose: Thermodynamic equilibrium in the European State-System.
The evolving State-System, evolving societies, the phase transition, the scientific revolution, innovations, social complexifications, ideologies etc. can be considered manifestations - "products" - of the accelerating EMIS-flows the 1st FTS pushed through the System.

24.3. At the bifurcation point: Entropy is a source of order

In classical thermodynamics, heat transfer - entropy - is considered a source of waste (degraded energy). However, under certain conditions FFE, entropy - tensions in the System, the equivalent of heat - can become a source of order in the system concerned. This was also the case in the System, when the bifurcation point was reached in 1480: At that point a (thermodynamic) relationship was established between entropy(-production) and free energy (KA) in the System; an unambiguous relationship between tension(-production) and war dynamics, regulated by the 1st FTS. The moment a system makes a transition towards an organized state FFE (a dissipative structure), the excess entropy that was increasingly produced in the preceding near-equilibrium state vanishes (62).
Through the bifurcation in 1480, the System produced a dissipative structure - the 1st FTS - that could ensure the System could sustain itself FFE, in the complex region: Its entropy-production was reduced and became regulated, and entropy was "systematically" dumped in e.g. the non-core.
In the complex region - regulated by the 1st FTS - the (State-)System had the ability to switch between different modes of behavior (stable/unstable, chaotic/periodic war dynamics, etc.) as the conditions varied. This flexibility and adaptability provided the (State-)System with choices; solutions - various possibilities - that could satisfy the Second Law and related principles that apply FFE.
The choices that were available were 'mediated' - regulated - by the 1st FTS.

24.4. A stability diagram of the System

It is possible to visualize the bifurcation process with the help of a stability diagram; see figure 24.1.
Each value of $\boldsymbol{X}$ (y -axis) represents a state of the System. The distance from equilibrium is represented by the parameter $\boldsymbol{\lambda}$ (x-axis). The thermodynamic branch represents a family of states of the System over time. However, when a system is driven FFE, at a certain point the stability of the thermodynamic branch is no longer assured.
The System also experienced such a development/dynamic: At a certain point, the System became (increasingly) unstable and entropy-production - and the interplay between entropy(-production) and KA - accelerated as a consequence of positive feedback mechanisms that became increasingly dominant: Tensions and issues increasingly fed on each other (as was later also the case during HCR's of RSP's, during the transient period). When eventually in 1480 a critical threshold was reached ($\boldsymbol{\lambda} > \boldsymbol{\lambda}_{critical}$), the System made a transition to a new branch, which corresponded to an organized state FFE (the 1st FTS, a dissipative structure).
In other words, beyond the critical value of the imposed gradient, a new social order was produced spontaneously, through a combination of deterministic and probabilistic factors, in accord with the Second Law. The emergent dissipative structure - the 1st FTS - can be considered a series of fluctuations that are stabilized by EMIS-exchanges with its environment: The 1st FTS produced the European State-System that was stabilized by its environment, which includes other subsystems of the System (including societies, and the non-core of the System).
Nonequilibrium instabilities give rise to a great variety of structures. If the kinetic equations of a system are known (which is not the case for the System, at this point), the point can be determined when the state of a system becomes unstable, by means of 'stability analysis' (44).

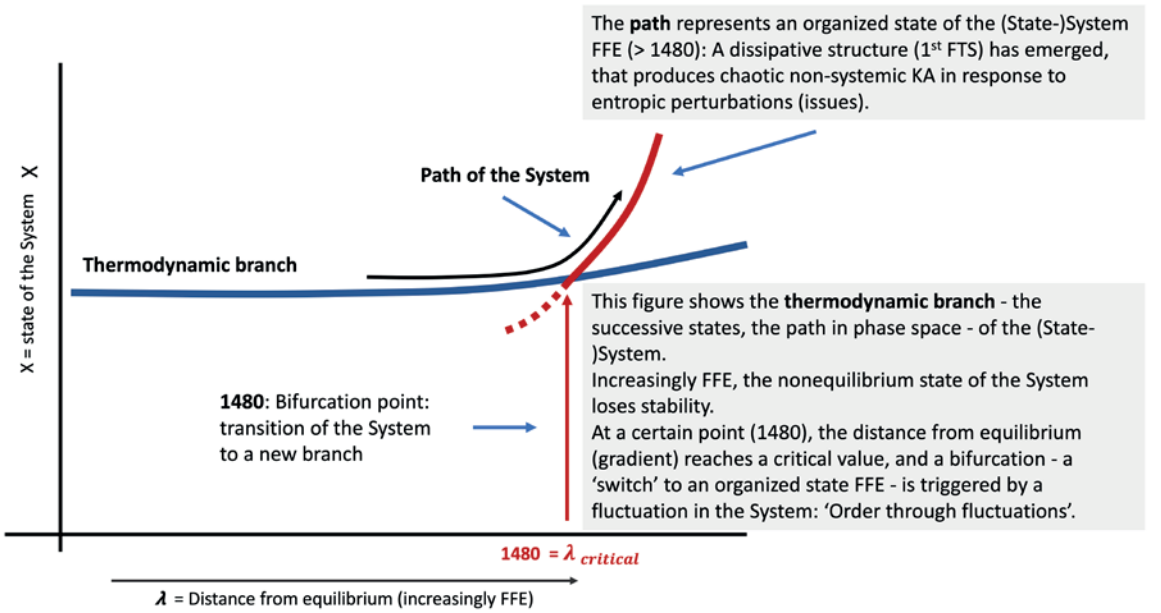


FIGURE 24.1: Stability diagram of the System. When in 1480, λ (the parameter that in indicative for the distance from equilibrium and the gradient) reached a critical value ($\lambda_{critical}$), a fluctuation (an incident, for example) was amplified 'at the right moment' (65) - involving a combination of probabilistic and deterministic factors - that favored one reaction path over a number of other equally possible paths. The crossing of a bifurcation is a stochastic process (65). The presence of an instability (i.e. in 1480), may be viewed as the result of a fluctuation (e.g. an incident in the contingent domain) that is first localized, and then spreads and leads to a macroscopic state FFE. The 'selected' path became the initial condition for the 1st FTS, a dissipative structure that was sustained until 1939, when the core of the System (The European State-System) and the 1st FTS eventually collapsed. The diagram shows schematically the transition of the System from an increasingly unstable state to an organized state FFE (to a chaotic regime), through a bifurcation in 1480. This type of behavior is also referred to as 'order through fluctuations', and refers to the many fluctuations in the System, of which one is at a certain point amplified (as just mentioned), and then determines the nature of the ordered state and the System's path.

24.5. Chirality

Bifurcations - including the bifurcation the System experienced in 1480 - involve symmetry-breaking: The transition from a disorderly (more) symmetric state to a less symmetric and more organized state.
Kondepudi et al. explain that "the chemistry of life as we know it is founded on a remarkable asymmetry" (44), and that chirality is a requirement for symmetry-breaking.
A structure whose geometrical structure is not identical to its mirror image is said to possess chirality or 'handedness'. Mirror-image structures of a chiral molecule are called enantiomers.
"The first great unifying principle of biochemistry is that the key molecules have the same 'hand' in all organisms. This is all the more remarkable because chemical reactions show equal preference for the two mirror-image forms (...)" (44).

The origin of biochemistry's hidden molecular asymmetry (discovered in 1857 by Louis Pasteur) remains elusive until today and is still subject of active research. The observations I make in this paragraph are also speculative.

Assuming that chirality is also a requirement for the symmetry-breaking (the bifurcation) the System produced in 1480, the question is then how chirality manifests itself in the System and what its origins could be. In this paragraph, I speculate on chirality's origin and appearance in the (State-)System.

Although the true origin of chirality (asymmetry) remains elusive, we can see how such a state might be realized in the framework of dissipative structures: Chiral asymmetry requires FFE-conditions to ensure amplification of asymmetries and maintenance of the ordered structure that emerges (44), as Kondepudi et al. explain: "First, we note that such an asymmetry can arise only under far-from-equilibrium conditions; at equilibrium, the concentrations of the two enantiomers must be equal. The maintenance of this asymmetry requires constant catalytic production of the preferred enantiomer in the face of interconversion between enantiomers, called racemization (racemization drives the system to the equilibrium state in which the concentrations of the two enantiomers will become equal.) Second, following the paradigm of order through fluctuations, we will presently see how, in systems with appropriate chiral autocatalysis, the thermodynamic branch, which contains equal amounts of L- and D-enantiomers *(IP: the two (mirror) versions of the parts of the system in this example)*, can become unstable. The instability is accompanied by the bifurcation of asymmetric states, or states of broken symmetry, in which one enantiomer dominates. Driven by random fluctuations, the system makes a transition to one of the two possible states." (44) Following a bifurcation, there is homochirality, a uniformity of chirality (handedness); life is founded on homochirality.

For the System's bifurcation in 1480, I propose the following speculative explanation. The System's bifurcation also requires the selection (and amplification through fluctuations) of a specific enantiomer present in the System. I assume that cooperation and conflict - respectively the reliance on non-kinetic- and kinetic-interactions - are the two "mirror-images' - enantiomers - of social structures (communities), and that kinetic-interactions were in 1480 selected as the preferred behavioral interactions - interaction-mode - of the (State-)System and embedded as the 'basic' solution in the organized state, after 1480.

During the period preceding the bifurcation in 1480, the kinetic (KA) mode of behavior was reinforced through autocatalytic reactions (the reinforcement of kinetic behavior, through positive feedback), a process that amplified small initial asymmetries.

The subsequent (social) evolution of the System (until today and in the future) is to a very high degree determined and shaped by the dissipative structure (the 1st FTS) and "underlying" enantiomer that was selected in 1480.

The 1st FTS - and its kinetic mode of operation - produced state-structures and a State-System (with its kinetic properties), which for their stability and survival relay heavily on kinetic interactions.

24.6. Lower entropy-production, following the bifurcation

Kondepudi et al. investigated (in general) how the rate of entropy production changes when a system moves from a "region below the critical point - when $\lambda < \lambda_{critical}$ - (when the system is in a more symmetric steady state), to a region above the critical point - when $\lambda > \lambda_{critical}$ - where the system is in an asymmetric (more organized) state, and show that above the critical point "the entropy production is lower for the

asymmetric state" (44). "Thus, when the unstable symmetric state makes a transition to the asymmetric state above the critical point, then entropy production decreases" (44). I assume, that after the bifurcation of the System in 1480, the entropy-production was not only organized (by the 1st FTS) but also lower. The System acquired coherence and 'focus' to ensure thermodynamic equilibrium in the European State-System was reached via the most efficient path.

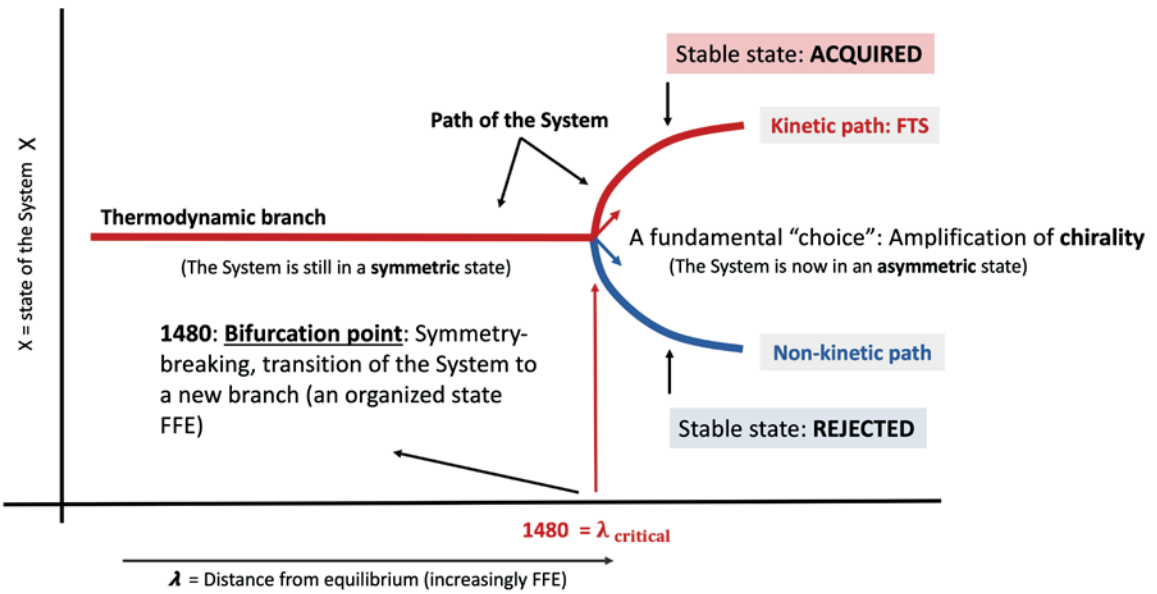


FIGURE 24.2: Bifurcation in 1480: Selection of the kinetic path to thermodynamic equilibrium of the European State-System. This figure shows a bifurcation diagram of the System. In 1480, the System bifurcated, implying a choice that determined the order and path of the System. The stable path that was acquired can be considered a kinetic path that was regulated by the 1st FTS, during the transition (1480-1945) to thermodynamic equilibrium of the core.

24.7. Fluctuations and correlations

In relation to fluctuations and correlations in a system - a fluid in the example of Prigogine et al. (65) - a question is what "the probability is at a given time of finding a number X for the concentration of a certain component. Obviously, this probability will fluctuate, as do the number of collisions among the various molecules involved. Calculations for equilibrium systems show that a classical probabilistic distribution - a Poisson distribution - is be obtained" (65). According to Prigogine et al. (65) two aspects of this distribution are of importance: (1) "the distribution leads to the law of large numbers" and (2) "thus fluctuations indeed become negligible in a large system". Furthermore Prigogine et al. observe: "One of the most unexpected results of recent research is that the situation changes drastically when we move to nonequilibrium situations. (...) when we come close to bifurcation points the fluctuations become

abnormally high and the law of large numbers is violated. This is to be expected, since the system may then 'choose' among various regimes. Fluctuations can even reach the same order of magnitude as the mean macroscopic values. Then the distinction between fluctuations and mean values breaks down" (65) and "long-range correlations appear. Particles separated by macroscopic distances become linked. Local events have repercussions throughout the whole system. It is interesting to note that such long-range correlations appear at the precise point of transition from equilibrium to nonequilibrium. From this point of view the transition *(IP: at the bifurcation point, '1480' in case of the System)* resembles a phase transition. I assume, but it cannot be verified because of a lack of data - that the System showed similar behavior close to and at the 1480-bifurcation point, in regard to KA - kinetic fluctuations/war-activity - in the System: KA and events became (increasingly) linked, through long-range correlations. Local events increasingly had repercussions throughout the whole System; as is typically the case at critical points (1618, 1792, 1914 and 1939).

Not only the 1480-bifurcagtion point demonstrates this typical behavior, as just described, but also the System during the transient period (1480-1945), when the 1st FTS accomplished a phase transition, and during which the (State-)System produced four critical points.

As discussed, analysis of war-data shows that the size-distribution of KA (wars), during the transient period (1480-1945), can be described with a power law, a typical distribution for critical phenomenon.

During the transient period, as was the case at the bifurcation point (1480), the (State-)System was organized through (sustained) long-range correlations and the behavior of the 1st FTS was remarkably coherent: During the transient period (1480-1945) - the phase transition of the European State-System - the temporal correlations were also very prominent, as the accurate 'timing' and consistent correlation of the four systemic wars show.

During the transient period, the 1st FTS regulated EMIS-flows, including KA; long-range correlations enabled long-range communication and coordination in the (State-)System/by the FTS. Although, systemic and non-systemic wars were (and still are) not always and necessarily correlated in the *contingent* domain (e.g. through social and political issues that connects them one way or the other) - in the deterministic (physical) domain KA is certainly connected/related: KA in the System, is an integral component of a coherent process - regulated by the FTS, in accord with the Second Law and related principles that apply FFE - to drive the State-System to thermodynamic equilibrium, via the most efficient path.

Although, for example, the 3rd systemic war (1914-1918, the First World War) and the Vietnam War, are not considered 'useful wars' - historians belief they could and should have be prevented (see also: 21) - that is not the case from a thermodynamic perspective (FFE): Both wars - KA - "served" the FTS (respectively the 1st and 2nd FTS) to ensure compliance of the (State-)System with the Second Law and related principles that apply FFE: The 3rd systemic war (1914-1918, the First World War) - a systemic war at that point in time - would have taken place anyway (the System was critical in 1914), and would have been triggered by another incident, if Archduke Franz Ferdinand was not murdered in Sarajevo, on 28 June 1914.

However, the (non-systemic) Vietnam War, could (and would) have been substituted by an alternative war if this issue was not amplified; but not necessarily at that exact same point in time and at that particular location (Vietnam). During RSP's there is flexibility, also because of the *chaotic* nature of non-systemic KA, which leaves a certain latitude to the FTS.

The Second Law and FTS are indifferent to the political and military outcome of wars, as long as deterministic demands of the System/FTS are be fulfilled.

24.8. From individual to collective behavior

The 1st FTS is the outcome of a combination of conditions, brought about by human activity and laws of physics that apply. Through the bifurcation in 1480, the System reached its nonequilibrium steady state (the 1st FTS) with an accompanying phase space characterized by fractal structures called strange attractors (to be discussed later), that generated chaotic non-systemic KA/war dynamics.
The dissipative structure (1st FTS) was 'imposed' on societies and states, and increasingly shaped their interactions: The 1st FTS constituted (and the 2nd FTS now constitutes) a template. The 1st FTS had (and the 2nd FTS has) a clear 'purpose': To ensure that the State-System (which is the structural component (appearance) of the FTS) reached (reaches) thermodynamic equilibrium (homeostasis) via the most efficient path.
Sustainment of the FTS requires regulation of EMIS-flows; these flows are the source of macro-order.
Once the FTS is established, EMIS-flows in the System - including war dynamics - are regulated by the FTS: Systemic and non-systemic KA is macroscopic - collective - behavior, of the (State-)System. The FTS - as is the case for dissipative structures in general - is "essentially a reflection of the global situation of nonequilibrium producing" the dissipative structure (65).

24.9. Application (1): Application of the Unified Principle of Thermodynamics

In this paragraph, I discuss the unified principle of thermodynamics, and its meaning for the System. According to Toussaint (92), who explains in reference to nonequilibrium systems: "To deal with this class of thermodynamics of nonequilibrium systems that are moved away from equilibrium and held at some distance from that equilibrium state, we propose the following corollary that follows from the proof by Kestin of the Unified Principle of Thermodynamics, that a system will tend toward its unique equilibrium state. Implicit in this observation is that a system will resist being removed from the equilibrium state. The degree to which a system has been moved from equilibrium can be measured by the gradients imposed on the system. As systems are moved away from equilibrium, they will utilize all avenues available to counter the applied gradients. Attractors can emerge so that the system organizes in a way that reduces or degrades the gradient. As the applied gradients increase, so does the system's ability to oppose further movement from equilibrium. If dynamic and or kinetic conditions permit, self-organization processes are to be expected. The building of organizational structure and associated processes degrade the imposed gradient more effectively than if the dynamic and kinetic pathways for those structures were not available" (92).
During the period that preceded the bifurcation (in 1480) and during the transient period (1480-1945), the System was pushed increasingly FFE, through the increased production of entropy caused by population growth and its effects. During the transient period, the gradient gained strength, and the 1st FTS - and related processes -consequently accelerated.
In accordance with the Second Law and related principles that apply FFE - the Unified Principle of Thermodynamics - the System resisted being 'pushed' increasingly FFE. The purpose of the processes and structures - including the FTS and State-System - that emerged in the core (Europe) in 1480, was to ensure that thermodynamic equilibrium in the core, was achieved via the most efficient path; the gradient would then be eradicated.

Prigogine explains: Systems utilize all avenues available to counter the gradient (force) that is applied, when they are moved away from equilibrium (FFE).
The paradox of the System FFE is that for the FTS to achieve its objective - thermodynamic equilibrium of the State-System - the FTS initially strengthens the gradient that drives/powers it - to gather enough energy, force and momentum - to eventually destroy itself and the gradient. The FTs ultimately achieves its purpose through self-destruction.

24.10. Application (2): From conduction to convection

Until in 1480 the bifurcation point was reached, entropy in the System was (re)distributed by conduction: Entropy was transferred through local interactions between parts/elements (individual humans and communities, etc.) in the System. This distribution process lacked any macroscopic organization.
When in 1480, the bifurcation point was reached, instabilities - entropic fluctuations - were (not only) amplified but were regulated by the 1st FTS.
In 1480, the initial symmetry (uniformity/homogeneity) of the System was broken and the dissipative structure that had emerged (the 1st FTS) could be sustained FFE.
From 1480 onwards, entropy-distribution was no longer accomplished through conduction only, but through convection ('in bulk', so to speak). The stable patterns that emerged, were (regulated by) the 1st FTS, and were instrumental in the processes of KA, aggregation, expansion and empowerment. Coherent macroscopic flows require mode-coupling.

24.11. Application (3): Randomness at macroscopic level

In this chapter, I again mentioned that there is an interplay between probabilistic and deterministic factors (between chance and constraint) in the System, e.g. in the selection of the path (a solution) at the bifurcation point (1480), but also at the critical points of RSP's (which constitute secondary bifurcations) in 1618, 1792, 1914 and 1945. Prigogine et al. observe, in this respect: "Once again, some properties quantum mechanics discovered on the microscopic level now appear on the macroscopic level (65). "Readers may be familiar with the Heisenberg uncertainty relations, which express in a striking way the probabilistic aspects of quantum theory. Since we can no longer simultaneously measure position and coordinates in quantum theory, classical determinism breaks down. This was believed to be of no importance for the description of macroscopic objects such as living systems. But the role of fluctuations in nonequilibrium systems shows that this is not the case. Randomness remains essential on the macroscopic level as well. It is interesting to note another analogy with quantum theory, which assigns a wave behavior to all elementary particles. As we have seen, chemical systems far from equilibrium (*IP: and I argue in this study the System as well*) may also lead to coherent wave behavior (65)" like so-called chemical clocks. This is also the case in the (State-)System, where the coherent behavior of the System during the transient period, consisted of four accelerating kinetic "waves".

24.12. Application (4): Von Clausewitz versus Sun Tzu

The phenomenon of chirality discussed in this chapter raises some questions. The idea I proposed, suggests that a 'kinetic path' was selected in 1480, and that KA was thereafter reinforced by the 1st FTS and 'institutionalized' in the core of the System. State-structures (with their typical characteristics) and consequently the State-System are manifestations - products - of the kinetic path.
Because the core dominated the interactions in the (State-)System, and Europe was also instrumental in the process of expansion to the non-core, a kinetic approach became eventually the standard mode of operation at a global scale. The non-kinetic cooperative-path can be considered the mirror image of the kinetic - conflict - path, this perspective suggests.
Von Clausewitz (1780-1831) his war theory 'On War' (22) reflects the kinetic approach of the 1st FTS, and his theory (not surprisingly) - Clausewitz is a product of the 1st FTS - emphasizes the application of force and destruction of the opponent.
Eastern cultures, on the other hand, emphasize a non-kinetic approach to conflict. In Asia (outside Europe), a 1480-type of bifurcation has not taken place.
Sun Tzu (544 BC-496 BC), author of "The Art of War", is a representative of a non-kinetic approach to war, according to Sun Tzu, "The supreme art of war is to subdue the enemy without fighting".
Through the processes and dynamics (KA, aggregation, expansion and empowerment) generated by the 1st FTS, during the transient period (1480-1945), and the subsequent adoption of state structures at a global scale of the System (institutionalized by the United Nations), the kinetic approach has now also become the dominant - globally adopted - mode of operation in the global (State-)System (1945-....).

25. The transient period (1480-1945)

25.1. Introduction

In the previous chapters, I already discussed the FTS and some of its features. In this chapter, I discuss two types (layers) of dynamics - R1- and R2-dynamics - that can be distinguished.

25.2. From an unorganized to an organized state FFE

During the period preceding the bifurcation in 1480, the System was driven increasingly FFE. As Kondepudi et al. explain: "In general, a system that is not in thermodynamic equilibrium need not be in a stationary (time-independent) state" (44) and "a basic feature of FFE systems is that extremum principles do not apply and "in all these systems is the possibility of amplification of small fluctuations under certain conditions, which makes the system unstable. These systems undergo instabilities often due to autocatalytic processes and make a transition to states with distinctly different organization", there is 'order through fluctuations'" (44). The complex behavior that is generated, include: "concentration oscillations, propagating waves and even chaos" (44). This behavior - chaotic dynamics - can also be observed in the System and is discussed in this chapter. A system - including the FTS and its structural component the State-System - can be maintained in a nonequilibrium state through a flow of energy and matter" which involves the environment of the System (44).

Once the transition was accomplished to an organized structure (the 1st FTS) in 1480, the excess entropy that was produced during the preceding period (< 1480) vanished and (entropy)-production was regulated by the 1st FTS. The 1st FTS had a well-defined purpose: To achieve thermodynamic equilibrium in the European State-System, via the most efficient path.

During the transient period (1480-1945), when the 1st FTS and its structural component, the European State-System, accomplished a phase transition, the non-core and societies constituted the environment of the European State-System, with which the FTS exchanged energy and entropy (EMIS), to sustain its operation. These organized exchanges, which also caused the 1st FTS to accelerate, manifested themselves as processes of KA (war dynamics in the contingent domain), aggregation (of the core, Europe), expansion to the non-core (colonialism) and empowerment of societies.

The purpose of the 1st FTS (1480-1945) was - and of the 2nd (global) FTS (1945-....) is - to accomplish thermodynamic equilibrium, in respectively the European and global State-System, via the most efficient path, in accord with the Second Law and related principles that apply FFE.

25.3. Two layers

Two distinct types of KA/war dynamics can be distinguished in the (State-)system, during the transient period: Chaotic non-systemic KA/wars during RSP's - KA dynamics I refer to as R1-dynamics - and cyclic (periodic) systemic KA/war, I refer to as R2-dynamics.
These dynamics served fundamentally different purposes: The chaotic non-systemic KA/war dynamics, during RSP's were instrumental in maintaining the current RSP - in maintaining continuity (the status quo) - while the cyclic/periodic systemic KA/wars, during critical periods, were instrumental in periodically lowering the energy state of the System, and in upgrading - changing - the order of the (State-)System.
During the transient period (1480-1945), four systemic KA/wars were produced: (1) the Thirty Years' War (1618-1648), (2) the French Revolutionary and Napoleonic Wars (1792-1815), the First World War (1914-1918) and the Second World War (1939-1945).

TABLE 25.1: Tipping points of RSP's of the 1st FTS (59).

RSP	Period	Tipping point
1	1480-1618	1514
2	1648-1792	1774
3	1815-1914	1856
4	1918-1939	Cannot be determined

The chaotic non-systemic KA/wars (R1-dynamics) were related to the FFE-state of the (State-)System; while the cyclic/periodic systemic KA/wars were a product of the MEP-Principle that applies near equilibrium.
The two types of dynamics were closely related and complementary: The cyclic/periodic systemic KA/wars were produced through a combination of the chaotic non-systemic KA during RSP's, and the effects of a network-effect that increasingly "smothered" non-systemic KA, once the tipping point of the RSP was reached. The accumulation of entropy caused - as a matter of time - the production of systemic KA/war (in 1618, 1792, 1914 and 1939).
The chaotic non-systemic KA (R1-dynamics) enabled cyclic/periodic systemic KA (R2-dynamics), while through the upgrade of the order of the (State-)System (through the R2-dynamics) continuation of the R1-dynamics was ensured, until 1939, when the critical point of the European (State-)system was eventually reached.
The chaotic non-systemic KA (R1-dynamics), I also refer to as the first layer of dynamics;
the cyclic dynamics that were subsequently "imposed" on the R1-dynamics - as a consequence of the network-effect - I also refer to as the second layer of dynamics.
The combination of the two types of dynamics and the synergetic effects that were generated - the FTS-dynamic - resulted in the balancing of continuity and change, while at the same time a phase transition was accomplished.

Because entropy-production in the (State-)System accelerated during the transient period (1480-1945), the life-span of successive cycles shortened, and in 1939 - when the 1st FTS reached the singularity in finite-time - the frequency of cycles (systemic KA/wars) and their magnitude (the free energy that was released), reached infinity, at least theoretically. At that point, the core of the System Europe) produced infinite amounts of entropy, at an infinite rate.
Because of the unsustainability of the condition in 1939, the European State-System - the core - collapsed, and the last stage of the phase transition (the 4th systemic war) could be accomplished.
In below table the characteristics of the layers and FTS are shown:

TABLE 25.2: Properties of the R1-, R2-, and the FTS-dynamics.

Property	R1-dynamics	R2-dynamics	FTS
Nature of dynamics	Chaotic non-systemic KA (chaotic non-systemic KA/ war dynamics).	Accelerating cyclic/ periodic KA/war dynamics.	Finite-time singularity dynamic accompanied by four accelerating war-cycles; a phase transition.
Distance from equilibrium	FFE.	Near- equilibrium.	A combination of dynamics FFE and near equilibrium.
Type of regime	Nonlinear regime.	Linear regime.	A combination of regimes.
Thermodynamic principles	Order through fluctuations and KA.	Minimum Entropy Production (MEP-principle), extremization.	A combination of principles: Order through the interplay between competing thermodynamic potentials.
Purpose/ function	Continuity: To maintain the status quo, by neutralizing and redistributing entropic perturbations through chaotic non-systemic KA.	Change: To upgrade the order and improve EMIS-regulation.	Optimization of EMIS-regulation by balancing continuity and change, to ensure the (State-)System follows the most efficient path to thermodynamic equilibrium.

25.4. A paradox: The System was FFE, but also near-equilibrium

The two types of regimes and accompanying dynamics during the transient period (1480-1945), served two different purposes: The purpose of the R1 chaotic non-systemic KA was to regulate entropic perturbations during RSP's in efforts to maintain the existing order, while the purpose of R2 cyclic systemic KA was to periodically upgrade the organization of the System, in order to ensure the (continued) performance of the (State-)System. While the chaotic R1 dynamics were a product of the organized state (the dissipative structure) FFE that emerged through a bifurcation in 1480, the R2 cyclic dynamics obeyed near-equilibrium thermodynamic principles.
To the R1- and R2-dynamics - the two layers of the FTS - apply different thermodynamic principles, respectively FFE thermodynamic principles and thermodynamic principles that apply to systems near-equilibrium and to phase-transitions.

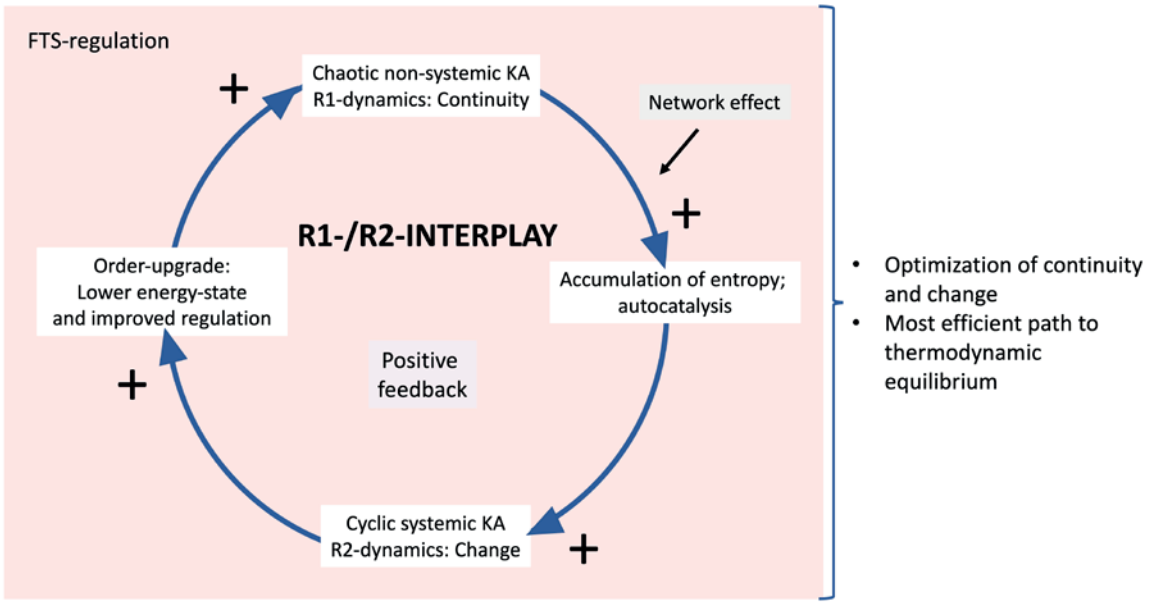


FIGURE 25.1: The interplay between dynamics of the FTS.

The different - and competing - thermodynamic potentials and their extremization, of which the R1- and R2-dynamics are manifestations, constitute the 'engine' of the FTS and its structural component (the State-System), that also power the processes of KA, aggregation, expansion and empowerment.

25.5. Simultaneous minimization and maximization of entropy-production

During stationary states - RSP's in case of the System - a system typically tries to minimize the total rate of entropy-production (44, 28). This 'behavior' - tendency - can also be observed in the System, as explained. Whereas, during RSP's, entropic perturbations (issues) are regulated through chaotic non-systemic KA (R1-dynamics), to maintain the status quo, the purpose of cyclic R2-dynamics is to reduce entropy-production, and the energy-/entropy state of the System.
The R2-dynamics could however not keep pace with the accelerating entropy-production in the (State-) System (caused by (mainly) population growth and increasing rivalries between societies/states, and enabled by the FTS, itself), which caused the European State-System's collapse in 1939.
Although, for a certain time-span - the period (1480-1939) - the entropy could be regulated by the 1st FTS, the 1st FTS ran ultimately out of options; the structure was pushed to near zero-entropy (reached in 1939) and consequently collapsed. While the FTS its regulation was based on the minimization of entropy-production (the MEP-principle), the FTS ensured the maximization of entropy production in the System, by enabling population growth and related processes.

Through these contradicting tendencies - which can be attributed to the interplay between competing thermodynamic potentials and their extremization - the FTS ensured that the most efficient path to thermodynamic equilibrium of the European State-System (core) was selected and utilized.

TABLE 25.3: The dynamics of the System and their manifestations in the contingent domain.

Stability conditions and principles			
Type of dynamic	**Stability condition**	**Stability principle(s)**	**Resulting behavior in the contingent domain**
First layer: R-1 non-systemic KA/ war dynamics FFE, chaotic in nature.	The System is stable to all perturbations that result in $d_iS > 0$: An increase in entropy (tensions) - an entropic perturbation - generates a kinetic response (KA) from the FTS. Through the KA entropy is neutralized and redistributed, and equilibrium is restored.	Entropy (-production) and entropic perturbations are neutralized and redistributed through KA. The System tries to maintain an entropic balance. In case of the System there is *'order through fluctuations'*, a phenomenon that refers to the bifurcation in 1480, and *'order through KA'* which refers to the maintenance of order during the transient period through the application of KA.	The State-System produces unpredictable chaotic non-systemic wars.
Second layer: R-2-dynamics near equilibrium, cyclic in nature.	The MEP-Principle applies to the near-equilibrium cyclic R-2 dynamics. The order of the (State-) System is periodically re-adjustment through periodic upgrades by means of systemic KA. The four cycles constitute a phase transition.	The periodic upgrades of the order of the System can be understood as measures of the FTS to minimize the entropy/energy state of the System, and to improve its (FTS) regulatory capacity. The R2-dynamics are a manifestation of the MEP-Principle, and certain properties - e.g. the rate of non-systemic KA - evolve linearly (which should not come as a surprise because the linear regime applies to R2-dynamics).	Systemic KA/wars came at an increasing pace: The 4th systemic war (the Second World War, 1939-1945), followed shortly after the 3rd systemic war (the First World War, 1914-1918), in accord with the deterministic regime (the 1st FTS) imposed by the Second Law and related principles that apply FFE.
Multi-layer: A combination of R1 and R2-dynamics. The combination of dynamics constitutes the 1st FTS, accompanied by four accelerating KA/war-cycles.	The 1st FTS - consisting of two cooperating dynamics: The R-2 dynamics sustain the R-1 dynamics, while the R-1 dynamics generate the R-2 dynamics. Through the FTS the most efficient path to thermodynamic equilibrium is selected and ensured.	An optimal balance between continuity and change, during the transient period (1480-1945).	During the Transient period (1480-1945), the core (Europe) became increasingly populated, connected, and its 'parts' increasingly interdependent. Increasing interdependence developed hand in hand with increasing competition and rivalries. The pace of life in the continuously accelerated.

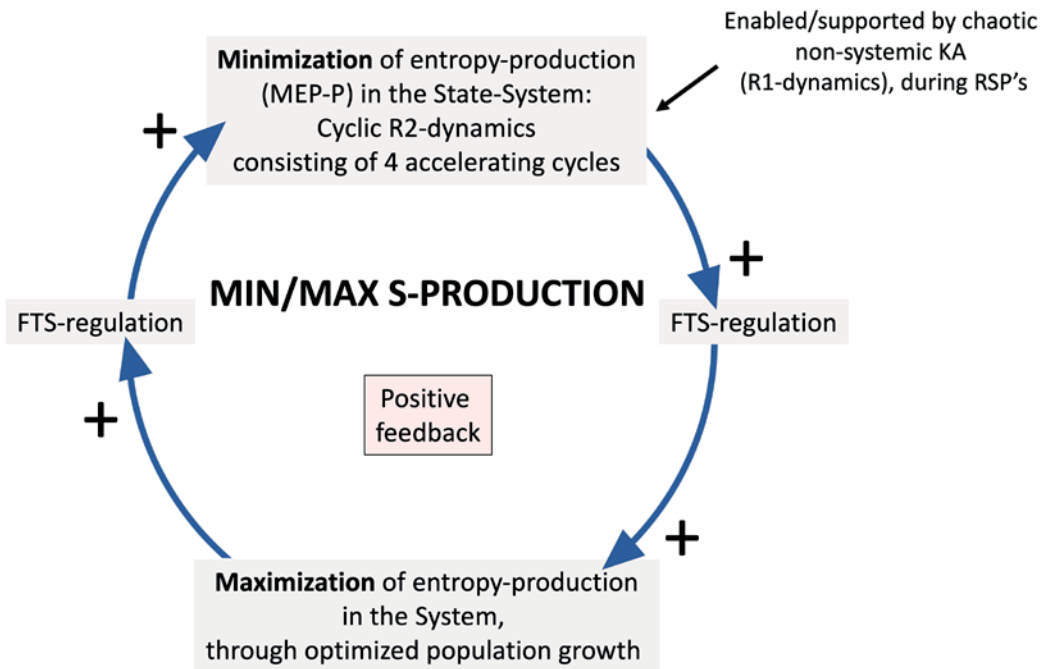


FIGURE 25.2: Simultaneous minimization and maximization of entropy-production at two levels of the System. The minimization and maximization of entropy-production of respectively the State-System and System play the same role as thermodynamic potentials in equilibrium theory (44, 62).

25.6. The monopolization of violence by states to meet contradicting demands of thermodynamic potentials

During the transient period (1480-1945), there were two types of control in the System simultaneously in place, in different - but interacting - subsystems: Homeostatic control in societies/states and FTS-control in case of the State-System.

In this paragraph, I discuss their fundamental differences, and the interplay between the two types of control.

In case of homeostatic control of a system, certain checks and balances are internalized, to ensure certain (key-) parameters of the system stay within certain ranges, and the system's operation is optimized, as much as possible. The corrective measures/actions initiated by the system (in homeostasis), can concern the internal and/or the external environment of the system. Social systems (as well as individual humans) have the (unique) ability - albeit within limitations - to manipulate their environment as well.

In case of homeostatic control, goal-seeking behavior - negative feedback structures - dominates a system's behavior.

State-structures provide homeostatic control to societies (they regulate). States ensure that certain societal and environmental parameters are kept within certain ranges. Once societal homeostatic control is established, the use of kinetic energy is minimized, to avoid destruction and destabilization.
The FTS regulates the (sate-)System. In case of the State-System, there is goal-seeking behavior, but this goal-seeking behavior does not qualify as homeostatic control. The goal the State-System seeks is thermodynamic equilibrium (at the level of the State-System). This (overarching) goal, was imposed on the State-System in 1480, through the 1st FTS. The overarching goal of the FTS, produced various dynamics and mechanisms to achieve this goal as efficient as possible, including: chaotic non-systemic KA (R1-dynamics) to regulate entropic perturbations (issues) during RSP's, and cyclic R2-dynamics to periodically upgrade the order of the System (to lower the State-System's energy-/entropy-state and to enhance its regulatory capabilities), during critical periods.
During the transient period (1480-1945), in Europe (the core), homeostatic control won terrain through aggregation, but at the same time, FTS-regulation - including KA - also intensified. Through aggregation - enhanced homeostatic control - societies produced more entropy (through their interactions) while their free energy potential also increased.
The state not only 'imposed' homeostatic control on societies, but also regulated their external environment - through active participation in the State-System and participation in FTS-regulation. Societies/states had to 'bridge' contradictory regulatory requirements of the H- and S-imperatives, they were simultaneously subject to: Whereas the internal (societal) use of free energy was - and had to be - minimized (to maintain homeostatic control), the external use of KA was maximized (to ensure a favorable environment). This was accomplished through the monopolization of violence (kinetic energy) by the State. Through the monopolization of violence (kinetic energy), internal stability was ensured, while the state's capacity to efficiently put kinetic energy to use in the State-System, was simultaneously maximized. The monopolization of kinetic energy by the state, is also an example how states deal with contradicting thermodynamic potentials, and how thermodynamic potentials are internalized in social structures.

25.7. Application (1): Fundamentally different characteristics of R1- and R2-dynamics

(This paragraph serves as a preview, to provide some perspective to the reader; these subjects will be discussed in detail in the next chapters). Apart from being related to different thermodynamic states (FFE in case of R1-dynamics and near-equilibrium in case of R2-dynamics) have R1- and R2-dynamics also fundamentally different quantitative properties, as below figures show. Despite these differences are the two types of dynamics closely related (complementary) and points the development of the quantitative properties of both types of dynamics to the presence of a critical threshold - a singularity in finite-time - that was actually reached in 1939.

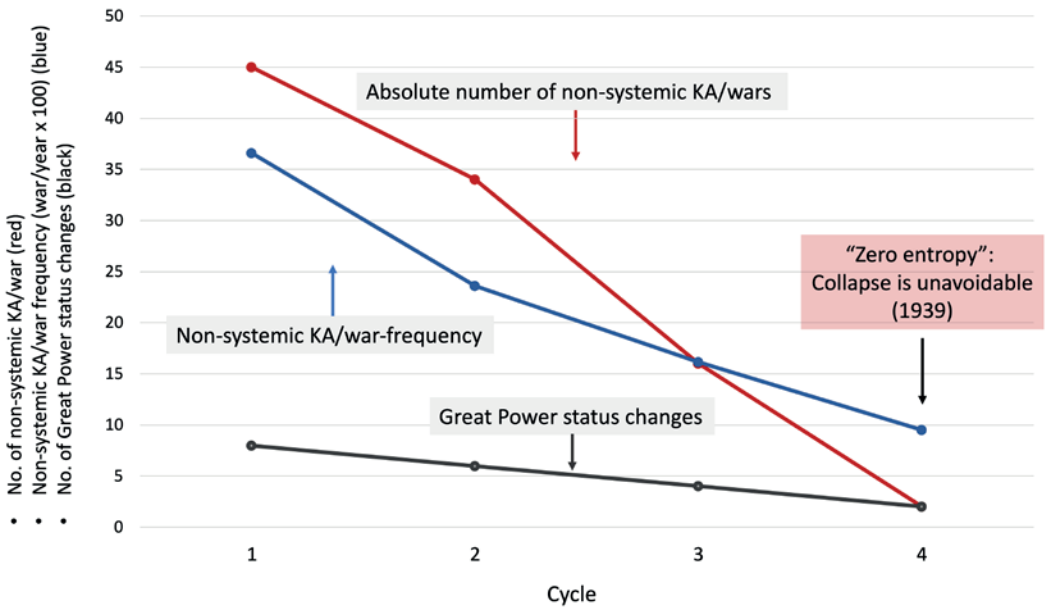


FIGURE 25.3: Quantitative properties of R1-dynamics, during the transient period (1480-1945). The decrease to zero of the value of the properties, points to the presence of a critical threshold, that was actually reached in 1939.

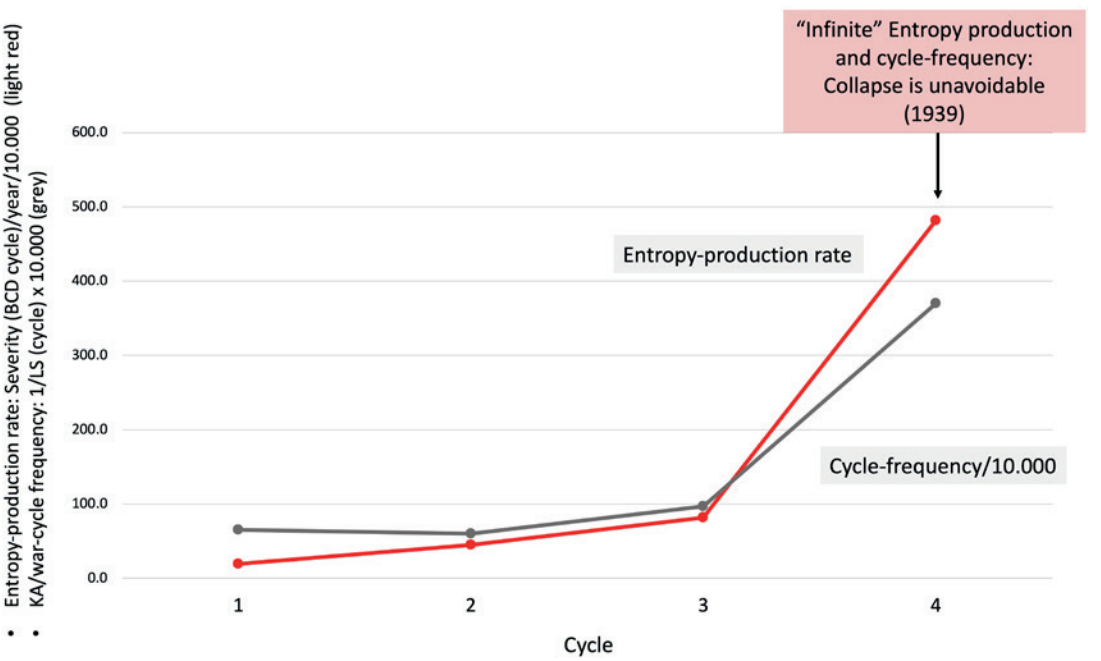


FIGURE 25.4: Quantitative properties of R2-dynamics, during the transient period (1480-1945). The accelerating increase of entropy-production, KA, and the acceleration of the cycle-frequency also point to the presence of a critical threshold, that was actually reached in 1939.

In below figure, the quantitative properties of both the R1- and R2-dynamics are included.

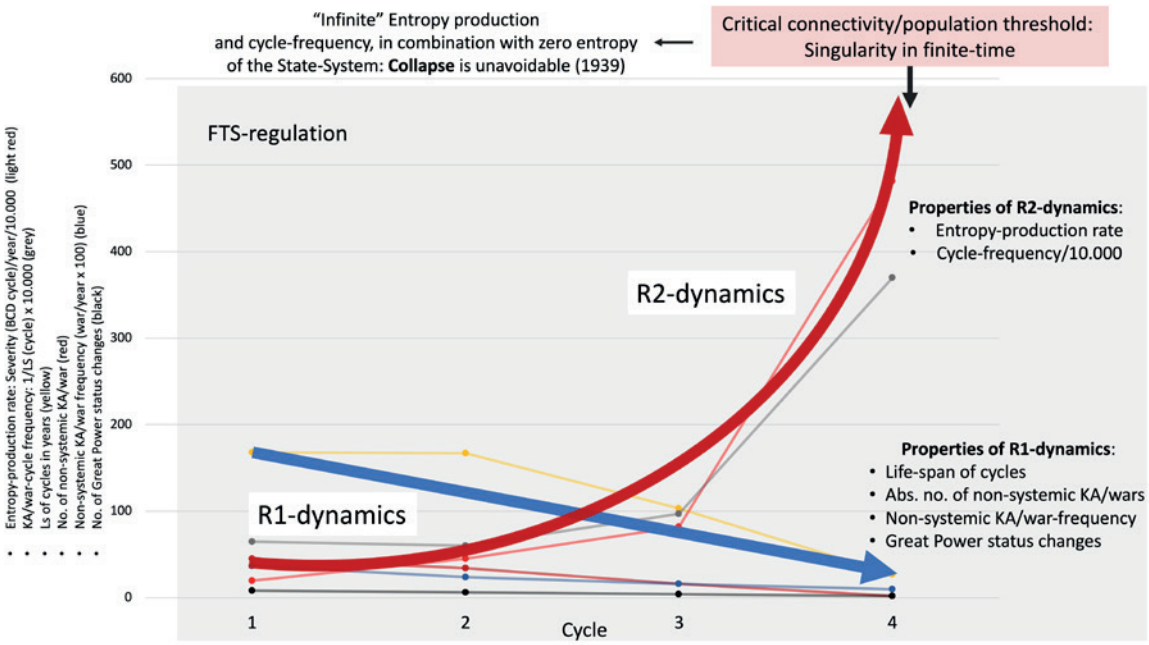


FIGURE 25.5: Quantitative properties of both the R1- and R2-dynamics, the presence of a critical threshold and the unavoidability of collapse of the European State-System.

25.8. Application (2): Attribution of dynamics

The System shows some typical 'behaviors', in some cases, this behavior can be attributed to the R1-, R2- or FTS- ('combined') dynamics. See below table for some examples.

TABLE 25.4: Attribution of dynamics.

Behavior	Type of dynamic
The intrinsic unpredictability of non-systemic KA	R1
The predictability of systemic KA	R2
The phase transition to thermodynamic equilibrium	FTS
The increased order in the System	FTS
The development of the State-System toward zero-entropy	R-2
The process of aggregation in the core, expansion of the core to the non-core, empowerment	R-2

25.9. Application (3): Both systemic and non-systemic KA are threshold phenomenon

Both systemic and non-systemic KA involve thresholds. Because of these thresholds - for example inertia of societies and the System - entropy can be temporarily 'stored' in the System. Storage allows for decoupling, as Sterman describes (87) and results in cyclic behavior. The network-effect allows for the accumulation of entropy (issues and tensions) during RSP's once, the tipping point is reached; the network-effect constitutes a threshold that enables the System to become critical and produce a systemic kinetic response.

25.10. Application (4): The course of the 1st FTS was to a high degree predetermined

The emergence of the 1st FTS, through a bifurcation in 1480, was instrumental in accomplishing a phase transition of the System to thermodynamic equilibrium (homeostasis) in the core (Europe). The bifurcation, the emergence of an organized state FFE - the 1st FTS - and the end-state (thermodynamic equilibrium in the European State-System/core of the System) result from the laws of thermodynamics and related principles that apply FFE.

The 'course' of the System's development in the deterministic domain (and to a high degree in the contingent domain as well) was set in 1480, and - given the parameters of the System (e.g. the rate of population growth) - the timing, duration and severity of systemic KA were predetermined, and could have been accurately calculated, if the thermodynamic properties of the (State-)System were known at the inception of the 1st FTS in 1480.

Although the 'course was set' in the deterministic domain (but also with some latitude for change, as discussed), in the contingent domain there was still contingent latitude. However, during the transient period (1480-1945), the contingent latitude was increasingly 'narrowed' and shaped by the PDLI- and PBMP-mechanisms. The contingent latitude shrunk to nearly zero, as did the entropy of the State-System; ultimately - in 1939 - the European State-System had run out of options and collapse was unavoidable.

26. R1-dynamics during the transient period

26.1. Introduction

As discussed, during the transient period (1480-1945), three distinct but closely related dynamics can be distinguished in the (State-)System: R1 and R2 dynamics, respectively chaotic non-systemic KA FFE dynamics and dynamics consisting of accelerating and systemic KA near-equilibrium, and the "combined" FTS dynamic, consisting of the R-1 and R2 dynamics, including the synergetic effects that are generated.
In the previous chapter, some general features of the FTS and of the R1- and R2-dynamics were discussed.
In this chapter, the focus is on chaotic non-systemic KA/war dynamics, and related aspects.
The subjects I discuss in this chapter include: (1) 'proof' for the *chaotic* nature of non-systemic KA, during RSP's, (2) the presence of a tipping points during RSP's and its origins and effects, (3) the differences between LCR- and HCR-non-systemic KA during RSP's and (4) the related processes of entropy-accumulation, autocatalysis, and the nucleation and percolation of VC's, during HCR's.

26.2. The typical life-cycle of war-cycles

The 1st FTS (1480-1945) was accompanied by four accelerating war-cycles. Analysis of the war-data shows that each cycle had an identical life-cycle: In each case, a RSP was followed by a relatively short critical period. The stability of a RSP - a stationary but dynamic steady state - is constantly tested by inevitable internal entropic fluctuations (issues and tensions); the spectrum of non-systemic kinetic responses (KA, wars) is determined by the structure of the System (72).
During successive RSP's, the (State-)System responded with chaotic non-systemic KA (R1-dynamics) to entropic perturbations, except during the 1st exceptional period (1657-1763), when the System was forced into a "periodic window" (to be discussed in chapter 30).
In figure 26.1 some properties of war-cycles are explained.

26.3. Quantitative properties of R1-dynamics, during successive RSP's of KA/war-cycles

The quantitative properties of R1-dynamics - non-systemic KA/wars during RSP's of KA/war-cycles - developed very regularly: The absolute number of non-systemic KA/wars during KA/war-cycles, the KA/war-frequency during KA/war-cycles and the number of Great Power status dynamics all decreased

(about) linearly to zero. These developments point to the existence of a critical threshold; a singularity; a singularity is a "point" when the properties of the (State-)System can no longer be defined, and the (State-)System exhibits extreme behavior.

This point was reached in 1939, at the end of the 4th RSP, and is also referred to as the critical point of the European State-System or the critical connectivity or population threshold of the European State-System.

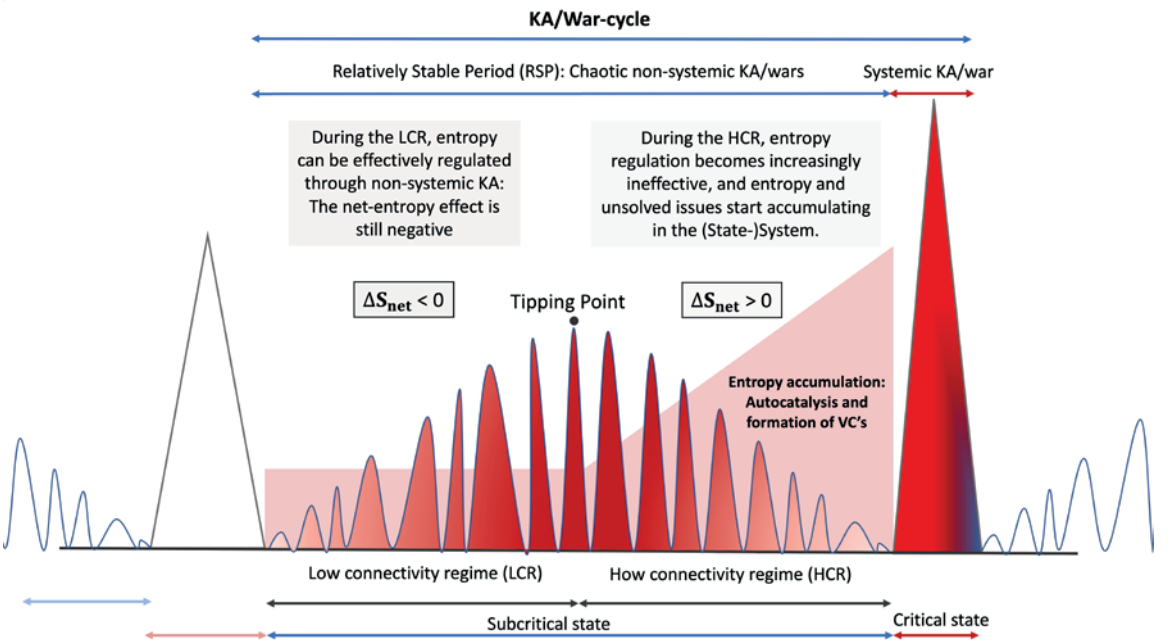


FIGURE 26.1: KA/War-cycle. This figure is a schematic representation of a war-cycle. The 1st FTS (1480-1945) was accompanied by four accelerating war-cycles. Each war-cycle had a similar life-cycle. Initially, following the bifurcation in 1480, and following systemic KA/wars (1648, 1815, 1918), the average size of chaotic non-systemic KA (non-systemic wars) was limited, but increased steadily, until the tipping point of the RSP (of the cycle) was reached. At that point, a network-effect increasingly limited the effectiveness of non-systemic KA (war) to 'neutralize' entropic perturbations (issues). Consequently, the average size of non-systemic wars started decreasing, while entropy accumulated in the System. Accumulation of entropy, autocatalysis and the percolation of VC's reinforced each other, and pushed the System to a critical state. Once the VC's spanned the System (full percolation was accomplished) and KA was totally suppressed, the (State-)System was in a critical condition and responded with systemic KA (a systemic war), this happened in 1618, 1792, 1914 and 1939.

The regime that preceded the tipping point I denote as the low-connectivity regime (LCR); the regime that follows the tipping point, is denoted as the high-connectivity regime (HCR), when typically, the network-effect undermines the effectiveness of KA. The term net-entropy effect ( ) refers to the sum of the entropy generated by the issue (the entropic perturbation, "supplied" by the S/T-field) () and the entropy that is neutralized through the use of non-systemic KA ($S_{neutralized}$).

During LCR's: $\Delta S_{net} = S_{issue} - S_{neutralized} < 0$, and during HCR's: $\Delta S_{net} = S_{issue} - S_{neutralized} > 0$

Contrary to what this schematic depiction of a war-cycle could suggest, the tipping point is not (necessarily) 'located' halfway through a RSP.

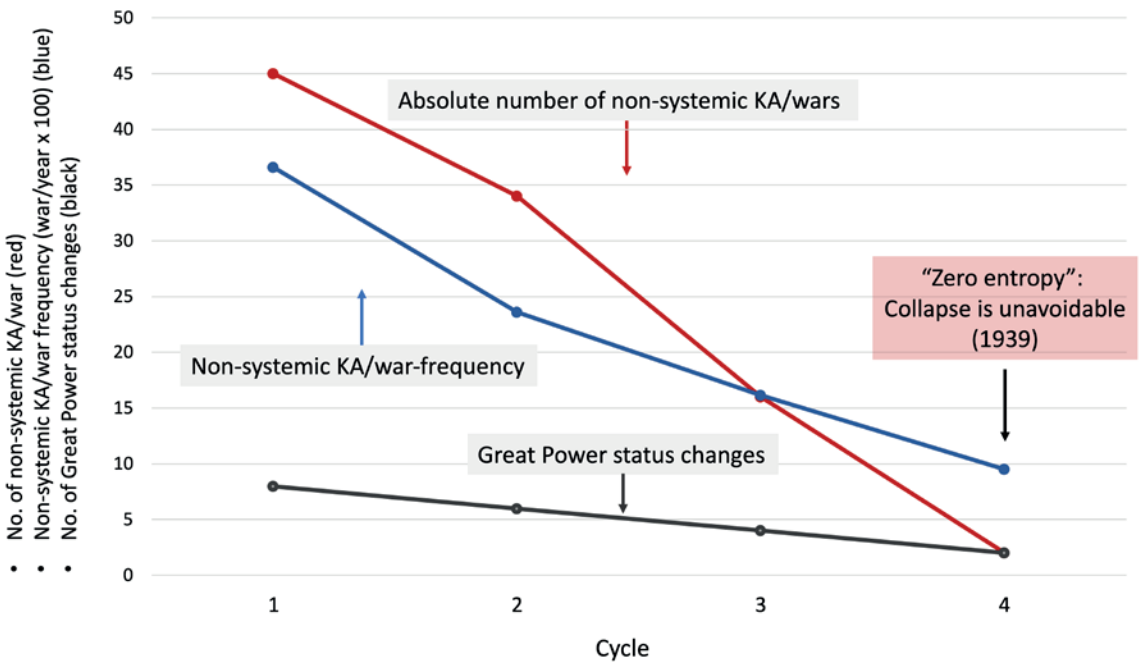


FIGURE 26.2: Quantitative properties of R1-dynamics, during the transient period (1480-1945). The decrease to zero of the value of the properties, points to the presence of a critical threshold, that was actually reached in 1939. The R1-dynamics and R2-dynamics are closely related.

26.4. Chaotic dynamics

As discussed, chaotic processes and dynamics are in fact highly ordered dynamics, despite their apparent randomness, and very sensitive for initial conditions; consequently, chaotic dynamics are intrinsically unpredictable. Chaos can be considered a form of oscillation; although this motion is deterministic, it is also highly irregular. In this paragraph I elaborate on some of these aspects.

Chaos plays an important role in nature. Chaotic (war) dynamics show that disorder in a certain range is compatible with order. Chaos also reveals that "randomness is not the result of experimental imperfections or of a complex environment that we cannot control, but rather is deeply rooted in the dynamics of perfectly deterministic systems involving few variables" (66). Chaos gives rise to order and information: Order and information are equivalent with low(er) entropy.

"For chaotic dynamics to emerge, a number of minimal conditions must be satisfied" (66). "During the 1960's the meteorologist Edward Lorenz discovered that dynamical systems involving only a few variables could present chaotic behavior after few bifurcations from the reference state (66). Lorenz's model provides a simplified description of the thermal convection problem in which only three modes give rise to chaotic dynamics" (66). This phenomenon is at the origin of the difficulties in weather prediction, and

I argue, at the origin of the unpredictability of certain properties of non-systemic wars, including their start time, duration and severity. War dynamics - KA of the system - involve flows that are equivalent with convection.

As discussed, chaotic dynamics are deterministic, but very irregular: "the trajectories in phase space are very sensitive to slight changes in the initial conditions, and wander in an erratic manner in certain regions in phase space" (66). In case of chaotic dynamics, there is a 'combination' of chance and constraints, at play. "Chaotic dynamics have fractal structures, and the overall structure of the attractor is repeated on all scales" (66).

It seems that at the 'center' of the chaotic attractor of the System is a fixed point also referred to as a saddle-focus: The trajectories are repelled away from this point in a two-dimensional surface of phase space, but 'simultaneously' attracted along a one-dimensional curve, that are also referred to as homoclinic orbits. An unstable and stable focus are - so to speak - combined in the saddle focus, which gives rise to instability, but with certain restrictions. In case of a saddle-focus, departing trajectories (along above-mentioned one-dimensional curve, constituting homoclinic orbits) are reinjected in the vicinity of the unstable fixed point" (66). According to Prigogine, "Homoclinic orbits are however very sensitive to variations of parameter values and are generally destroyed if the parameters do not satisfy a strict equality" (66).

The "form" of the strange (chaotic) attractor - explains the simultaneous "randomness" - instability - of chaotic non-systemic KA/wars, but also the restrained nature of these dynamics. Periodic dynamics - the System produced during the 1st exceptional period (1657-1763) - were much more extreme - unrestrained - than their chaotic counter parts, as I will show later.

Contrary to more extreme periodic non-systemic KA (non-systemic war dynamics), do chaotic war dynamics ensure optimized exploration of phase state, allow for nucleation and percolation of VC's, and thus for the storage of information. As discussed, this are preconditions for the System to become critical, produce a systemic response and to upgrade its organization. Chaos, development and evolution, and sustainment of the FTS are closely related phenomena.

"Typically, the trajectories in phase space of chaotic dynamics consist of orbits, or orbit-like forms. Lyapounov exponents provide a measure for the instability of motion (in phase space) and the sensitivity to the initial conditions. Lyapounov exponents describe the mean rate of exponential divergence of two initially close trajectories" (66).

In case of case of dissipative systems, the property of asymptotic stability - the phenomenon that after perturbations dissipative structures resume their 'original' dynamics - implies the possibility of these systems attracting chaos (66). This is also the case for the System: Chaotic war dynamics are the default dynamics of the System during RSP's. Chaotic war dynamics were only periodically (and very predictably) interrupted by systemic KA during relatively short critical periods (systemic wars). The accumulation of entropy (tensions and issues) caused by the network-effect, their nucleation in VC's and the percolation of these VC's are the causes of these critical periods and systemic KA. The abnormal (non-chaotic) war dynamics during the 1st exceptional period (1657-1763), were the only departure from the otherwise very regular FTS-dynamics during the transient period (1480-1945).

26.5. Indications for the chaotic nature of non-systemic KA of the System

Various 'indicators' point to the *chaotic* nature of non-systemic KA of the (State-)System, during the transient period (1480-1945).

(a) The number of degrees of freedom of the System. The type of dynamics the System produces during relatively stable periods depends on several conditions; including on the so-called number of degrees of freedom of the System: The number of degrees of freedom during relatively stable periods determines the nature of the system's war dynamics: chaotic - in case the number of degrees of freedom is more than two - or (quasi-)periodic or subdued - in case the number of degrees of freedom is only two.
I assume that the "effective" number of Great Powers in the (State-)System, determines its number of degrees of freedom. The two exceptional periods provide us with insights in the workings of the System and FTS. The two exceptional periods, from respectively 1657-1763 (the 1st exceptional period) and 1945-1989 (the 2nd exceptional period), have in common that their dynamics in the contingent domain were dominated by the intense rivalries between respectively Britain and France, and the United States and the Soviet Union. There were only two possibilities; all other Great Powers present in the System at that time, were aligned with one of the two dominant rivals. Consequently, the number of "effective" degrees of freedom of the System during the exceptional periods was temporarily reduced to two, and the (State-)System consequently produced periodic non-systemic KA during the 1st exceptional period, and during the 2nd exceptional period, non-systemic KA was suppressed because the mode-coupling of the System was affected (as I explain later).

(b) The typical orbits in phase space. Non-systemic KA/wars produce trajectories in phase space. During the period 1495-1945, the 1st FTS produced ten orbits (of four orbits the configuration is somewhat indeterminate) in phase space, and during the 1st exceptional period (1657-1763), the System produced zigzag patterns in phase space (the non-systemic KA was periodic, to be discussed later). Circular trajectories - orbits - in phase space, point to the chaotic nature of dynamics. In paragraph 26/9, phase space during the period 1495-1618, is discussed.

(c) Lyapunov-exponents. To calculate the Lyapunov exponents of the war dynamics of the System, I have selected two pairs of wars (designated as serial 1 and serial 2), of which the initial conditions in phase state (their respective sizes and intensities) are close to one another. I consider the point at which these two wars show nearly similar conditions (size and intensity values) the origin of both trajectories.
However, a note of caution must be made; although the initial conditions for size and intensity are more or less approximate in phase state, in 'time of occurrence,' they differ significantly. The start time of the respective wars (i.e., pair 9–36 (serial 1) and pair 9–39 (serial 2)) are 74 and 87 years apart, respectively. As a consequence, both trajectories of a single pair were subject to different levels of 'noise' (stochastic factors). I assume that noise only had a limited impact on the deterministic nature of non-systemic wars. Serials 1 and 2 concern war numbers 9 and 39 and war numbers 9 and 36, respectively. Next, I have determined $\boldsymbol{\lambda}$ for: $\| \Delta \boldsymbol{I}(\boldsymbol{t}) \| = \| \Delta \boldsymbol{I}(\boldsymbol{0}) \| \, \boldsymbol{e}^{\lambda(t)}$.

TABLE 26.1: Near identical pairs in phase space. This table provides information on the selected pairs with almost similar initial conditions (59).

Pairs with initial conditions			
Serial	**Pair**	**Start value size, both wars**	**Start value intensity (/1000), war 1 and war 2**
1	9–39	0,20	0,057 and 0,024
2	9–36	0,20	0,057 and 0,049

TABLE 26.2: Lyapunov exponent serial 1. The Lyapunov exponent » 1.02 (59)

Serial 1: Lyapunov exponent ≈ 1,02				
t	**9**	**39**	**Abs |9-39|**	**Λ**
0	0,057	0,024	0,033	NA
1	0,043	0,127	-0,084	0,93
2	0,42	0,149	0,271	1,05
3	0,958	0,003	0,955	1,12
4	0,041	1,685	-1,644	0,98

TABLE 26.3: Lyapunov exponent serial 2. The Lyapunov exponent » 2.51 (59)

Serial 2: Lyapunov exponent ≈ 2,51				
t	**9**	**36**	**Abs |6-36|**	**Λ**
0	0,057	0,049	0,008	NA
1	0,043	0,195	-0,152	2,94
2	0,42	1,086	-0,666	2,21
3	0,958	0,024	0,934	2,38

These two pairs show a positive Lyapunov exponent, which points to chaotic dynamics. The values of the separate exponents are in relatively close proximity, particularly when different noise levels are taken into account. Not all wars (pairs) in close proximity in the phase state have positive Lyapunov exponents. These results are, however, encouraging, assuming the war dynamics are chaotic, as I propose (59).

(d) Autocorrelation. Autocorrelation is the cross-correlation of a signal with itself. It is a method to detect non-randomness. In below figure the autocorrelations lag-1 until lag-8 are shown of the sizes (in terms of fraction) of KA/non-systemic wars during the period 1495-1618, during the 1st RSP (1495-1618, because of a lack of date for the period 1480-1495), and of KA/non-systemic wars during the 1st exceptional period

(1657-1763). The analysis shows (1) the significant lower and more random autocorrelations during the 1st RSP, and (2) the significant higher and regular autocorrelations during the 1st exceptional period. These findings are consistent with the assumption that during the 1st RSP the KA/non-systemic wars dynamics were chaotic in nature, and during the 1st exceptional period more regular, in fact periodic (to be discussed later).

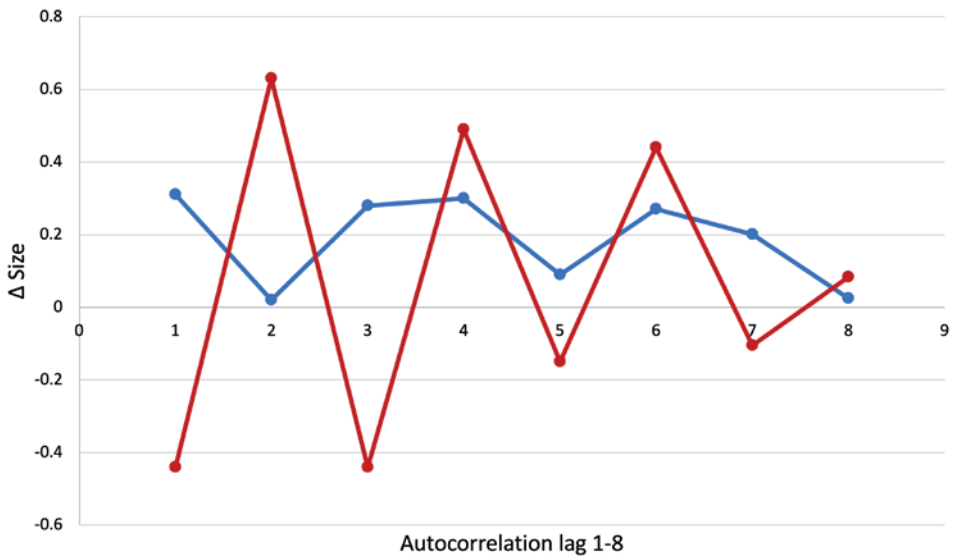


FIGURE 26.3: Autocorrelation. This figure shows the development of lag-1 until lag-8 autocorrelations of KA/war dynamics during the 1st RSP (period 1495-1618, in blue) and during the 1st exceptional period (1657-1763), in red. During the 1st exceptional period the autocorrelations were significantly stronger and developed more regularly, consistent with the assumption that these 'abnormal' KA/war dynamics were not chaotic, but periodic in nature. During the 1st RSP (period 1495-1618), the System produced 45 non-systemic wars; I calculated the lag-1 autocorrelation of this series of wars by determining the correlation coefficient between the sizes (fraction) of wars 1-44 with 2-45, the lag-2 autocorrelation by determining the correlation coefficient between the sizes of wars 1-43 with 3-45, etc. (59)

(e) Unpredictability. The KA/war-dynamics of the (State-)System are intrinsically unpredictable. Key-properties of chaotic non-systemic KA cannot be predicted, as decisionmakers, military strategists and historians know (however, this does not refrain them from often suggesting otherwise). Historians also observed that the System was much more predictable during both exceptional periods (when non-systemic KA was non-chaotic).

(f) The temporary 'switch' to periodic dynamics during the 1st exceptional period. The assumption that normally (by default), the non-systemic KA/war dynamics of the System are chaotic in nature, but during the 1st exceptional period (1657-1763) temporarily periodic, is not only supported by data-analyses, the properties of the war dynamics of the system, the typical trajectories in phase space, and the calculation of Lyapounov exponents, but also by the fact that the war dynamics switched from chaotic to periodic (1657) and vice versa (1763). Although these types of dynamics differ fundamentally in important

respects, both types of dynamics are closely related in the sense that systems follow a standard sequence of types of dynamics before reaching chaotic behavior, from (quasi-)periodic to chaotic, as Feigenbaum (Feig) demonstrates (to be discussed later, in more detail). In consider these particular switches (in fact bifurcations, in 1657 and in 1763), further circumstantial proof for the assumption that the default dynamics are indeed chaotic in nature, and that the emergence of periodic dynamics, was not just a random event (as far these types of events exist).

26.6. The tipping point

In this paragraph, I discuss the tipping point of RSP's/cycles; its origins and effects.
At a certain point during RSP's - the tipping point of a RSP - entropy-regulation in the System becomes increasingly problematic and entropic perturbations can consequently no longer be sufficiently regulated: Entropy - issues and tensions - then start accumulating in the (State-)System. The accumulating issues and tensions are 'stored' in VC's that increasingly percolate the System and causes the System to become eventually critical and produce systemic KA (a systemic war). The systemic KA is used by the FTS to upgrade its order, and to produce a next RSP. The process of entropy-accumulation that starts once the tipping point of a RSP is reached, initiates an autocatalytic process: During HCR's of RSP's, the production of issues and tensions (entropy) in the (State-)System, become involved in their own synthesis. This process jeopardizes the stability of the RSP and order that is in place. During the transient period (1480-1945) this happened four times, in: 1618, 1792, 1914 and in 1939.
Analysis of the non-systemic war dynamics during RSP's shows that it is possible to identify a tipping point in the development of the average size of chaotic non-systemic KA (of non-systemic wars) during RSP's: At a certain point (the tipping point) the average size of non-systemic KA starts to decrease.
The presence - the emergence - of a tipping point during RSP's/cycles can be explained from two (complimentary) perspectives:

(a) The presence of a tipping point during RSP's explained from a thermodynamic perspective. Entropy requires regulation. Entropy regulation is a function of the FTS; during RSP's the FTS applies non-systemic KA to neutralize entropic perturbations (issues and tensions). However, kinetic activity - wars - are also irreversible processes and - in their efforts to regulate entropy - also generates entropy, as a byproduct, so to speak. Initially, when an order has just been upgraded (following a systemic war), the tension level is still relatively low, and entropic perturbations are still small.
Over time the entropy-level in the System increases and entropic perturbations - and the KA that is generated in response - also increase. Consequently, the average size of non-systemic KA/wars increases. However, at a certain point - the tipping point of the RSP/cycle - the entropy generated by the kinetic activity (in response to the entropic perturbation) exceeds the entropy that can be effectively neutralized and redistributed, at that point:
$\Delta \boldsymbol{S}_{net} = \boldsymbol{S}_{issue} - \boldsymbol{S}_{neutralized} > \boldsymbol{0}$, and the FTS scales back the size of non-systemic KA; the drug (KA) that is applied has become worse than the disease, and has contra productive effects.
Once the tipping point is reached, the RSP is in the HCR. By down-sizing non-systemic KA, the damage to the order (status quo) can be limited. However, the entropy-production in the System does not stop, even accelerates: Entropy starts accumulating, an autocatalytic process is triggered, and VC's nucleate

and percolate the System. In the contingent domain, there is increasing social and political volatility and radicalization. Criticality is unavoidable, and the accumulated entropy (issues and tensions) and free energy (military capabilities) are released an put to use by means of systemic KA/war.

(b) The presence of the tipping point during RSP's explained from a network perspective. To explain the origin and effects of the network-effect from a network perspective, I make use of research by Watts, discussed in the paper with the title: "*A simple model of global cascades on random networks*" (93). The main objective of Watts' paper is "to explore how the vulnerability of interconnected systems to global cascades depends on the network of interpersonal influences that governs the information that individuals have about the world, and therefore (governs) their decisions." I assume, that KA/wars can be considered kinetic cascades in the System, and that these cascades depend on certain characteristics of the network of VC's (consisting of issues, tensions and states) in the System. Watts focuses on how "small initial shocks (*IP: Entropic perturbations in case of the System*) can cascade to affect or disrupt large systems that have proven stable with respect to similar disturbances in the past."
Watts' research helps us to understand how the susceptibility of the System to KA/war, depends on the properties of the network of VC's, as well as on how decisions are made that concern the application of kinetic energy (*see also 2020*); i.e. on the connectedness of the network of VC's and the thresholds nodes (states) apply to the use of kinetic energy.
States are nodes in the network of VC's, consisting not only of states but also of issues (entropic perturbations), and tensions (entropy). In relation to a particular issue and the states that are involved, a state is in war - does apply kinetic energy and participates in KA - or is not in war (does not apply kinetic energy and does not participate in KA).
The network of VC's can be considered a network of binary switches, that are switched *on* (kinetic energy is applied, war), or switched *off* (kinetic energy is not applied, no war).
Watts research shows, that these types of binary networks produce cascades - i.e. KA/wars with a certain size (in terms of fraction) and frequency, in the (State-)System - that depend on the connectedness of the network, and decision thresholds nodes apply to switch their behavior (e.g. from 'no KA' to 'KA', or vice versa). In case of this study, the connectedness of VC's and the thresholds nodes (states) apply to switch to KA/war, impact on the size and frequency of KA/wars in the (State-)System, I assume (59)
Watts' research shows that when the connectedness of these networks increases that at a certain point, the size of cascades starts to decrease (instead of further increasing), as can be observed in the System in respect to the size of KA/wars, during RSP's.
Increased connectedness results in local stability of the network. I assume that the connectedness of VC's - the connectedness of states, issues and tensions - affects the size of non-systemic KA - of non-systemic wars - during RSP's. When issues in the System become increasingly connected with each other, states become entangled, and more restrained in their war-activity. This behavior can also be observed by (decisionmakers of) states in the System.
Thus, increased connectedness of the network of VC's during RSP's, results in increased (local) stability, once a certain degree of connectedness is achieved. This moment is referred to as the tipping point of the RSP.
The network-effect - which is based on the increased stability of the network caused by its increased connectedness - can be explained with a simple example. If the threshold level of an issue (e.g. to switch to KA) is determined to be 0,40, this means that this state will switch to a positive war decision when 0,40 of the states that are connected to the issue concerned switch to war as well (regarding this issue). When

10 states are connected to this issue, of which three (or 0,30 states) are prepared to engage in war, an additional fourth state that switches to war will cause a switch to a positive war decision by the state that uses a threshold of 0,40. If, however, this particular state has 100 connections, of which 30 are prepared to engage in war (or 0,30 states), an additional positive switch of just one state will not cause such an effect: The connectedness will increase to 0,31, and the threshold of 0,40 is not reached.
The higher level of connectivity produces a local stability effect in the network. 'Local' implies that the stability effect that is created through increased connectivity only concerns a particular issue and the states that are connected to this issue. If states become increasingly more connected, additional 'islands' of local stability emerge in the network, and the stability of the "overall" network/system increases.
Multiple local stabilities caused by increased connectivity produce, at a certain point system-wide stability and thus hamper non-systemic wars (release events) from taking place.
The multiple local stability effects deprive the System of a mechanism to regulate non-systemic energy releases, causing a massive buildup of entropy and free energy. This typically happens during HCR's, when close to the critical point of the RSP, non-systemic KA dies out. This buildup pushes the System to criticality and causes a systemic response (war) instead, thereby allowing for a massive entropy-/energy-release and an upgrade of the order of the System (59).

26.7. Two regimes during RSP's

Because of the existence of a tipping point during RSP's (that can be observed during of RSP's of the first three war-cycles), it is possible to distinguish a low- and a high-connectivity regime (respectively LCR and HCR) during RSP's. In below table, the different characteristics of the LCR and HCR are shown.

TABLE 26.4: Fundamental differences between low- and high-connectivity regimes (LCR's and HCR's).

Characteristic	LCR	HCR
When	Precedes the tipping point of a RSP.	Follows the tipping point of a RSP.
Average size of KA	The average size of the non-systemic KA (non-systemic wars) increases.	The average size of the non-systemic KA (non-systemic wars) decreases.
Entropy-regulation	Entropy is effectively regulated: KA is not constrained.	Entropy is not effectively regulated: KA is increasingly constrained and entropy and unsolved issues accumulate in the System.
Net-entropy effect	$\Delta S_{net} < 0$	$\Delta S_{net} > 0$

26.8. The impact of the tipping point: The emergence of a second layer of dynamics

Once the tipping point of the RSP is reached - because of the restraining effect of the network-effect - entropy-regulation through non-systemic KA becomes increasingly ineffective. Consequently, entropy accumulates, an autocatalytic process is triggered (issues and tensions become instrumental in their own (accelerating) production), VC's nucleate, and percolate the System. The System becomes critical and produces a systemic response (systemic KA/war).
The accumulated entropy and free energy that are released and put to use during the critical period, is instrumental in the upgrade of the order. The upgraded order results in a new RSP, that has - at least for the time being - a lower entropy- and energy-state.
During the transient period (1480-1945), this cycle repeated itself four times, acceleratingly, until the European State-System collapsed in 1939.
The chaotic non-systemic KA (R1-dynamics), in combination with the network-effect, were - so to speak - responsible for the emergence of a second layer of cyclic R2-dynamics, which was imposed on the R1-dynamics. These two layers of dynamics were complimentary and enabled each other: R1-dynamics produced R2-dynamics, that ensured that R1-dynamics could resume during a next cycle. Through this interplay, regulated by the FTS, continuity (the purpose of R1-dynamics) and change (R2-dynamics) were optimized, to ensure the State-System followed the most efficient path to thermodynamic equilibrium, in accord with the Second Law and related principles that apply FFE.

26.9. Damped oscillation during the 1st RSP

In this paragraph I discuss some properties of the non-systemic KA, during the period 1495-1618. The period 1480-1945, is not included, because of a lack of data. During the period 1495-1618, the System produced 45 non-systemic wars (48). In figure 26.4, the circular trajectories (orbits) in phase space are shown.
At orbital level, the 45 non-systemic wars constituted a damped oscillator. The oscillations converged on a point - the critical point of the 1st RSP - when the non-systemic KA was complete damped (66), and KA-regulation was completely suppressed by the stability-effect generated by the network-effect.
Sterman explains: "In an oscillatory system, the state of the system constantly overshoots its goal or equilibrium state, reverses, then undershoots, and so on. The overshooting arises from the presence of time delays in the negative loop. The time delays cause corrective actions to continue even after the state of the system reaches its goal, forcing the system to adjust too much, and triggering a new correction in the opposite direction" (87). Different types of oscillations can be distinguished, including "damped" oscillations. The equilibrium of a damped oscillator is said to be locally stable (*IP: a RSP is locally stable*). "Perturbations will cause the system to oscillate, but it will eventually return to the same equilibrium (87) (*IP: The initial order that was established in 1480, in this case*). While many oscillatory systems are damped, the equilibriums of other systems are locally unstable, meaning that small disturbances tend to move the system further away from the equilibrium point" (87).
Analysis of these trajectories shows, that these 45 wars can be grouped in nine 'orbits', and that properties of the wars making up the respective orbits, also developed very regularly (59). See table 26.5.

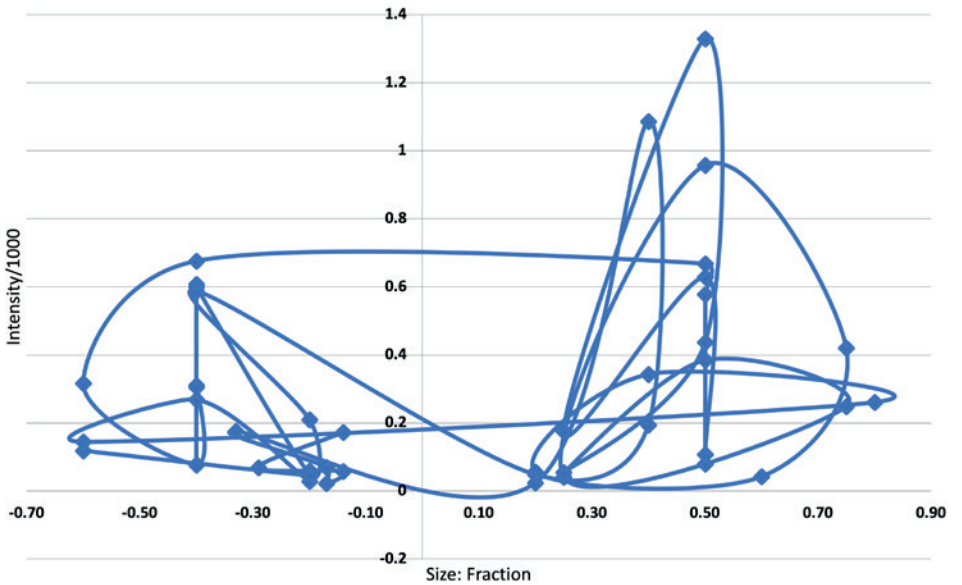


FIGURE 26.4: Orbits in phase space, during the 1st RSP (period 1495-1618). This figure shows nine orbits (circular and circular-like trajectories) the State-System produced in phase state (with size (fraction) and intensity as variables) during the 1st RSP (n = 45, period 1495-1618, data from Levy (48). In the first quadrant, the orbits with a left-handed direction are shown. In the second quadrant, right-handed orbits are shown. I have constructed this 'attractor' by visually identifying circular orbits in phase state and determined whether these trajectories follow a left-handed or right-handed trajectory. Next, I have projected the right-handed trajectories in the second quadrant. Further analysis reveals that orbits do not develop arbitrarily; these groupings develop with a certain regularity. These typical orbits exhibit visual similarities with strange attractors, which is typical for chaotic systems.

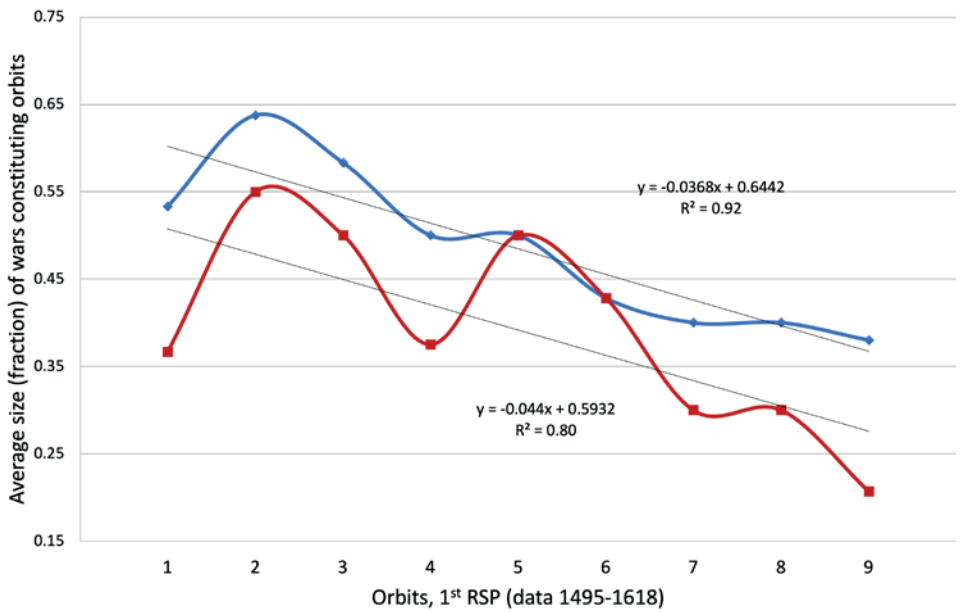


FIGURE 26.5: Damped oscillations. This figure shows the average size of non-systemic KA/wars making up nine orbits the System produced during the 1st RSP (period 1495-1618). The property developed very regularly: The orbits constitute a damped oscillator (data from Levy (48)). In the red plot, Great Power wars with one Great Power are included (n = 45); in the blue plot, Great Power wars only involving one Great Power are excluded (n = 30). In case, Great Power wars involving only one Great Powers are excluded, the damping nature of the non-systemic war dynamics is more prominent.

TABLE 26.5: Orbits during the 1495-1618. The non-systemic KA/wars the (State-)System produced during the 1st RSP (period 1495-1618) constitute nine orbits (59). Only one Great Power participated in KA/wars marked with blue. Data based on Levy (48).

Nr Levy	War/orbit	Direction	Intensity	Fraction	Start	End
1	1/1	R	119	0,60	1495	1497
2	2/1	R	45	0,20	1497	1498
3	3/1	R	60	0,20	1499	1503
4	4/1	R	29	0,20	1499	1500
5	5/1	R	269	0,40	1501	1504
6	6/1	R	145	0,60	1508	1509
7	1/2	L	261	0,80	1511	1514
8	2/2	L	343	0,40	1512	1519
9	3/2	L	57	0,20	1513	1515
10	4/2	L	43	0,60	1515	1515
11	5/2	L	420	0,75	1521	1526
12	1/3	L	958	0,50	1521	1531
13	2/3	L	41	0,25	1522	1523
14	3/3	L	249	0,75	1526	1529
15	4/3	L	384	0,50	1532	1535
16	1/4	L	55	0,25	1532	1534
17	2/4	L	438	0,50	1536	1538
18	3/4	L	1329	0,50	1537	1547
19	4/4	L	176	0,25	1542	1550
20	1/5	?	629	0,50	1542	1544
21	2/5	?	107	0,50	1544	1546
22	3/5	?	79	0,50	1549	1550
23	4/5	?	578	0,50	1551	1556
24	5/5	?	668	0,50	1552	1556
25	1/6	R	676	0,40	1556	1562
26	2/6	R	316	0,60	1556	1559
27	3/6	R	78	0,40	1559	1560
28	4/6	R	310	0,40	1559	1564
29	5/6	R	77	0,40	1562	1564
30	6/6	R	306	0,40	1565	1568
31	7/6	R	608	0,40	1569	1580
32	1/7	R	600	0,40	1576	1583
33	2/7	R	50	0,20	1579	1581
34	3/7	R	210	0,20	1583	1590
35	4/7	R	588	0,40	1585	1604
36	1/8	L	49	0,20	1587	1588
37	2/8	L	195	0,40	1589	1598
38	3/8	L	1086	0,40	1593	1606
39	4/8	L	24	0,20	1600	1601
40	1/9	R	175	0,33	1610	1614
41	2/9	R	70	0,17	1615	1618
42	3/9	R	23	0,17	1615	1617
43	4/9	R	58	0,14	1617	1621
44	5/9	R	69	0,29	1618	1619
45	6/9	R	173	0,14	1618	1621

Figure 26.5 shows, that the orbits (the average sizes of non-systemic wars, making up these nine orbits) constitute a damped oscillator: Non-systemic KA/wars making up orbits can be considered efforts of the System to re-establish a certain balance - equilibrium - during the 1st RSP. Because these corrective actions (orbits) were implemented with a delay, they caused over- and undershoots (oscillations).
The tipping point of the 1st RSP was reached in 1514, the damping occurred (not surprisingly) during the HCR, of the 1st RSP. The damping of the oscillations over time, can be attributed to the network-effect: to the increasing (local) stability produced by the increasing connectedness of VC-clusters during the HCR; KA was increasingly suppressed.
When the oscillations eventually faded out - meaning that KA was completely suppressed - the System became critical and produced a systemic KA/war (the Thirty Years' War, 1618-1648).
In below figure, the configuration of phase space is schematically shown for the damped oscillator (1495-1618), - for the "solutions" the 1st FTS produced (KA), to correct entropic perturbations during the 1st RSP (stationary state) - and how the (State-)System evolved to the critical point, while performing damped oscillations (66).
The trajectories - with orbits as units - spiraled around the critical point before finally (1618) converging to it.
The figure visualizes the compression of phase space, during the 1st RSP; the available solutions - in terms of non-systemic KA in response to entropic perturbations (issues) - decreased to zero (1618).
It is not clear if and how the deterministic dynamics (the orbits and damped oscillations in this case) are related to dynamics in the contingent domain, e.g. certain social and political issues; further historical research is required.

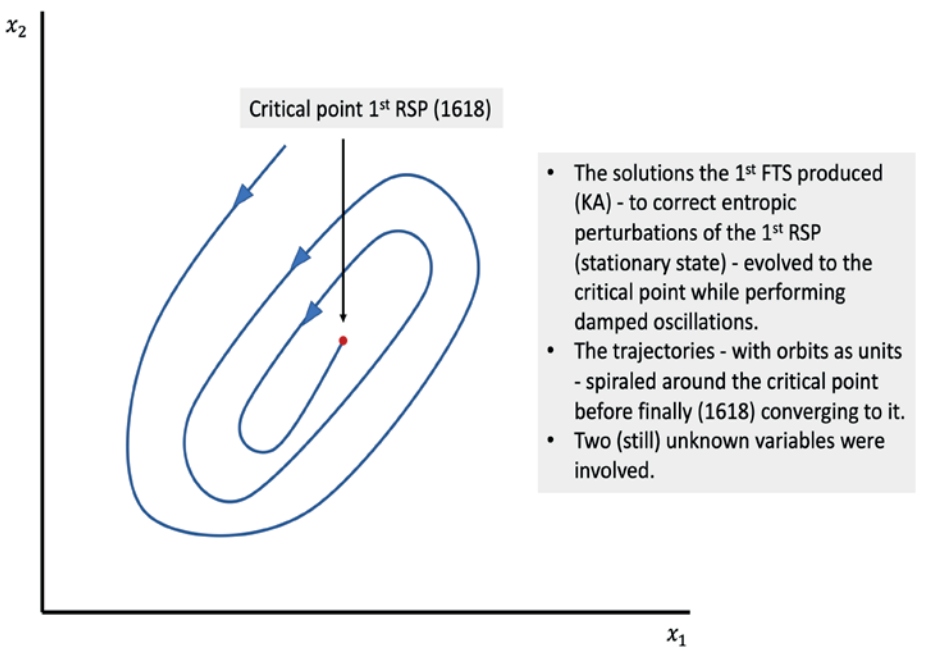


FIGURE 26.6: Phase space configuration, involving orbits during the 1st RSP (period 1495-1618).

26.10. Consistency of dynamics during successive RSP's

For the first three cycles, it is possible to determine the tipping points, by analyzing the development of the average size of non-systemic KA, during the respective RSP's.
It is now possible to distinguish six war-clusters - a LCR- and HCR-war-cluster for each RSP of each cycle that include non-systemic wars that at least involved two Great Powers (59). These clusters should reveal some regularities, if LCR- and HCR-regimes, are not mere 'artefacts'; theoretical constructs without any meaning. Figures 26.7 and 26.8 respectively show the average size of non-systemic wars, making up the war-clusters and the frequency of wars during their respective life spans.
Based on this perspective - the identification of LCR- and HCR- war-clusters, it is possible to make a number of observations:

- *The average size of non-systemic KA/wars making up successive war-clusters developed in accordance with theoretical predictions*. The average size of war-clusters developed predictably:
  - During each RSP, the average size of wars during LCR's was larger than during HCR's of the same RSP.
  - The average size of wars during LCR's of successive RSP's decreased consistently.
  - The average size of wars during HCR's of successive RSP's was distorted: The average size of wars during the HCR of the 2nd RSP (1774-1792) that followed the 1st exceptional period (1657-1763) was lower. I assume that this was a consequence of the series of exceptionally large abnormal non-systemic wars the (State-)System produced during the exceptional period that preceded it.
  - The overall size of war-clusters decreased, pointing to increasing local stability of the (State-) System, consistent with the continuous increases of the connectivity of the System.
- *The frequencies of non-systemic KA/wars making up successive war-clusters developed in accordance with theoretical predictions*. Apart from a distortion caused by the third and fourth war-clusters - the war-clusters of the 2nd RSP (1648-1792) that includes the 1st exceptional period (1657-1763) - the frequencies of successive war-clusters decreased regularly. I assume that without the distortions caused by the abnormal non-systemic war dynamics during the 1st exceptional period (1657-1763), the decrease would be linear. During the 1st exceptional period (1657-1763), the 2nd RSP (1648-1792) was stuck in its LCR (1648-1775) it seems (as I explained, because the non-systemic KA was too unrestrained). This figure suggests that the (State-)System produced a lower, respectively a higher number of non-systemic wars, during respectively the LHR and HCR of the 2nd RSP.
- *The volatility index of the System (VIXS) decreased linearly*. I define the volatility of the System (VIXS), as the product of the average size of non-systemic KA/wars making up war-clusters, and their respective war frequencies: VIXS = average size × frequency. The VIXS decreased about linearly. See figure 26.9.

The regularities in the development of war-clusters, are consistent with earlier observations.

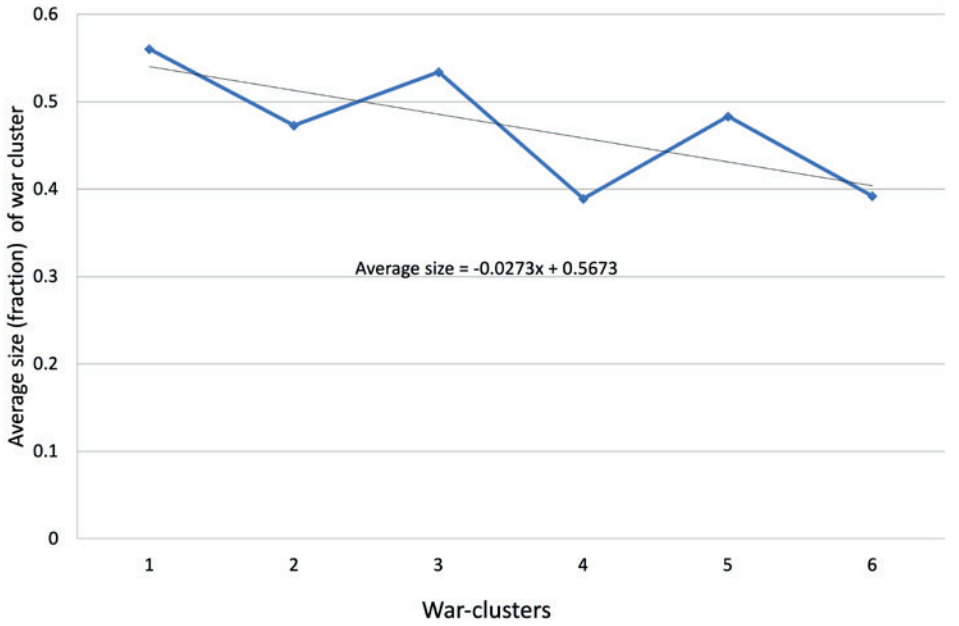


FIGURE 26.7: Average size of non-systemic wars of war-clusters. This figure shows the average size (in terms of fraction) of six war-clusters that can be distinguished during the first three RSP's of the 1st FTS. Clusters 1-2, 3-4, and 5-6 respectively concern the 1st (period 1495-1618), 2nd (1648-1792) and 3rd (1815-1914) RSP's. War-clusters 1, 3, and 5 are LCR-clusters; 2, 4, and 6 represent HCR-clusters. Data from Levy (48).

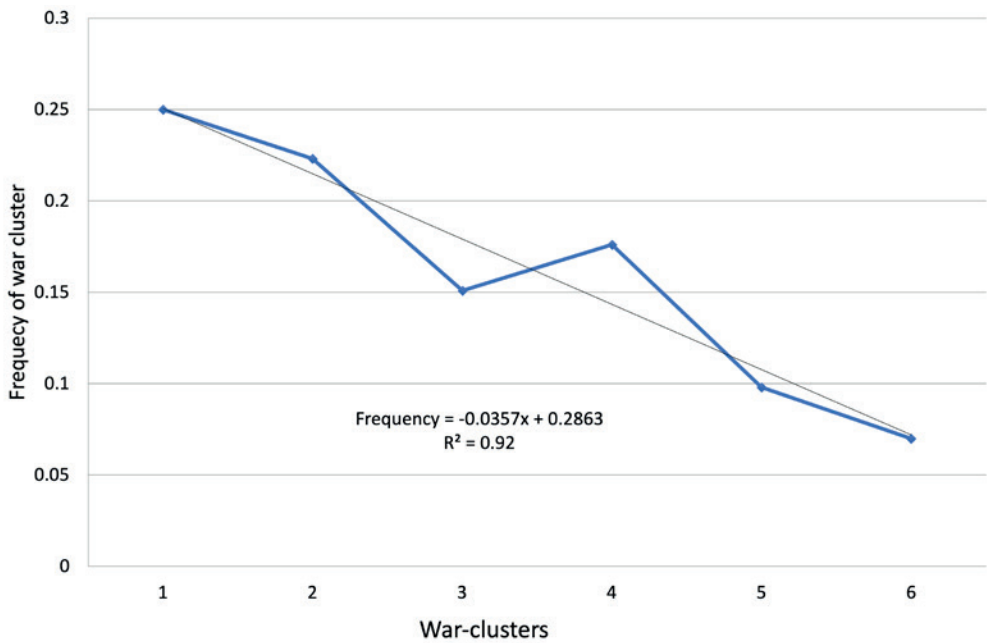


FIGURE 26.8: Frequencies of non-systemic wars during war-clusters. This figure shows the frequencies of non-systemic wars (number of wars divided by the life span of the cluster) during the six war-clusters that can be distinguished during the first three RSP's of the 1st FTS. Clusters 1-2, 3-4, and 5-6 respectively concern the 1st (period 1495-1618), 2nd (1648-1792) and 3rd (1815-1914) RSP's. War-clusters 1, 3, and 5 are LCR-clusters; 2, 4, and 6 represent HCR-clusters. Data from Levy (48).

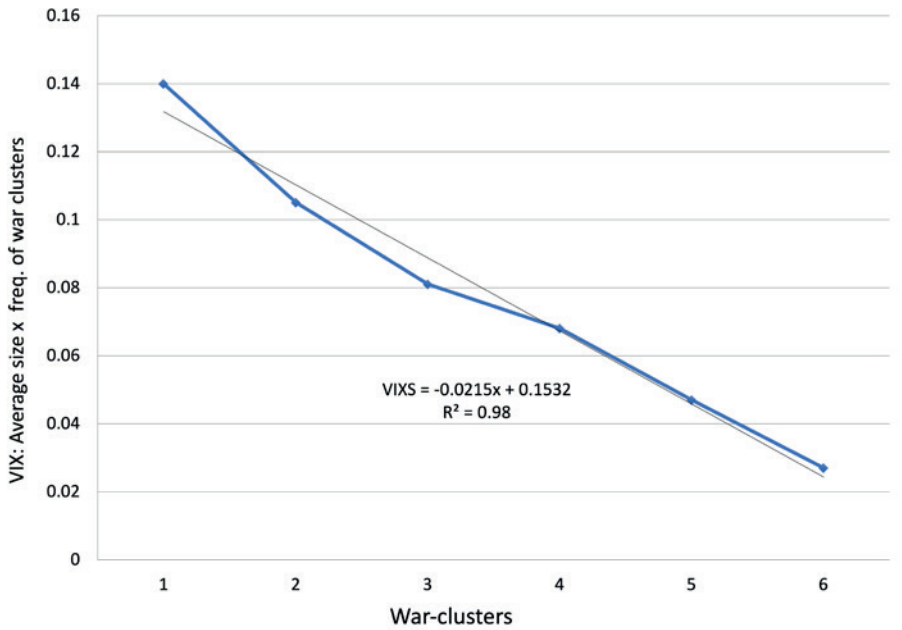


FIGURE 26.9: Development of VIXS. This figure shows the development of the volatility index of the System (VIXS), during the first three RSP's of the 1st FTS: The VIXS decreased about linearly, suggesting that distortions in the average size and frequencies of war-clusters were 'leveled out' (corrected). Clusters 1-2, 3-4, and 5-6 respectively concern the 1st (period 1495-1618), 2nd (1648-1792) and 3rd (1815-1914) RSP's. War-clusters 1, 3, and 5 are LCR-clusters; clusters 2, 4, and 6 represent HCR-clusters. Data from Levy (48).

26.11. For the (State-)System to function optimally, non-systemic KA must be chaotic

As discussed in previous chapters, chaotic dynamics are highly functional and are a prerequisite for the System to function optimally, and for the 1st FTS and State-System to develop/evolve.

Although, chaotic dynamics are intrinsically unpredictable, they are also restrained, as the properties of abnormal (non-chaotic) non-systemic KA/wars during the 1st exceptional period show (1657-1763) (to be discussed).

Chaotic dynamics allow for the formation (nucleation) of VC's, and for the network-effect to emerge (at the tipping point). The chaotic dynamics ensure an autocatalytic process is triggered (issues and tensions produce more issues and tensions), issues and tensions (entropy) can accumulate, VC's - with the right properties - can nucleate and percolate the System, once the tipping point is reached and the RSP is in the HCR. VC's also store information i.e. the solutions the chaotic war dynamics produce during RSP's (in terms of 'corrections' of the existing order/status quo).

Chaotic dynamics also ensure that phase space is optimally explored, and that the VC's that are formed, have fractal structures that allow for the divergence of the correlation length, once the (State-)System becomes critical; criticality is required for an upgrade of the order.

The upgraded order – and the next RSP it supports – ensures a lower entropy-/energy-state of the System (at least temporarily), and improved regulatory capabilities.
Until, and that is a matter of time, the upgraded RSP also becomes saturated with entropy, and the process repeats itself.

26.12. Application (1): VC's set the stage for the next systemic KA/war and serve as a gateway

During HCR's of RSP's, VC's nucleate and (increasingly) percolate the (State-)System. Once percolation is accomplished (the VC-network spans the (State-)System, this was the case in 1618, 1792, 1914 and 1939) and the (State-)System is fully charged, the System becomes critical, and produces a systemic response.
At that point (at the critical point: 1618, 1792, 1914 and 1939), the VC-clusters are the result of the preceding chaotic non-systemic war dynamics, and the exploration of phase space that has taken place. The VC-clusters constitute the initial condition for the critical period that follows, and their configuration – and the information that is stored in the clusters – shape the systemic KA.
VC's constitute a gateway - so to speak - to the next order/RSP, that is interactively produced during the critical period (systemic KA/war). The VC's contain elements for possible solutions.

26.13. Application (2). Accumulation of entropy and its consequences in the contingent domain

The existence of a tipping point - the fact that entropy regulation becomes at a certain point (the tipping point) problematic and ineffective - is also not without consequences in the contingent domain. From the tipping point onwards, the average size of non-systemic KA/wars decreases, and entropy instead of being neutralized and redistributed and issues (between states in the (State-)System) being solved, entropy - issues and tensions - starts accumulating in the (State-)System. The entropy starts to penetrate societies. The entropy tries to find an 'escape' through other means/channels. Because of the increasing accumulation of entropy, also in societies, societal uncertainty and disorder increase. Societal uncertainty results in political volatility and social unrest.
Once the tipping point is reached and entropy starts accumulating, radical ideas - political and religious- find a much more 'fertile' breeding ground in societies. Humans and societies try to make sense of the (increasing) uncertainty and fear. Because moderate political ideas and solutions are seen as the cause of the uncertainty and unrest, moderate politics and moderate solutions are discredited, and more radical ideas and solutions are accepted. More radical ideas are instrumental in reducing entropy and pushing vulnerable societies towards zero-entropy. I discuss these dynamics later in more detail.

26.14. Application (3): Lessons learnt form chaotic non-systemic KA/wars

Because of sensitivity of chaotic non-systemic KA/war, for the initial conditions of the (State-)System, the properties of chaotic non-systemic KA/war are intrinsically unpredictable. This also means that it

is problematic to assign causes to certain effects (related to the KA/war) in hindsight: The very small differences in initial conditions that had significant impact on the KA/war, can (probably) not even be identified.

Other factors also contribute to the unpredictability of KA/war dynamics, include the fact that probabilistic factors also play a role in deterministic dynamics, and that contingent latitude (entropic indeterminateness (34)) allows for different solutions, that can satisfy the S-imperative.

The unpredictability of KA/war dynamics explains that it is very problematic to derive lessons learnt for these wars, and that these so-called lessons learnt always turn out to be wrong. The Vietnam War (1965-1975), the Gulf War (1990-1991), the Iraq War (2003-2011) and the War in Afghanistan - to name some recent wars - have in common that predictions that were made turned out to be wrong; the fact that so-called lessons learnt from preceding wars were used, was/is part of this problem.

The expectation was - for example - that the Iraq War (2003-2011), would be a short war, like its predecessor, the Gulf War. The success of the Gulf War was attributed to the application of overwhelming force; a practice that was at the time 'anchored' in the so-called 'Powell doctrine'. Which is a remarkable lesson learnt, given the fact that during the Vietnam War the United States had also applied massive kinetic energy, but to no avail: Massive destruction was (and still is) not a solution.

A similar approach - based on the Powell doctrine - did also not have the desired effect in case of the Iraq War (2003-2011), when again overwhelming force was applied through - what was named - a 'shock and awe' campaign.

The only lesson that can be learned from non-systemic KA/wars, is that these type of wars (contrary to systemic KA/wars) are intrinsically unpredictable, and that this property (unpredictability), should be the guideline for planning and conducting these types of war, and for setting expectations.

27. Stages of non-systemic ka/wars

27.1. Introduction

Before elaborating on the cyclic/periodic systemic KA during critical periods - the R2-dynamics generated by the 1st FTS (1480-1945) - in this chapter, I discuss the stages of non-systemic KA - how non-systemic KA/wars 'emerge', evolve and eventually fade-out. - and what factors impact on this process.
Not all entropic perturbations - issues and incidents - trigger non-systemic kinetic responses, as I explained. The response of the (State-)System to entropic perturbations is regulated by the FTS: The FTS 'selects' entropic perturbations (issues and incidents) that are amplified during RSP's; a process that involves probabilistic and deterministic factors and the high sensitivity of chaotic dynamics to the initial conditions of the (State-)System (the conditions of the System at the moment of perturbation): small differences can lead to very different dynamics and outcomes.
The fact that certain barriers prevent and contain KA (systemic and non-systemic), also is a factor that impacts on the emergence and subsequent 'size' of a kinetic response: KA is a threshold phenomenon. Barriers also block - so to speak - the "interaction pathway" between the S/T-field (of the FTS) and local entropic perturbations and must be overcome.

27.2. Amplification of entropic perturbations

The System continuously generates entropic perturbations (issues and incidents). Mostly, these perturbations fade-out and have no significant impact on the dynamics and development of the (State-) System. However, certain entropic perturbations act as attractors for entropy-transfer from the S/T-field and generate kinetic responses; these perturbations are amplified. These amplified perturbations/issues are regulated by the FTS, including the size and duration of the KA.
In case of entropic perturbations (issues or incidents), three sources of entropy are potentially involved:

- *Source (1)*: Entropy(-production) related to the 'local' issue or incident itself (entropic perturbation);
- *Source (2)*: Entropy-transfer from the S/T-field to the entropic perturbation (issue or incident);
- *Source (3)*: Entropy generated by the KA related to the perturbation/issue: KA – war - is also an irreversible process, that inevitable generates entropy.

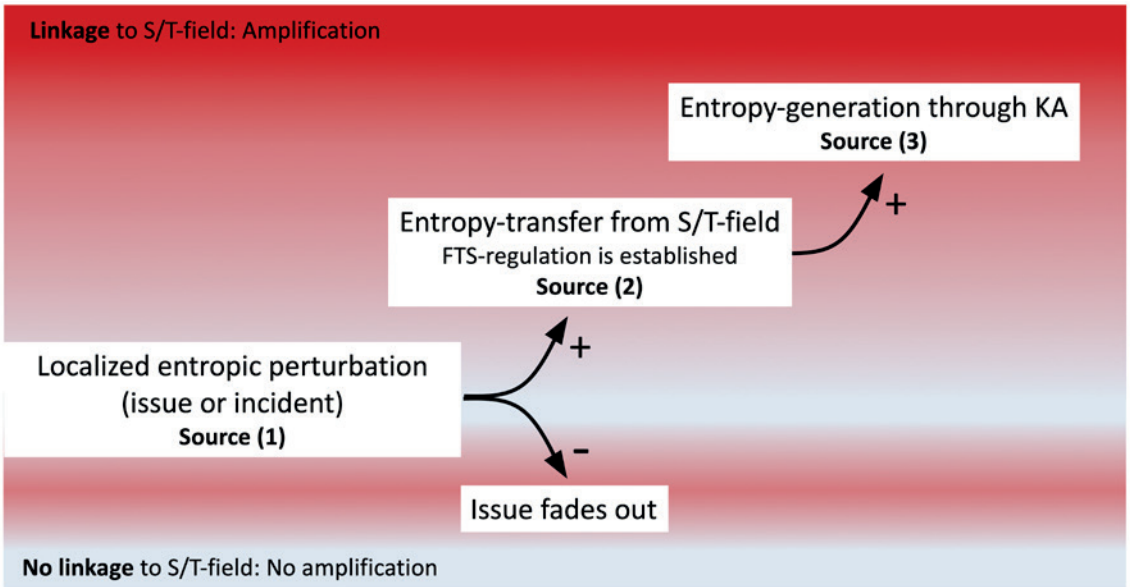


FIGURE 27.1: Sources of entropy.

Based on the sources of entropy that are involved, two categories of non-systemic KA/wars can be distinguished, see below table:

TABLE 27.1: Categories of non-systemic KA/war.

Categories of KA/wars			
	KA/war category	**Remarks**	**Entropy source**
1	Localized non-systemic KA/wars: No FTS-regulation	The perturbation/issue does not become linked to the S/T-field and stays isolated (local).	(1) and (3)
2	Non-systemic KA/wars: FTS-regulation	The perturbation/issue becomes 'linked' to the S/T-field and is amplified.	(1), (2) and (3)

For a perturbation/ issue to become FTS-regulated, it must have a certain "activation entropy", it seems. The activation entropy depends on nonlinear effects that are generated, i.e. through the amplification of certain aspects of the issue. Besides certain deterministic elements, probabilistic elements and the sensitivity of the (State-)System for certain conditions play also an important role in the selection of entropic perturbations/issues that will be scaled up: There is an interplay between probabilistic and deterministic factors. Because of the probabilistic elements involved in issues and incidents, their entropic potential and 'ability' to generate kinetic responses, cannot be established.

As history and contemporary developments show, we are not able to accurately predict even the most basic properties of issues and wars: Sometimes issues we expect to escalate just fade out, while in other cases, we are taken by surprise when a localized and initially insignificant incident escalates into non-systemic KA, as was for example the case with the Arab Spring that started in Tunisia in 2010, with a seemingly minor incident, but activated a (not yet fully percolated) VC.

27.3. Stages of non-systemic KA/war

At a certain point, entropic perturbations can trigger non-systemic KA. The non-systemic KA (itself) also contributes to the 'total' entropy-production related to the entropic perturbation (issue or incident) and can provide the perturbation with sufficient activation entropy to involve the FTS. At that point, FTS-regulation is established: The perturbation is linked to - 'plugged in' - the S/T-field. In the contingent domain this linkage can for example be established when a Great Power gets involved in the perturbation/ issue.

The key-properties of non-systemic KA/wars (like their duration and size) are determined by the FTS and involve probabilistic and deterministic factors.

The purpose of KA is to neutralize and redistribute entropy; at a certain point during the 'evolution' of a non-systemic war (KA), the kinetic response fades out, because entropy is effectively neutralized and redistributed. The solution to the issue is embedded in VC's the FTS helps shape during RSP's.

In figure 27.2, the stages of non-systemic KA are described.

The same stages of non-systemic KA shown in above figure, can also be related to a time-line, as shown in figure 27.3.

The process – the stages of non-systemic KA – depicted in figure 27.3, can be explained as follows. An issue or incident produces an entropic perturbation. In case of this example, through a combination of probabilistic and deterministic factors, the (initially) local perturbation is connected to the S/T-field, and the interplay between perturbation and field results in the amplification of the perturbation. At a certain point (threshold (1)), a kinetic response is triggered and is also regulated and further amplified by the S/T-field. The purpose of the non-systemic KA is to 'neutralize' entropy-production and to redistribute entropy, to ensure the steady state (the status quo) is restored and maintained.

Threshold (1) is the KA-trigger; the moment the KA is initiated by the FTS.

The KA-trigger point (threshold (1)) is increasingly higher, once the tipping point is reached, because of the restraining effect of the network-effect.

Once KA is initiated, the total entropy of a perturbation/ issue is: $\boldsymbol{S}_{Total} = \boldsymbol{S}_{Perturbation} + \boldsymbol{S}_{Field} + \boldsymbol{S}_{KA}$.

During the KA/war, entropy is neutralized and redistributed. At a certain point, KA is downgraded, and $\boldsymbol{S}_{Total}$ starts to decrease. The downscaling of KA happens when a second threshold is reached. At that point, the dynamics of the KA change: A negative - inhibitory - feedback structure becomes dominant.

With embedding I refer to the process of 'fitting' a solution - an arrangement - for a perturbation/issue in the order of the System. The solution can be considered an (organizational) modification to the order of the RSP. Embedding takes place in the network of VC's, which is an integral component of the S/T-field and phase space; the solution is a 'modification' to the existing order. The embedding of the arrangement can also be considered as information storage (in the network of VC's), and results in a compression of phase space; the available microstates to the State-System decreases.

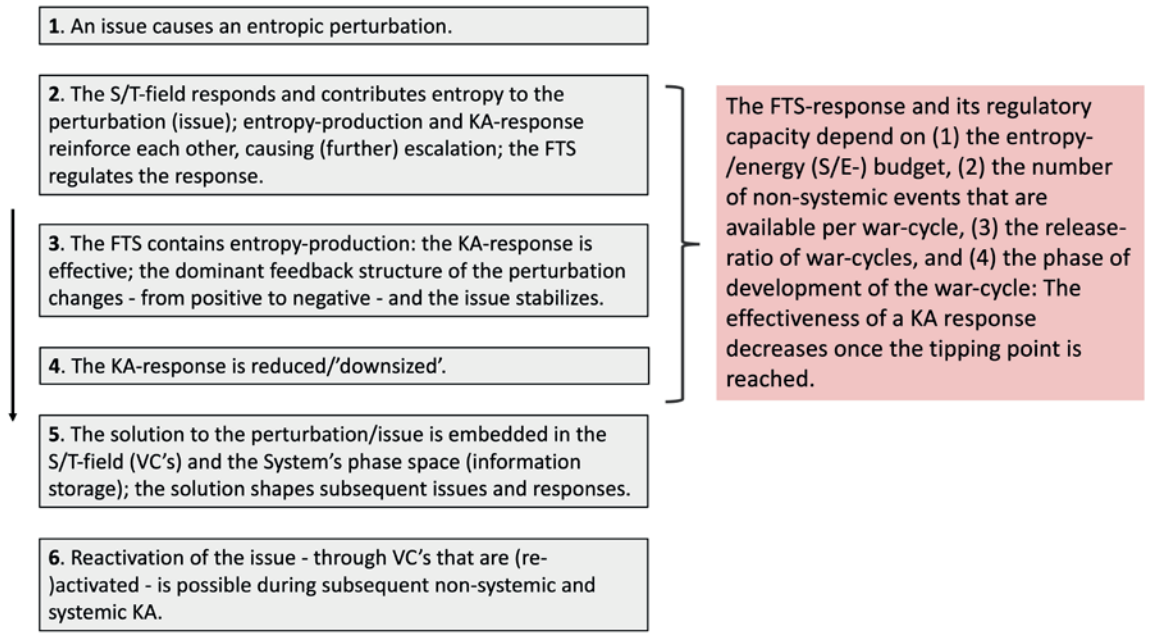


FIGURE 27.2: Stages of non-systemic KA (1).

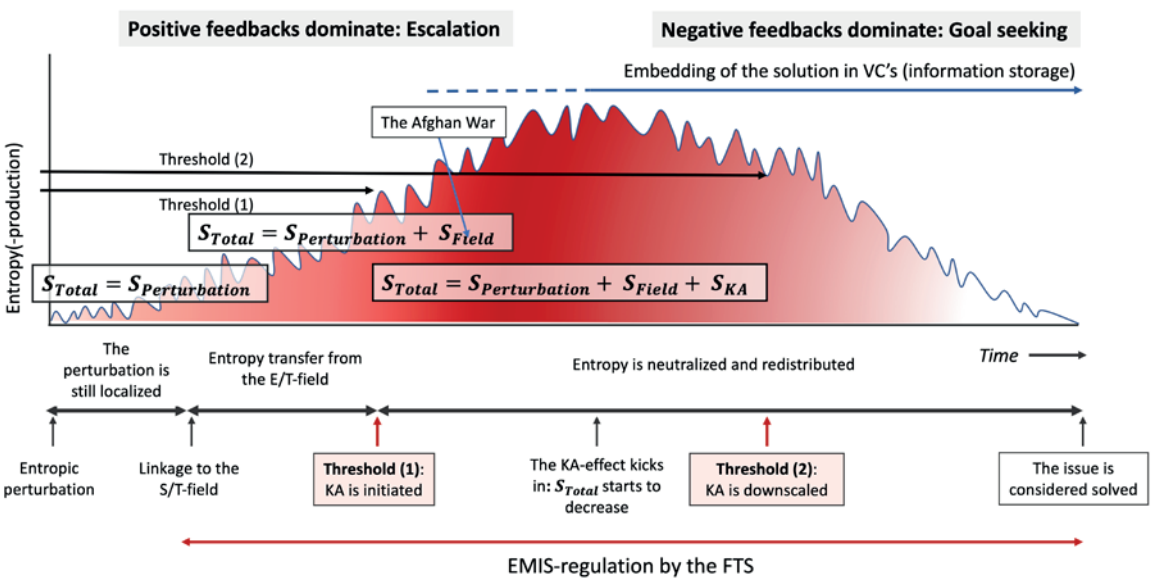


FIGURE 27.3: Stages of non-systemic KA (2).

The process of embedding which continuously takes place during RSP's, I also refer to as (RSP-)nucleation. Through embedding the issue and its solution become part of the history of the (State-)System; but not 'history' in the sense that the issue has no (future) consequences for the System. The embedded solution impacts on the network - 'landscape'/configuration - of VC-clusters, interacts with other and new issues and by doing so shapes the workings of the System and possibly future decisions.
Through the embedding of the solution, the entropy(production) caused by the perturbation, is neutralized and redistributed. However, during the RSP or the systemic KA that eventually follows, the issue can re-emerge.
In case of re-emergence during the next systemic KA, the solution potentially also impacts on the design of the new order.
The network of VC-clusters that forms during the RSP and eventually percolates phase space, can be considered a flexible 'blueprint' that shapes the next order of the System, which is designed and implemented during the next systemic KA.
It is important to make a distinction between the dynamics of the network *of* VC's and the dynamics - KA-activity/war - *on* that network.

27.4. The FTS-response and regulation

In figure 27.3, the stages of non-systemic KA are shown. Analysis of the war-data shows that the 1st FTS imposed a very strict regime, which I assume reflects the optimization accomplished by the Second Law and related principles that apply FFE.
The 'exact' FTS-response and its regulatory capacity during RSP's are a function of several factors/ conditions: (1) the entropy/energy (S/E)-budget of the war-cycle, (2) the number of available kinetic events, (3) the release-ration of the war-cycle, and (4) the phase of development of the war-cycle.

- *The S/E-budget*. This study shows that the total kinetic activity was very accurately defined per KA/ war-cycle, in accordance with the 'demands' of the Second Law and related principles that apply FFE. The (State-)System - and its dynamics (FTS) - is highly deterministic. The only exception – in some respects - is the 2nd cycle (1648-1815), when the otherwise very strict regularities were distorted by the abnormal war-dynamics during the exceptional period (1657-1763). I refer to the available kinetic energy (KA) during cycles, as the S/E-budget of a KA/war-cycle.
- *The number of non-systemic events (KA/wars)*. Not only is the total KA per war-cycle very accurately defined (if the FTS is not distorted, as was the case during the 1st exceptional period), but also the absolute number of non-systemic events (non-systemic wars) during subsequent war- cycles. See figure 27.4.
- *The release-ratio*. The severity of a systemic war in terms of BCD, divided by the total severity of all wars during the cycle, I define as the release-ratio of a cycle. The release-ratio is an indicator for the energy-distribution during cycles. During the unfolding of the 1st FTS, the release-ratio of successive cycles increased very regularly: During successive cycles an increasing proportion of the kinetic energy that was put to use, was applied during critical periods (through systemic KA/war). Not surprisingly, the 1st exceptional period (1657-1763) caused a distortion; see figure 27.5.

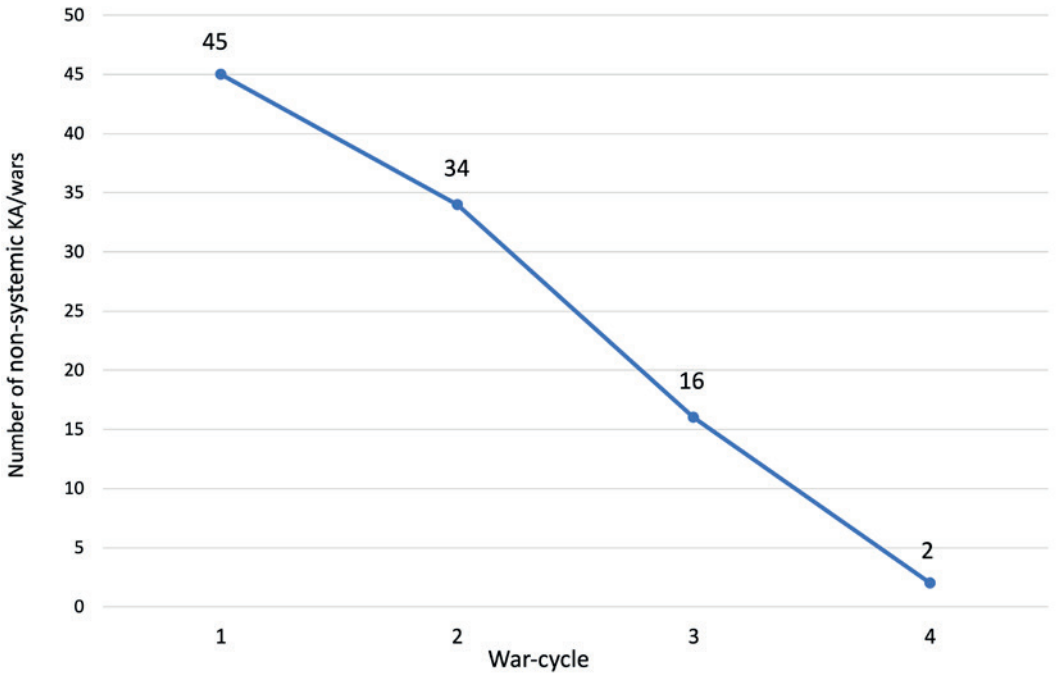


FIGURE 27.4: Number of non-systemic KA/wars during successive KA/war-cycles, during the transient period (1480-1945). Expansion wars excluded; data from Levy (..).

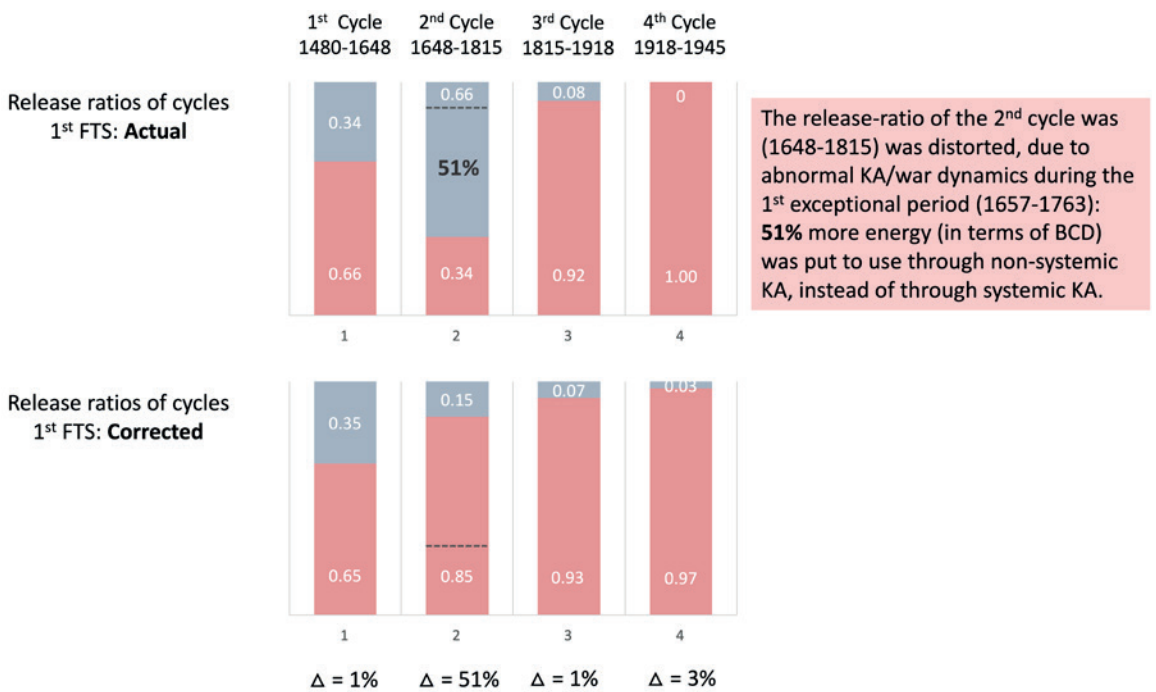


FIGURE 27.5: Release-ratios of cycles of the 1st FTS (1480-1945). Release-ratios also place constraints on the distribution of KA. Release-ratios will be explained later.

- *The phase of development*. The last factor/condition that constraints and shapes the FTS-response during RSP's, is the phase of development of the RSP. Before the tipping point of the RSP is reached and the network-effect kicks in, kinetic responses (KA) are much more effective in regulating entropy. Once the tipping point of the RSP/cycle is reached, the effectiveness of KA-responses - and consequently the average size of KA/wars - decreases.

The factors and conditions discussed in the previous paragraph, imposed increasing constraints (limitations) on the (State-)System and 1st FTS. Eventually in 1939, when the System reached the singularity in finite time, the S/E-budget was (theoretically) infinite, while simultaneously the number of available non-systemic KA-events had reached zero, and entropy could only be neutralized and redistributed through systemic KA.
At that point the 'logic' of the FTS broke down, and the (State-)System (the core, generating the entropy and KA), theoretically entered a condition of 'permanent criticality' - infinity war - which was unsustainable: The 1st FTS produced infinite amounts of entropy and required infinite KA, which required infinite input of resources, which were destroyed through the systemic KA that was generated. Consequently, in accordance with the laws of thermodynamics and related principles, the System initiated the last step in the phase transition (the 4th systemic war, 1939-1945, the Second World War).

27.5. Application (1): The thermodynamics of KA/war

The (State-)System and societies/states are systems that must obey physical laws, e.g. the Second Law and related principles that apply FFE. KA/war is a kinetic response of the (State-)System to entropic perturbations, in accord with the Second Law and related principles that apply FFE. Non-systemic KA is triggered and regulated by the FTS, to ensure that the System complies with the Second Law and related principles, and that the State-System follows the most efficient path to thermodynamic equilibrium. A combination of probabilistic and deterministic factors determines which perturbations/issues are amplified by the FTS.
In above paragraphs, I have discussed various mechanisms that are involved in the 'emergence' of non-systemic KA (which by definition involve the FTS, and must be considered system-behavior), and the subsequent stages of KA.
In this paragraph, I have a closer look at the interplay between non-systemic KA/war and the (State-) System and determine conditions that determine the 'utility' of KA, of force (military capabilities), from an entropy-/energy-perspective. What KA can be potentially effective/useful to the State-System?
To maintain the coherence of the FTS and the State-System, KA must be generated and sustained. KA of the System - regulated by the FTS - is instrumental in the (State-)System's development and evolution, and of its components (i.e. societies/states).
These processes - the construction and maintenance of order - require free energy, as Military capabilities constitute the free energy that is applied in the State-System during KA/war, in the contingent domain. Military capabilities are generated through the transformation of 'societal' energies into military capabilities; a process that is regulated by the state, and in which entropy (issues and tensions) serve as a catalysator.
The free energy that is released during KA/war is instrumental in the further organization of the (State-) System.

To build structures - to further organize the (State-)System - so-called energetically favorable processes, which release energy (like KA/wars) and produce entropy (in the process), must be coupled to energetically unfavorable processes, which 'absorb' - use - free energy to sustain or upgrade the order of the System. This coupling is accomplished and regulated by the FTS.

Before discussing the utility of KA, I first discuss the terms "energetically favorable" and "energetically unfavorable" processes and explain why they must be coupled.

According to the Second Law, a process can proceed only spontaneously, if it results in a net increase in disorder (entropy, $\Delta \boldsymbol{S} > \boldsymbol{0}$) of the 'overall' system.

The criterion for an increase in disorder ($\boldsymbol{S}$) of the overall system "can be expressed most conveniently in terms of the quantity free energy", $\boldsymbol{F}$, of a system (2). As explained in chapter 3, $\Delta \boldsymbol{F}$ is a measure for the disorder $\boldsymbol{S}$ that is created ($\boldsymbol{E}$ (the total energy) = $\boldsymbol{F}$ (free energy) + $\boldsymbol{S}$ (entropy), at least if the system is not open). The value of F is of interest only when a system undergoes a change - as is the case for KA/war (a correction is made, or the order is upgraded) - and the change in $\boldsymbol{F}$ ($\Delta \boldsymbol{F}$), is critical (2).

A reaction or process $\boldsymbol{Y} \rightarrow \boldsymbol{X}$ is said to be energetically favorable - the process can take place spontaneously - if the free energy of $\boldsymbol{Y}$ is greater than the free energy of $\boldsymbol{X}$. Then, $\Delta \boldsymbol{F} < \boldsymbol{0}$ and the disorder of the overall system (environment) can increase during the process ($\Delta \boldsymbol{S} > \boldsymbol{0}$), in accord with requirements of the Second Law.

However, if the reverse process $\boldsymbol{X} \rightarrow \boldsymbol{Y}$ would occur, $\Delta \boldsymbol{F} > \boldsymbol{0}$, and the environment would become more ordered ($\Delta \boldsymbol{S} < \boldsymbol{0}$), this process can only occur, if it is coupled to a second, energetically favorable reaction/process, which supplies the free energy, and ensures the Second Law is not violated (2).

KA/war qualifies as energetically an *un*favorable "reaction": $\Delta \boldsymbol{F} > \boldsymbol{0}$: Based on the thermodynamic analysis of KA/war two minimal requirements are critical for KA/wars to take place spontaneously: (1) The Second Law $\boldsymbol{S} = \boldsymbol{d_e S} + \boldsymbol{d_i S} \geq \boldsymbol{0}$ cannot be violated, which requires the coupling of the KA/war to a suitable environment (for the exchange ("dumping") of entropy), and because KA/war is an energetically unfavorable reaction/process ($\Delta \boldsymbol{F} > \boldsymbol{0}$), (2) the KA/war must be coupled to a second energetically favorable reaction/process. These basic requirements apply to non-systemic KA/wars, systemic KA/wars, but also to the phase transition that took place during the period 1480-1945. These are deterministic factors that (besides probabilistic factors) impact on the selection of entropic perturbations (issues) for amplification by the FTS.

The fact that the MEP-Principle applies to (State-)System results in the following direction of development of the entropy and free energy of the State-System:

$\boldsymbol{S}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_1}) > \boldsymbol{S}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_2})$ and $\boldsymbol{F}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_1}) < \boldsymbol{F}_{\boldsymbol{State\text{-}System}}(\boldsymbol{t_2})$, this can be considered a third requirement that applies to KA/war dynamics in the State-System.

In case of KA/war in the State-System, societies and other states (not involved in the KA/war) and the "wider" System, serve as environments for the exchange of entropy, to ensure that the first requirement ($\boldsymbol{dS} = \boldsymbol{d_e S} + \boldsymbol{d_i S} \geq \boldsymbol{0}$) is not violated.

The coupling of the energetically unfavorable KA/war process to energetically favorable societal processes, ensures the KA/war can spontaneously proceed. These societal processes concern the transformation of societal energies into military capabilities; a process in which entropy (tensions) serve as catalysator. These societal processes are directed by the state, which uses its double linking-pin function (as regulator of societies, and environments of societies, including the State-System, see chapter ...).

The FTS - a manifestation of the Second Law and related principles that apply FFE - ensures that the third requirement $S_{State\text{-}System}(t_1) > S_{State\text{-}System}(t_2)$ and $F_{State\text{-}System}(t_1) < F_{State\text{-}System}(t_2)$ is not violated; this ensures that the most efficient path to thermodynamic equilibrium of the State-System is followed.
If these minimum requirements are not met - apart from the fact that the selection of an entropic perturbation (issue) for amplification also involves probabilistic factors - the KA/war cannot and will not take place. The KA/wars the (State-)System produced - that by definition includes all wars in Levy's database - met the three requirements.
I will use these requirements to discuss two KA/wars in the next paragraphs: A KA/war that did not take place, and the War in Afghanistan, which is considered a failed war.

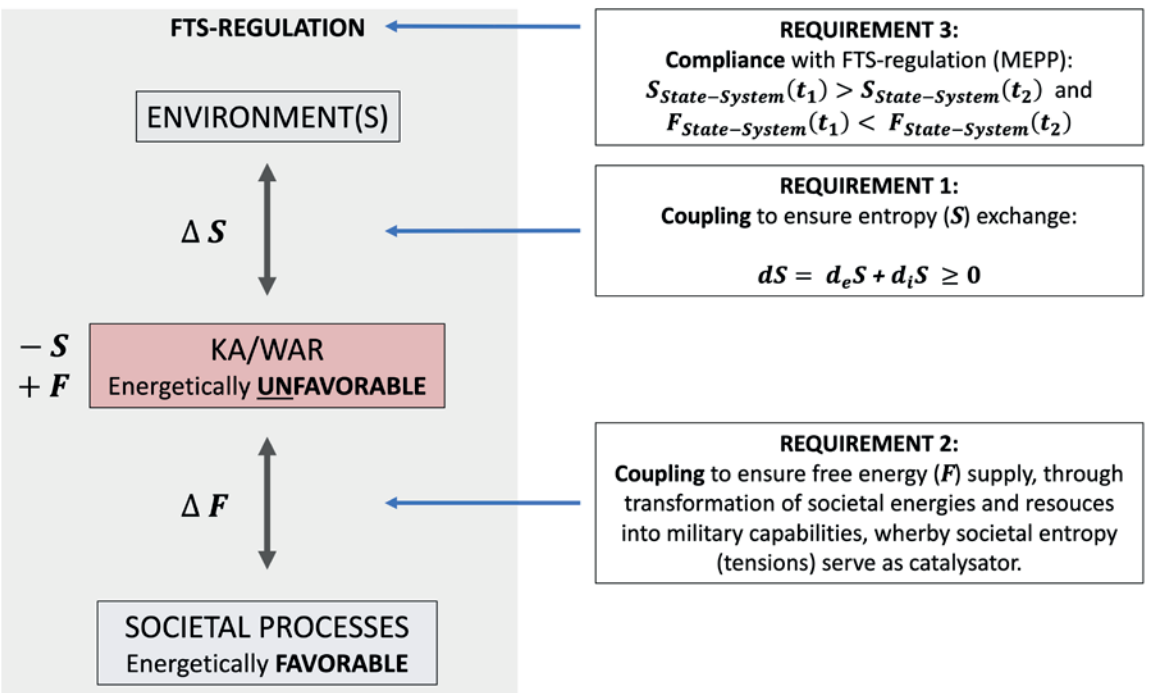


FIGURE 27.6: Schematic representation of requirements for KA/war.

27.6. Application (2): The KA/war that did not take place

Many people expected in reaction to the Al Qaeda attacks on the United States on 11 September 2001, a "Third World War". This is however not what happened. But why should (could) the assassination of Archduke Franz Ferdinand on 28 June 1914 in Sarajevo, cause a World War, and was this not the case for the much larger incident on 11 September 2011?

A world war - a systemic KA - this study shows, requires the t (State-)System to be in a critical condition; VC's must have percolated the (State-)System and must be fully "charged". Only then - in case of criticality - can the energetically favorable societal processes be activated that can supply (be coupled to) the energetically unfavorable systemic KA.
This was the case in 1914, data-analysis shows, and a limited incident could at that point trigger the very susceptible (State-)System and produce a systemic response: the second requirement was met. If Archduke Franz Ferdinand had not been assassinated on 28 June 1914, another incident - around the same time - would have caused the systemic response that was due.
The (State-)System was not critical on 11 September 2011, and a systemic response was impossible; the second requirement was not met.
Consequently, the kinetic response of the (State-)System was - and only could be, as explained - non-systemic.

27.7. Application (3): A failed war

From the perspective of the United Nations, NATO etc. the War in Afghanistan can be considered a failed war: Despite the overwhelming military (and economic) superiority of the US and NATO, is it impossible to conclude this war, even after almost twenty years. The reason that this is the case, has however nothing to do with the above discussed three requirements: The War in Afghanistan does not violate these requirements. The problem with the War in Afghanistan is in essence twofold: (1) In Afghanistan foreign states fight with a non-state actor - with a significant part of the population of Afghanistan (the Taliban) - which is not represented in Afghanistan's (disconnected) state-structure, and for that reason a solution cannot be "found" and not be embedded in the State-System. At the same time - and that is the second reason - the War in Afghanistan has attracted most Great Powers directly and indirectly, and the issue is no longer local: the war in Afghanistan is not about the Taliban.
Although the War in Afghanistan has no practical utility for the US and NATO (if the original motivations to start the war are used as a reference), the War in Afghanistan does - by definition, like all other KA/wars - serve the FTS and thermodynamic requirements of the (State-)System. The KA/war contributes to the sustainment of the 2nd FTS and the global State-System, i.e. by producing entropy.

28. R2-dynamics during the transient period

28.1. Introduction

During the transition period (1480-1945), two interacting 'layers' of dynamics can be distinguished in the (State-)System/FTS, respectively, a layer of chaotic non-systemic KA during RSP's (also referred to as R1-dynamics) and a layer of cyclic/periodic systemic KA dynamics, generated during critical periods (also referred to as R2- dynamics). The R1-dynamics were discussed in chapter 26. In this chapter, I discuss in more detail some properties of the cyclic/periodic R2-dynamics of the System.

The R2-dynamics consisted of four accelerating cycles that were instrumental in a transition of the European State-System to thermodynamic equilibrium. The R2-dynamics emerged from the R1-dynamics through a network-effect. At a certain point during RSP's - the tipping point of a RSP - a network-effect caused the accumulation of entropy (tensions and issues), and the effectiveness of the FTS EMIS-regulation was consequently negatively affected.

Both types of dynamics interacted and were inseparably linked. The R1- and R2-dynamics are the 'components' of the FTS-dynamic. The FTS ensured that continuity and change were balanced in the (State-)System, during the transient period (1480-1945), and that the European State-System accomplished thermodynamic equilibrium via the most efficient path.

Different thermodynamic principles applied to the two types of dynamics: FFE thermodynamic principles apply to R1-dynamics (non-systemic KA), whereas thermodynamic principles that apply near-equilibrium and to phase transitions, apply to R2-dynamics (the cyclic systemic KA of the (State-)System).

The following subjects will discussed in this chapter: Properties of R2-dynamics; the attractor of R2-dynamics; intermediate states and periodic corrections of the energy-state of the State-System; minimum entropy-production and the linear regime; the relationship between chaotic non-systemic KA during RSP's and the critical state of the State-System; the coexistence region; the phase transition of the System and its effects; the thermodynamics involved in aggregation; the collapse of the European State-System (1939); collapse of the hierarchical structure of the core; an overview of the fundamental differences between systemic and non-systemic KA/war, and various applications.

28.2. The R2-dynamics: Features, quantitative properties and their relationships

The 1st FTS was accompanied by four accelerating cycles, each cycle consisting of a RSP and a critical period, when change (an upgraded order) was implemented.

The R2-dynamics concern the cyclic/periodic layer of dynamics, generated by the R1-dynamics, in combination with the network-effect. While the R1-dynamics are concerned with maintaining the existing order (status quo) and continuity, the R2-dynamics are concerned with periodically upgrading the existing order through systemic KA, and thus with change. In figure 28.1 the dynamics are shown.

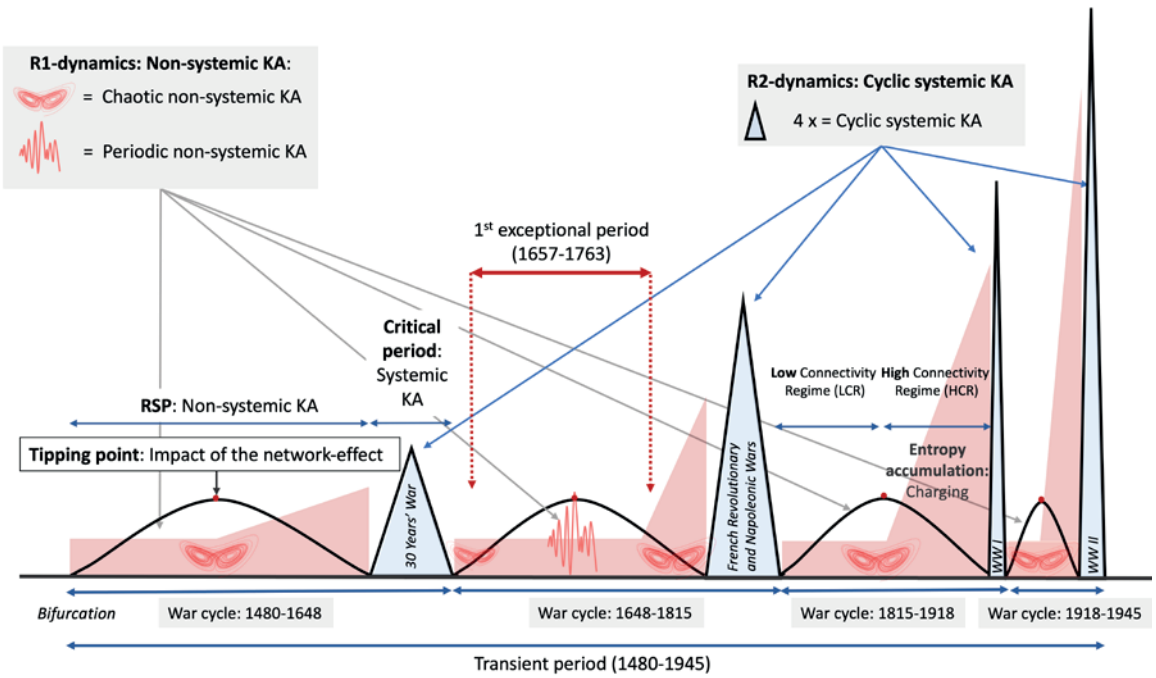


FIGURE 28.1: A schematic depiction of the 1st FTS and the two layers of dynamics.

As explained, the FTS was instrumental in accomplishing a phase transition of the (State-)System, with two effects: (1) Thermodynamic equilibrium was accomplished in the core of the System (Europe), and (2) the core (Europe) and non-core merged into a global system.

The severity, durations, timings and release-ratios of successive cycles, RSP's and systemic KA, developed very regularly: These properties and related dynamics are closely related: The shortening of the life-span of successive cycles - signifying an increasing frequency - and the simultaneous increase of their respective severities - signifying an increasing amplitude/magnitude of cycles - are a consequence of the accelerating entropy-production by the (State-)System, during the transient period (1480-1945).

Order updates (through systemic KA/war) were required at an accelerating pace, until collapse of the European State-System was eventually unavoidable in 1939. The drivers that powered these dynamics, I discussed in chapter 21.

Analysis of the KA/dynamics shows distortions in the dynamics of the (State-)System, during the 2nd cycle (1648-1815), that were caused by abnormal (non-chaotic) KA/dynamics, during the 1st exceptional period (1657-1763).

TABLE 28.1: Properties of the actual and corrected 1st FTS. This table shows quantitative properties of the actual and corrected 1st FTS (59), data from Levy (48). The non-systemic KA of the System during the period 1480-1495 is not included (data is not available); RR is the abbreviation for release-ratio, LS for Life-span

		1st FTS: Actual				1st FTS: Corrected			
Cycle	Period	Systemic KA/war (BCD)	Total KA-cycle (BCD)	RR	LS	Systemic KA/war (BCD)	Total KA-cycle (BCD)	RR	LS
1	1480-1648	1.971.000	2.976.000	0,66	153	1.971.000	3.036.000	0,65	168
2	1648-1815	2.532.000	7.550.300	0,34	167	4.900.000	5.750.000	0,85	154
3	1815-1918	7.734.300	8.429.080	0,92	103	8.100.000	8.720.000	0,93	103
4	1918-1945	12.948.300	12.953.300	1,00	27	11.100.000	11.500.000	0,97	22,5

TABLE 28.2: Correlation coefficients of properties of the actual 1st FTS. This table shows the correlation coefficients of properties of the actual 1st FTS accompanied by four accelerating cycles (1480-1945, data 1480-1945 excluded (not available)). 'Severity cycle' stands for the sum of the severities of all KA/wars (non-systemic and systemic) of successive cycles, severity in BCD; 'Severity RSP' stands for the sum of the severities of non-systemic KA/wars during successive RSP's, severity in BCD; 'Severity SW' stands for the severity of systemic wars of successive cycles, severity in BCD; 'LS cycle' stands for the life-span of successive cycles in years; 'LS RSP' stands for the lifespan of successive international orders in years; 'LS SW' stands for the lifespan of systemic wars in years; 'No. non-sw' stands for the absolute number of non-systemic wars during respective cycles; 'Intensity cycle' stands for the intensities of successive cycles, intensity defined as the total severity of KA/wars during cycles divided by their respective life spans; 'Intensity RSP' stands for the intensities of successive cycles, intensity defined as its total severity of non-systemic wars during successive RSP's divided by their respective life spans; 'Intensity SW' stands for the intensity of systemic KA/wars, intensity defined as the severity of systemic wars, divided by their lifespan; 'Pop size Eur.' stands for the populations size of Europe, at the start of the systemic KA/wars of successive cycles (59).

	Actual FTS	1	2	3	4	5	6	7	8	9	10	11
1	Severity cycle											
2	Severity RSP	-0,24										
3	Severity SW	0,90	-0,63									
4	LS cycle	-0,85	0,71	-0,99								
5	LS RSP	-0,80	0,72	-0,96	0,99							
6	LS SW	-0,82	0,49	-0,87	0,79	0,69						
7	No. non-sw	-0,95	0,49	-0,98	0,93	0,87	0,93					
8	Intensity cycle	0,87	-0,50	0,91	-0,94	-0,96	-0,61	-0,85				
9	Intensity RSP	-0,22	1,00	-0,62	0,70	0,71	0,47	0,47	-0,49			
10	Intensity SW	0,81	-0,67	0,94	-0,90	-0,83	-0,97	-0,95	0,72	-0,65		
11	Pop size Eur.	0,89	-0,56	0,96	-0,91	-0,83	-0,97	-0,99	0,77	-0,54	0,99	

Assuming, the otherwise very regular and consistent dynamics of the System (1st FTS) were not distorted, it is possible to construct a corrected (theoretical) version of the 1st FTS, that can serve as a reference: The distortions - and their impacts - will be discussed later in detail.
Tables 28.1, 28.2 and 28.3 show (more) characteristics of the cycles of the actual 1st FTS:
Based on these characteristics, it is possible to calculate various correlation-coefficients for properties of the System, which I consider indicative for the consistency of the 1st FTS. The correlations are not only statistical, or artifacts, as this study shows.

TABLE 28.3: Correlation coefficients of properties of the corrected 1st FTS. This table shows the correlation coefficients of properties of the 'corrected' - undistorted - 1st FTS. The fine-tuning is based on a model of the 1st FTS, that is accompanied by four (not five) accelerating cycles. In this model, the globalization effect, is not included; the model concerns 'Europe only' (59).

Corrected FTS		1	2	3	4	5	6	7	8	9	10	11
1	Severity cycle											
2	Severity RSP	-1,00										
3	Severity SW	1,00	-1,00									
4	LS cycle	0,84	0,96	-0,96								
5	LS RSP	-0,92	0,92	-0,92	0,99							
6	LS SW	-0,96	0,96	-0,96	0,88	0,82						
7	No. non-sw	-1,00	1,00	-1,00	0,95	0,92	0,96					
8	Intensity cycle	0,84	-0,84	0,84	-0,95	-0,98	-0,69	-0,83				
9	Intensity RSP	0,71	-0,71	0,71	-0,87	-0,92	-0,54	-0,70	0,98			
10	Intensity SW	0,95	-0,95	0,95	-1,00	-0,99	-0,88	-0,94	0,94	0,87		
11	Pop size Eur.	0,98	-0,98	0,98	-0,93	-0,88	-0,99	-0,97	0,77	0,63	0,93	

28.3. The limit cycle attractor of R2-dynamics

During the transient period (1480-1945), the attractor of the R2-dynamics was a limit cycle (periodic attractor): The behavior of the R2-dynamics can be depicted as four closed trajectories in phase space that spiral into their respective predecessors.
The periods became increasingly shorter in duration, because of the accelerating entropy-production in the (State-)System, that powered these dynamics. Four times, the (State-)System followed the same successions of states: Each cycle consisted of a RSP, followed by a systemic kinetic response when the (State-)System had become critical (respectively in 1618, 1792, 1914 and 1939).

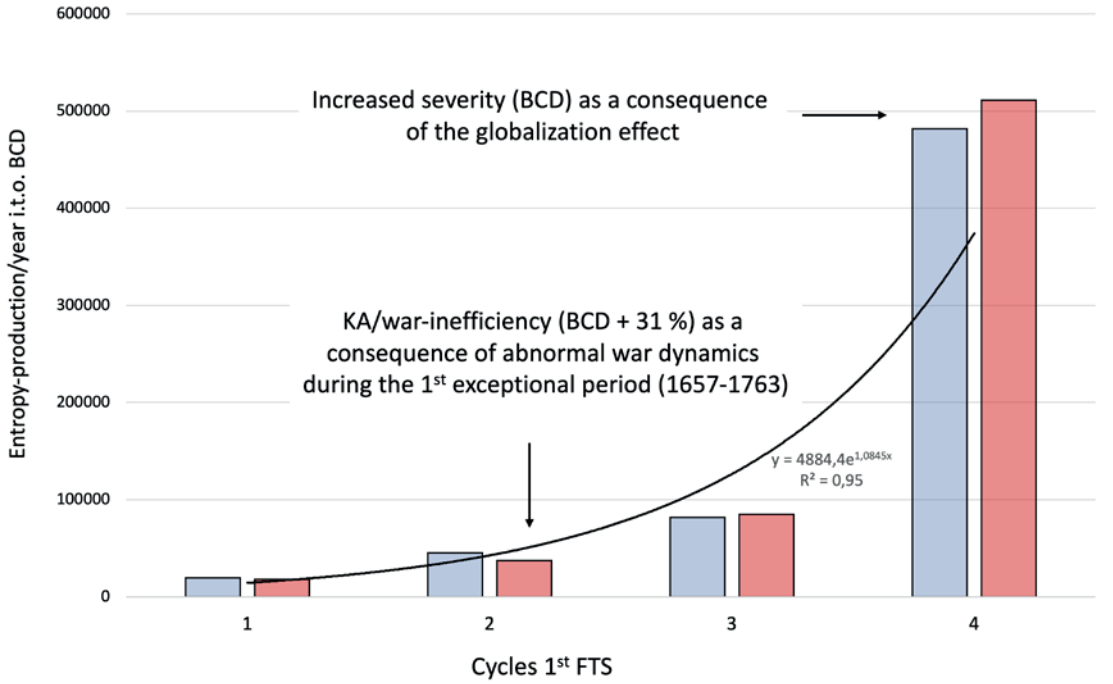


FIGURE 28.2: Accelerating entropy-production, during successive cycles of the 1st FTS (n = 114, based on data Levy (48)). Entropy-production per year accelerated; this growth was unsustainable and caused the collapsed of the European State-System in 1939.

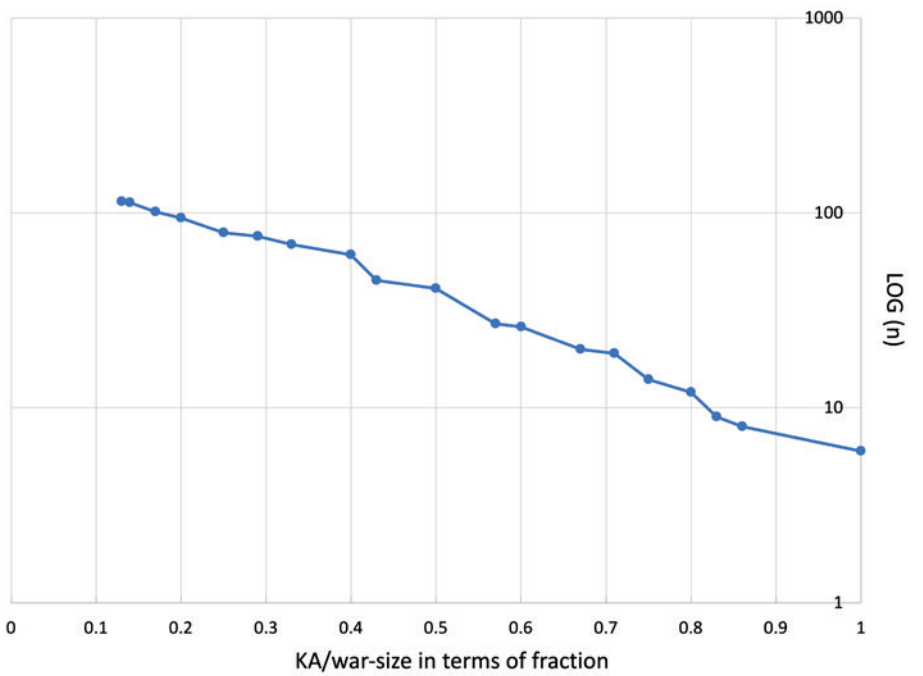


FIGURE 28.3: Size-distribution of KA/wars, during the transient period 1495-1945. This figure shows the cumulative distribution of the sizes of KA/wars in term of fractions, presented as a Zipf-distribution, during the transient period 1495-1945 (Data from Levy (48)); KA/wars during the 1st exceptional period (1657-1763) and expansion KA/wars are included. The size-distribution can be described with a power law with $R^2 = 0{,}89$ or with an exponential function with $R^2 = 0{,}99$ It is also possible to distinguish two different power-law distributions for two separate regions (sizes up to 0,43 and sizes between 0,43 and 1,0). To establish the exact nature of the size-distribution is further research required.

At a certain point - when the State-System reached a critical threshold in 1939 (the singularity in finite-time) - the accelerating cycles (R2-dynamics) could no longer be sustained, and the System (its core) collapsed: These events triggered the last step in the phase transition of the State-System, that was taking place during the transient period (1480-1945). The critical threshold corresponds with 'infinite' entropy-production and - what can be denoted as - the critical population size of the European State-System.
It is also possible, to consider the four cycles (R2-dynamics) as relaxation fluctuations and the 1st FTS as a punctuated equilibrium dynamic: Four times during the transient period (1480-1945), a process of chaotic non-systemic KA in the System FFE, was punctuated by short critical periods, when in response to accumulated entropy KA was put to use to upgrade the System.
Through systemic KA/wars and the upgrades they are instrumental in, accumulated entropy is released, the energy-state of the (State-)System is reduced, and the ability of the FTS to regulate EMIS-flows is improved, at least for the time being.

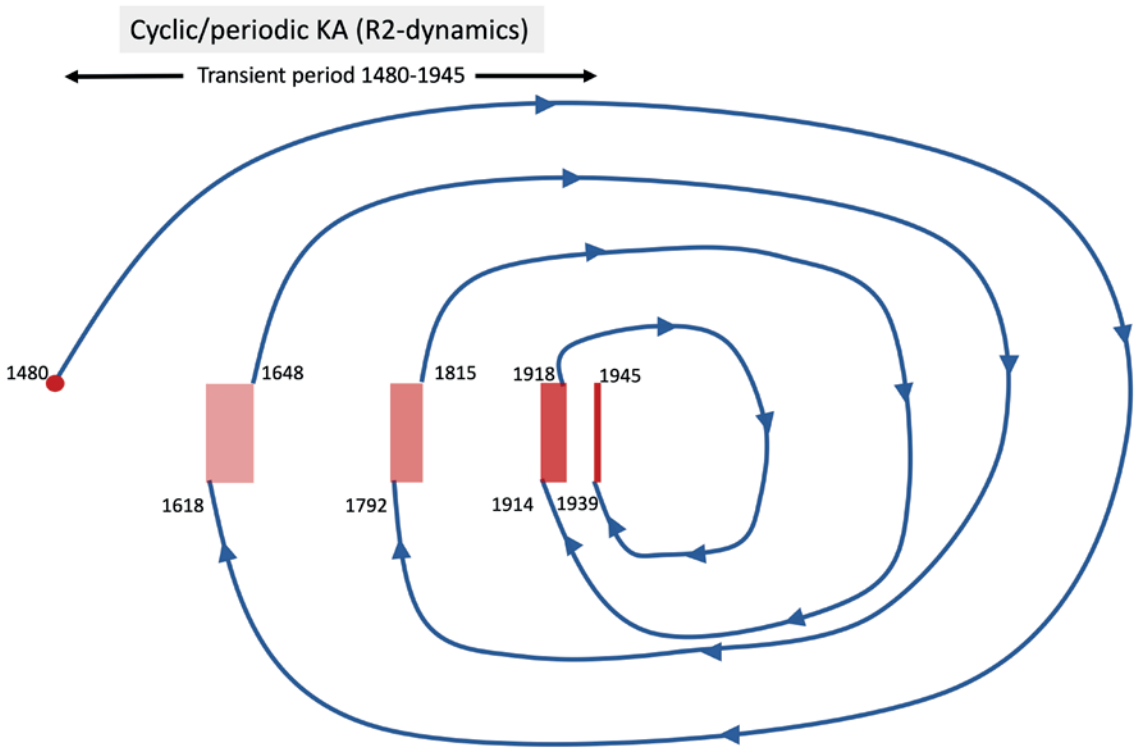


FIGURE 28.4: The attractor of the R2-dynamics is a limit cycle. The behavior of the cyclic/periodic R2-dynamics can be depicted as four closed trajectories in phase space that spiral into their respective predecessors. A limit cycle was the attractor of the (State-)System, during the transient period (1480-1945). The four trajectories contain a stationary point within their interior. The critical threshold (reached in 1939) can be considered the stationary point: when the point was reached, the last step in the phase transition was triggered, and the core of the European State-System was pushed ("sucked") into a new a stability domain: A state of thermodynamics equilibrium, where EMIS-regulation could be accomplished through homeostatic control.

Systemic KA/wars are instrumental in the relaxation of the (State-)System; in lowering its energy-state, which is (in case of the (State-)System FFE) equivalent with its entropy-state. However, the relaxation fluctuations have their limitations and only had a temporary stabilizing effect on the (State-)System: At a certain point (1939) 'relaxation by upgrade' was no longer effective and the final step in the phase transition could no longer be delayed. The relaxation fluctuations were a prelude to the eventual transition of the European State-System to thermodynamic equilibrium.

28.4. Intermediate states and periodic corrections of the energy-state of the State-System

In accord with the Second Law, a system always tries to achieve and maintain equilibrium. The purpose of R2-dynamics is to re-establish equilibrium: Through four accelerating cycles, the (State-)System was able to periodically lower its energy- and entropy-state, before collapse became unavoidable in 1939.
Despite the efforts of the 1st FTS (through the R2-dynamics it produced), entropy-production accelerated during the transient period (1480-1945); the (State-)System was increasingly pushed FFE and became increasingly irreversible (entropy-production is a measure for irreversibility).
The frequency and the amplitude of KA/war-cycles increased: "the more irreversible the macroscopic process, the more positive must be the minimum total entropy production" (27).

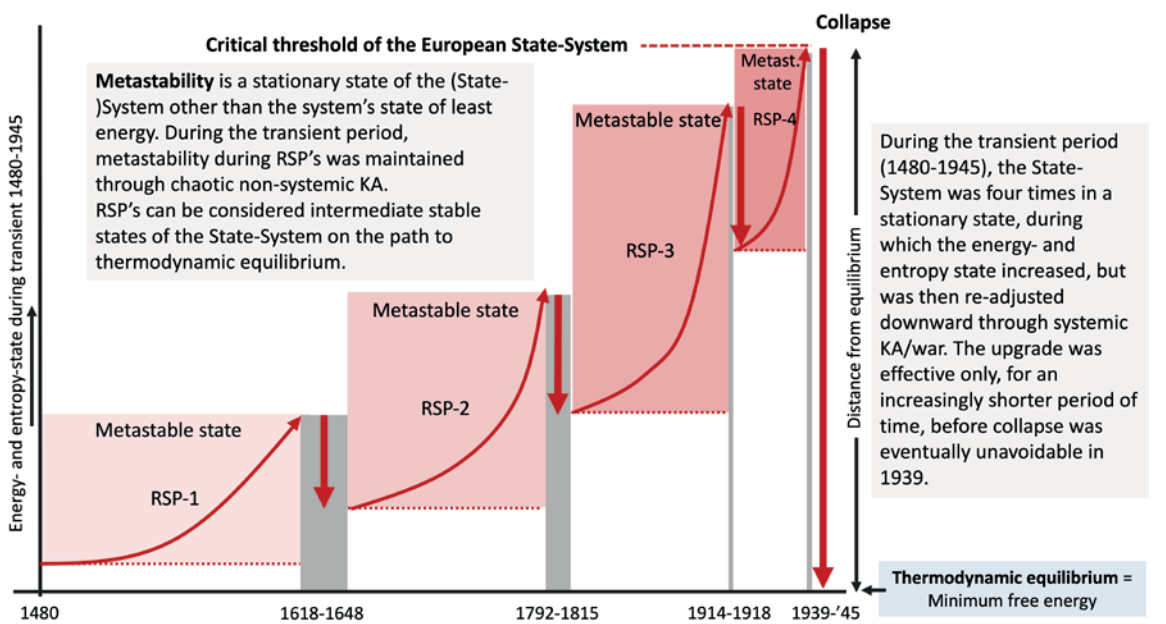


FIGURE 28.5: Periodic downward corrections of the energy-state of the (State-)System through R2-dynamics (1480-1945). The corrections - the 1st FTS - could not keep pace with the accelerating entropy-production, and collapse was a matter of time.

The increasing irreversibility of the (State-)System during the transient period (1480-1945), is related to other developments/phenomena in the (State-)System, including: The increasing work that was (and had to be) accomplished by the 1st FTS and on the (State-)System (28), and the minimum entropy that had to be produced over time by the (State-)System, to serve as a source of order. However, despite periodic order-updates through systemic KA/wars, the last development resulted in an overall increase in entropy-level, during the transient period: $S_{1918} > S_{1815} > S_{1648} > S_{1480}$. Through the increasing irreversibility, the present looked increasingly different from the past.

28.5. Minimum entropy-production and a linear regime, during the transient period (1480-1945)

In chapter 13, I have explained that the MEP-Principle applies to the State-System, while the System maximizes its entropy-production. In the System, these principles play the same role as thermodynamic potentials in equilibrium theory.

The related dynamics - R1-, R2-and System-dynamics - were regulated by the 1st FTS: The 1st FTS ensured that the State-System achieved thermodynamic equilibrium via the most efficient path. The process constituted a phase transition.

In modern thermodynamics, a relationship is observed between stationary states near equilibrium, the extremization of entropy-production and a so-called linear regime. The term linear-regime refers to the linear evolution of certain properties (rates) of a system under certain conditions: The very regular - linear-evolution of certain properties of the (State-)System during successive RSP's, is a typical phenomenon of open systems near equilibrium (66).

Kondepudi et al. observe that "In general, forces and flows are coupled in thermodynamic systems" (44). "For conditions close to equilibrium, a general theory based on linear relations between forces and flows is formulated; the forces drive the flows[2]" and at equilibrium, all corresponding flows vanish (44). "Close to the thermodynamic equilibrium – called the 'linear regime' – thermodynamic formalism can be used to show that rates (of reactions) are linearly related to the affinities" (44). The reaction rate of chemical reactions refers to the conversion of the reactants to the products and vice versa; these reactions depend on collusions (between reactants), which involve a force (affinity).

In regard to linear regimes, Kondepudi et al. also observe that that stationary states in the so-called linear regime "are also states that extremize (*IP: In case of the State-System "minimize"*) the internal entropy production" (44). Kondepudi et al. explain: "In the linear regime, where the Onsager reciprocal relations are valid, all stationary states in which unconstrained thermodynamic flows vanish are characterized by the following general extremum principle: "In the linear regime, the total entropy production in a system subject to flow of energy and matter (...) reaches a *minimum* value at the nonequilibrium stationary state" and 'the rate of increase of entropy plays the role of a potential '. The general formulation and the demonstration of the validity of this principle is due to Prigogine" (44).

The question now is - given the relationship between stationary states in nonequilibrium systems, extremization - i.e. minimization - of entropy-production and the existence of so-called linear regimes - if besides stationary states (RSP's), extremization of entropy-production in the State-System, also the

2. Though the flows are driven by the forces, they are not entirely determined by them; the flows can depend on other factors such as the presence of catalysts (44).

"typical" linear relationships can be observed, during the transient period (1480-1945); when the State-System neared - step-by-step, cycle-by-cycle - equilibrium, through a phase-transition that was directed by the 1st FTS.

Analysis of war-data shows, that indeed a linear regime was 'in place', during the transient period (1480-1945): Certain properties (rates) of the State-System - related to the R2-dynamics - developed (decreased) linearly. During the transient period, the number of non-systemic KA (non-systemic wars) and the number of Great Power status changes (during successive RSP's), decreased linearly, and can both be considered 'reaction rates' of the System.

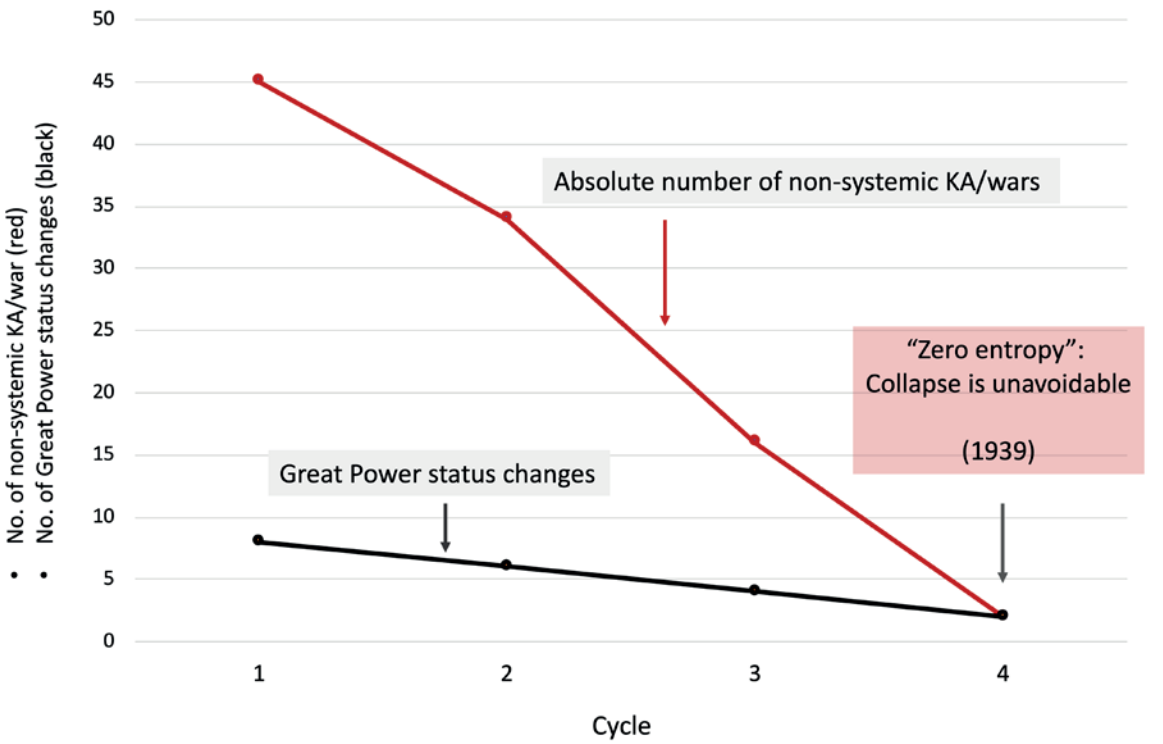


FIGURE 28.6: A linear regime for R2-dynamics, during the transient period (1480-1945), based on data from Levy (48).

These observations confirm that the relationship between stationary states in the nonequilibrium System, the extremization of entropy-production and the existence of a so-called linear regime, can also be observed in the (State-)System.

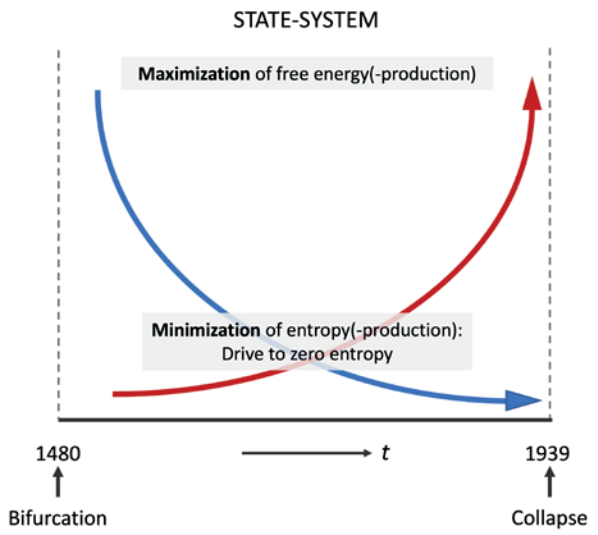
During the transient period (1480-1945), the paradox of the System was that although the System was increasingly FFE, the State-System was simultaneously pushed to equilibrium and zero entropy and experiencing a phase transition. As I explained, the increasing frequency and amplitudes of the systemic KA/wars in the core of the (State-)System during this period - the acceleration of the cyclic R2-dynamics - were indicative of the increasing instability of the State-System and of the phase transition taking place.

The cyclic systemic KA (R2-dynamics) were instrumental in the drive to zero entropy of the State-System. The dynamics of the System - R1-, R2- and FTS-dynamics, in which the interplay between competing thermodynamic potentials and their extremization played a vital role, were regulated by the 1st FTS: By ensuring population growth - and through the process of aggregation - entropy-production accelerated and 1st FTS could power itself; the entropy was used as a source of order to shape the (State-)System and ensure that the State-System followed the most efficient path to thermodynamic equilibrium.
Once the cyclic systemic KA (R2-)dynamics achieved zero entropy in/of the European State-System, and the 1st FTS simultaneously produced 'infinite' amounts of entropy, the European State-System collapsed, and the phase transition was accomplished through a final step (the 4th systemic KA/war, the Second World War, 1939-1945).
Based on the observations discussed in this paragraph, it can be useful to introduce the terms social affinity - which is indicative for a social force - and social reaction rates.
In case of chemical reactions, the thermodynamic force that corresponds with a flow of matter is called affinity; affinity is a state function; "the affinity is the driving force for chemical reactions" and "a nonzero affinity implies that the system is not in thermodynamic equilibrium and that chemical reactions will continue to take place, driving the system towards equilibrium" (44). Social affinity can be defined as: "the force that corresponds with EMIS- flows - including KA (war), and the (related) processes of aggregation and expansion and empowerment"; social affinity drives social interactions. When thermodynamic equilibrium was achieved in the European State-System (albeit with a delay until 1989), following the phase transition (1480-1945), there was zero social affinity in the European State-System.
Social reaction rate can be defined as the speed at which societies and states aggregate/merge; the social reaction rate is about the speed of social transformation. Other factors than social affinities determine social reactions rates, including the presence of positive feedback loops (catalytic processes), and the (indirect) effects of the constraint that drives the FTS, and determines the Systems pace of life.

28.6. Implementation of the MEP-Principle: Contradictory effects during the transient period

During the transient period (1480-1945), the R2-, FTS-dynamics and phase transition were shaped by the MEP-Principle; by the efforts of the State-System and 1st FTS to implement this principle. In efforts of the State-System to contain entropy-production and accomplish MEP, the System produced seemingly contradictory effects during the transient period (1480-1945): During the transient period, the State-System was pushed to zero entropy - through its efforts to achieve MEP - but entropy-production in the System accelerated: The 1st FTS also enabled accelerating population growth and the process of aggregation (in)directly also contributed to the accelerating entropy-production in the (State-)System.
Zero-entropy was eventually reached in the European State-System in 1939, at the same time when entropy-production in the System reached 'infinity'; consequently, the gradient and force that were generated were maximum and collapse of the European State-System, and the final step in the phase transition were now unavoidable.

Implementation of MEP of/in the State-System required the European State-System's collapse and destruction, and the 'implementation' of homeostatic control. This was eventually achieved (in Europe) through the 4th systemic war (1939-1945, the Second World War, the final step in the phase transition). MEP in the State-System was achieved when the phase transition was accomplished in 1945.



During the transient period 1480-1945, the core of the European State-System made a transition from (increasing) FFE to thermodynamic equilibrium. During this period a dissipative structure (the 1st FTS) regulated entropy(-production), including through KA.
In 1939, the core of the System (Europe) reached a critical threshold and consequently produced infinite amounts of tensions (entropy). At that point, the 1st FTS had pushed the European State-System to zero entropy and the free energy (potential) was (consequently) maximized, at the same time. During the transient period, the constraint became increasingly strong, and the force applied to the European State-System by the 1st FTS was also maximized.
In 1939, the core of the System collapsed and 'infinite' amounts of free energy (kinetic energy) were put to use at an 'infinite' rate. The consequence was a phase transition with two effects : (1) Thermodynamic equilibrium was achieved in the European State-System and (2) the core and non-core merged into a single globalized State-System.

FIGURE 28.7: The impact of the MEP-Principle. This figure is a schematic depiction of the impact of the MEP-Principle on the State-System during the transient period (1480-1945): While the State-System was 'pushed' to zero entropy, the free energy potential and KA was maximized. In 1939, the core collapsed.

28.7. Stability-nucleation during Systemic KA (systemic wars)

This research shows that a "nucleation theory view of nonequilibrium transitions" (66), also applies to the (State-)System. Autocatalytic processes and nucleation were not only involved in the bifurcation of the System (1480), but also occurred during HCR's of RSP, when entropy accumulated in the (State-)System (involving an autocatalytic process) and a network of VC's was formed through a process of nucleation, and during critical periods (systemic KA/wars), when the (State-)System implemented upgraded orders. During critical periods - during systemic KA/wars - accumulated entropy is released and massive amounts of KA are put to use. Criticality of the (State-)System - the divergence of the correlation length - ensures that systemwide communication and coordination is enabled. Interactively states search for a new viable (upgraded) order that ensures that the energy-state of the System is reduced, and regulatory capabilities are improved.

The process is autocatalytic as well, at least during a certain phase. However, at a certain point, solutions start to 'nucleate', to take shape in the (State-)System. This process during critical periods, can be referred to as stability-nucleation: Through a process of nucleation, the (State-)System re-solidifies, and implements an upgraded stationary state (RSP).
In figure 28.8, the stages of development are explained.

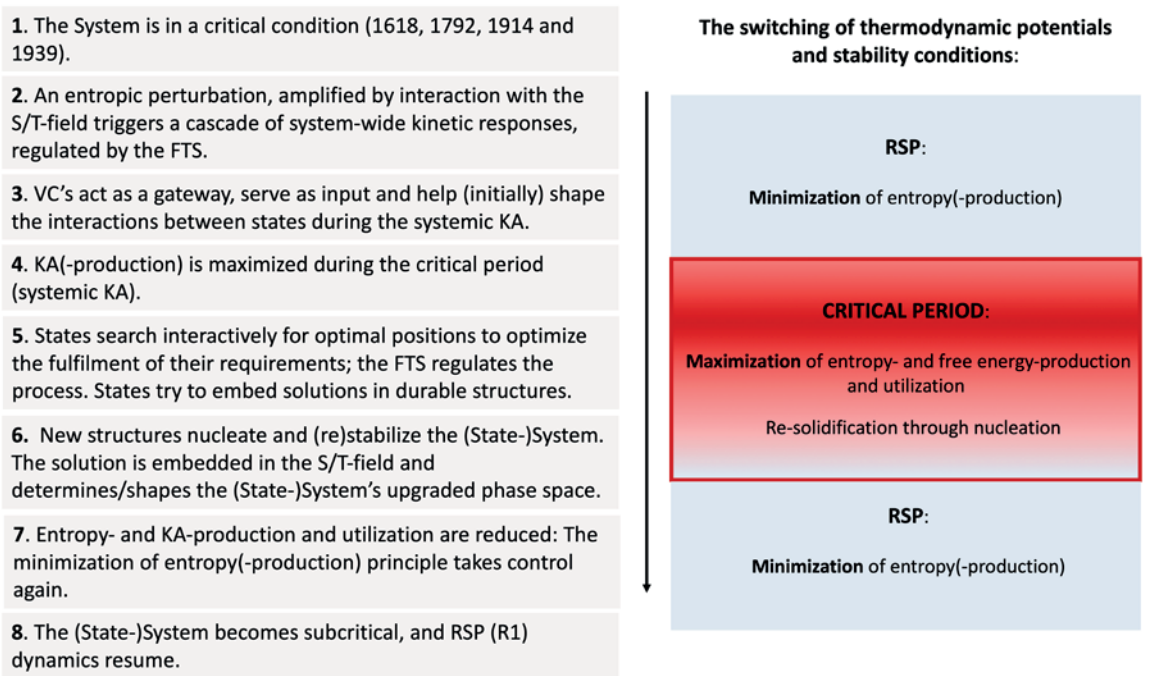


FIGURE 28.8: Stability nucleation during critical periods.

28.8. The second-order phase transition of the System

In far-from-equilibrium systems, loss of stability can lead to a wide variety of complex nonequilibrium states; in equilibrium systems, loss of stability can lead to phase separation[3] or phase transitions. Fluctuations in macroscopic systems become increasingly large near critical points and are no longer extremely small (44). During the transient period (1480-1945), the 1st FTS accomplished a phase transition of the State-System, from FFE to thermodynamic equilibrium; a process that was accompanied by

3. Phase separation refers to the phenomenon when a single-phased system makes a conversion to a multi-phased system.

increasingly large fluctuations. The systemic KA of the State-System - the fluctuations in the State-System - became increasingly large when the critical point was neared. The critical point of the State-System was reached in 1939.

Phase transitions can be understood in terms of stability: "Stability theory can be applied to critical phenomena of liquid-vapor transitions and the separation of binary mixtures. When the applied pressure and temperature are altered, systems can become unstable, causing their physical state to transform into another distinct state. When the pressure on a gas is increased, for example, it may lose its stability and make a transition to a liquid. Similarly, when the temperature of a two-component liquid mixture (such as hexane and nitrobenzene) changes, the mixture may become unstable to changes in its composition; the mixture then separates into two phases, each rich in one of the components" (44).

Phase transitions involve critical points. According to Solé (81) "the term critical point is used to describe the presence of a very narrow transition domain separating two well-define phases, which are characterized by distinct macroscopic properties that are ultimately linked to changes in the nature of microscopic interactions among the basic units".

In 1480, the System experienced a bifurcation (also referred to as a nonequilibrium phase transition) from an unorganized unstable state FFE to an organized state FFE (a dissipative structure; the 1st FTS).

During the transient period (1480-1945), the 1st FTS was instrumental in accomplishing a phase transition to thermodynamic equilibrium of the European State-System. The transient period can be considered an extended transition domain.

The macroscopic properties of the phase preceding the transient period (before the bifurcation (< 1480)) differed fundamentally from the macroscopic properties of the phase (thermodynamic equilibrium) following the transient period (> 1945); these changes are closely related to changes between the basic units - societies - of the (State-)System.

In case of the phase transition of the State-System, the transient domain is not particularly narrow (at least from a human) perspective. In case of the (State-)System, the phase transition was accompanied by four cycles, each cycle was defined by a critical point/period; in 1939 - when the European State-System collapsed - the European State-System had reached the final (actual) critical point, which triggered the last stage of the phase transition (the 4th systemic KA/war, 1939-1945, the Second World War). After the phase transition, there was no longer a distinction between states - separate units - in the core of the System (Europe, albeit there was a delay in the implementation of homeostatic control until 1989, caused by the 2nd exceptional period (1945-1989)). During the transient period, there was a process of nucleation taking place (as well): The process of aggregation, from 300 state-like structures in 1480 to two units in 1945, and one unit in 1989).

"A critical phase transition is characterized by some order parameter $\emptyset(\mu)$ that depends on some external control parameter μ (such as temperature) that can be continuously varied" (81). The connectedness of nodes in the System (of individual humans, communities, societies, etc. which determines the presence of homeostatic control) and population size are respectively the order and control parameters of the (State-)System.

A distinction can be made between a first- and second-order - respectively discontinuous and continuous - phase transitions, as explained in chapter 17. The State-System experienced a second-order phase transition during the transient period: When the control parameter population size increased, the State-System (core) made a gradual (not a sudden) change from an organized state FFE (1480) - consisting of 300 units, and a total population of 83 million - to thermodynamic equilibrium (> 1945/1989, one unit)

(80, 81). During a second-order phase transition a system is "between order and disorder", as was the case for the State-System, during a transient period: There was order in societies/states and disorder between societies and states; order and disorder competed during the transient period.
According to Solé, "a characteristic fingerprint of the onset of a second-order phase transition is the amplification of fluctuations close to the instability point". "At μ_c they become very large" (80, 81). This behavior can also be observed in the State-System during the transient period (1480-1945), when the size of fluctuations - of cyclic systemic KA (R2-dynamics) - became increasingly large when the critical point (1939) was neared. In case of the State-System, μ_c was reached in 1939; μ_c correspondents with - what can be denoted as - the critical population size of the European State-System, when the European State-System produced infinite amounts of entropy and could no longer be regulated (by the 1st FTS).

28.9. The relationship between chaotic non-systemic KA during RSP's and the critical state of the State-System

During criticality, so-called critical phenomena - related to the physics of critical points - can be observed: e.g. divergence of the correlation length and fractal behavior.
During the transient period (1480-1945), RSP's (stationary periods) that were regulated by chaotic non-systemic KA (R1-dynamics), periodically (four times) and (but only temporarily) collapsed. During the first three critical periods, the order of the RSP (stationary state) was upgraded, and through these order-updates was the State-System increasingly pushed nearer the critical point (μ_c, 1939) of the European State-System.
Despite the apparent disorder during criticality (the temporary break-down of the order/stationary state), the (State-)System had a very specific and useful configuration: The correlation length diverged - and spanned the (State-)System - and KA had a fractal organization. These characteristics ensured that communication and coordination at and 'between' all scales of the (State-)System was enabled, which enabled the search for and implementation of an upgraded RSP.
The typical fractal organization of military capabilities, and how these capabilities are deployed - in fractal structures - are also manifestations of the fractal behavior of the (State-)System (59).
This study shows, the (State-)System can only become critical, if the non-systemic KA/wars during RSP's is chaotic in nature; as the effects of abnormal non-systemic dynamics during the 1st exceptional period (1657-1763) of the 2nd cycle (1648-1815) show (discussed in chapter 30). Chaotic non-systemic KA/wars during RSP's ensure that VC 's with fractal structures nucleate and percolate the (State-)System. It is a requirement for the (State-)System to be prepared by chaotic non-systemic KA during RSP's that produce VC's with fractal structures that subsequently enable a critical condition - including a divergence of the correlation length - when these VC's are eventually activated.
Although systemic KA - KA during critical periods - is by definition system-sized (involves all Great Powers present in the State-System), *system-sized* KA does not by definition qualify as *systemic* KA.
During the 1st exceptional period, the System produced several system-sized wars. These wars were however not triggered by the percolation of VC's with fractal structures that were produced through chaotic non-systemic KA: There was no fractal nucleation and percolation. The divergence of the

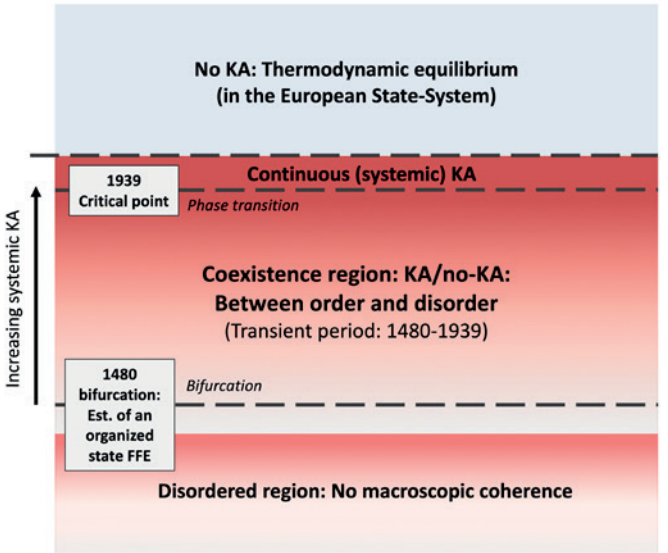
correlation length could not be achieved, consequently 'criticality was not possible'. The conditions for multi-scale interactions - to find and implement an upgraded order - were not present, and consequently these system-wide wars could not produce upgraded orders.
Because of the unconstrained (extreme) nature of the abnormal (periodic) non-systemic KA/dynamics during the 1st exceptional period, these wars could not contribute to a process of fractal nucleation and percolation, that would eventually produce a critical condition and a systemic KA/war. Consequently, criticality and a next (2nd) systemic KA/war was delayed: Chaotic non-systemic KA/dynamics had to be restored, which required an end to the intense rivalries between Britain and France.
The chaotic non-systemic KA resumed in 1763 analysis of trajectories in phase space show, and the (State-)System became critical again in 1792. "Reconstruction" of a non-distorted 1st FTS shows that the abnormal KA/dynamics during the 1st exceptional period (1657-1763) caused a delay of 13 years (59). During the 1st exceptional period, the (State-)System was momentarily pushed from the most efficient path to thermodynamic equilibrium.

28.10. Coexistence region

During the transient period (1480-1945) - when the phase transition was accomplished - the State-System was in a state 'between order and disorder' and two phases - with and without KA - coexisted: There was order and no KA within societies/states and disorder and KA between societies/states. This region is also referred to as the coexistence region: Parts of the System generated KA, and other parts did not; two phases coexisted.
The (State-)System can be considered collection of units (societies) that are (already) in thermodynamic equilibrium (where EMIS-regulation is accomplished through homeostasis), while the interactions between these societies (through states) are still controlled by the FTS through KA. During the transient period (1480-1945), through the process of aggregation (nucleation of societies/states) the units (societies/states) in thermodynamic equilibrium (with homeostatic control) grew in size and at the same time decreased in number.
Societies can be considered 'islands' of equilibrium (and stability). During the transient period, the size of these 'islands of equilibrium' (of societies/states) increased, and consequently the number of states decreased (as a consequence of the process of aggregation).
The constant reconfiguration of the State-System - the aggregation/merging of societies and state-structures - were efforts of the 1st FTS to find a configuration that minimized the entropy-production and to optimize EMIS-regulation, given the population growth in the (State-)System and continuously intensifying rivalries between societies and states.

28.11. A phase diagram of the System

A phase diagram in physical chemistry is a diagram that shows the conditions (like for example pressure, volume, etc.) at which thermodynamically distinct phases occur and coexist. I applied this 'technique' to the State-System for the transient period (1480-1945). The purpose of this phase diagram is to better understand the phase transition that was unfolding during that period.



In **1480,** the System experienced a bifurcation from an increasingly unstable state FFE to an organized state FFE. From **1480-1945**, the (State-)System was in a transient period 'between order (no KA) and disorder (KA)': KA and no-KA coexisted and were regulated by the 1st FTS, to achieve thermodynamic equilibrium in the European State-System.
During the transient (coexistence) period, the rate (the frequency) of systemic KA (systemic wars) and their magnitudes increased. In **1939**, the critical point of the European State-System was reached and the frequency and magnitude of systemic KA became 'infinite'. This condition was unsustainable, and triggered the final step in the phase transition.
In **1939**, when the European State-System the critical point, the core self-destructed because of the infinite KA that was utilized by the infinite entropy that was (being) produced. This resulted in a power vacuum and the opportunity for the Soviet-Union (which still had sufficient resilience) and the United States (an outside Great Power) to establish an interim order in Europe until **1989**, when the Soviet-Union collapsed and homeostatic control was implemented in the former core (Europe).

FIGURE 28.9: The coexistence region, between order (no KA) and disorder (KA).

The diagram shows the phase diagram of the European State-System, during the transient period (1480-1945). During the transient period, the State-System was between order (no KA, in societies/states) and disorder (KA between societies/states). Two phases, order and disorder coexisted. Whereas societies/states had already achieved homeostasis (no KA), between societies/states - in the State-System, one level up - regulation had still to be accomplished through the 1st FTS, by applying KA.
During the transient period, a process of nucleation - aggregation - was taking place: The size of societies/states increased (through merging/aggregation), while their number decreased. The aggregating units became increasingly connected and non-decomposable; rivalries/competition intensified. The units not only became larger but were also able to mobilize and deploy increasing amounts of kinetic energy (military capabilities).
During RSP's of cycles, a dynamic steady state - a certain balance - could be established between KA and non-KA; between order and disorder, regulated by the 1st FTS.
The blue curve shows the path of the European State-System in phase space, during the transient period; the thermodynamic branch that was selected.
The curve is defined by the 'equality' of KA and entropy-production in the (State-)System: A stationary state could be accomplished in the State-System, because entropy-production could be regulated through KA through the 1st FTS.
Population size, indicative for the connectedness and entropy-production in the (State-)System, is the control parameter of State-System. The size of units - societies/states - is the order parameter of the State-System.
During the transient period, the 1st FTS pushed the State-System to zero-entropy, in accordance with the MEP-Principle that applied to the State-System. During the transient period, the number of entities

(societies/states) was reduced (the degree of aggregation increased) from circa 300 in 1480 to one entity (society) following the System's collapse in 1939 (actually there was a delay until 1989, as I explain later). The degree of aggregation ('density' of the core of the System) is the order parameter.
In 1939, the critical point of the State-System (μ_c, the critical population size) was reached, the (State-) System produced infinite amounts of entropy and KA, the core collapsed and consequently the final step of the phase transition was triggered (the 4th systemic war, the Second World War, 1939-1945).

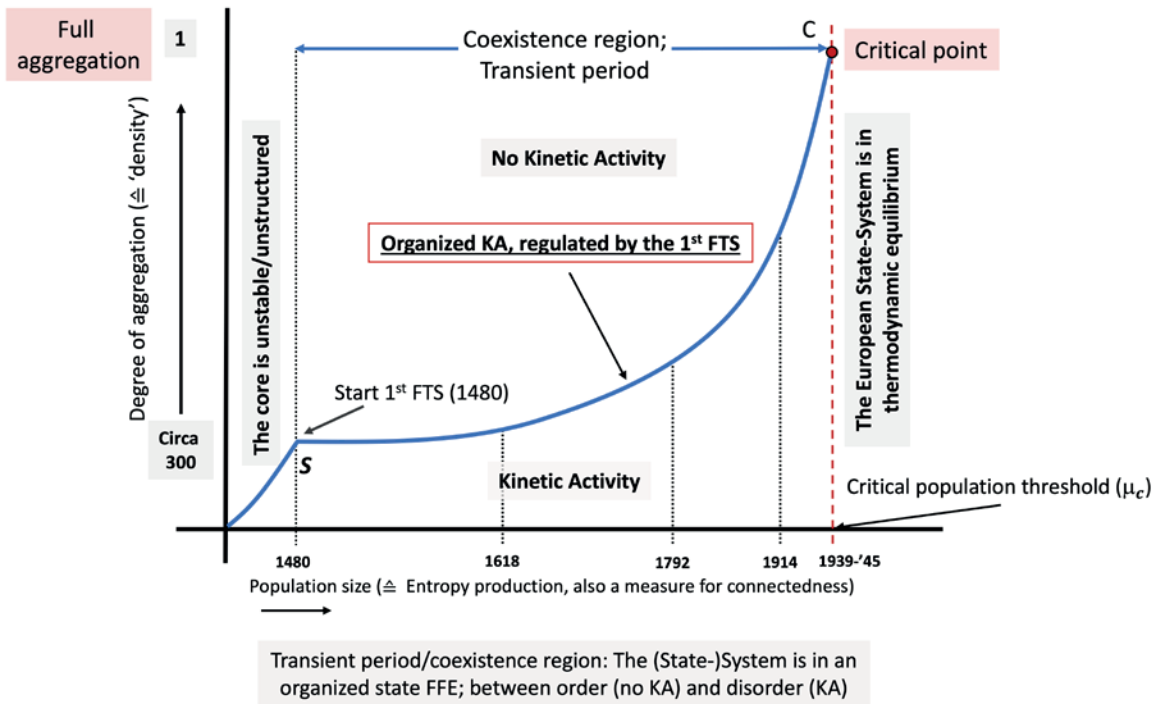


FIGURE 28.10: Phase diagram of the European State-System, 1480-1945.

28.12. The effects of the phase transition: Globalization of the State-System

The phase transition had two complementary and fundamental impacts on the (State-)System. It should be reminded that the 1st FTS emerged in Europe in 1480. The purpose of the 1st FTS was to ensure the most efficient path of the European State-System to thermodynamic equilibrium. FTS-regulation also involved a process of expansion of the core (Europe) to its environment (the non-core). This process is described and discussed in more detail later.

Until the phase transition was accomplished (in 1945), there was a sharp distinction between a core (Europe) and a non-core (the rest of the world): The non-core 'served' - was subjugated to - the operation of the FTS/core. The non-core - the environment of the core - played an essential role in the emergence and sustainment of the 1st FTS, as I already explained.

However, over time, the non-core increasingly developed, and was/became modeled according to the core, at least in some respects. Although the non-core was subjugated to the core, several non-core communities and societies were able to maintain or acquire autonomous positions: Eventually, the United States and Japan both acquired Great Power status, respectively in 1898 and 1905 (48).

At the moment of collapse of the core in 1939, core and non-core were already to a high degree integrated. The moment the core collapsed, (excess) entropy-production from the core was also pushed to the non-core, and (further) 'fueled' rivalries between core-states in the core, between core-states and non-core-states and between non-core-states themselves.

'Localized' entropic perturbations were reinforced through the also increasingly globalized S/T-field, and VC's in the core and non-core became increasingly connected. Through Germany's declaration of war against the United States on 11 December 1941, in reaction to Japan's attack on the United States in Pearl Harbor on 7 December 1941, the Asian and European VC's became connected. 11 December 1941 can be considered the moment the core and non-core became fully connected and the State-System globalized. EMIS-regulation had now a global scope, and the components for a 2nd global FTS were established.

The purpose of the 2nd FTS (1945-....) with its global scope, is similar to the purpose of the 1st FTS (1480-1945): To accomplish thermodynamic equilibrium of the *global* State-System, via the most efficient path at a global scale.

The linkage and merging of core and non-core, the loss of control of the core (of core-states) over non-core territories (their colonies), the reconfiguration of EMIS-flows and the emergence of a 2nd (global) FTS contributed to a process in which non-core societies acquired full autonomy. These societies now adopted - and had to adopt according to the new rules of the upgraded (United Nations) order - independent/sovereign state-structures.

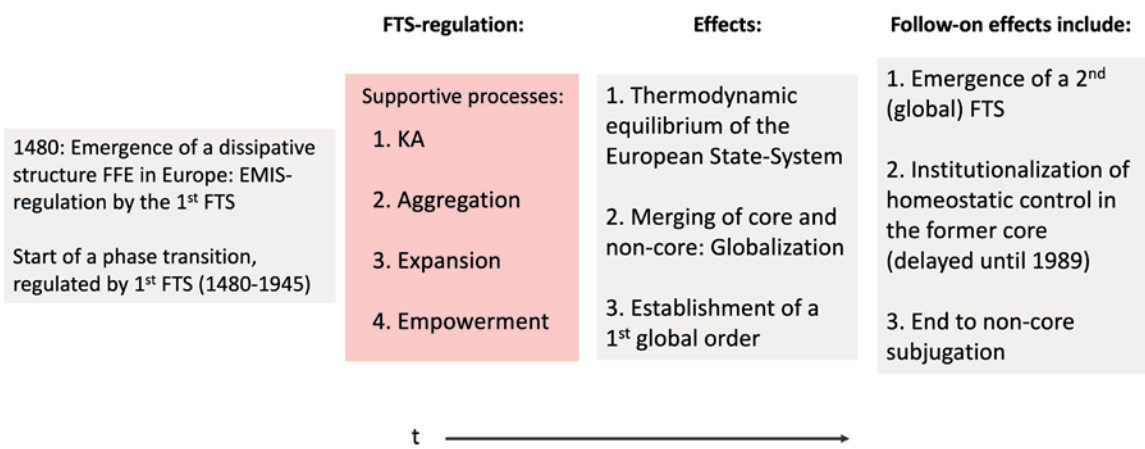


Figure 28.11: Overview of immediate and follow-on effects of the (1st) phase transition (1480-1945). A 2nd phase transition is now taking place to thermodynamic equilibrium of the global State-System.

28.13. The thermodynamics involved in aggregation

The process of aggregation during the transient period (1480-1945), was an integral component of the phase transition. Through aggregation societies and their respective state-structures merged into larger entities. Aggregation requires that barriers are overcome, eradicated. To overcome barriers, a certain amount of activation energy is required (44).

During the period 1480-1939, the number of states decreased from circa 300 in 1480 (with a total population of circa 83 million), to circa 25 in 1939 (with a total population of circa 544 million), the final step to a single entity was accomplished during the final stage of the phase transition (the 4th systemic war, the Second World War, 1939-1945), albeit with a delay until 1989 (caused by the 2nd exceptional period (1945-1989)).

I assume that (at least in some respects), the process of aggregation in the (State-)System, is identical to a process of clustering of molecules in a physical system, during a phase transition, e.g. from a fluid to a solid state. In case of the clustering of molecules, the clustering takes place "through fluctuations because the Gibbs free energy change for such transformations is positive" and "if the Gibbs energy of the random fluctuations is large enough a critical nucleus of radius r will form and begin to grow, thus initiating a phase transition" (44). The laws that govern these fluctuations need to be known to understand the dynamics of nucleation (44).

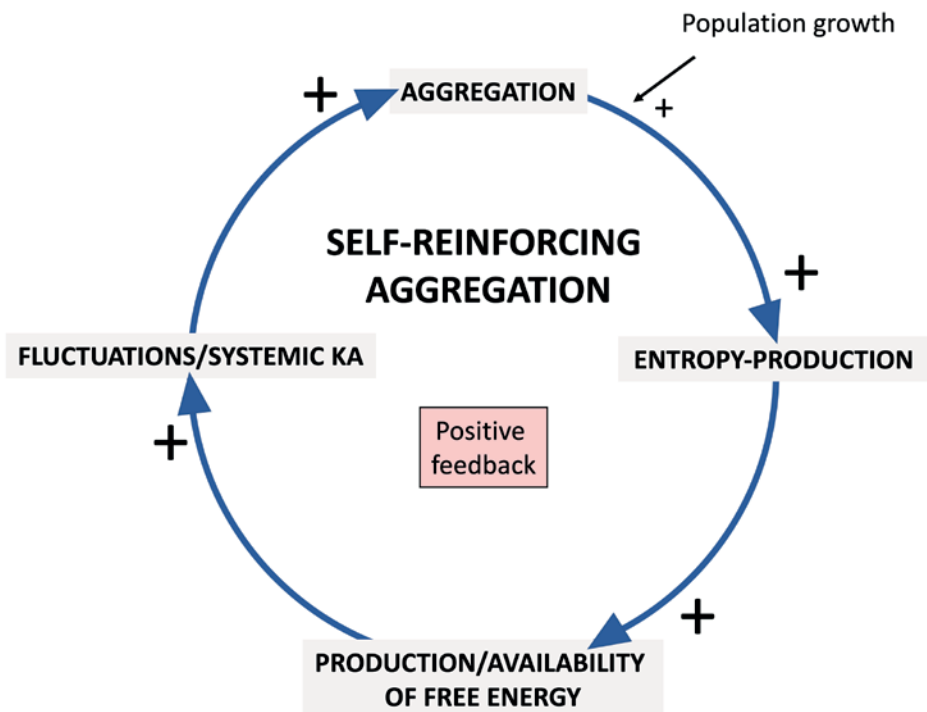


FIGURE 28.12: Aggregation was/is a self-reinforcing process.

The entropy that was generated in the (State-)System through interactions between societies/states, served as a catalyst in the transformation of societal energies into kinetic (military) capabilities.
In case of the clustering - nucleation/aggregation - of societies/states, the resulting increase in entropy-production in the (State-)System, resulted in increasingly large kinetic fluctuations (systemic KA), which ensured that the phase transition could be sustained (1480-1945), until full aggregation was (stage 3A) was accomplished.
The Gibbs free energy change resulting from aggregation - the transformation/merging of societies/states - was positive and could 'power' a self-reinforcing process.
Each cycle that accompanied the 1st FTS, corresponds with a decrease in the number of states in the core (Europe). The process of aggregation ensured the availability of accelerating 'amounts' of free energy that were required to sustain the 1st FTS and (thus) the phase transition.
A close relationship exists between the increasing size of societies/states that merged during successive cycles and the increasing size of the kinetic fluctuations (systemic KA) the (State-)System required during the transient period, to accomplish thermodynamic equilibrium of the European State-System.

28.14. Collapse of the European State-System (1939)

The cyclic - accelerating - R2-dynamics were instrumental in the phase transition and eventual collapse of the European State-System in 1939. When the European State-System collapsed in 1939, only one more 'step' to thermodynamic equilibrium was required: The last stage of the phase transition was accomplished by the 4th systemic KA/war (the Second World War, 1939-1945).
In 1939, the entropy-production in the European State-System was 'infinite', the State-System had reached zero-entropy, and the free energy in the System was maximized. Because of its characteristics, the 4th systemic war can be referred to as an 'infinity war', through which the core self-destructed.
In fact, the European State-System and 1st FTS, already carried at their inception in 1480, the seeds for their eventual - and predictable - self-destruction, given the dependence of the FTS on KA to sustain its operation and its path to thermodynamic equilibrium. Self-destruction through an "infinity war" is also the unavoidable outcome of the 2nd FTS.
When in 1939, the European State-System reached the singularity in finite-time, the critical threshold of the European State-System, a series of closely related dynamics and events can be observed:

a. *Critical condition*. In 1939, the European State-System became critical for the fourth and last time during the transient period (1480-1945). At that point, as was the case during the three preceding precursory critical points (1618, 1792 and 1914), VC's which had nucleated during the preceding RSP (1918-1939), had fully percolated the System and were fully 'charged'. At the critical point, there was a divergence of the correlation length, that allowed for a cascade of multiscale and system-wide kinetic responses.
b. *Unsustainable entropy-production: Singularity in finite time*. During the transient period, the entropy-production had accelerated. The acceleration was unsustainable and caused a singularity in finite time. The singularity was reached in 1939, and the State-System could no longer be sustained and consequently collapsed; in 1939 the European State-System produced 'infinite' amounts of entropy.
c. *1939: Singularity in finite time, critical threshold, critical population size, non-decomposability*. These phenomena and terms are related and concern the same phenomena from a different perspective

and/or scientific discipline. 544 Million is the critical population size of the System(core); the maximum population size the 1st FTS and European State-System could sustain and regulate, given the EMIS-flows a population of such a size generated in the (State-)System. A population of 544 million produced infinite amounts of entropy. The critical population size of 544 million is also equivalent with a certain degree of connectedness - or (non-)decomposability - of societies/states in the European (State-)System. The critical population size, critical connectedness and non-decomposability go hand in hand. In 1939, the 1st FTS reached the singularity in finite-time and collapsed: The acceleration of war-cycles could no longer be sustained.

d. *Sufficient activation energy*. The 'infinite' production of entropy in 1939, was equivalent with 'infinite' KA, and caused an "infinity war". However, an 'infinity war', was not a feasible course of action for the (State-)System: It required infinite free energy input, which was impossible to accomplish (due to a lack of resources), apart from the fact that the application of kinetic energy (KA) increasingly undermined the ability of societies/states to generate the free energy (military capabilities) that was required. Although the 'infinite' entropy-production and systemic kinetic response in 1939 was unsustainable, the (State-)System could now generate sufficient activation-energy to produce a systemic fluctuation (systemic KA) that was large and powerful enough to 'break' the barrier that separated the European State-System FFE from thermodynamic equilibrium, and push the core into a new stability domain, where EMIS-regulation could be accomplished by homeostatic control. The phase transition of the State-System qualifies as a fluctuation-induced transition.

e. *Full aggregation stage 3A ('aggregation enabled')*. During the final step in the phase transition - the 4th systemic war (the Second World War, 1939-1945) - following the European State-System's collapse in 1939, the final step in the process of aggregation of the core (Europe) was almost accomplished. During the transient period (1480-1939), the number of states had decreased from circa 300 in 1480 to circa 25 in 1939. Full aggregation stage 3A ('aggregation enabled') - equivalent with thermodynamic equilibrium in the State-System - was not the only effect of the phase transition: Full aggregation stage 3A ('aggregation enabled') of the core and merging of the core and non-core in a single global System, went hand in hand.

However, the self-destruction of the core caused a delay in the actual aggregation. The "infinity war" (1939-1945) - the self-destruction of the European State-System (core) - had created a (power) vacuum. This vacuum was filled by the United States and Soviet Union. As I describe in chapter 33, the occupation of the core resulted in an interim solution, the 2nd exceptional period (1945-1989), when the core could recover. In 1989, following the collapse of the Soviet Union and the resumption of chaotic non-systemic KA and FTS-regulation, the process of aggregation (from stage 3A to 3B) could resume in the former core.

f. *Zero entropy and maximum free energy*. During the transient period (1480-1945), the State-System (core) was pushed to zero entropy, a state it reached in 1939. At that point the State-System had run out of options, there were no viable microstates available anymore. At the same time, the 1st FTS had to cope with infinite entropy-production and worked at an infinite rate/tempo to neutralize and redistribute the entropy. Zero entropy in the State-System went also hand in hand with a maximization of free energy. In 1480, the System (the core, Europe) consisted of circa 300 loosely connected communities (states) with a variety of organizational structures, with a total population of circa 83 million. In 1939, the System had changed fundamentally, and consisted of circa 25 highly standardized and tightly connected state-structures, with a total population of circa 455 million.

The organization of military capabilities of these states - the subsystems tasked with putting free energy to use - was based on the same organizational fractal design principle, that ensured optimized distribution of free energy. Various closely related factors and conditions contributed to the drive to zero entropy and standardization: First of all, the minimization of entropy-production principle that applied to the State-System; this was the underlying and 'unescapable' driver of this process. The 'push' to zero entropy - and thermodynamic equilibrium - was reinforced by the PDLI-mechanism. During the transient period, the constraint - collective dimension - became increasingly strong and ensured that states in the European State-System became increasingly subject to the same selection criteria: The ability to develop, produce and deploy kinetic energy increasingly became the defining property for a state; this property determined its well-being (including security) and survival. Competition intensified, but its 'scope' continuously narrowed - focused - on the use of superior kinetic capabilities. The increasing availability - maximization - of kinetic energy of/in the European State-System during the transient period, is consistent with the drive to zero-entropy of the European State-System, and the near-equilibrium regime that applied the State-System.
Another factor that contributed to the push to zero entropy and maximum free energy of the State-System, was the fact that standardization contributed to the process of aggregation. 'Identical' states and societies could more easily aggregate (merge), because certain incomplementarities were (already) eradicated, EMIS-flows could be (more easily) synchronized and become subject to a single homeostatic control structure. This combined structure could utilize economies of scale and scope that could also contribute to its ability to produce and project (more) free energy: Expansion, growth, size, well-being and survival are related.

g. 'Robust yet fragile' at two levels. The phenomenon that increasing robustness (stability) and fragility of a system go hand in hand, is referred to as 'robust yet fragile' (17). Increasing robustness and increasing fragility are two sides of the same coin. This phenomenon is also manifest in the (State-) System, at the level of RSP's and at the level of the (State-)System:

(1) <u>Increasing robustness and fragility of RSP's/orders</u>. Once the tipping point of a RSP is reached, the average size of non-systemic KA (non-systemic wars) starts to decrease and reaches (near) zero (size), shortly before the (State-)System becomes critical and the RSP collapses. This is a manifestation of the phenomenon of increasing robustness (stability) and fragility of the order of RSP's.

(2) <u>Increasing robustness and fragility of the System</u>. During the transient period (1480-1945), the number of non-systemic wars (KA) and the non-systemic KA/war-frequency of successive RSP's decreased linearly to near zero (during the 4th RSP, 1918-1939). The increasing robustness of successive RSP's went hand in hand with the increasing fragility (instability of the European State-System). The decreasing life-span of successive war-cycles is indicative for the increasing fragility (instability) of the State-System. The increasing rate and magnitude (severity) of systemic KA point to the increasing instability of the State-System. At system-level increasing robustness and fragility also went hand in hand.

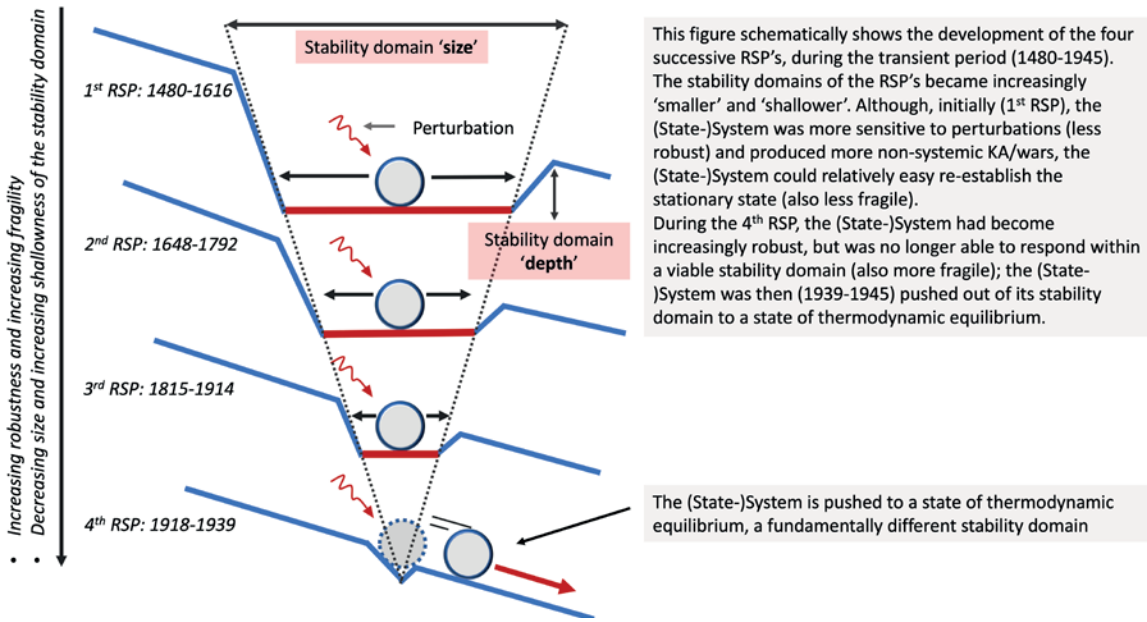


FIGURE 28.13: Increasing robustness and increasing fragility, during the transient period (1480-1945).

28.15. Collapse of the hierarchical structure of the core

Simon points to the relevance and evolutionary advantage of hierarchical structures, that are nearly-decomposable (77), as discussed in chapter 6, Simon also observes that the interactions *within* hierarchical structures - between elements in a single structure - typically have a higher frequency and shorter time horizon than interactions *between* nearly-decomposable structures. This behavior can also be observed in the (State-)System, where the network and frequency of interactions *within* states (societies) are much denser and respectively higher, than *between* states (societies). Typically, in case of the societies, states are tasked with interactions with other states, and responsible for security issues.

During the transient period (1480-1945), this changed in the European State-System: States (societies) became increasingly connected, not only internally, but also with other states(societies). Exchanges and interactions became more frequent, more elaborate and more intense. The near-decomposability of the core decreased; the System (core) developed from a loosely coupled to a tightly connected network. The increase in the number and size, etc. of irreversible processes not only contributed to (increasing) entropy-production of the System, but also impacted on the EMIS-regulation of the System. The increasing connectedness and increasing non-decomposability also drove the process of aggregation. At a certain point, it was more efficient - also from an EMIS-regulation point of view - to integrate states and establish a single homeostatic control structure.

The final step - from circa 25 states to a single structure (albeit with a delay until 1989) - was made during the 4th systemic war (the Second World War, 1939-1945), after the core's collapse in 1939. At that point, the core had reached 'critical connectedness', when hierarchical structures could no longer be maintained, and in fact no longer existed.

During the transient period, the hierarchical architecture of the core was undermined through the increasing connectedness and interdependence of societies and states.

The increasing interdependence of societies and states included their security, which became an increasingly scarce basic requirement: Societies and states became increasingly depended on other states, while at the same time, mutual competition and rivalries increased: More interdependent, yet more insecure.

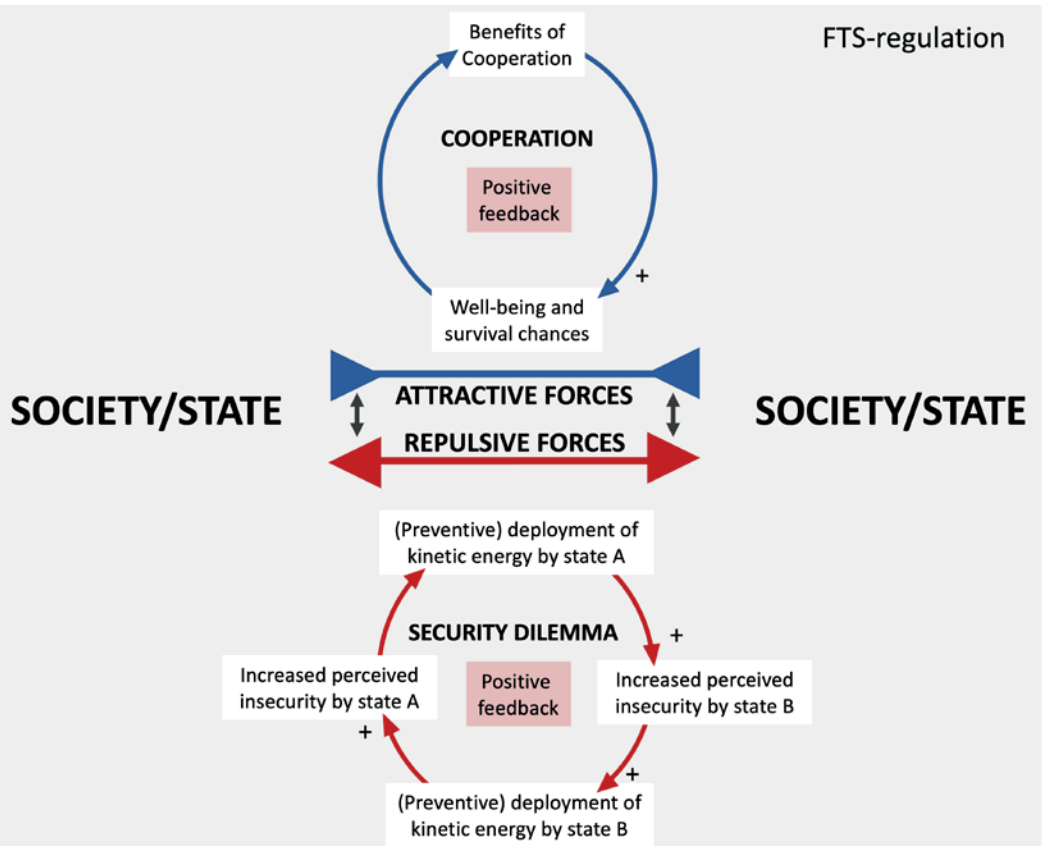


FIGURE 28.14: Interplay between attractive and repulsive forces. The dynamic of the FTS/State-System can also be considered as an interplay - competition -between two tendencies, not only between order and disorder, but also between attractive and repulsive forces. Collective benefits that can be accomplished by cooperation - e.g. through the (collective) exploitation of economies of scope and scale - contribute to attractive forces; whereas increased competition caused by e.g. scarcity of resources - a dynamic that is reinforced by the security dilemma - contributes to repulsive forces that are simultaneously at play. Over time, attractive forces - cooperation - were stronger then repulsive forces.

28.16. An overview of the fundamental differences between systemic and non-systemic KA/war

Non-systemic and systemic KA/wars are fundamentally different phenomena - dynamics - and differ fundamentally in a number of respects: A systemic war is not just a 'larger' non-systemic war, there are qualitative differences.

Chaotic non-systemic KA/wars are kinetic responses to entropic perturbations during RSP's of war-cycles. Their purpose is to maintain the (dynamic) steady state - the status quo - of the (State-)System FFE.

Systemic KA/ wars on the other hand, are kinetic responses to accumulated entropy (accumulated during the HCR of the preceding cycle), during a critical state of the System. Their purpose is to upgrade the order of the (State-)System, in accord with the MEP-Principle.

TABLE 28.4: Fundamental differences between systemic and non-systemic KA/wars. This table shows the fundamental differences between non-systemic and systemic KA/wars. So far, the (State)System has generated four systemic KA/wars (KA): (1) the Thirty Years' War (1618-1648), (2) the French Revolutionary and Napoleonic Wars (1792-1815), (3) the First World War (1914-1918), and the Second World War (1939-1945). All other wars are non-systemic wars.

	Non-systemic KA/war	Systemic KA /war
Type of dynamic	R1, FFE.	R2, near equilibrium.
Phase of war-cycle	During RSP's, relatively long subcritical periods.	During relatively short critical periods.
Attractor	Strange (fractal) attractor.	Limit cycle.
Nature of dynamic	Chaotic dynamics.	Cyclic/periodic dynamics.
Trigger of KA	Through entropic perturbations during RSP's.	An incident triggers a massive response and accumulated entropy is released.
Predictability	Timing, duration, size and severity are intrinsically unpredictable; there is a high sensitivity for initial conditions.	Timing, duration, size and severity of systemic KA (systemic wars) are highly predictable.
Size of kinetic response/KA	Limited in size (in terms of fraction): Not all Great Powers are involved.	The kinetic response is system-wide: All Great Powers are involved.
Correlation length (CL)	CL < 1: System-wide communication and coordination are not enabled.	CL = 1, and a divergence of the correlation length: System-wide communication and coordination are enabled. During criticality (systemic KA), the divergence of the correlation length, ensures the involvement of all Great Powers, and enables the exploration of viable solutions and the selection and implementation of an upgraded order.
Purpose	Continuity: EMIS-regulation of the existing order; maintenance of the status quo; exploration of phase space; the outcome of the KA is embedded in phase space/vulnerable-clusters.	Change: Design and implementation of an upgraded order.
Nucleation	Non-systemic KA (non-systemic wars) is preceded by a process of local nucleation of tensions and issue(s).	Systemic KA (systemic war) is preceded by a system-wide process of nucleation during RSP's (RSP-nucleation).

Because historians and social scientists have failed to identify the fundamental differences and properties of these two types of war, they also have failed to identify patterns in KA/war-dynamics.
Based on the previous analysis, the fundamental differences between chaotic non-systemic KA (chaotic non-systemic wars, intrinsic to the FFE R1-dynamics of the System) and systemic KA (intrinsic to the accelerating cycles of R-2 dynamics of the System) can now be identified.

28.17. Application (1): Components of the FTS and phase transition

In this paragraph, I show the different components of the 1st and 2nd FTS, and the phase transition that was accomplished during the transient period (1480-1945), in two graphic depictions of the 1st FTS and transition.

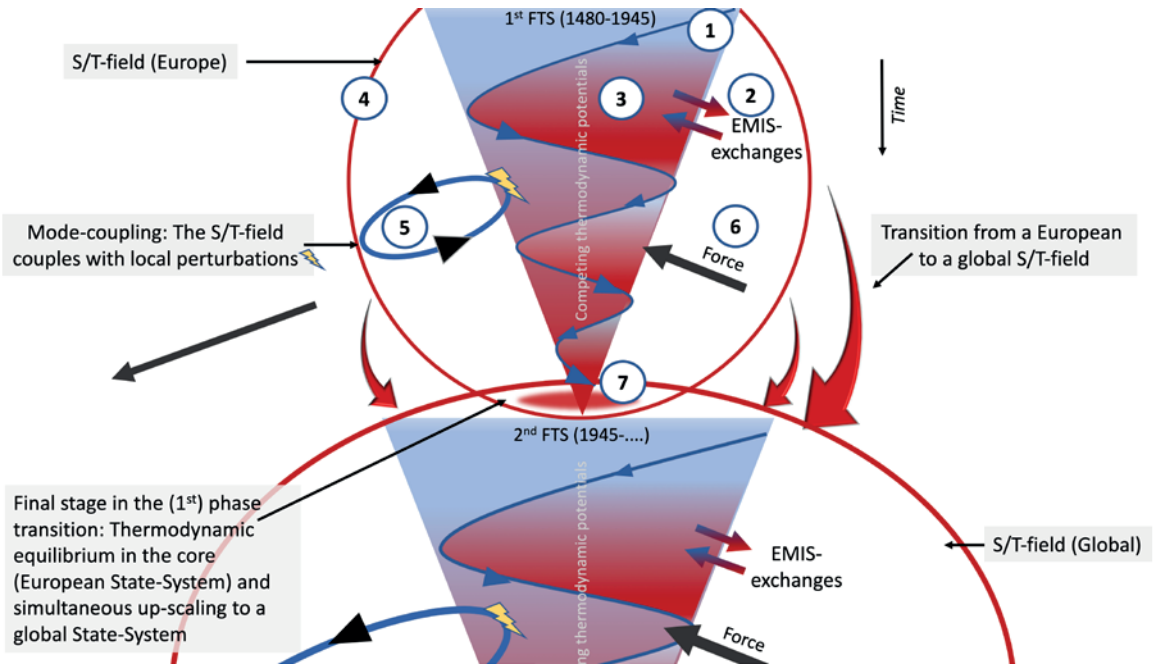


FIGURE 28.15: Components of the FTS and transition. In this figure, a schematic representation of the 1st FTS and the transition to the 2nd FTS is shown. The components/mechanisms are numbered: (1) Refers to the bifurcation that resulted in the emergence of the 1st FTS in 1480; (2) refers to EMIS-exchanges of the 1st FTS with its environment (societies/states and the non-core); (3) refers to the KA the FTS generated and the four KA/war-cycles that were produced during the transient period (1480-1945); (4) refers to the presence of a S/T-field; (5) refers to mode-coupling; (6) to the force the FTS applies to the (State-)System and (7) to the final stage of the phase transition (the 4th systemic KA/war, the Second World War, 1939-1945), and the actual transition.

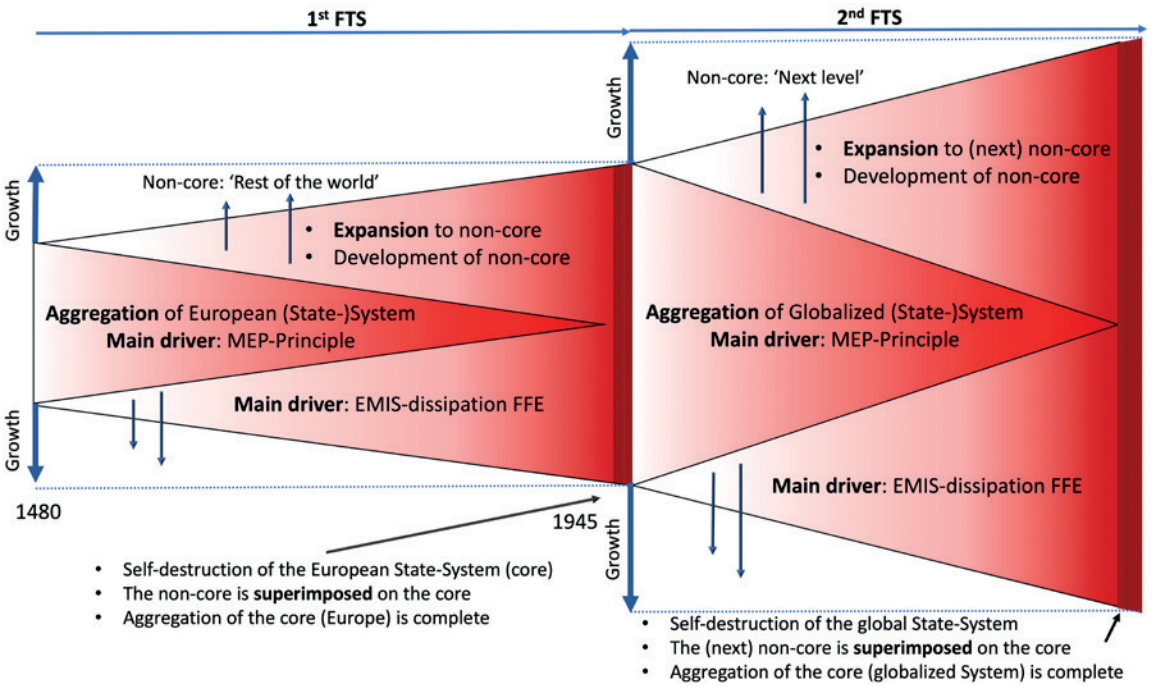


FIGURE 28.16: The processes of aggregation, expansion and growth, accomplished by the 1st and 2nd FTS.

28.18. Application (1): R2-Cycles could not keep pace

According to Chaisson (20): "Cyclic behavior is typical of a dissipative structure that organizes (or reorganizes) itself in a way as to minimize the production of entropy", this is a disequilibrium process, Chaisson explains, that "not coincidentally, mimics the metabolism of many living organisms whose cycles transport energy".

This is also the case for the (State-)System this study shows: During the transient period 1480-1945, the (State-)System tried to minimize entropy-production through cyclic R2-dynamics. However, these efforts failed - as I explained - because the 1st FTS - of which the R2-dynamics are an integral component - at the same time facilitated the accelerated production of entropy in the System (through population growth).

28.19. Application (2): A note on Self-organized criticality (SOC)

The three critical events (the three systemic wars, that preceded the fourth), can be considered precursory 'steps' - a necessary prelude to - the actual transition that was triggered in 1939.

During RSP's, the (State-)System was in a subcritical condition: The (State-)System can be considered a stationary state that was periodically punctuated by relatively short critical periods, by systemic KA (systemic wars).

It could seem, at first sight, that the (State-)System was/is attracted to a critical state; these types of systems are sometimes also referred to as SOC-systems, SOC stands for Self-Organized Criticality. But, although the (State-)System meets most requirements to qualify as a SOC-system, the most important qualification is not met: A critical condition is not the preferred condition of the System, neither its attractor. The System did not and cannot stabilize at the critical point: Criticality is equivalent with systemic KA/war. Thermodynamic equilibrium is the attractor of the System: Short critical periods are instrumental in 'paving' the (most efficient) path to this state, and intrinsic to the phase transition of the State-System.

28.20. Application (3): An upgraded order is a snapshot

An order is designed and implemented through systemic KA/war during criticality and is based on the power and influence of Great Powers, at that moment in time. An order that is implemented can be considered a snapshot.
The upgraded order does not anticipate the (unavoidable) increase in the rate of entropy-production due to (continuing) population growth and intensifying interactions between societies/states (which unavoidably cause increasing rivalries in the System), but in the contingent domain certain measures/ arrangements are adopted to ensure stability.
Through the allotment of certain privileges (to themselves), the most powerful Great Powers try to ensure that they can ward off potential future challengers of the status quo; the allotment of a veto right to the five permanent members of the Security Council of the United Nations, and their ('self-allotted') privilege to develop and possess nuclear military capabilities, are such privileges in the current order. Through this mechanism is ensured that the most powerful states have the highest stake in maintaining the new status quo, which serves their interests best.
The 'new' order is based on the EMIS-production and flows at the time of its design and implementation; consequently, the capacity for EMIS-regulation of a (new) order has its built-in limitations. Initially, at the start of the new RSP, entropy(-production) can still be effectively regulated; however, it is a matter of time, before regulation becomes problematic, and the System will eventually become critical (again).

28.21. Application (4): A deterministic template is forced on the contingent domain

The FTS, imposes a deterministic regime - template - on the (State-)System, which determines / shapes kinetic activity, its pace of life (PoL) of the (State-)System, etc. Within this deterministic framework certain characteristics of war-cycles and KA - for example the number of non-systemic events during RSP's and the timing, duration, and severity of systemic wars - were already predetermined, at the moment of bifurcation in 1480 (assuming the 1st FTS could be sustained).
Although there is contingent latitude, this latitude decreased during the transient period (1480-1945): Systemic KA was forced on the (State-)System with an increasing frequency and magnitude.
As I explain later, the same conditions that produced and sustained the 1st FTS during the period 1480-1945, are now also in place, and data-analysis confirms that a 2nd - now global - FTS is now in progress.

28.22. Application (5): The accelerating Pace of Life (PoL) of the System

During the transient period (1480-1945), the accelerating production of entropy in the (State-)System, in combination with the Second Law and related principles that apply FFE, forced the (State-)System - and social and political processes (life, so to speak) - to accelerate: Successive critical periods - systemic KA - followed each other more and more quickly. At a certain point, the acceleration could not be sustained (1939) and collapse was unavoidable. The term PoL, I reserve for the contingent domain of the System (59). The PoL is a function of the acceleration of the 1st FTS.

By comparing the life-span of successive cycles, the acceleration factor of successive cycles can be calculated: $f_{acceleration} = (L(n) - L(n+1))/L(n)$ (L is the life-span of the cycle).

I have calculated the acceleration factors of the corrected 1st FTS, these are respectively: (1) 0,083, (2) 0,331 and (3) 0,782. The successive acceleration factors increased regularly (the acceleration can be best described with a power law): The life-spans of successive cycles shortened acceleratingly, and consequently collapse of the (State-)System was just a matter of time.

The acceleration is also indicative for the increasing force the 1st FTS applied to the State-System, to force the European State-System 'into' a state of thermodynamic equilibrium.

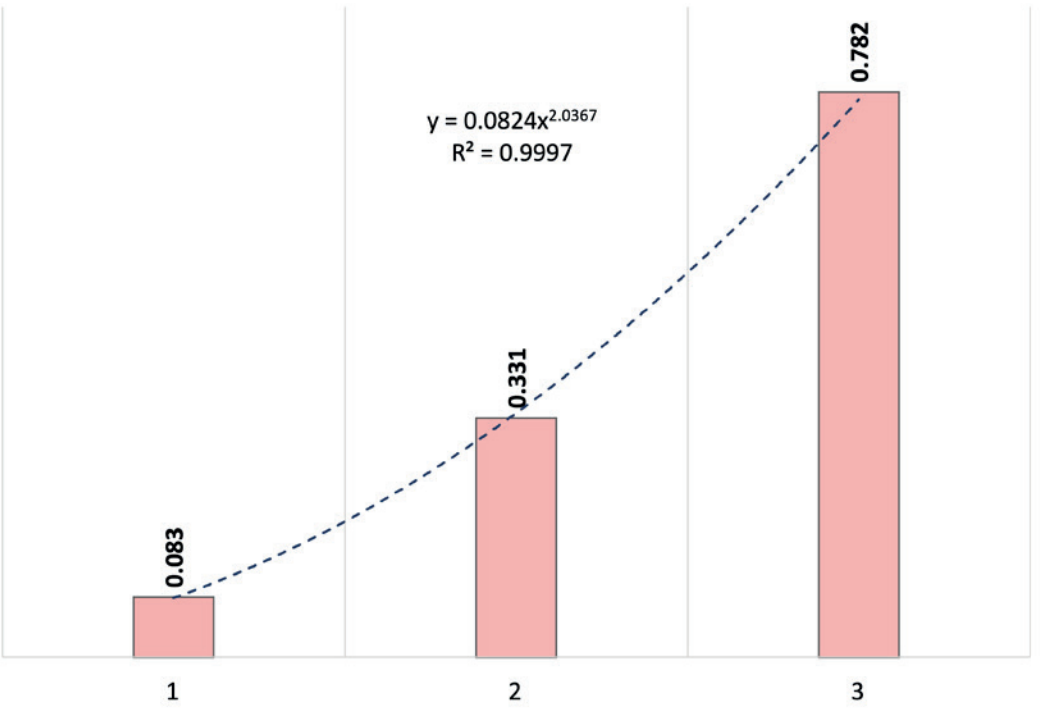


FIGURE 28.17: Development of acceleration factors of the (corrected) 1st FTS (1480-1945).

28.23. Application (6): An accelerating treadmill

The four systemic kinetic responses (systemic KA/wars) the 1st FTS produced during the transient period (1480-1945), came at an increasing rate (frequency) and with an accelerating severity (amplitude, magnitude). In 1939, when the System (the 1st FTS) reached the critical threshold, systemic kinetic responses (systemic wars) were produced at an 'infinite' rate (with an 'infinite' frequency) and with an infinite severity. This condition was unsustainable, not only could the required kinetic energy not be produced at such a frequency (rate) and in such (infinite) amounts, its use also implied complete (self-) destruction of the core of the System and its units (societies/states). The FTS generated its own momentum, and as is the case with accelerating treadmills, stepping of an accelerating treadmill - or out of the System, that constitutes the treadmill - has its risks, especially if (as is the case with the 1st FTS) the treadmill itself is vital for one's survival. The treadmill is a trap, the 1st FTS is a war trap.

28.24. Application (7): An example of the contingent implications of a correlation length of one and the divergence of the correlation length of VC's in the (State-)System

During the transient period (1480-1945), the (State-)System became critical four times: in 1618, 1792, 1914 and 1939. At those points, VC's percolated the System, and were - so to speak - fully charged with entropy.

Analysis of the war data shows that the (State-)System was critical in 1914 (59). The start of the First World War (the 3rd systemic war, 1914-1918) demonstrates the practical meaning of the divergence of the correlation length, in the contingent domain.

The divergence of the correlation length enabled a relatively small incident (i.e. the assassination of Archduke Franz Ferdinand in Sarajevo, 28 June 1914) to reverberate ('cascade') through the entire System, in a short period of time, and to trigger a massive kinetic response; the 3rd systemic KA/war (better known as the First World War).

There still is a lot of speculation about why and how such a devastating 'global' war could unexpectedly emerge as a consequence of a relatively small incident. I argue that at the time Archduke Franz Ferdinand was assassinated in 1914, the (State-)System had reached a critical state, as a consequence of the buildup of entropy (issues and tensions) in the preceding decennia; the tipping point of the 3rd RSP was in 1856 (59).

The critical state of the (State-)System in 1914, explains the System's behavior; criticality implies a divergence of the correlation length and consequently a very high susceptibility to perturbations. The divergence of the correlation length enabled system-wide and multiscale KA, and allowed for system-wide communication and coordination, required to interactively construct - to select - and implement an upgraded order.

The fact that the years before the start of the First World War (1914), were considered relatively stable, can be attributed to the stability effect produced by the network-effect. This typical behavior (a stable period that is followed by a systemic response to a perturbation) is what took politicians in 1914 by surprise and still 'misleads' historians in their efforts to make sense of the unexpected outbreak of the First World War (21).

The cause of the 3rd systemic war - the First World War - was not the assassination of Archduke Franz Ferdinand, but the critical state of the System, at the time. This means that if Archduke Franz Ferdinand had not been assassinated in June 1914, another incident would have had a similar devastating (and surprising) non-linear impact. A (3rd) systemic war was unavoidable and imminent at that time, however not necessarily the version - the First World War - as we now know it; other versions were available. To put it otherwise: The (3rd) systemic KA/war - as well as the other systemic KA/wars - was a deterministic response (regulated by the 1st FTS), that was triggered and to a certain extent shaped in the contingent domain, by a probabilistic incident; the assassination of Archduke Franz Ferdinand. The start of the First World War is another good example of the interplay between probabilistic and determinist factor in the System.

28.25. Application (8): Survival requires expansion

The 1st FTS was and the 2nd global FTS is, a self-destructive dynamic: Thermodynamic equilibrium of the European State-System could - and thermodynamic equilibrium of the global State-System can - only be accomplished through self-destruction, to ensure last barriers to equilibrium are eradicated. Self-destruction was (and is) an integral part of the transition to thermodynamic equilibrium of the State-System, in accord with the laws of thermodynamics and related principles FFE.

The nature, behavior and the unavoidable 'end-point' of a FTS - self-destruction - raise an existential issue for humanity: Assuming the 2nd global FTS (1945-....) is sustained, we are indeed on a path to thermodynamic equilibrium, but this path also includes in its final stage, the necessary collapse of the global State-System through a self-destructive infinity war.

The System and humanity could survive the first collapse (1939) and the infinity war that followed (the 4th systemic war, the Second World War, 1939-1945), because of the regional (European) scope of the 1st FTS (Europe) and the creation during the transient period, of a non-core that could (following the 4th systemic war) 'absorb' the core after it self-destructed. The 1st FTS was not only instrumental in the European State-System's and its own self-destruction, but also ensured its continuation by laying the groundwork for a global State-System and a 2nd FTS, during the transient period; expansion was - and is - a precondition for long term survival.

It is no coincidence that the process of expansion (colonization) started and accelerated in earnest when the bifurcation took place in 1480, the 1st FTS emerged and took control. The process of aggregation in the core and expansion to the non-core were closely related and synchronized, as analysis of the war-data confirms (to be discussed later). It is also no coincidence that the process of expansion and consolidation ended (was accomplished) when the European State-System (core) collapsed and the 1st FTS accomplished - through self-destruction - the final step in the phase transition (1939-1945).

The 2nd FTS has initiated its own process of expansion: In the physical domain, humanity started exploring and is now colonizing space; space is the next frontier and level of expansion. In the abstract domain, there is also expansion, into a virtual world/domain.

If the 2nd FTS is sustained, and the same growth-logic applies to the global State-System, then humanity can only ensure its survival and further growth through further expansion, to ensure that a global State-System that has reached thermodynamic equilibrium through self-destruction, can be incorporated in an extended System.

29. Interplay between R1- and R2-dynamics during the transient period

29.1. Introduction

In this chapter, I discuss a number of similarities and differences between chaotic non-systemic KA (R1-dynamics) and cyclic systemic KA (R2-dynamics). I also discuss some features of the FTS-dynamic, including the changes in dominant feedback structures during KA/war-cycles of the 1st FTS.

29.2. Similarities and differences between dynamics: An overview

Chaotic non-systemic KA (R1-dynamics) and cyclic systemic KA (R2-dynamics) are two closely related 'components' of the FTS. The 1st FTS emerged in 1480 through a bifurcation. The 1st FTS was instrumental in the accomplishment of a phase transition of the European State-System to thermodynamic equilibrium. The R2-dynamics emerged - so to speak - from the R1-dynamics, which became at a certain point during RSP's subject to a network-effect. The network-effect caused the accumulation of entropy, which generated the R2-dynamics.
In tables 29.1 and 29.2, the differences and similarities between both types of dynamics are summarized.

TABLE 29.1: Differences between R1- and R2-dynamics.

	R1-dynamics	R2-dynamics
Level	RSP.	State-System.
Thermodynamic state	FFE.	Near equilibrium.
Purpose	Neutralize entropic perturbations, to maintain the existing stationary (steady) state; continuity.	Lower the energy-state of the State-System, and improve the regulatory capabilities of the FTS, by putting accumulated entropy to use; change.
Condition	State-System in a subcritical state.	State-System in a critical state.

TABLE 29.2: Similarities of R1- and R2-dynamics.

	RSP's / R1-dynamics	State-System / R2-dynamics
Source of order	Entropy.	Entropy.
Purpose KA	Neutralization of entropic perturbations through non-systemic KA.	Neutralization/redistribution of accumulated entropy through systemic KA.
Paradox	Regulation of entropic perturbations during RSP's results in a massive systemic kinetic response (KA), due to the accumulation of entropy caused by the network-effect.	Minimization of entropy(production) in the State-System results in a phase transition, due to the accelerating production of entropy and accelerating KA, generated by the FTS.
Nucleation	Nucleation of VC's due to accumulation of entropy caused by the network-effect, during HCR's of RSP's	Nucleation (= aggregation) of societies/states due to a phase transition, required to accomplish thermodynamic equilibrium in the State-System.
Compression of phase space	Once the tipping point of a RSP is reached, its options - possible solutions for entropic perturbations - decrease: Although entropy-production accelerates and entropy (new possibilities) accumulate, they cannot be put to use: Options are 'blocked' by the network-effect.	During the transient period, the (State-)System's options - possible microstates that comply with the macrostate of the (State-)System - decrease: Although entropy(-production) accelerates, entropy cannot be put to use in/by the State-System, which is pushed to zero entropy.
Trigger to criticality	The RSP reaches a critical threshold, and a critical response (systemic KA) is triggered when the VC's percolate the System.	The State-System reaches the critical point/ threshold (1939), when the State-System reaches zero entropy and entropy-production becomes infinite.
Autocatalysis	The accumulation of entropy during HCR's initiates an autocatalytic process, and tensions and issues (entropy-production) create positive (self-reinforcing) loops; through this process VC's nucleate and percolate the (State-)System and the (State-)System is pushed into a critical state.	The combination/interplay of R1- and R2-dynamics initiates an autocatalytic process, through various positive loops that are created: Aggregation produces more aggregation.
Origin of self-organization	Entropy is the source of order, its autocatalytic production in combination with the stability condition shapes the process of self-organization.	Entropy is the source of order, its autocatalytic production in combination with the stability condition shapes the process of self-organization.
Robust yet fragile	Following the tipping point, RSP's become more robust; increased robustness goes hand in hand with increased fragility. At critical points of RSP (1618, 1792, 1914 and 1939), the RSP's are absolute stable (because of the connectedness of VC's) but also absolute fragile and consequently collapses.	During the transient period, the robustness of the (State-)System increase, while its stability is undermined and its fragility increases. At the critical point of the European State-System (1939), the (State-)System is absolute robust and absolute fragile and consequently collapses.
Effect of the dynamic	Upgrade of the order of the RSP.	Thermodynamic equilibrium of the State-System.

In figure 29.1, the main similarities of both dynamics are shown: From a more abstract point of view are the processes R1- and R2-dynamics enable identical.

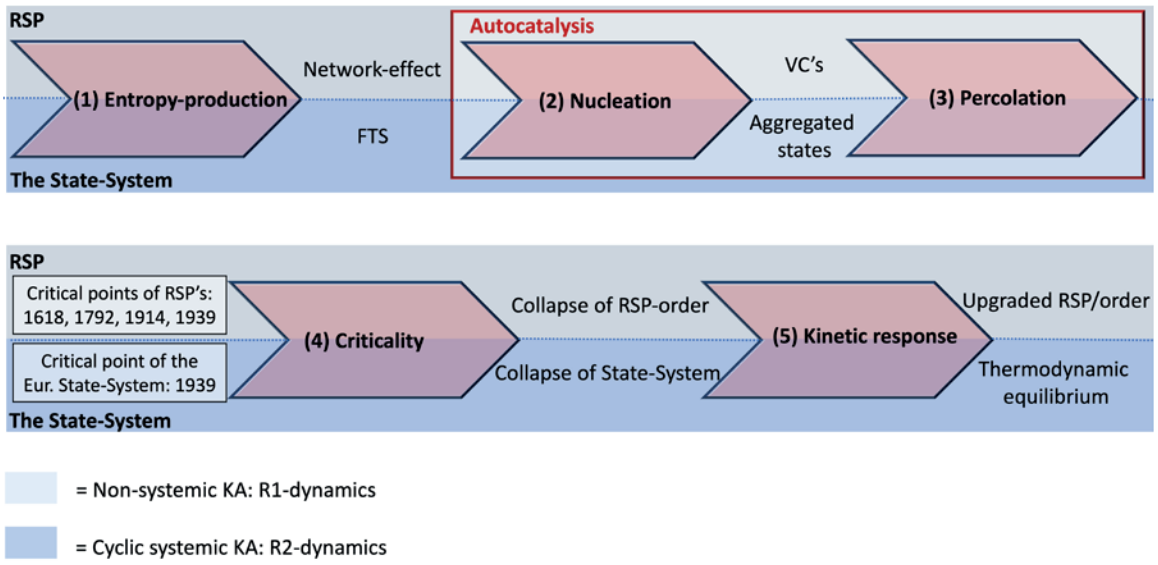


FIGURE 29.1: Similarities between R1- and R2-dynamics enabled processes, at two levels.

29.3. Balancing continuity and change

In (living) systems, a distinction can be made between processes that must ensure the continuity of existing structures, and processes that must ensure that structures adapt in response to changes in the system's environment (internal or external).

This distinction can also be observed in societies /states and the (State-)System; in social systems in general. Both processes require EMIS-exchanges and regulation.

In case of the (State-)System - as I explained - R1-dynamics ensure continuity, while R2-dynamics are responsible for necessary change; between both dynamics there is an interplay that is regulated by the FTS. In fact, the R1-dynamics produce - in combination with the network-effect - the cyclic R2-dynamics of the (State-)System, which ensure - through the periodic upgrades that are made to the (State-)System - that the R1-dynamics regain functionality and are no longer suppressed by the network-effect. The FTS balances continuity and change, with the purpose to ensure that the State-System accomplishes thermodynamic equilibrium via the most efficient path.

Continuity and change constitute a positive feedback loop in the State-System: Continuity - RSP's - enable population growth and (further) development; through the network-effect RSP's also ensure the accumulation of entropy and periodic criticality. Periodic criticality - when the FTS responds with systemic KA/war- enables periodic upgrades of the order (RSP's) of the System. Further population growth and development are ensured through these upgrades.

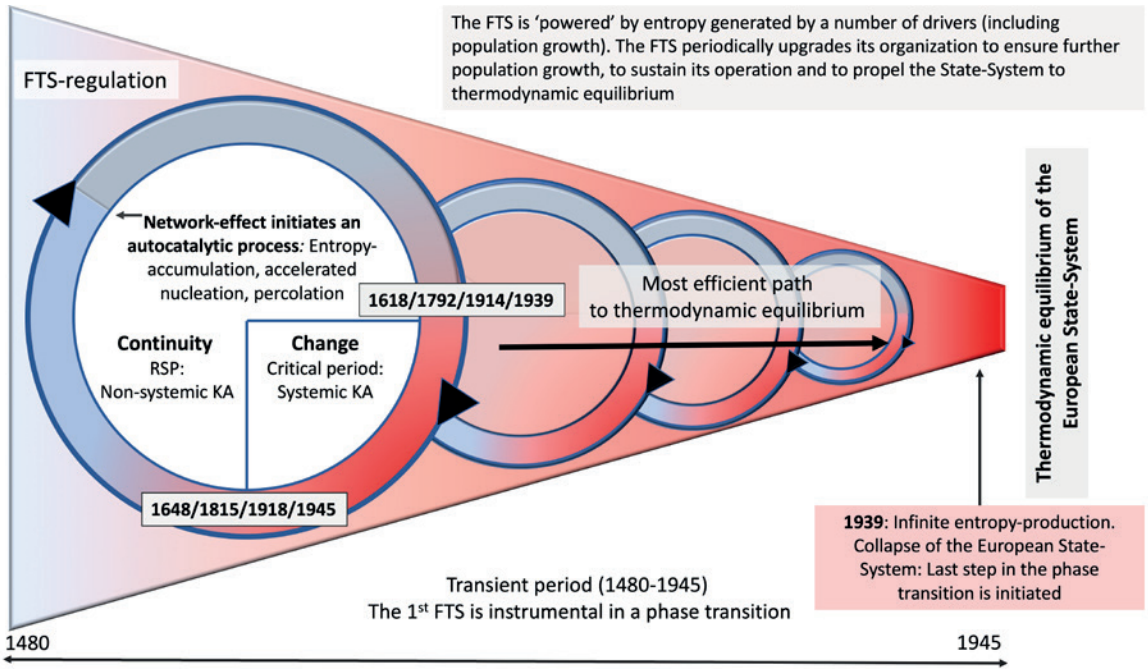


FIGURE 29.2: Continuity and change constitute a positive feedback loop in the State-System, regulated by the FTS.

29.4. Changes in dominant feedbacks during KA/war-cycles

KA/war-cycles have identical life-cycles. During KA/war-cycles there is an interplay between R1- and R2-dynamics, and during the different stages of KA/war-cycles - LCR's and HCR's of RSP's and critical periods - dominant feedback loops - that drive the dynamics of the (State-)System - change very regularly.
In figures 29.3 - 29.6, the dominant feedbacks are shown (in red), during the successive stages of KA/war-cycles.

29.5. Nonlinear resonance

During the transient period (1480-1945), an external force applied by the 1st FTS caused the KA to oscillate. The frequency of the oscillations that were produced - of the R2-cyclic dynamics - depended on the severity of the Systemic KA/war, and vice versa. This behavior qualifies as nonlinear resonance.
In physics, nonlinear resonance is the occurrence of resonance in a nonlinear system. In case of nonlinear resonance, resonance frequencies depend on the amplitude of the oscillations.

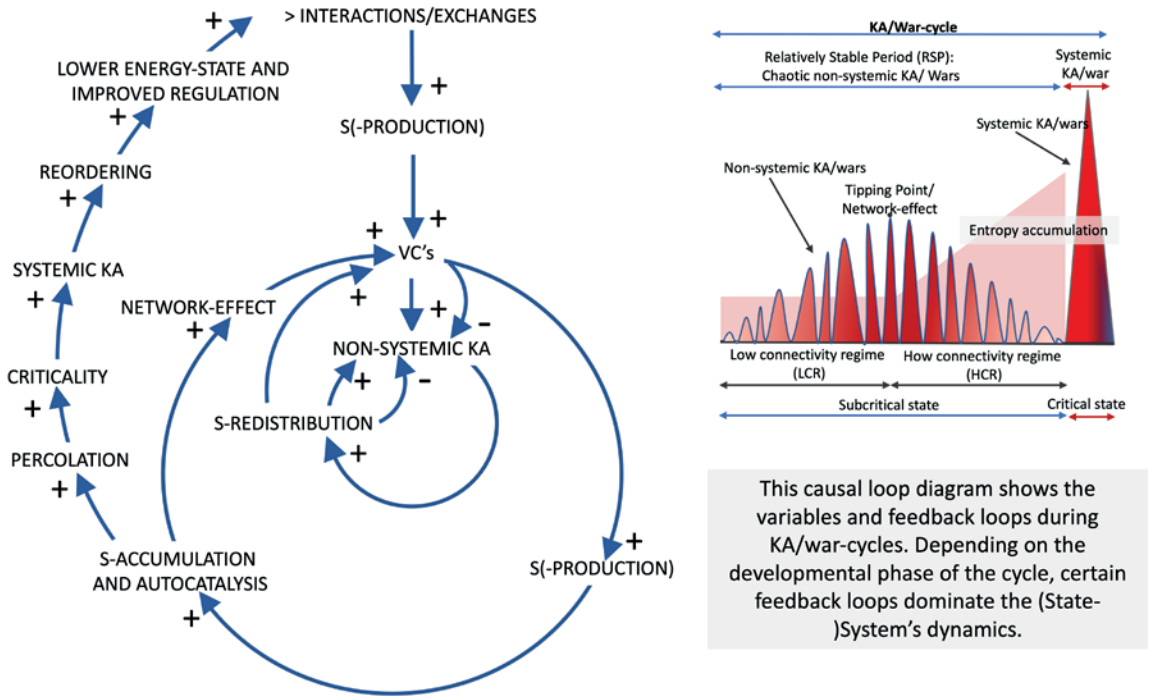


FIGURE 29.3: Feedback loops during KA/war-cycles. This figure shows the CLD of KA/war-cycles.

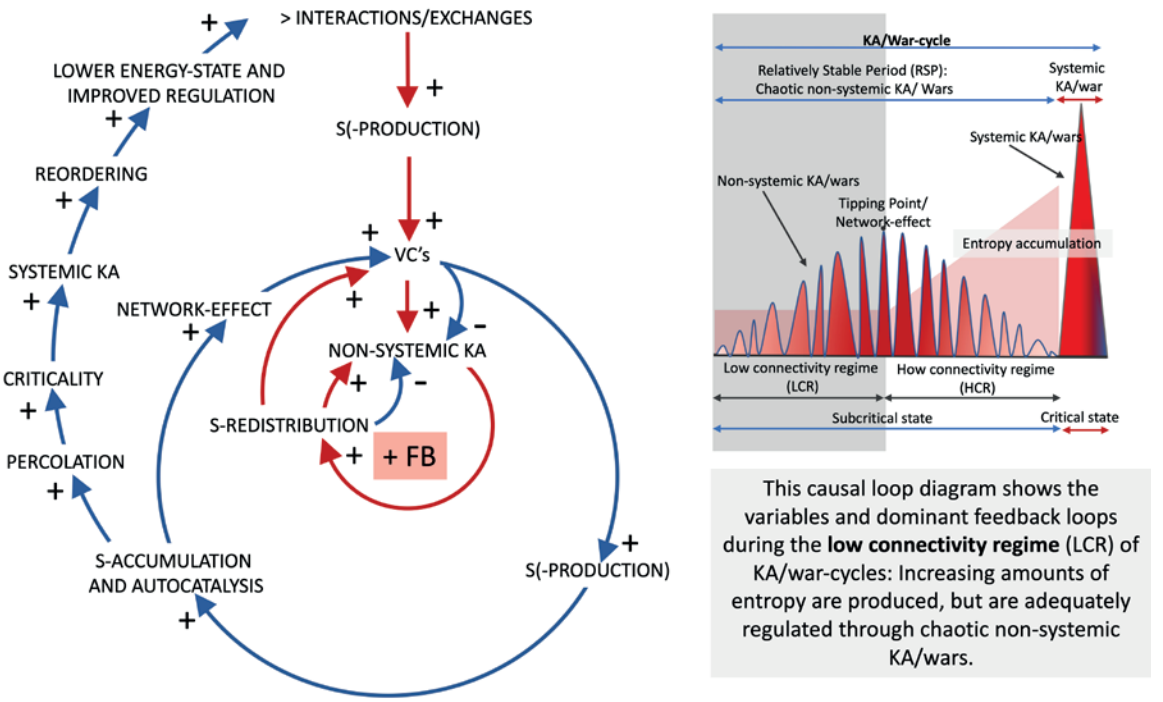
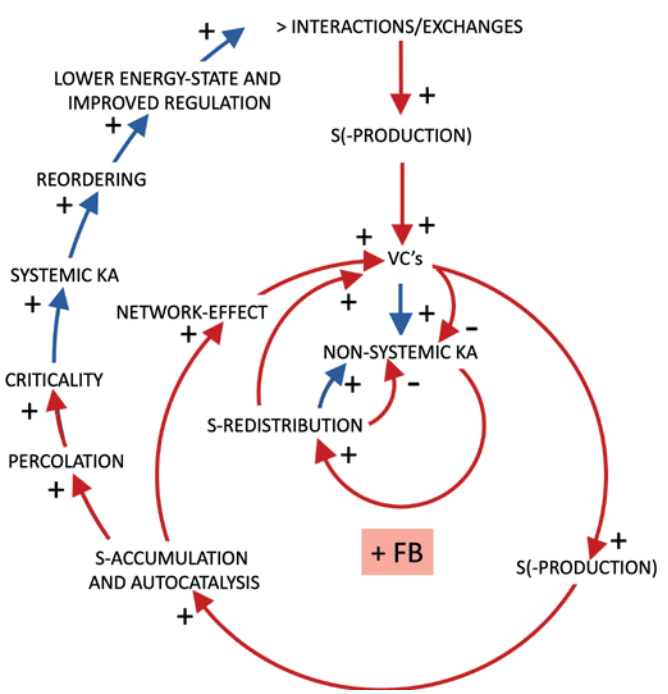
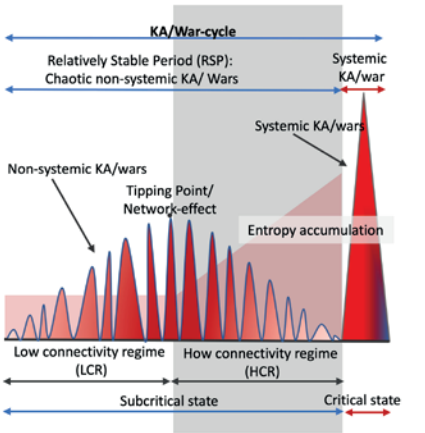


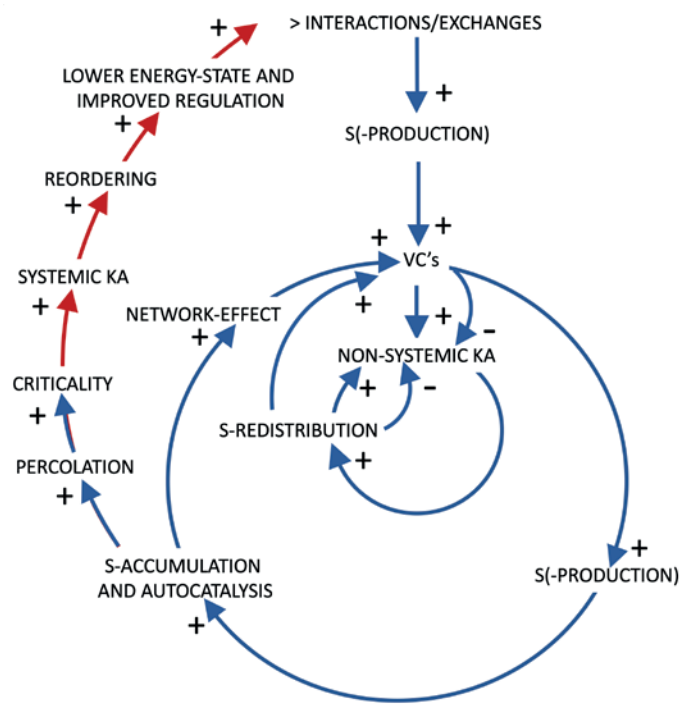
FIGURE 29.4: Dominant feedback loops during LCR's of KA/war-cycles.

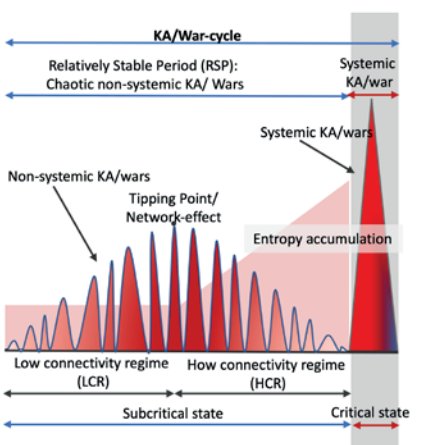




This causal loop diagram shows the variables and dominant feedback loops during the **high connectivity regime** (HCR) of KA/war-cycles: The effectiveness of KA-regulation decreases because of the network-effect; consequently, entropy starts accumulating and an autocatalytic process is initiated. The (State-)System is pushed toward a critical state.

FIGURE 29.5: Dominant feedback loops during HCR's of KA/war-cycles.





This causal loop diagram shows the variables and process during the critical phase of KA/war-cycles: During **criticality**, a systemic kinetic response is triggered, which is used to implement an upgraded order that ensures a lower energy-state and improved EMIS-regulation, during the next RSP (at least for the time being).

FIGURE 29.6: Dominant feedback loops during critical periods of KA/war-cycles.

In case of the (State-)System, accelerating entropy-production (driven by population growth and reinforced by processes generated by the 1st FTS), resulted in an increase in the force that was applied to the State-System. Consequently, the frequency and amplitude of R2-dynamics, increased in conjunction. The emergence of nonlinear resonance is related to the intricate relationship between R1- and R2-dynamics and the increasing robustness of successive RSP's: During the transient period (1480-1945), the State-System had to deal with accelerating entropy-production, the 1st FTS had to regulate. Because regulation (utilization and redistribution) during successive RSP's through non-systemic KA became increasingly constrained, the State-System became increasingly dependent on entropy-regulation through cyclic systemic KA (cyclic R2-dynamics). The development of the release-ratios is a manifestation of this development.

Consequently, the frequency and amplitude of the cyclic R2-dynamics increased hand in hand, and (thus) the (State-)System's instability; eventually (in 1939) collapsed could no longer be delayed.

A condition for a system to generate (nonlinear) resonance is the ability of the system to store and transfer energy between different storage modes (96). In case of the (State-)System, entropy- and free energy-storage is accomplished during HCR's of RSP's, through the forming of VC's induced by the network-effect. The moment the (State-)System becomes critical the stored entropy and energy are put to use through/during systemic KA/war. During the transient period, the 'storage-capacity' of the System during successive RSP's increased; increasing robustness of successive RSP's allowed for increased storage of entropy.

TABLE 29.3: Correlation between frequency and amplitude of successive cycles of the 1st FTS.

	Actual 1st FTS		Corrected 1st FTS	
	Frequency	Amplitude (Severity cycle, in BCD)	Frequency	Amplitude (Severity cycle, in BCD)
1	0,0065	2.976.000	0,0060	3.036.000
2	0,0060	7.550.300	0,0065	5.750.000
3	0,0097	8.425.080	0,0097	8.720.000
4	0,0370	13.003.300	0,0444	11.500.000
Correlation coefficient	0,84		0,82	

According to Prigogine, *resonance is not exceptional and signals that a qualitative change in behavior of the system is required* (66). This is also the case for the (State-)System: The accelerating oscillations of the State-System cannot be sustained and signal that a qualitative change of the State-System is required; collapse of the State-System and a phase transition are just a matter of time.

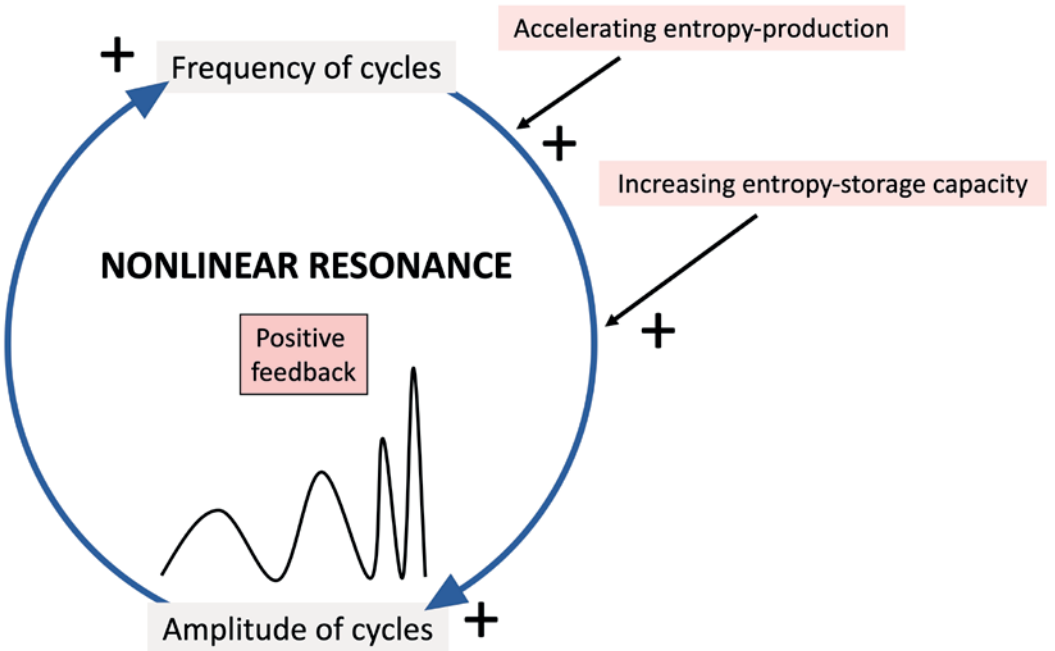


FIGURE 29.7: Nonlinear resonance in the State-System.

29.6. The development of the release-ratios of war-cycles determined the time-scale of the phase transition (1480-1945)

The ability of the (State-)System to neutralize and redistribute - 'diffuse' - entropy through non-systemic KA during successive RSP's decreased very regularly, until eventually (during the 4th RSP (1918-1939)) - utilization and redistribution of entropy was no longer possible through non-systemic KA.

This development is not only revealed by the decreasing number of non-systemic KA events (non-systemic wars) during successive RSP's, but also by the development of the release-ratios of successive war-cycles.

The moment utilization and redistribution of entropy was no longer possible during RSP's (by means of non-systemic KA), the State-System collapsed. The development of the release-ratios impacted on the time-scale of the phase transition.

The release-ratio is a function of various factors, including: The development of the robustness of RSP's, the rate of entropy-production, thermodynamic properties of the (State-)System and the regulatory performance of the FTS (other processes than utilization and redistribution of entropy through KA: i.e. through the processes of aggregation, expansion and empowerment).

29.7. Continuous reinforcement and acceleration of the 1st FTS

In this paragraph, I discuss the relationship between several concepts and properties of the (State-) System and FTS, including the constraint, the gradient, forces and flows, and thermodynamic potentials and stability conditions of the (State-)System and its subsystems . The relationship between these properties constitute a powerful mechanism that drives the FTS.

At the heart of the FTS - the 'engine' that drives the (State-)System - lies the interplay between competing thermodynamic potentials and their extremization; including the *maximization* of entropy-production in the System (with population growth - enabled and 'shaped' by the FTS - as an important driver) and the *minimization* of entropy(-production) in the State-System, through cyclic R2-dynamics that pushed the State-System to zero-entropy (in accordance with the MEP-Principle).

The competition between the thermodynamic potentials reinforced the constraint - the gradient - of the (State-)System, and the forces and (EMIS) flows that were consequently generated.

The increasing force that was applied to the State-System by the 1st FTS, caused the acceleration of KA-cycles and reinforced the European State-System's momentum to thermodynamic equilibrium.

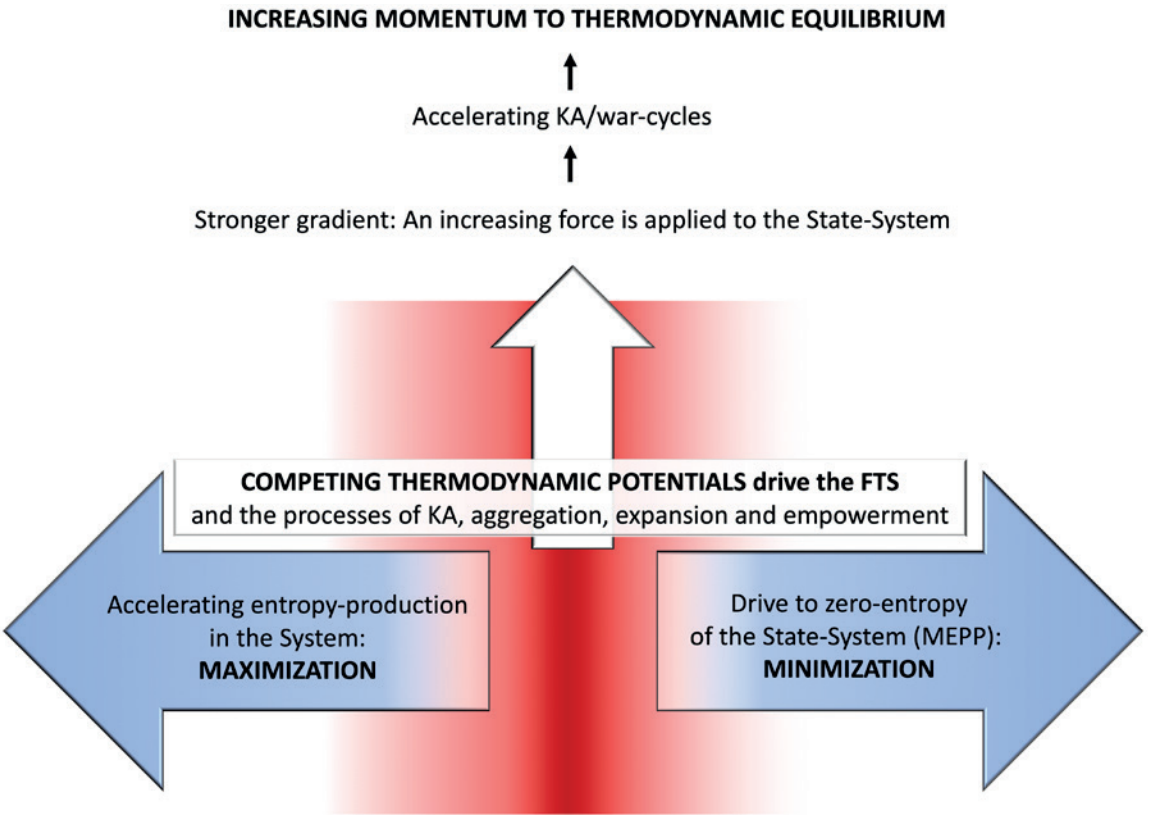


FIGURE 29.8: The interplay between competing thermodynamic potentials constitute the engine of the FTS.

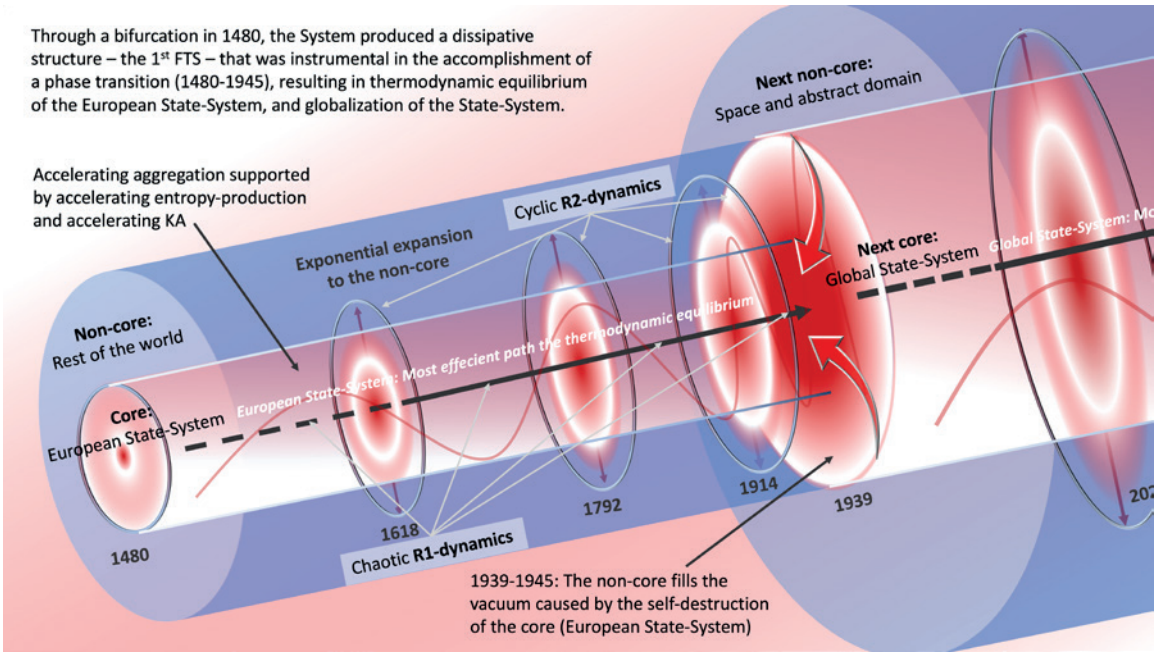


FIGURE 29.9: The 1st FTS depicted as an engine.

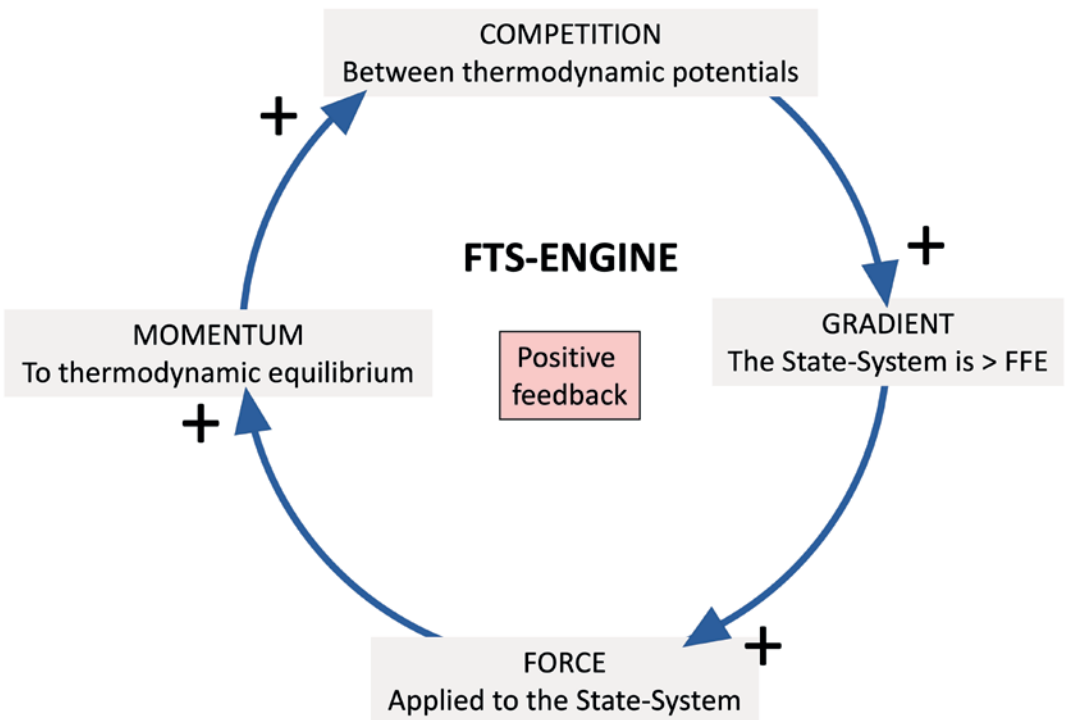


FIGURE 29.10: CDS of the FTS-engine.

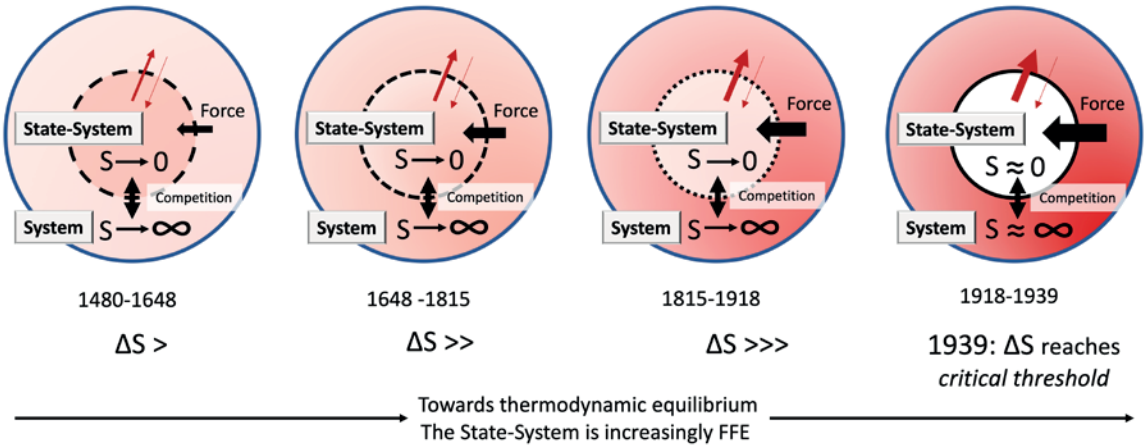


FIGURE 29.11: The interplay between competing thermodynamic potentials strengthens the gradient and the force that is applied by the FTS. This figure shows schematically, how the gradient - and consequently the force applied by the FTS on the European State-System - became stronger during the transient period (1480-1945).

29.8. From a multitude of interactions between individual humans to systemic KA

It is now possible to understand the relationship between the multitude of 'micro-interactions' between individual human beings in societies, and the macroscopic behavior - including systemic KA - of the (State-)System. Individual human beings must fulfill a set of basic requirements to ensure their well-being and survival. Because of the scarcity of resources, interactions are competitive. Human interactions and processes are irreversible processes that generate entropy. Entropy manifests itself in social systems as uncertainty, tension, new possibilities and opportunities and threats. More entropy also means more diversity. Entropy - tensions - must be regulated, to balance continuity (structure) with change.

Humans group in 'clusters' - communities and societies - to improve their ability to fulfill basic requirements. More interactions mean more entropy(-production), and consequently the collection of communities and societies is pushed increasingly further from equilibrium. Socials systems are also physical systems that must 'obey' thermodynamic laws and principles that apply. At a certain point, sufficiently FFE, the increasing instability of the System causes a bifurcation and entropy(-production) is now (also) a source of macro-order: There is order through fluctuations.

The emergent dissipative system - the FTS - organizes and regulates EMIS-flows in the (State-)System, with the purpose to push the State-System to thermodynamic equilibrium, in accord with the Second Law and related principles that apply FFE.

Entropy(-production) and free energy(-production) - tensions and military capabilities - are 'equivalent' in the (State-)System FFE. Free energy is used to neutralize and redistribute entropy. In short, the entropy that is produced through interactions and social processes is at a certain point regulated by an emergent dissipative structure, that uses free energy - military capabilities - to neutralize and redistribute entropy (tensions). The FTS connects micro-behavior to macroscopic regulation.

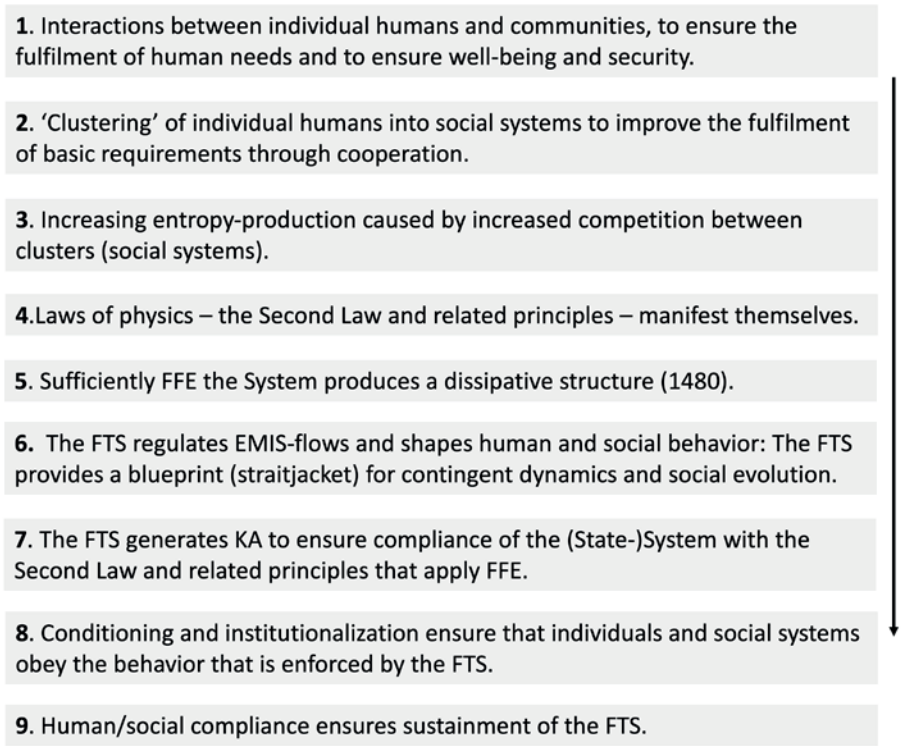


FIGURE 29.12: The linkage of micro-interactions and behavior to (macro) regulation by the FTS.

29.9. Critical speeding up, not slowing down by the (State-)System

Critical slowing down (CSD) is a critical phenomenon that can sometimes be observed in case of phase transitions. However, there is not necessarily a slowing down, sometimes a speeding up can be observed (96).

Critical slowing down is defined as a sharply marked increase in the relaxation (or recovery) time of a system close to a phase transition, and is considered a dynamical signature of criticality, that can be

used as a warning signal for a critical transition, and an indicator of future changes (15, 24, 46, 69, 70, 71). Relaxation time refers to the rate at which a system recovers from small perturbations. Critical slowing down is for example observed in case of ecosystem collapse (71).
I consider the development of the duration of successive systemic KA/wars during the transient period (1480-1945) indicative for the recovery time of the (State-)System following a collapse of a RSP. In case of the (State-)System, the duration of successive systemic KA/wars shortened acceleratingly (consistent with the development of other properties).

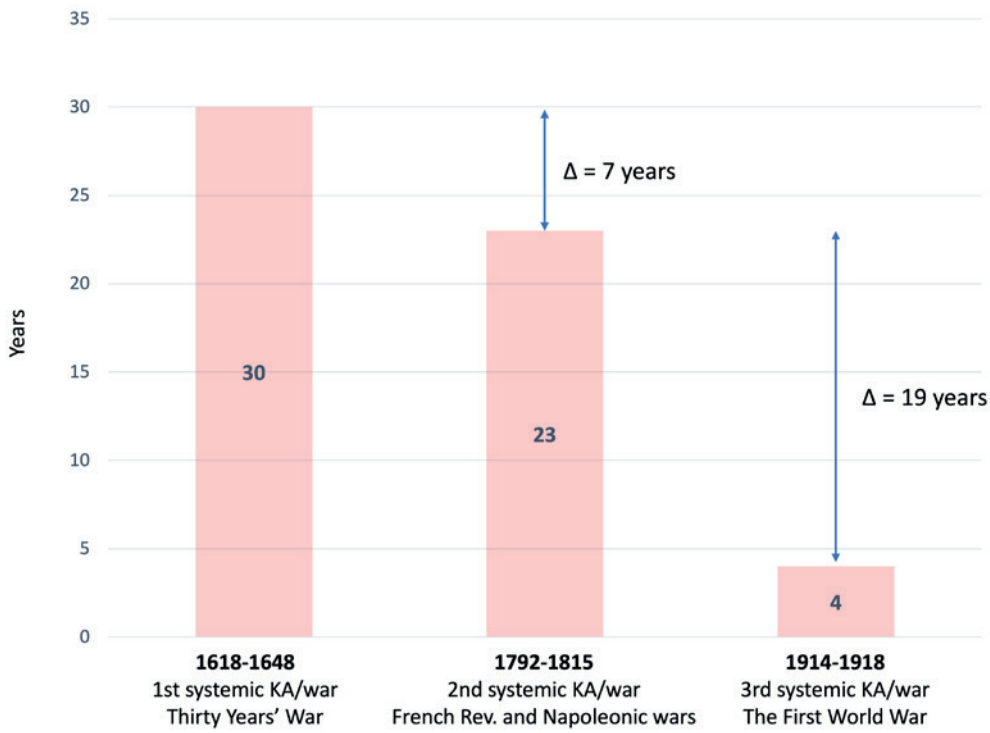


FIGURE 29.13: Accelerating shortening of the recovery time.

The analysis shows that in case of the State-System, there is an accelerating shortening of the duration of systemic KA/wars, in other words, a speeding-up - not a slowing down - of recovery times, when the critical point is neared.
The speeding-up can be attributed to the accelerating entropy-production of the (State-)System and the FTS-regulation.
The 4th systemic war (the Second World War, 1939-1945), is not included in the analysis. Contrary to its three predecessors, this war was not an exclusive European systemic war, but also involved the Great Powers Japan and the United States: Through - during - the 4th systemic war, the State-System globalized, I assume that the globalization-effect of the phase transition added to the war's duration.

According to the corrected version of the FTS, the duration of the 4th systemic war would have been 2,5 years (the acceleration is taken into consideration, but the globalization effect is excluded).

29.10. Application (1): The FTS is a war-trap and equalizer

During the transient period (1480-1945), when a phase transition was accomplished by the 1st FTS, the European State-System neared zero entropy, and diversity was squeezed out of the European State-System. Shortly before the collapse of the European State-System, the organization of state-structures, including of their military capabilities (organizations tasked with putting free energy to use in response to entropic perturbations and accumulated entropy) were highly identical (standardized). The process of standardization contributed to the process of aggregation of societies and states: Incomplementarities and inconsistencies were eradicated and/or equalized, and the establishment of homeostatic control was consequently simplified.

In 1939, the European State-System - the 1st FTS - had 'mobilized' enough momentum, entropy- and (activation) energy, to eradicate the final barriers to thermodynamic equilibrium in the core.

30. Abnormal war dynamics during the 1st exceptional period (1657-1763)

30.1. Introduction

During the transient period (1480-1945), the 1st FTS produced four accelerating war-cycles, and accomplished a phase transition of the European State-System (core) to thermodynamic equilibrium (aggregation stage 3A). Analysis of war-data shows distortions of the non-systemic KA during the period 1657-1763, during the RSP of the 2nd cycle (1648-1815), of the otherwise very regular and consistent chaotic non-systemic KA during successive RSP's of the (State-)System.
In this chapter, I analyze the abnormal non-systemic systemic KA (war dynamics) during what I designate as the 1st exceptional period (1657-1763); their characteristics and causes and effects.
During the period 1945-1989, the (State-)System experienced a 2nd period with abnormal non-systemic KA (war dynamics), during the 1st cycle of the 2nd (global) FTS. This is the 2nd exceptional period - better known as the Cold War - which will be discussed later.
As I explain, during the 1st exceptional period, the number of degrees of freedom of the System were temporally reduced, and the State-System was in a so-called *periodic window*.
This also affected the mode-coupling of the (State-)System and consequently the efficiency and development of the European State-System and 1st FTS.
When in 1763, the (State-)System recovered and resumed chaotic non-systemic KA, the State-System could develop toward a critical state (1792) and upgrade its order through a 3rd systemic KA/war (1792-1815, known as the French Revolutionary and Napoleonic Wars).

30.2. Default KA-dynamics of the System

What I assume is a normal life-cycle of war-cycles, I use as a reference for the analysis. Normally, a war-cycle consists of a RSP followed by a critical period. During RSP's, the (State-)System maintains a (dynamic) steady state, by responding to entropic perturbations with *chaotic* non-systemic KA. At a certain point - the tipping point of the RSP - non-systemic KA becomes increasingly inhibited by the effect of a network-effect. From the tipping point onwards, entropy-regulation becomes problematic and entropy starts accumulating in the (State-)System. The accumulation accelerates a process of nucleation of VC's, causes

a process of autocatalysis (entropy-accumulation generates more entropy through self-reinforcement), and causes VC's to percolate the (State-)System. It is a matter of time and the RSP becomes critical, then collapses and the (State-)System generates a systemic KA/war. During the systemic KA (systemic war) the accumulated entropy is used to upgrade the order of the State-System, and to implement a next (upgraded) RSP.

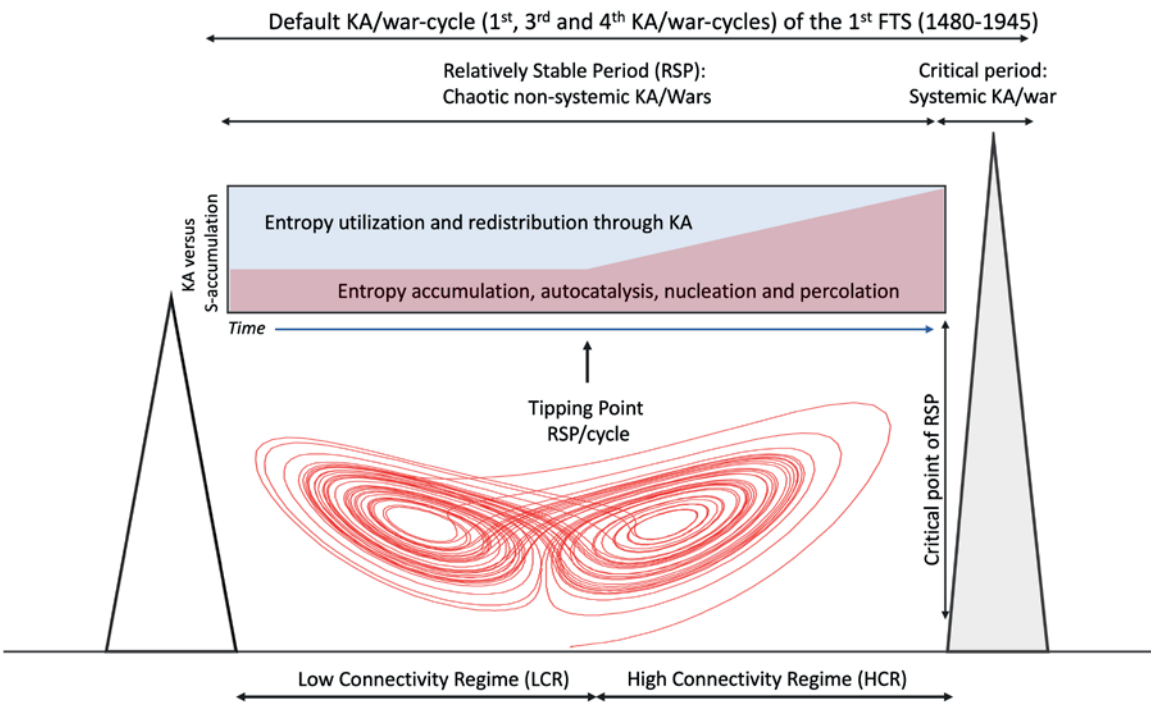


FIGURE 30.1: Schematic depiction of a default KA/war-cycle.

30.3. Characteristics of abnormal non-systemic KA during the 1st exceptional period 1657-1763

Analysis of war-data and behavior of KA-dynamics in phase space reveal that during the period 1657-1763 - that is during the 2nd RSP (1648-1792) of the 2nd war-cycle (1648-1815) - the characteristics of the non-systemic KA differed fundamentally: Normally, non-systemic KA is chaotic in nature, but during the period 1657-1763, the non-systemic KA was periodic.

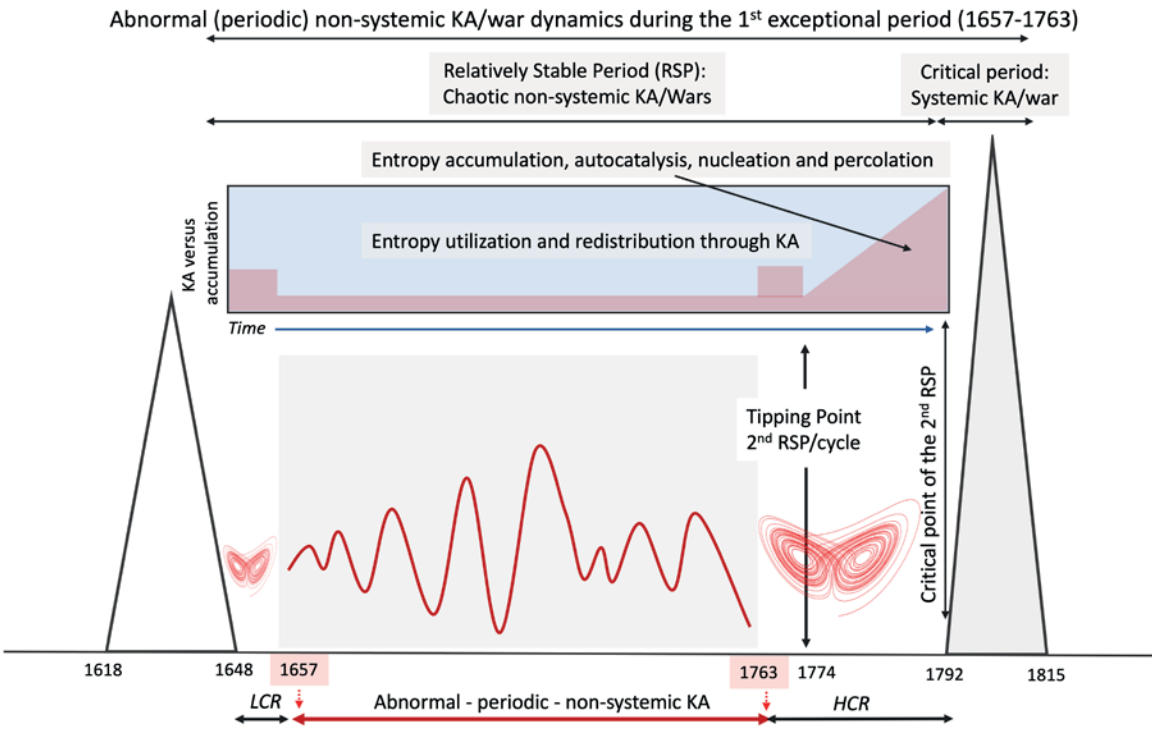


FIGURE 30.2: Abnormal non-systemic KA during the 1st exceptional period (1657-1763), during the 2nd KA/war-cycle (1648-1815).

30.4. Analysis of abnormal non-systemic KA (1657-1763)

Analysis of war-data reveals the characteristics of the abnormal - periodic instead of chaotic - non-systemic KA, during the 1st exceptional period (1657-1763).

1. *Autocorrelation*. The development of the autocorrelation points to the abnormality - periodicity - of non-systemic KA, during the period 1657-1763. See figure 30.3.
2. *Behavior in phase space*. The orbital trajectories - typical for chaotic dynamics that are shaped by strange (fractal) attractors - cannot be observed during the period 1657-1763. During the period 1657-1763, the trajectories reveal the periodic nature of the abnormal non-systemic KA. See figures 30.4 and 30.5.
3. *Data-analysis*. Data-analysis reveals the periodic nature of the abnormal non-systemic KA in more detail: Two subcycles - with highly consistent properties - can be distinguished: (to be discussed in paragraph 30/10). See figure 30.6.

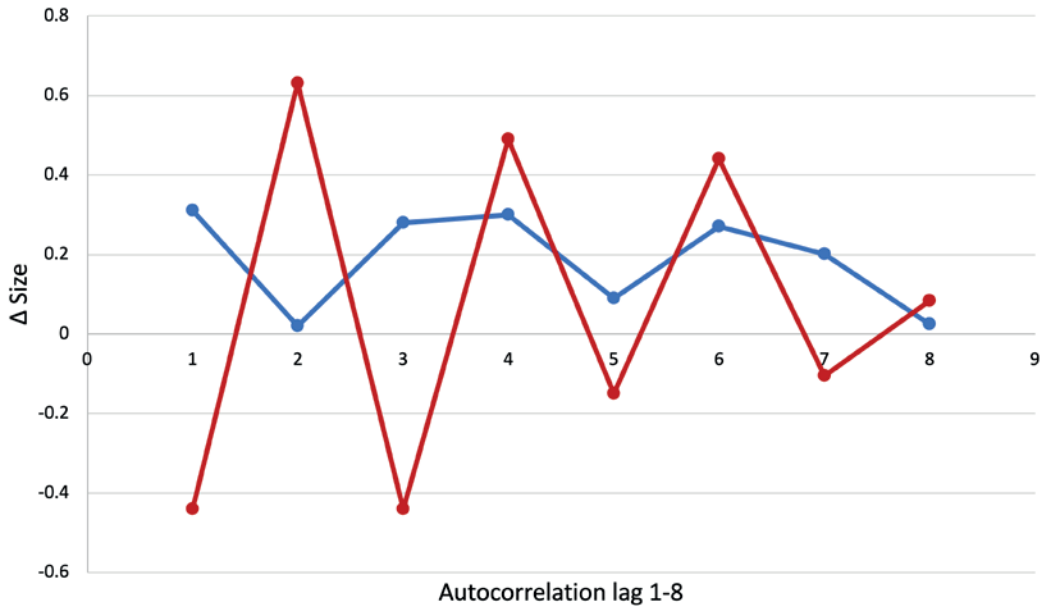


FIGURE 30.3: Autocorrelation of a set of non-systemic KA/wars during the 1st RSP (1480-1618) in blue, and during the 1st exceptional period (1657-1763) in red; based on data from Levy (59).

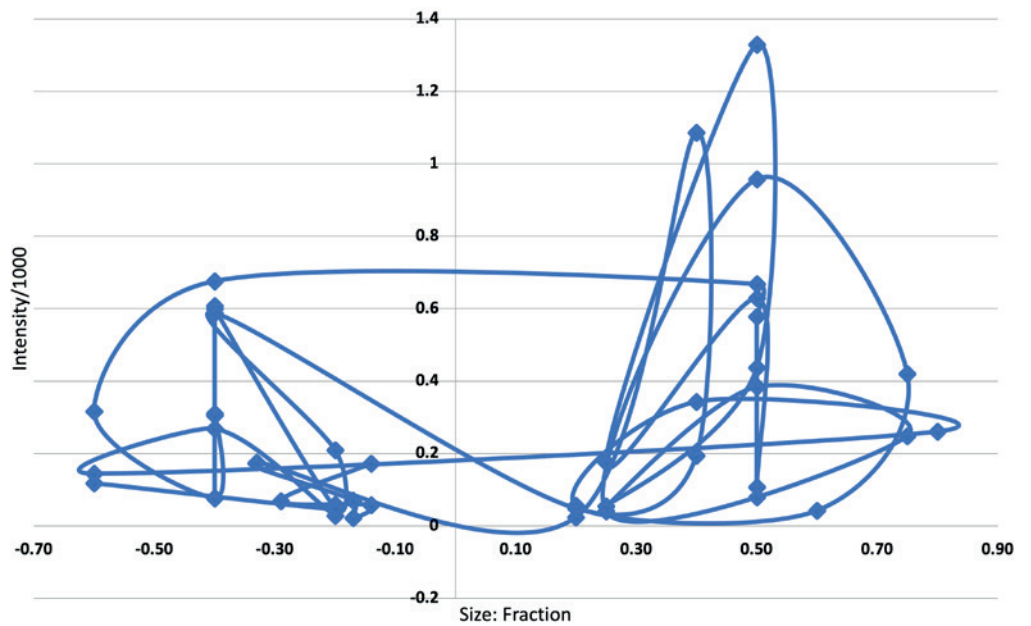


FIGURE 30.4: The typical orbital trajectories in phase space, in case of chaotic non-systemic KA. Development of the size (fraction) and intensity of successive non-systemic KA/wars during the 1st RSP (period 1495-1618), n = 45, based on data Levy (48).

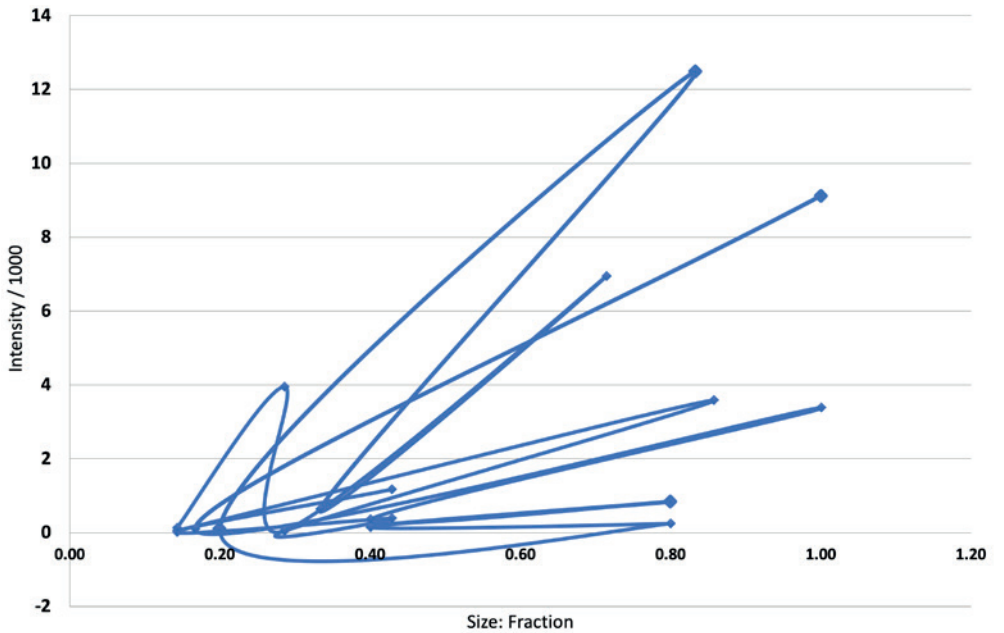


FIGURE 30.5: The trajectories - typical for periodic dynamics - in phase space, during the 1st exceptional period (1657-1763). Development of the size (fraction) and intensity of successive non-systemic KA/wars during the 1st exceptional period (1657-1763), n = 20, based on data Levy (48).

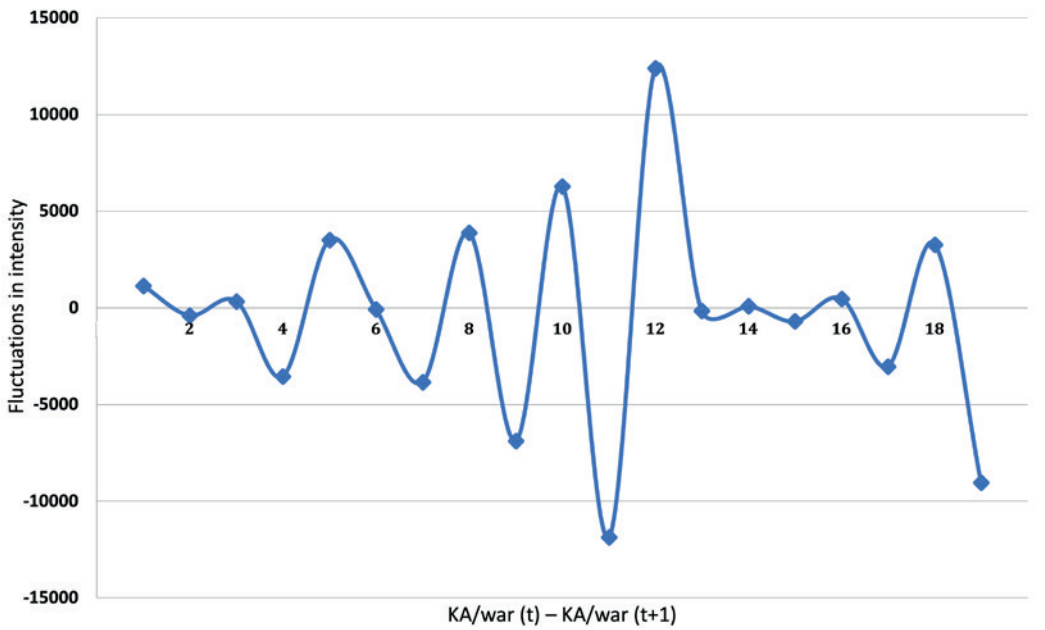


FIGURE 30.6: During the 1st exceptional period (1657-1763), two highly consistent subcycles can be identified; n = 20, based on data Levy (48). During the period 1657-1763, the System produced periodic KA/war dynamics, a series of highly regular non-systemic war dynamics. This abnormal behavior - these abnormal non-chaotic war dynamics - can be attributed to a temporary decrease in the number of degrees of freedom, from more than two (n > 2) to two (n = 2). The oscillations the (State-)System produced during this period, with very regular periods and amplitudes, depended on the parameters of the (State-)System, including its degrees of freedom (n = 2, during this period), and were intrinsic to the System as is the case with chaotic war dynamics). These oscillations measured time through internally generated dynamics, and can be considered a "war clock", comparable to a chemical clock (66).

30.5. Interpretation of abnormal non-systemic KA (1657-1763): More extreme non-systemic KA

The differences in the properties of chaotic and periodic dynamics are related to the number of degrees of freedom in the system concerned. In case of chaotic dynamics, the degrees of freedom n > 2, while in case of periodic dynamics n = 2.

Chaotic dynamics are more constrained, while periodic dynamics can be more extreme; periodic dynamics lack 'built-in' inhibition, provided by an additional degree of freedom. This is also the case for chaotic and non-systemic KA in the (State-)System. The size and severity of non-systemic KA during the 1st exceptional period show a lack of inhibition: During the 1st exceptional period (1657-1763), the (State-)System produced two *system-wide* wars (not to be confused with *systemic* wars): The War of the Austrian Succession, 1739-1748 (war 76 in Levy's data-set) and the Seven Years' War, 1755-1763 (war 77 in Levy's data-set) (48). Despite their system-size, these wars do not qualify as systemic. During their occurrence the (State-)System was not in a critical condition, there was no divergence of the correlation length, and consequently these wars could not be used to upgrade the order of the (State-)System.

I attribute the temporary reduction in the degrees of freedom of the (State-)System - causing the more extreme periodic non-systemic KA - to the intense rivalries between the United Kingdom (Britain) and France during the period 1657-1763. During this period, all issues and (war) dynamics in the (State-)System were subjugated to the rivalries between the United Kingdom and France: Due to these intense rivalries, entropy was produced at an accelerated ('unconstrained') rate, and immediately put to use; the entropy (issues and tensions) could not be stored in VC's.

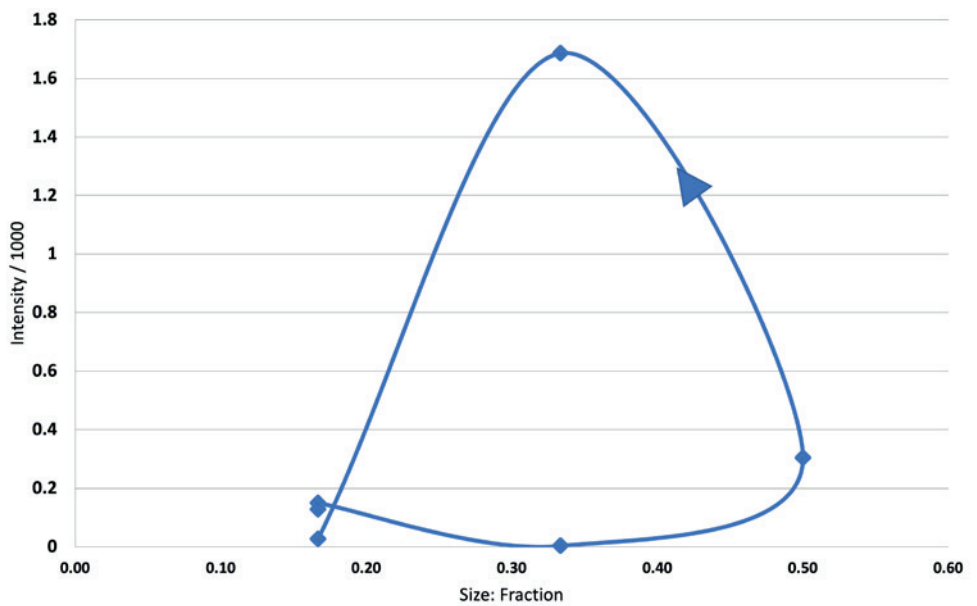


FIGURE 30.7: Non-systemic KA/wars resumed orbital trajectories in phase space in 1763, the moment chaotic dynamics resumed. This figure shows the development of the size (fraction) and intensity of chaotic non-systemic KA/wars during the period 1763-1792, which produced a single orbit; n = 6, based on data from Levy (48).

Other Great Powers were aligned with either the United Kingdom or France, and issues between them became consequently 'overconnected'. The System-dynamics were consequently 'simplified' and became hyper-excited: States took only two variables - the position of the United Kingdom and France - into consideration in their war-decisions; a third - other - variables did not affect war-decisions (59). The war dynamics had a strong 'all-or-nothing' - unrestrained - character: Over-connection resulted in hyper-excitement. As I explain later, the same mechanisms - intense rivalries, a reduction in the degrees of freedom and over-connection, but in this case between the United States and the Soviet Union and their respective allies - can explain the abnormal non-systemic KA during the 2nd exceptional period (1945-1991, the Cold War), as well.

In 1763, when the intense rivalries between the United Kingdom and France were decided (in favor of the United Kingdom), a third degree of freedom was again 'activated', and the (State-)System resumed its default chaotic non-systemic KA, as the resumption of orbital trajectories in phase space confirms.

30.6. Interpretation of abnormal non-systemic KA (1657-1763): Distorted mode-coupling

This interpretation is based on a thermodynamic perspective on the processes - KA - in the System. Mode-coupling is responsible for the establishment of long-range correlations between interactions (66), in case of the (State-)System, between local entropic perturbations (issues) and a collective dimension (the S/T-field). Mode-coupling is required for macroscopic behavior: Mode-coupling enables, and shapes coordinated EMIS-flows in the (State-)System. Inadequate mode-coupling undermines the efficiency and performance of the FTS.

The degree of mode-coupling is a function of the constraint, and of the gradient (and force) the constraint produces. Because of the intense rivalries between the United Kingdom and France during the 1st exceptional period (1657-1763), there was no longer balanced mode-coupling that allowed for *chaotic* non-systemic KA: n = 2 undermined balanced mode-coupling in the (State-)System, and chaotic non-systemic KA could not be enabled (supported). "Local issues" - so to speak - no longer existed, issues had become over-connected. The constraint applied a force that was too strong on the (State-)System. EMIS-flows were consequently distorted and the (State-)System - the 1st FTS - adapted its dynamics accordingly.

30.7. Interpretation of abnormal non-systemic KA (1657-1763): Suboptimal exploration and innovation, no nucleation and no criticality

Chaotic dynamics combine several useful properties of the (State-)System, I already explained discussed in the preceding chapters. These properties include: Highly optimal exploration of phase space, but at the same time constrained in their energy-release ('free yet constrained' dynamics), the enablement of a process of autocatalysis and nucleation of fractal VC's, the ability to embed solutions (to entropic perturbations) and modifications to the order of the RSP in these VC's, the ability to store not only information, but also entropy in these VC's, and the ability to produce the conditions (a divergence of the correlation length of VC's and KA) for criticality. Criticality is required for the emergence of systemic KA/war, and the upgrading of the (State-)System to a next level of organization (RSP). *Chaotic* non-

systemic KA/wars ensured further development of the State-System and sustainment of the 1st FTS, and eventually the accomplishment of the phase transition; *periodic* non-systemic KA/wars on the other hand undermined the further development of the State-System.
Non-chaotic - periodic - non-systemic KA, cannot support a process of nucleation and percolation. VC's - assuming they are not immediately destroyed by the extreme periodic non-systemic KA/wars - do not have the fractal properties that are required to produce a critical condition. The trajectories in phase space do also not ensure maximum exploration and information storage.

30.8. Resumption of normal - chaotic - non-systemic KA (1763)

As I mentioned in this chapter, in 1763 a third degree of freedom was again 'activated', when the intense rivalry between the United Kingdom and France was decided (in favor of the United Kingdom): The (State-)System immediately resumed (default) chaotic non-systemic KA. The resumption of orbital trajectories in state space confirms the resumption of chaotic non-systemic KA, in 1763.
It was just a matter of time, before the (State-)System became critical in 1792 and produced a 3rd systemic war (1792-1815, the French Revolutionary and Napoleonic Wars).
Analysis of the war-data shows that the (State-)System reached the tipping point of the 2nd RSP (1648-1792) of the 2nd cycle (1648-1815) in 1774 (59).
The 1st exceptional period occurred during the LCR of the RSP: The (State-)System is more sensitive for distortions of its non-systemic dynamics during LCR's of RSP's. Following the tipping point - when the network-effect produces stability - the RSP becomes increasingly robust and less sensitive for perturbations and distortions.
During the HCR of the 2nd RSP (1774-1792) - which was a relatively short period - the (State-)System was able to produce VC's that could percolate the System and produce a critical state. The processes of nucleation and percolation were accelerated by the preceding (periodic) non-systemic KA.

30.9. Consequences/impacts of abnormal non-systemic KA (1657-1763) on the System/1st FTS

The abnormal non-systemic KA (war-dynamics) during the 1st exceptional period (1657-1763), had an impact on the operation and development of 1st FTS: The abnormal non-systemic KA was detrimental to the efficiency of the 1st FTS, caused a distortion in the release-ratio, and caused a delay in the development of the 1st FTS and European State-System (59). See table 30.1.

1. Reduced efficiency. Figures 30.8 and 30.9 visualize the reduced efficiency of the 1st FTS during the 2nd cycle (1648-1815). The globalization effect of the phase transition (1480-1945), caused an increase in KA during the 4th cycle (1918-1945).

TABLE 30.1: Properties of the actual and corrected 1st FTS. This table shows quantitative properties of the actual and corrected 1st FTS (59), based on data from Levy (48). The non-systemic KA of the System during the period 1480-1495 is not included (data is not available); RR is the abbreviation for release-ratio, LS for Life-span

		1st FTS: Actual				1st FTS: Corrected			
Cycle	Period	Systemic KA/war	Total KA cycle	RR	LS	Systemic KA/war	Total KA cycle	RR	LS
1	1480-1648	1,971,000	2,976,000	0.66	153	1,971,000	3,036,000	0.65	168
2	1648-1815	2,532,000	7,550,300	0.34	167	4,900,000	5,750,000	0.85	154
3	1815-1918	7,734,300	8,429,080	0.92	103	8,100,000	8,720,000	0.93	103
4	1918-1945	12,948,300	12,953,300	1.00	27	11,100,000	11,500,000	0.97	22,5

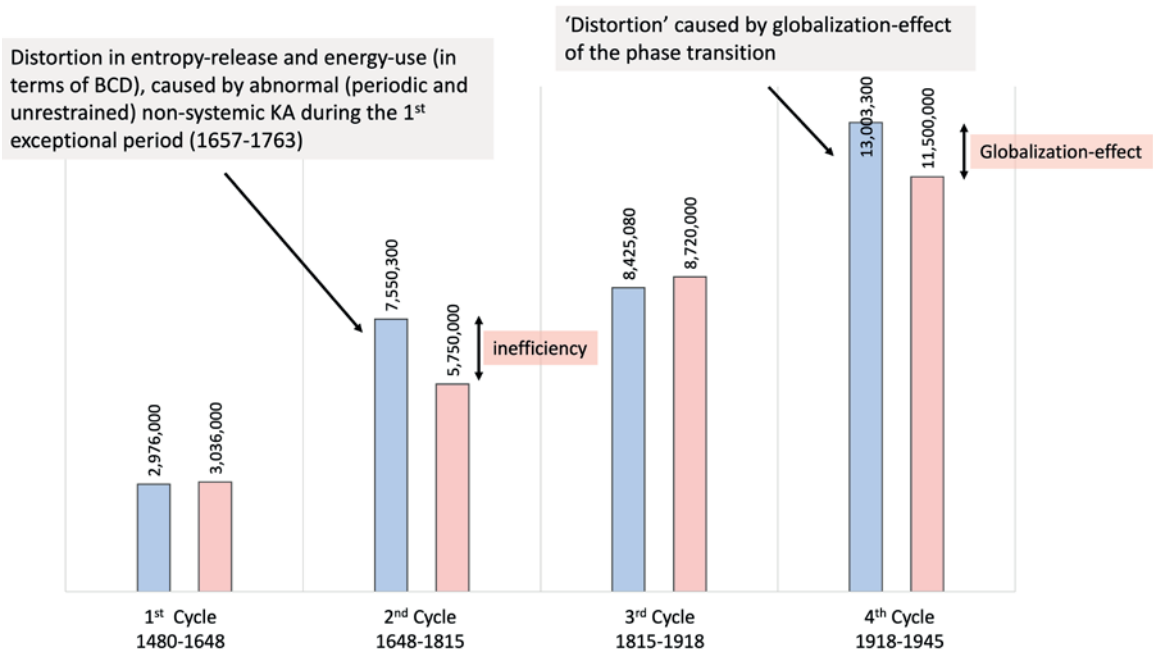


FIGURE 30.8: Reduced efficiency during the 2nd cycle (1648-1815) (1). Actual 1st FTS in blue; Corrected 1st FTS in red. Based on data from levy (48).

2. Distorted distribution/release-ratio. Not only was more KA (and thus entropy) generated during the 2nd Cycle. The distribution of KA between non-systemic and systemic KA was also distorted, as the development of the release-ratios shows. In chapter 36 I discuss the efficiency of the 1st FTS from a thermodynamic perspective and argue that it was a highly efficient structure, except for the 2nd cycle (1648-1763). See figure 30.10.

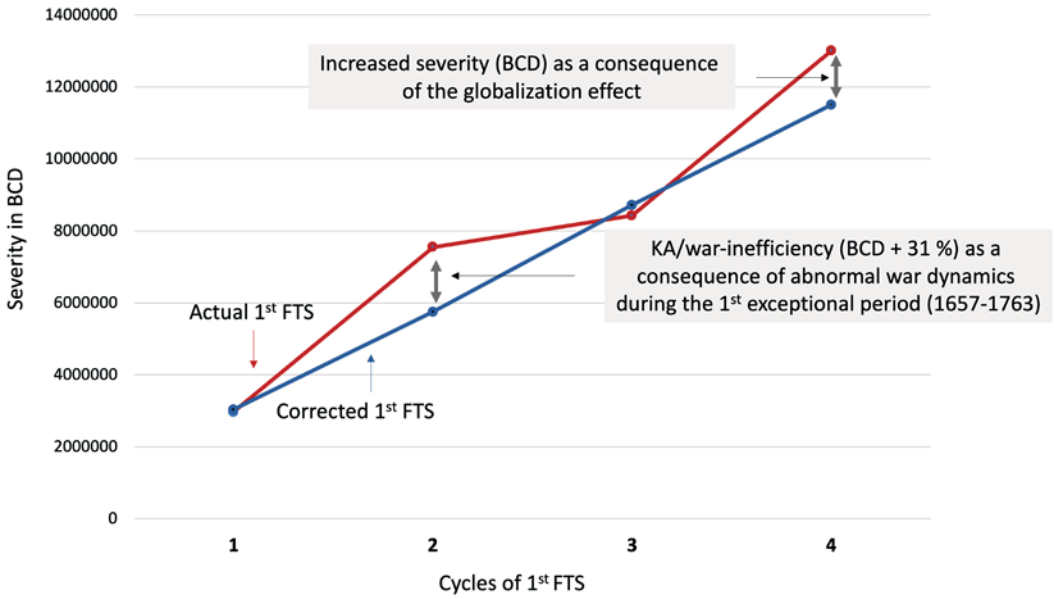


FIGURE 30.9: Reduced efficiency during the 2nd cycle (1648-1815) (2). Actual 1st FTS in blue; Corrected 1st FTS in red. Based on data from Levy (48).

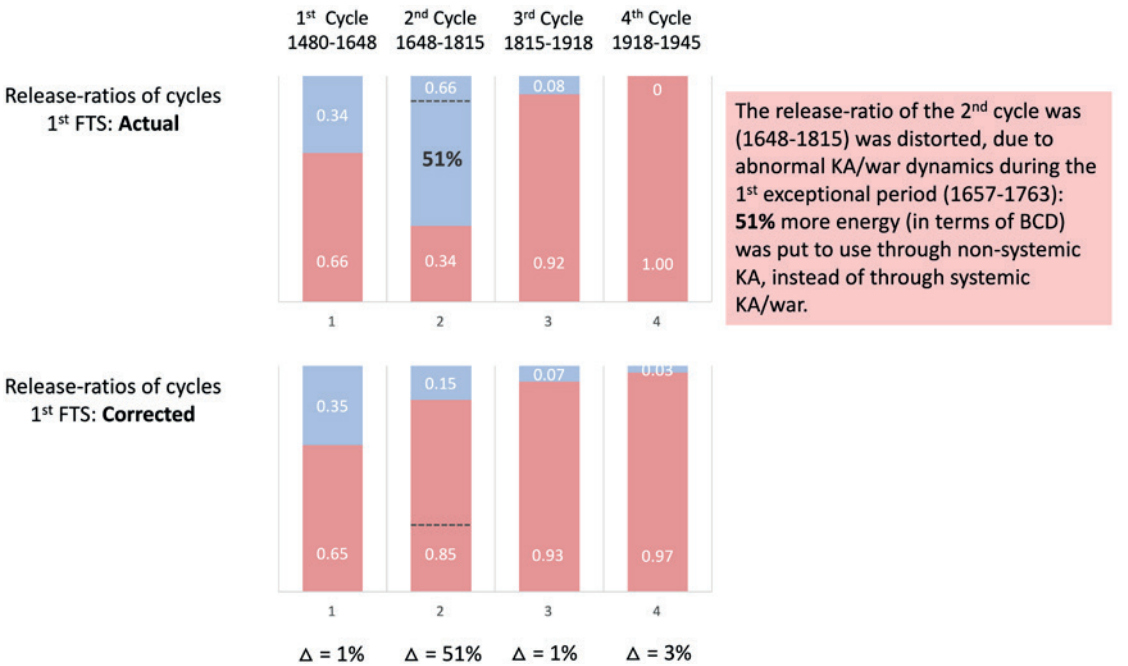


FIGURE 30.10: Distortion of entropy and energy-distribution during the 2nd cycle (1648-1763) of the 1st FTS. The release ratio indicates what amount (proportion) of the entropy/energy that was produced and put to use during a cycle, was produced and put to use during the critical period (through systemic KA/war). The figure visualizes the significant distortion of the release ratio of the 2nd cycle (1648-1815): Most of the entropy and energy were released and put to use during the RSP of the cycle (1648-1792); the distortion can be attributed to the unrestrained periodic non-systemic KA/wars, during the 1st exceptional period (1657-1763). During the RSP of the 4th cycle (1918-1939), entropy could no longer be regulated through non-systemic KA/war: All entropy and energy were released and put to use during systemic KA of the 4yh cycle (1939-1945); The 1st FTS reached its regulatory limitations in 1939, and the European State-System consequently collapsed. (59). Based on data from Levy (48).

3. Delayed development. Assuming a regular development of the life-span of successive cycles - consistent with the regular development of other properties - it is possible to determine (through interpolation) the delay the abnormal non-systemic KA/wars during the 1st exceptional period (1657-1763) caused: The delay was 13 years. This delay - I assume - had a knock-on effect and also delayed the further development of the 1st FTS. If this is indeed the case, this means that the European State-System would have collapsed in 1926, if the 1st FTS was not distorted.

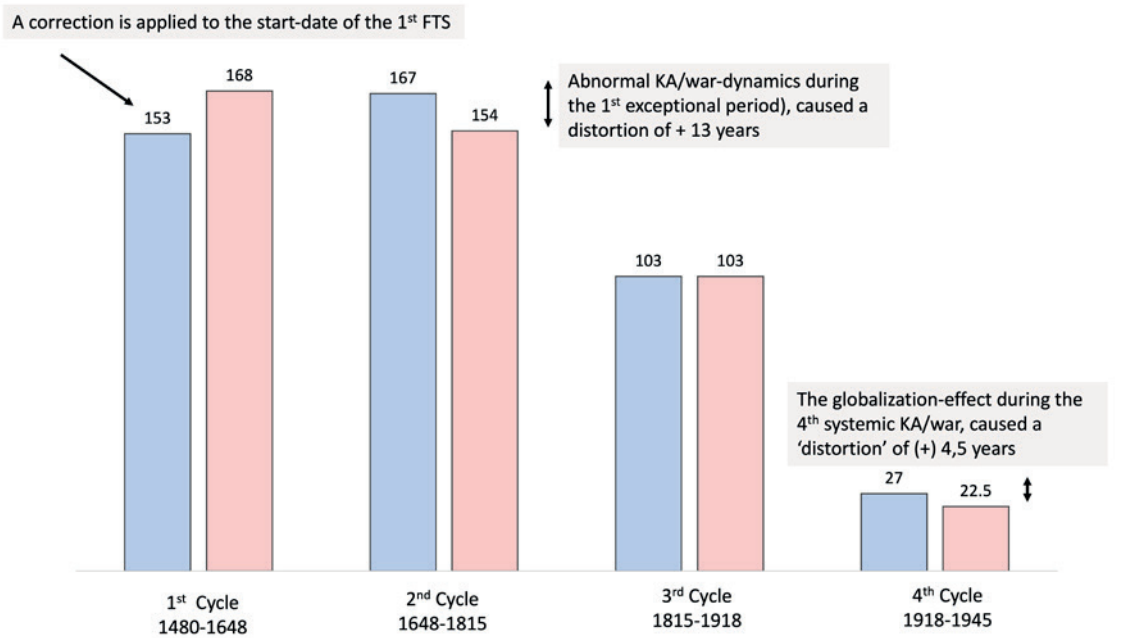


FIGURE 30.11: Delayed development caused by abnormal KA/war-dynamics during the 2nd cycle (1648-1763) of the 1st FTS. Actual 1st FTS in blue; Corrected 1st FTS in red. Based on data from Levy (48).

30.10. A periodic window

The fact that the (State-)System produced periodic non-systemic KA/war dynamics during the 1st exceptional period (1657-1763), preceded and followed by chaotic non-systemic KA (respectively before 1657 and after 1763), was - so to speak - no coincidence and is consistent with the existence of regularities in the approach of systems to the chaotic region; a phenomenon that is also relevant for the emergence of organized states in systems FFE (66).

"A remarkable simple regularity in the approach to the chaotic region is the "Feigenbaum sequence". "It concerns any system whose behavior is characterized by a very general feature, that is, for a determined range of parameter values the system's behavior is periodic, with a period T; beyond this range, the

period becomes 2T, and beyond yet another critical threshold, the system needs 4T in order to repeat itself. The system is thus characterized by a succession of bifurcations, with successive period doubling. This constitutes a typical route going from simple periodic behavior to the complex aperiodic behavior (*IP: chaotic behavior*) occurring when the period has doubled ad infinitum" (65) and when "the entire state space (...) belongs to a single chaotic attractor displaying instability of motion and sensitivity to the initial conditions" (66).
However, during the route to chaos - on the onset of chaos - when the parameter is increased, so-called "periodic windows" appear, when chaotic behavior (grey areas in figure 30.12) abruptly end and the system temporarily reverts to periodic behavior (white areas in figure 30.12); to put it otherwise: The chaotic region contains narrow windows in which chaotic behavior reverts to periodic motion.

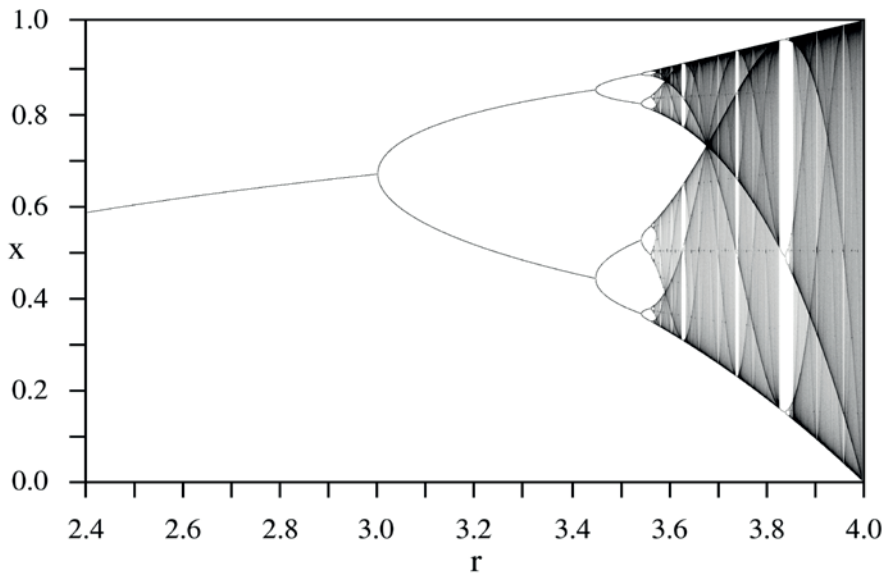


FIGURE 30.12: Feigenbaum sequence. This figure shows a bifurcation diagram of a logistic map. "The diagram shows the forking of the periods of stable orbits; each of these bifurcation points is a period-doubling bifurcation. The ratio of the lengths of successive intervals between values of r for which bifurcation occurs converges to the first Feigenbaum constant" (96). The Feigenbaum constant » 4.669. This typical behavior, as Feigenbaum observed, "(...) occurs with exactly the same quantitative characteristics for whole families of maps (...)", there is metric universality (66). The figure shows that eventually (when the parameter r is increased), "the entire state space (...) belongs to a single chaotic attractor displaying instability of motion and sensitivity to the initial conditions" (66). The grey and white areas represent respectively chaotic and periodic behavior.

Although, because of a lack it cannot be proofed that the (State-)System followed the Feigenbaum sequence on its road to the chaotic region (reached in 1480), the (State-)System reverted to periodic behavior during the 1st exceptional period, this study shows, which is consistent with the patterns Feigenbaum has identified (29). It seems that the intensity of the rivalries between Great Powers - the numbers of the degrees of freedom of the State-System - impacted on the emergence of the periodic window.

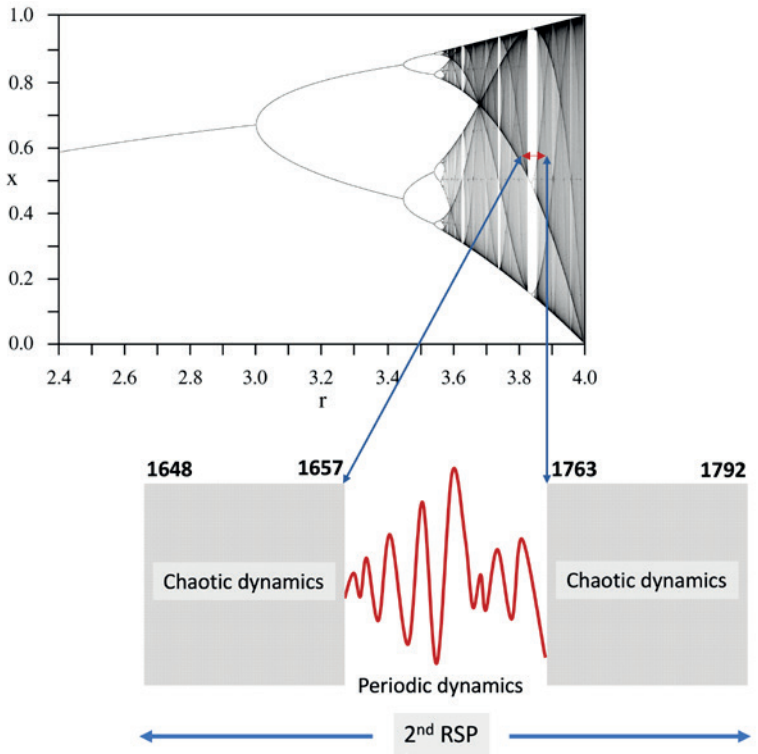


FIGURE 30.13: The periodic window (1657-1763) in the dynamics of the 1st FTS (1). This figure shows how the periodic window (the 1st exceptional period, 1657-1763), 'fits' in the Feigenbaum sequence.

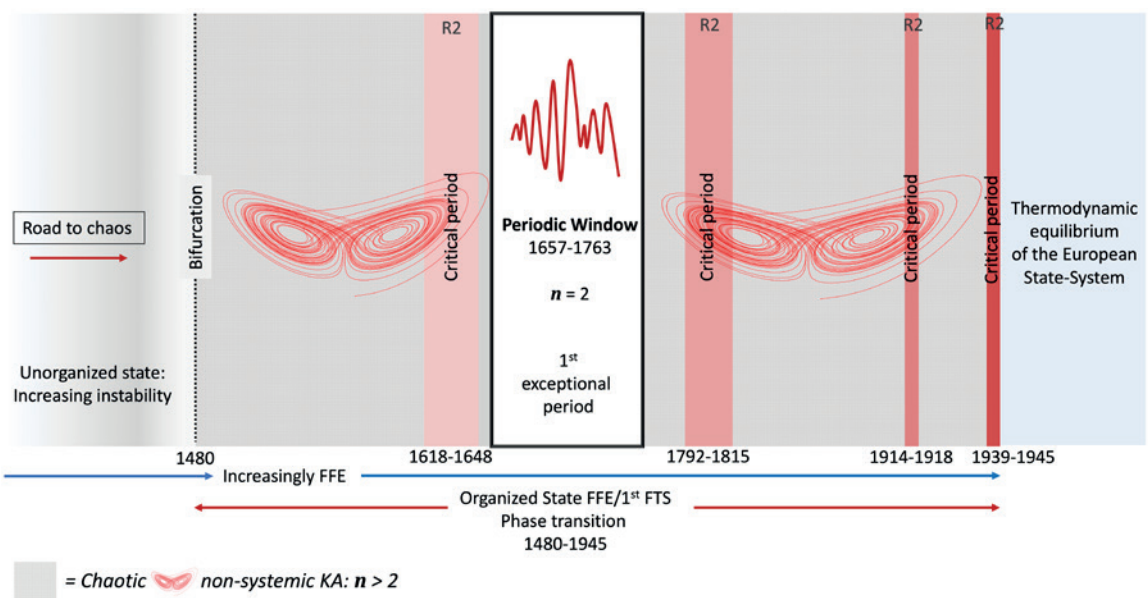


FIGURE 30.14: The periodic window (1657-1763) in the dynamics of the 1st FTS (2). This figure places the periodic window (the 1st exceptional period, 1657-1763), within the overall framework of the dynamics of the 1st FTS, during the transient period (1480-1945).

I argue that the 1st exceptional period (1657-1763) constitutes a periodic window, see figures 30.13 and 30.14. Several observations and regularities suggest this is the case: (1) The fact that the periodic non-systemic KA/ during the 1st exceptional period was preceded and followed by chaotic non-systemic KA, as the Feigenbaum sequence suggests, and (2) that the periodic dynamics during the 1st exceptional period were very consistent.

A closer look at the periodic dynamics reveals some (other) regularities: Two sub-cycles can be distinguished, respectively consisting of 13 non-systemic KA/wars, making up the 1st sub-cycle (during the period 1657-1716), and a 2nd sub-cycle consisting of 7 non-systemic KA/wars, during the period (1716-1763) (59), based on data from Levy (48). See figure 30.15.

Each sub-cycle contains four non-systemic KA/wars each that determine/define the respective sub-cycle (respectively the wars with the numbers 62, 65, 67 and 69, and the numbers 71, 73, 75 and 77).

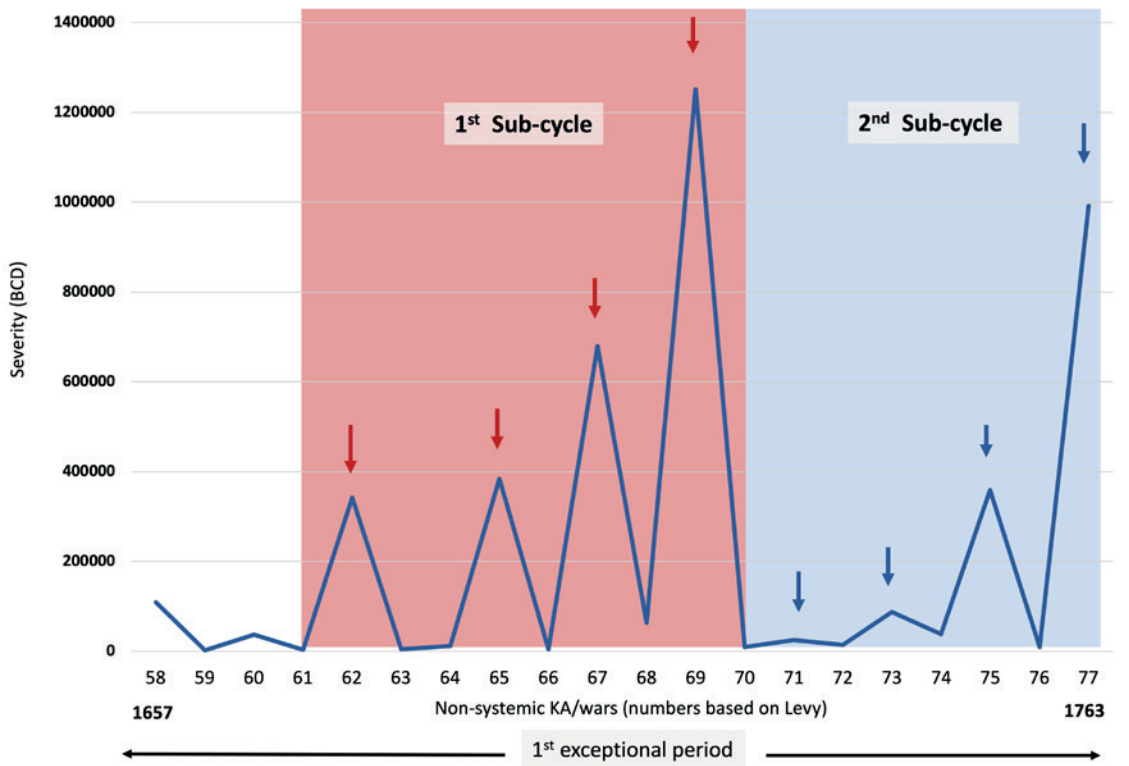


FIGURE 30.15: The periodic non-systemic KA/wars during the 1st exceptional period (1657-1763), contain two subcycles.

The two sub-cycles were synchronized, in respect to their severities and frequencies.

Figure 30.16 shows the consistency of the two sub-cycles produced during the periodic window; during the 1st exceptional period. The severities (in terms of BCD's), of the wars making up the respective cycles,

developed not only very regularly, but also very consistently, as is to be expected, if the KA/wars are 'in' the same periodic window. The correlation coefficient of the severities of the two sets of four wars making up the two sub-cycles is: ***0.999***.

It is also possible to determine the war-frequency of both sub-cycles, based on the respective sets of four wars. The four wars making up the 1st sub-cycle, took place during a period of 49 years; the four wars making up the 2nd sub-cycle during a period of 45 years (the duration of the periods are calculated by determining the time between the end-date of the 'last' war, and start-date of the first war of a set (sub-cycle), respectively 1721 - 1672 = 49 years and 1763 - 1718 = 45 years, based on data from Levy (48)). The KA/war-frequency of the 1st sub-cycle is ***0.082 KA/year***, the KA/war-frequency of the 2nd sub-cycle is ***0,089 KA/year***. The difference in frequency is negligible.

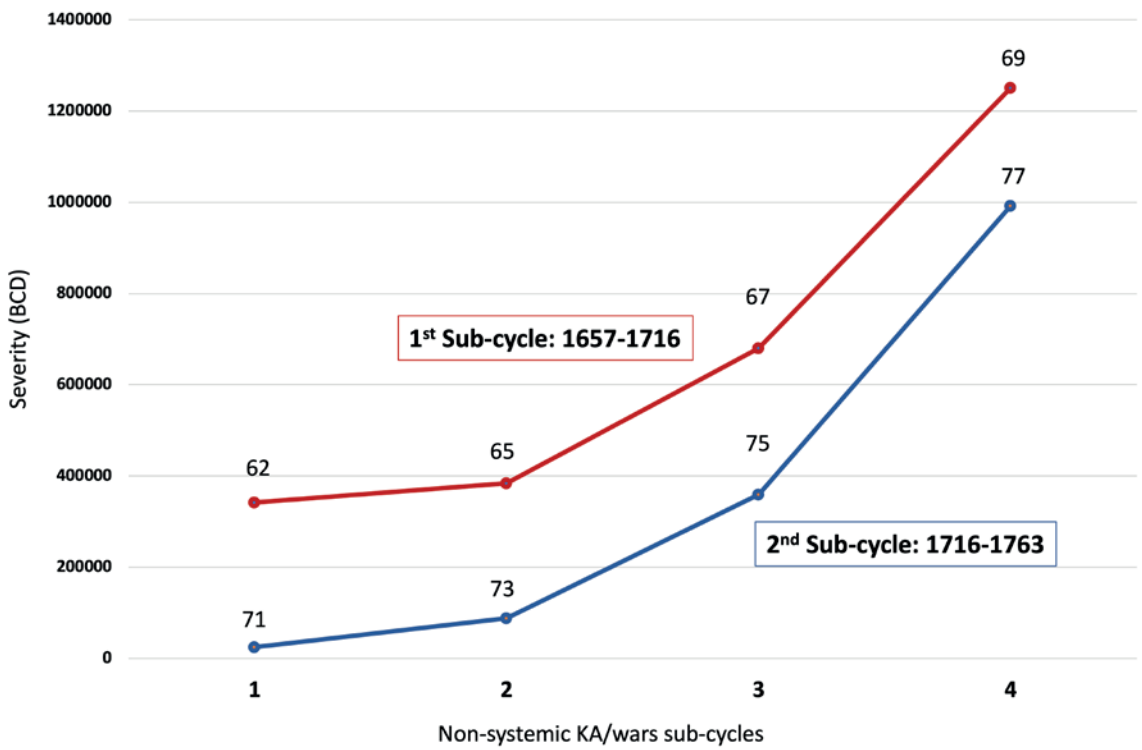


FIGURE 30.16: Synchronized intensities of non-systemic KA/wars of sub-cycles. The number of the wars are based on Levy's data-set (48).

The differences between abnormal - periodic - non-systemic KA and default - chaotic - non-systemic KA are summarized in table 30.2.

TABLE 30.2: Different properties of chaotic and periodic non-systemic KA.

Chaotic - default - non-systemic KA	Periodic - abnormal - non-systemic KA during the 1st exceptional period (1657-1763)
Degrees of freedom > 2.	Degrees of freedom = 2.
Intrinsically unpredictable.	Regular and highly predictable.
More constrained in size and severity.	More extreme in size and severity.
Enable the nucleation and percolation of VC's with fractal structures and the development of the System to a critical state.	Hinder the development of the System to a critical state.
Ensure optimal performance and efficiency of the FTS.	Cause inefficiencies and delay in the operation of the FTS and development of the System.

30.11. Application (1): Interaction between domains

The periodic window - the 1st exceptional period (1657-1763) - can be considered a demonstration of the interaction between the contingent and deterministic domain. In this particular case, the temporary intense rivalries between Britain and France, resulted in a change in the number of degrees of freedom of the State-System from n > 2 to n = 2. The change in parameters resulted in a 'switch' from chaotic to periodic KA/war dynamics in 1657.
In 1763, when the rivalries were resolved (in favor of Britain), the rivalries in the (State-)System 'normalized, and default chaotic non-systemic KA/war dynamics resumed. These switches in respectively 1657 and 1763, also qualify as bifurcations.

30.12. Application (2): Construction of a corrected model of the 1st FTS and alternative histories

The abnormal non-systemic KA during the 1st exceptional period, impacted on the performance of the 1st FTS, as explained in this chapter. Assuming that, the 1st FTS was not distorted, it is possible to construct a 'corrected' - undisturbed - 1st FTS. This model can serve as a reference. For further details, I refer to source (59).
Although the performance was negatively impacted, the impact was not significant. The analysis shows that the 1st FTS - the European State-System - was remarkably resilient and structurally stable - the (State-) System quickly recovered from the distortion and resumed default chaotic non-System KA. Structural stability concerns the sensitivity of a dynamical system - its trajectories in state space - for perturbations. Although, the impairment of efficiency of the 1st FTS (the European State-System) was in the end limited, because of the recovery that was accomplished, the impact of the abnormal non-systemic KA - of the 1st exceptional period - shows that the *chaotic* nature of non-systemic KA is a strict requirement for the FTS and (State-)System to develop.

As I explain later, the effects of the 2nd exceptional period (1945-1989, the Cold War) confirm the necessity for *chaotic* non-systemic KA for the (State-)System to develop.

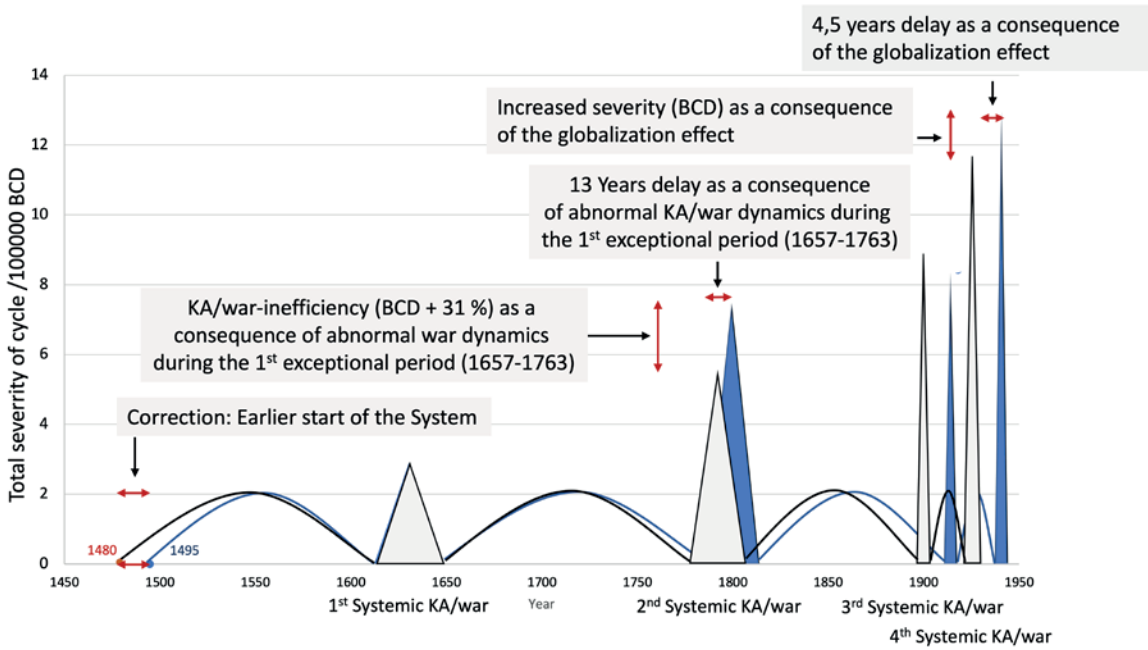


FIGURE 30.17: Comparison of the actual and corrected 1st FTS. This figure visualizes the differences between the actual (in blue) and corrected (theoretical) 1st FTS (in grey). The abnormal non-systemic KA during the 1st exceptional period (1657-1763), caused inefficiencies and a delay in the development of the 1st FTS of 13 years (59). If the 2nd cycle was not distorted, the 1st FTS would have produced a 2nd, 3rd and 4th systemic war respectively in 1779, 1901 and in 1926, the analysis suggest. Other social and political issues in the contingent domain would have shaped these systemic wars: There would have been no Napoleon, no Archduke Franz Ferdinand, whose assassination would have triggered the First World War (the 3rd systemic war) and no Hitler; other protagonists would have appeared on the scene.
Interaction between the deterministic and contingent domains - involving the security dilemma and interacting self-fulfilling prophecies - would have ensured that 'enough' entropy and energy would have been available, at the right time, as I explain later. As long as the S-imperative is satisfied, the Second Law and related principles that apply do not interfere.

30.13. Application (3): The relevance of the exceptional periods from a scientific point of view

Although the impact of the abnormal non-systemic KA during the 1st exceptional period on the overall performance of the 1st FTS was limited in the end, the relevance of these abnormal dynamics - and during the 2nd exceptional period (1945-1989) - from a scientific research perspective cannot be underestimated: The abnormal dynamics shed light on the default dynamics of the (State-)System and its behavior, and also allow for the testing of (additional) conjectures and hypotheses.

If the 1st FTS would not have produced periodic non-systemic KA during the 1st exceptional period (in response to a decrease in the degrees of freedom, due to the intense rivalries), that would have been inconsistent - in contradiction with - the conjecture that the (State-)System is a highly deterministic system that obeys the laws of thermodynamics and related principles.
The confirmation of the consistency of the dynamics of the 1st FTS contributes to the theory that is being developed in this study.
The structural stability of the 1st FTS shows the (in)sensitivity of the State-System to (certain) perturbations and can also be helpful in determining the possible effects of climate change on the KA of the System; a subject I discuss later in more detail.

31. Non-core development during the transient period

31.1. Introduction

In this chapter, I discuss the development of the non-core from a thermodynamic perspective, and from the perspective of the contingent domain.

31.2. A thermodynamic perspective on expansion and non-core development

For the emergence and sustainment of dissipative structures a suitable environment is required for entropy-exchange (b2). These requirements explain the intrinsic expansive tendencies of dissipative structures, including of the 1st and 2nd FTS.

The non-core ("the rest of the world"), constituted the environment for the core (Europa) that ensured the 1st FTS could emerge in 1480 (discussed in chapter 24), and the 1st FTS could be sustained during the transient period (1480-1945), until the European State-System eventually reached thermodynamic equilibrium.

The process of expansion to the non-core - and developments in the non-core - and the process of aggregation in the core (Europe), were closely related, and complementary processes: Colonialism and European integration - and KA/war-activity - were closely related. These processes enabled and reinforced each other.

From a thermodynamic perspective, it is no coincidence that the start of the 1st FTS in 1480 and the acceleration of colonialism, and the accomplishment of the phase transition in 1945 (aggregation stage 3A of the European State-System) and the end of colonialism, were synchronized; they constitute the same process, regulated by the 1st FTS (1480-1945).

It is also no coincidence, that with the start of the global State-System in 1945, exploration of space and efforts to colonize space also started: The global State-System also needs a suitable environment that enables EMIS-regulation, required for the sustainment of the 2nd (global) FTS and the global State-System.

The tendency of social systems - of societies, (especially) Great Powers, and the (State-)System – to expand is contained in the requirements of the Second Law and related principles that apply FFE.

31.3. Phases in the expansion of the core (Europe)

Given the regular development of the core - e.g. the regular and consistent development of four accelerating KA-cycles that accompanied the 1st FTS - it can be expected that the process of expansion to the non-core and certain non-core developments also produced certain regularities, that are consistent with other properties of the FTS.

This is indeed the case; in this paragraph I show by analyzing the KA of the (State-)System that the processes of aggregation (integration) in the core (Europe) and its expansion to the non-core were synchronized.

During the transient period (1480-1945), the 1st FTS was accompanied by four accelerating KA/war-cycles, and the core of the System (Europe) developed – aggregated - from a large collection of loosely connected and diverse units (in 1480) into a highly integrated State-System consisting of 25-30 highly standardized states (in 1939).

During this process of aggregation (integration), the core of the System (Europe), simultaneously expanded to the non-core, in accordance with requirements of the Second Law and related principles that apply FFE, to sustain the 1st FTS. The KA/war dynamics of the (State-)System reveal how the process of expansion occurred.

It is possible to distinguish five phases in the expansion process, see table 31.1:

TABLE 31.1: Five expansion-phases of the System (1480-1945).

Phase	Timing	Characteristics	Triggers
(I) Core formation and initial aggregation/ integration: (1480-1812): Internal core dynamics only (from a KA-perspective).	Starting 1480	During the period 1480-1812 all Great Power war dynamics still take place within Europe, the core of the System (Data from Levy (48)).	During the period 1480-1812; internal core dynamics only.
(II) Core expansion: Core-states generate KA in the non-core.	Starting 1812	European Great Powers become involved in or start wars outside of Europe.	The War of 1812, 1812-1814, war 88 in Levy's dataset marks the beginning of this phase. Other wars that are part of phase two are wars no.: 97, 99, 104, 105, 110, and 112 (data from Levy (48)).
(III) Non-core involvement in the core (European State-System).	Starting 1914	Non-European Great Powers become involved in KA/war-dynamics, in the core (Europe).	The United States' involvement in the 3rd systemic war (the First World War, 1914-1918) marks the beginning of this phase.
(IV) Non-European states autonomously produce their own KA/war dynamics in the non-core.	Starting 1931	Non-European Great Powers initiate their own Great Power wars outside of Europe, without the direct involvement of European Great Powers.	The Manchurian War (109, involving Japan and China) marks the beginning of this phase (data from Levy (48)).
(V) Globalization of the System and merging of core and non-core.	Starting 1941	KA/War dynamics - the European and Asian VC/KA-clusters - become connected on a global scale.	Japan attacks the United States (Pearl Harbor, 1941), and Germany (ally of Japan), declares war on the United States, connecting war clusters in Europe and Asia.

The 1480-bifurcation started the 1st FTS (1480-1945), including phase (I) of the process of expansion. However, during phase (I), there was no expansion to the non-core, which involved non-systemic KA/war. The "War of 1812", initiated phase (II) of the process of expansion and was the first non-systemic KA/war outside of the core, involving a European Great Power (data from Levy (48)). The "War of 1812" was the first expansion war of a series of nine, until 1939.

Figures 31.1 until 31.5, visualize the five phases of the process of expansion (1480-1945).

From the perspective of the contingent domain, the expansion process to the non-core can be understood as attempts of European societies/states, to enhance their capacity to (better) fulfill their basic requirements and achieve more power and influence to 'position' themselves in core dynamics (in relation to other European states in Europe).

The expansion of core states to the non-core can be considered an energy 'input' for the core of the System; however, this input/import of energy into the core of the System was accompanied by "exporting" rivalries among European states to the non-core. It was only a matter of time before the non-core developed its own 'autonomous' entropy and free energy, which led to the import of non-core entropy and free energy into the core.

The processes of aggregation and expansion were complimentary and reinforced each other, see tables 31.2 and 31.3 and figure 31.6.

Analysis of KA/war data shows that the process of aggregation in the core (Europe) and the core's expansion to the non-core were highly synchronized, not only from a 'functional' perspective (such as in the self-reinforcing nature of the integration/expansion processes) but also with respect to the pace at which both processes unfolded; both processes - the processes of aggregation (integration) and expansion - unfolded in concert, with about the same pace. This should not come as a surprise: Both processes were 'powered' by the entropy-production in the core of the System (Europe), and were regulated by the 1st FTS (1480-1945).

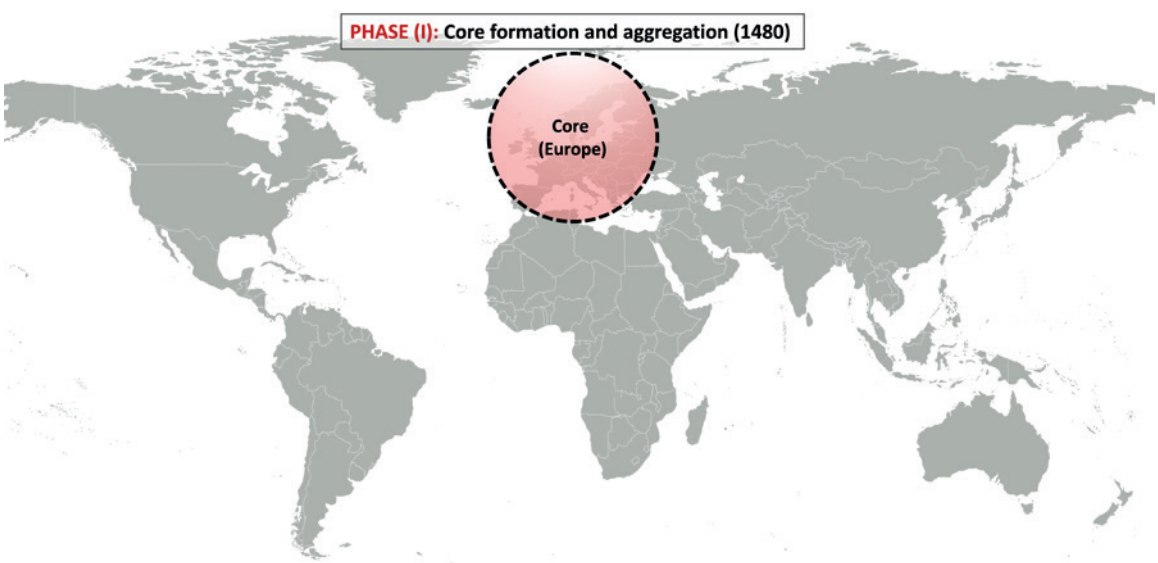


FIGURE 31.1: Phase (I) expansion.

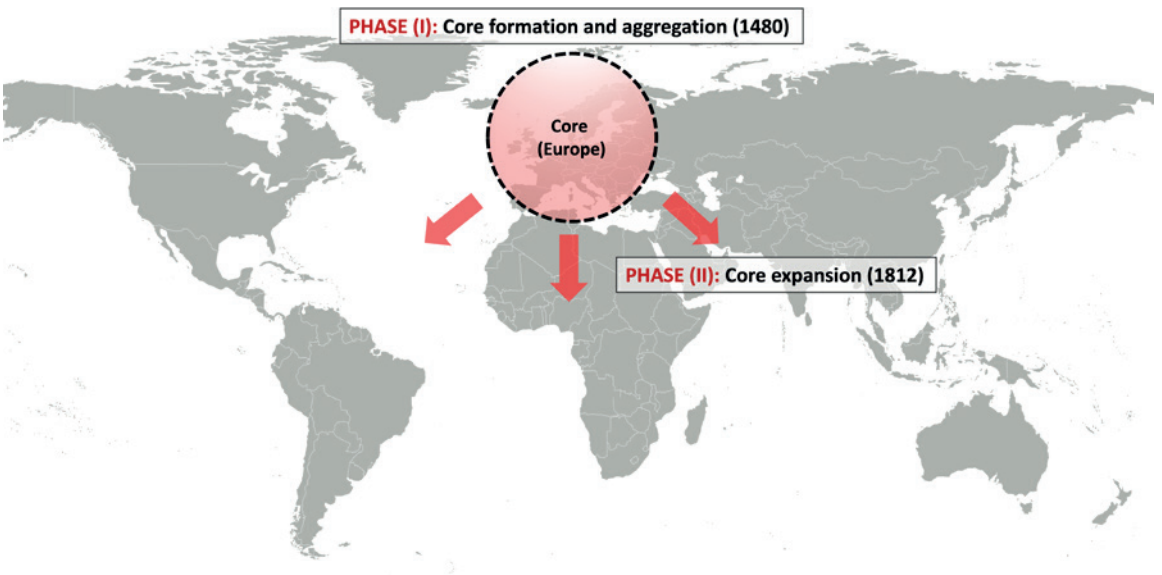


FIGURE 31.2: Phase (II) expansion.

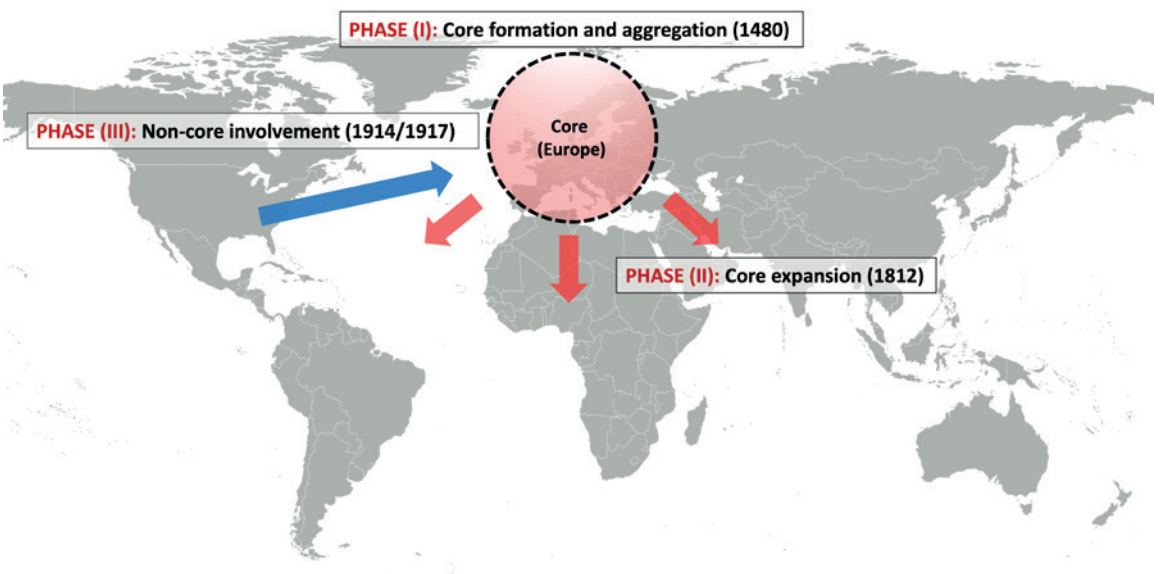


FIGURE 31.3: Phase (III) expansion.

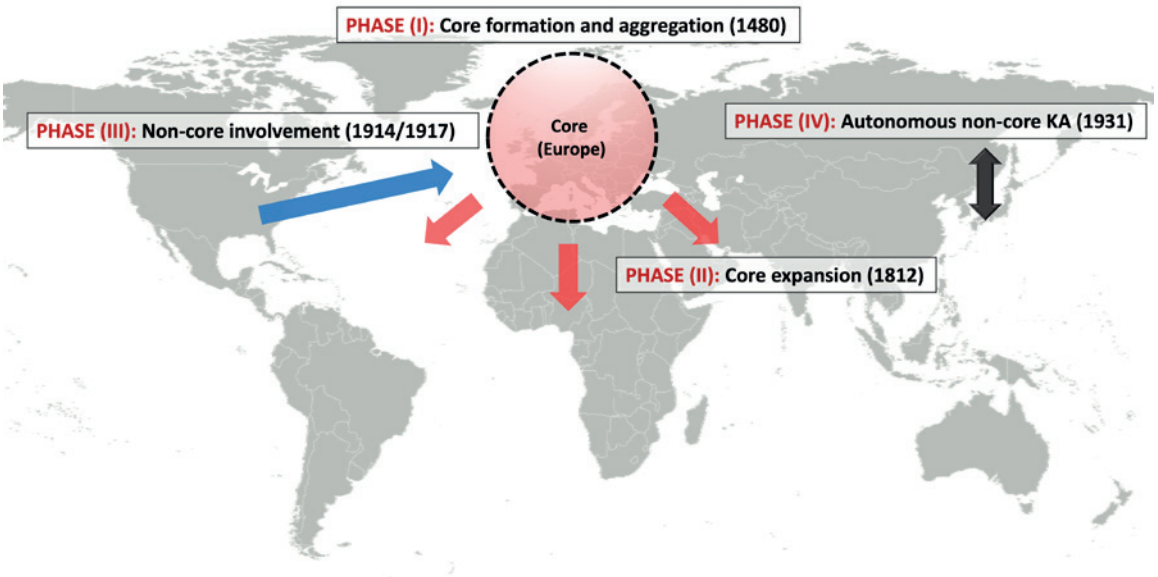


FIGURE 31.4: Phase (IV) expansion.

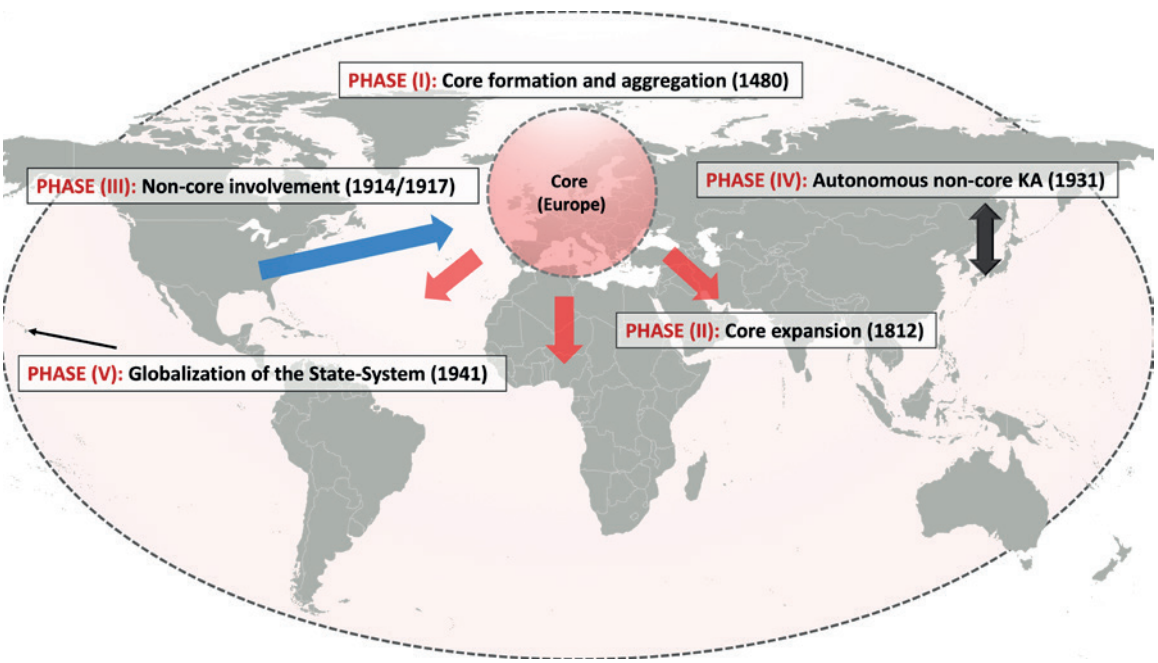


FIGURE 31.5: Phase (V) expansion.

TABLE 31.2: Phases in the expansion of the core, and their duration (1480-1945). The globalization of the State-System was accomplished in 1941; = 1941

Phase	Start date ($T_{Start\ phase}$)	Time to globalization ($T_{Globalization} - T_{Start\ phase}$)
(I) Core formation and start aggregation.	1480	461
(II) Core expansion.	1812	129
(III) Autonomous non-core formation and active involvement in core.	1914	27
(IV) Non-European powers autonomously produce their own war dynamics.	1931	10
(V) Globalization of the System and merging of core and non-core.	1941	0

TABLE 31.3: Duration of the respective cycles of the 1st FTS and of respective phases of expansion (1480-1945).

	Aggregation $T_{Critical} = 1939$		Expansion $T_{Globalization} = 1941$	
Cycle/Phase	$T_{Start\ cycle}$	$T_{Critical} - T_{Start\ cycle}$	$T_{Start\ phase}$	$T_{Globalization} - T_{Start\ phase}$
1	1480	459	1480	461
2	1648	291	1822	129
3	1815	124	1914	27
4	1918	21	1931	10

TABLE 31.4: Expansion wars 1st FTS (1480-1945). based on data from Levy (46).

	Number Levy	Name	Period	Great Power involvement
1	88	War of 1812	1812-1814	England
2	97	Anglo-Persian War	1856-1857	England
3	99	Franco-Mexican War	1862-1867	France
4	104	Sino-French War	1884-1885	France
5	105	Russo-Japanese War	1904-1905	Russia
6	109	Manchurian War	1931-1933	Japan
7	110	Italo-Ethiopian War	1935-1936	Italy
8	111	Sino-Japanese War	1937-1941	Japan
9	112	Russo-Japanese War	1939-1939	Russia, Japan

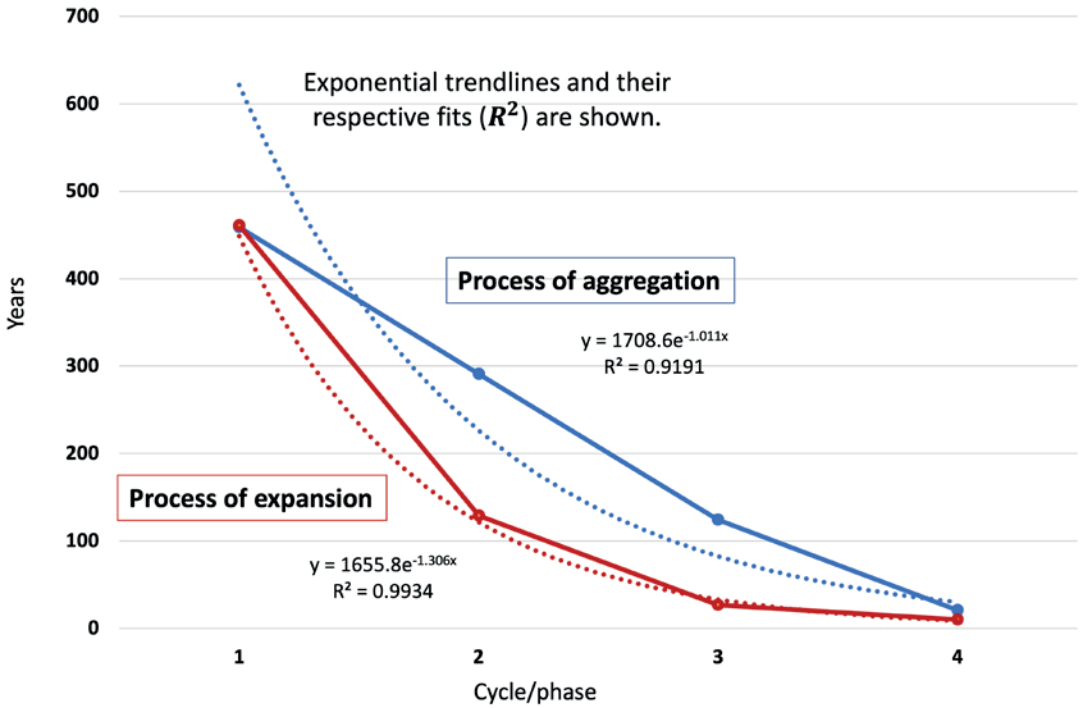


FIGURE 31.6: Consistency of the processes of aggregation and expansion. This figure shows the acceleration of the processes of integration (blue) and expansion (red), during the transient period (1480-1945). For data, see table above. The figure shows that both processes accelerated at about the same rate. It confirms the close relationship between both processes; a relationship that was to be expected, given their complementarity as supporting processes of the 1st FTS. The correlation coefficient of the two series is 0.93, which is not only indicative for a statistical relationship, but arguably also for a causal relationship.

31.4. Expansion KA/wars during successive cycles of the 1st FTS (1480-1945)

During the four relatively stable periods the (State-)System produced respectively 45 - 34 - 21 - 6 (in total: 106) non-systemic wars. A closer look, reveals that nine of these wars, concern the expansion of the core of the System to non-core territories, and autonomous non-core KA/war dynamics states in the non-core produced.

In table 31.4 I specify these wars.

Although the 'War of the American Revolution' (war number 81 (1778-1784) in Levy's dataset (48)) took place outside the core of the System (outside Europe), I do not consider this war an 'expansion war', but

foremost a European War that was fought outside the core of the System. Contrary to the nine expansion wars (mentioned in above table), three Great Powers were involved in the 'War of the American Revolution': France, England and Spain[4].
The "War of 1812" I consider the first expansion war the (State-)System produced (1480-1945) and which started phase (II) of the process of expansion (for a KA-perspective).
Based on this distinction, two categories of non-systemic KA/wars can be distinguished: Non-expansion wars (97 in total) and expansion wars (9 in total).
It is possible to calculate the proportion of expansion wars of the total number of non-systemic KA/wars produced by the (State-)System during respective cycles (see table 31.5). The calculations show, that during the 4th RSP (1918-1939), four out of six non-systemic KA/wars were expansion wars.
Analysis also shows that the proportion of expansion wars during the transient period (1480-1945), increased exponentially, see figure 31.7.

TABLE 31.5: Proportion of expansion wars during successive cycles (1480-1945).

Cycle	Non-systemic wars (total)	Expansion wars	Proportion (expansion wars)
1	45	0	0,000
2	34	1	0,029
3	21	4	0,190
4	6	4	0,667

In both cases - if expansion of the core is defined in terms of phases (see previous paragraph) and in terms of an increase in the proportion of expansions wars during cycles - the increase is exponential.

31.5. Expansive tendencies of societies and states

Adams (3) studied the expansive tendencies of societies and states, especially of Great Britain, during the 19th and early 20th century. These tendencies are of closely related to the necessary expansion of the core to the non-core, the process driven by the 1st FTS, to ensure adequate EMIS-exchanges and regulation. Adams observes that "one form this expansion takes is in the appearance of new social structures; in thermodynamic terms, new dissipative structures" (3). The 'emergence' and development of the United States for example, can be understood as such.

4. I consider the "War of the American Revolution" (1778-1784, Levy, no. 81), involving three Great Powers (France, the United Kingdom (Great Britain) and Spain) a core (European) non-systemic war, and not an expansion war. The first war that qualifies as an expansion war was the "War of 1812" (1812-1814, Levy, no. 88).

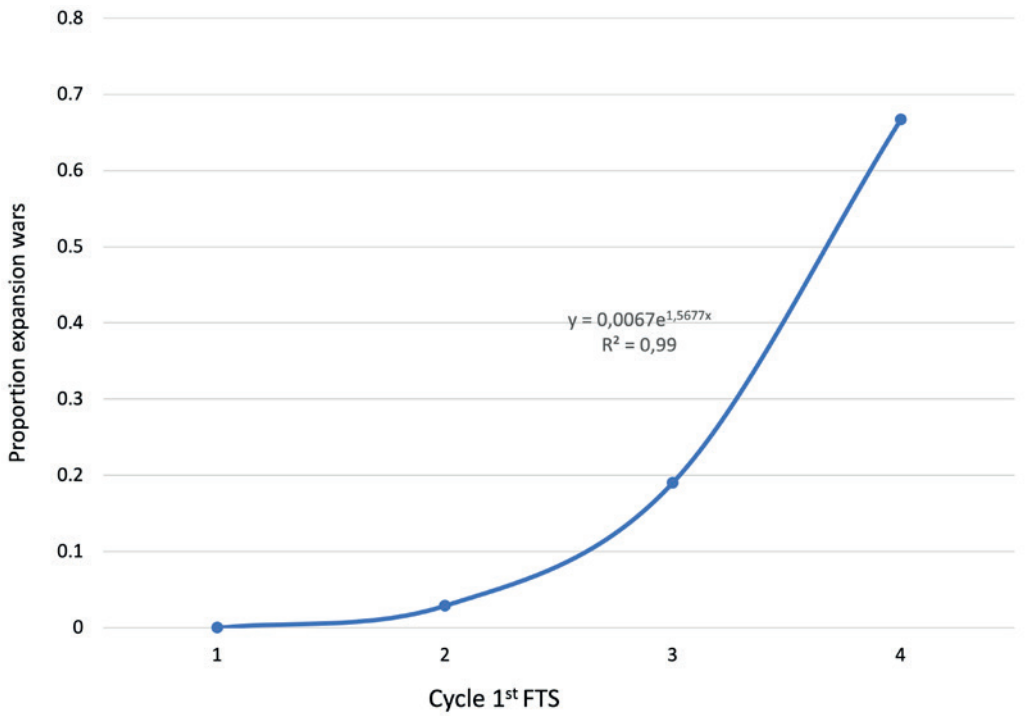


FIGURE 31.7: Exponential growth of the proportion of expansion wars, during the four successive cycles of the 1st FTS (1480-1945). The fit of the trendline () is based on cycles 2-4.

Adams study and observations concern the contingent domain, and especially economic expanded. Adams' observations contribute to our understanding of the interactive' development of the core and non-core of the System, during the transient period (1480-1945), and how 'step-by-step' homeostatic control develops.

Adams observes, that "during this expansive era, Great Britain increasingly incorporated more and more of the environment into itself. (..) It used up much of its forests, then started in on coal and iron. At the same time, it gradually filled the islands more heavily with people and carved the landscape-cluttering it with industrial and urban structures, slicing it with railroads, blotching it with slag heaps. Of equal, if not greater, importance was the reach into foreign areas where it captured products and began the heavy dependency on imports that marked British survival from the eighteenth century onwards" (3). Great Britain in this era was a great expanding dissipative structure, consuming increasing amounts of energy. Dissipative structures are not just "bulwarks or inhibitions against the loss of energy or the increase of entropy. (..) On the contrary, they hasten the expenditure, conversion, and transformation of energy" (3); Not only was (for example) British society an example, but also the FTS. The FTS and the State-System are 'vehicles' that accelerate the transformation and (purposive) use of energy and ensure that thermodynamic equilibrium is achieved as efficient as possible.

Adams also discusses the setting up of an infrastructure that supported core / non-core interactions and exchanges, from the perspective of Adams, the drivers were economic (profitability).

I quote from Adams (3): "Not only colonies, but also the United States and European and Latin American sovereign countries were the recipients of services and exported capital. As the first industrial nation, Britain contributed both to the building of the areas that could demand her exports and to developing the foreign capacity to produce the imports she increasingly needed. Quite naturally, the maturing of foreign markets and producers gradually changed them from dependents to competitors".

"As foreign markets expanded, Britain's external constructions moved elsewhere. Between 1870 and World War I, her foreign investments gradually shifted from Europe to empire countries, especially to Canada, Australia, and New Zealand".

"In expansion a very important process involves the structure and its environment. In a successful structure effective and presumably correct ways to control its output enable the structure's environment to provide the inputs necessary for the structure. A structure must exercise certain controls over its environment and bring it into a systematic relation to itself for this process to work. The relations between the structure and those portions of the environment will affect each other. They, together with the structure, begin to form a new larger structure, an arrangement composed of previous structures as they become modified, plus new elements and relations that emerge as parts of the newly emerging whole. *(IP: Adams describes how core states became increasingly connected to the non-core and vice versa)*. In this way a new and larger structure comes, into being, and, as this new, larger structure confronts its own environmental problems, it too undertakes to adapt this environment to meet its input and output needs (3). If we look at Britain as a society that was expanding significantly—expanding home production, imports, exports, earnings, credits abroad, and population—we must also look at the outside environment that allowed this. Markets do not just appear when goods arrive, and capital is by definition low in underdeveloped areas. In fact, Britain had to underwrite the Creation of much of this environment".

"I *(IP: Adams)* would argue that Great Britain underwent a deceleration in energy per capita consumption in the late nineteenth century because as the first industrial nation, she had to create a worldwide, industrially oriented environment, indispensable to continuing as an industrial power. She had to create an environment, at the international level, which would provide the necessary external inputs, and which would be willing to accept outputs. In doing this, she quite wittingly exported machinery, technical expertise, patent rights, and capital- as well as labor - that helped initiate the emergence of industrial organization elsewhere in the world. This export is very apparent in the early nineteenth century but continued unabated in later years and increased just before World War I. The construction of an environment appropriate to Great Britain's interests must have appeared appropriate to the individual investors, for the foreign enterprises often paid very well. It also fitted industrial interests needing foreign markets, and it fitted interests of the workers by inhibiting governmental interference in their attempts to obtain a more prominent share of the obviously growing wealth. The dialectic, however, in the process was that this very outpouring of British goods made it possible for the social environment to develop outside, and especially for Germany and the United States to hasten their own development so that by the end of the century Great Britain had dropped into second place in many major indices of production and development. The environmental construction to which Britain was contributing was the economic development of the world, and this development necessarily included her future competitors, competitors that already had resources that Britain did not have and were developing others. To these native advantages they were able to add that which Britain exported."

"What Britain was building was a worldwide social structure that, on the one hand, necessarily led to her own slowdown but, on the other, was unquestionably essential for her own survival. She was building

survival devices or mechanisms, which, if we see them as parts of an emerging whole, we can regard as a kind of survival vehicle; an extensive social, political, and economic complex that would both sustain and supply her" (3).

This logic was also applied by its rivals. This development - the need for states to expand to the non-core - further fueled rivalries (also in the core), while at the same time mutual interdependencies - also the shared interest for a functioning order - increased.

"At the same time, it required that she make important internal readjustments - among which were those resulting in a deceleration in the growth energy consumption per capita. To see this change in a larger, theoretical perspective, we must jump to a totally different social context. Human individuals in their growth and socialization spend a great deal of time trying to rearrange the environment, to change their own patterns or behaviors, to cope better with their surroundings, to assure that the resources they will need for survival will be available when they need them and that the environment will accept the outputs that they are capable of giving. In doing this they use a number of survival vehicles. Most of those that they use in the early years of life already exist. The first social survival vehicle is the organic womb of the mother. Immediately upon birth, infants enter a more complex social unit, the domestic unit. This unit provides nutrients, affection, physical care, and the training that is to equip them to survive as adults. Later, play groups and social groups teach skills in interpersonal relations. Schools and churches incubate further social skills but also specifically try culturally to train the nervous system in prescribed ways, to program the individuals to react in a limited series of ways. Later still, business or industrial organizations, governmental or private agencies, provide income. If these seem inadequate, other groups, labor unions or political organizations, may be sought to find redress or supplemental help. All these social groups or units may be seen as social survival vehicles, created collectively at some time to help in the survival of the individuals who initiated them. A survival vehicle_is, then, in the first instance a social assemblage that is brought into being by individuals to better the conditions of their own survival. It is a larger dissipative structure, within which the individuals may hope to be buffered against harsher elements of the environment and to receive specific things that they need. Vehicles will, however, follow their own evolution. Some expire rapidly; others may become of special interest to a few of the members. The leaders (for example, the parents in the domestic unit, the teachers and administrators in the schools and universities, religious leaders in churches, the owners and managers of businesses, and the labor and political leaders) all have a particular interest in the survival of the vehicles. Thus, the survival vehicles often incorporate mechanisms leading to their own perpetuation. As such units become self-organizing and self-maintaining, they also will incorporate elements that can lead them later to launch into a trajectory of expansion or to be limited in what they do. This development, of course, means that the very survival vehicles that individuals have helped to construct may be taken from their control (if they were ever in their control) and may follow a path that is in fact against the best
interests of individual members."

"Thus, survival vehicles, once in being, become autonomous and independent of the interests of the individual members. On reflection, it is apparent that the notion of a hierarchical nest of survival vehicles, dissipative structures that have emerged out of collectivities of lesser dissipative structural components, satisfies the problem of both individuals and social organizations, operations with their own dynamics, within a single conceptual model. With them it is possible to see a social organization (1) as an outgrowth of the activity of its individual component parts down to and including the individual human beings and their individual nervous systems and genetic structure, and (2) as a system of social

parts operating on a level of their own in response to the environment as seen at that level. Reductionism is not a problem here because the model entertains the factors that operate both from the lower levels and from the collateral elements at the higher level. Moreover, it allows us to pursue the emergence of new levels with the same multiple perspective. Although space does not allow me to go into the details here, the hierarchical structuring of survival vehicles can also reveal how counter-organizations or counter-vehicles emerge and the individual dynamics behind them, as well as the emergent controls from various levels. From the point of view of energetic analysis, each vehicle and each hierarchical nest of vehicles must be seen as a separate dissipative structure. Each operates through a required input of human energy and material resources; each is an energy conversion mechanism. Each also operates through an organization of power relations, an organization of nervous systems, communication systems, triggers, and so on. These microflows of energy act as control devices, catalysts, inhibitors. They direct and constrain the decisions and actions of the individuals involved. Each survival vehicle must both ensure its own inputs and be constantly concerned with output policy, the effect of its actions and products on the social environment and the physical environment. Survival vehicles are complex social units operating in fluctuating environments and, as such, experience natural and often unpredictable fluctuations on their own part. Not only can the amount and kinds of energy that are expended and channeled by these survival vehicles be calculated, but we should also initially assume that the laws of thermodynamics are as applicable to these processes as to those observed in nonhuman biological activities. Thus, we should expect, following Cottrell, that where vehicles are using increasing amounts of energy, the amount required for the maintenance of a survival vehicle will increase more rapidly than the increase in total energy flow of the vehicle. We should also expect, following Margalef, that as vehicles of greater scope come into being, they will do so by the systematic exploitation of lesser vehicles, including especially those that compose them *(IP: These - and related subjects - I discuss later, in relation to social evolution)*. They will take more energy away from the lesser vehicles, especially in the form of controls. They will compete with other units, other vehicles—often of quite different kinds—for resources."

"The question now is, why should we make something of the emergence of new structures? The answer, in brief, is that the appearance of new structures implies the appearance of an assemblage of parts that contain their own deterministic order or laws of behavior.

A structure can only be explained in terms of a recounting of the parts and the natural behavior of those parts. So long as each member of the assemblage acts in terms of the behavior of the component parts and each responds to a given set of unstructured conditions, then the total behavior must be couched in reductionistic terms that relate to those circumstances. When the assemblage takes on its own emergent behavior, however, then the new behavior can no longer be explained solely in reductionistic terms. Rather, explanation concerning the whole new structure now must be couched in terms that relate this new behavior to the set of conditions in which it occurs. This fact has been recognized in the larger scope of human knowledge: "Scientific knowledge is organized in levels, not because reductionism in principle is impossible, but because nature is organized in levels, and the pattern at each level is most clearly discerned by abstracting from the detail of the levels far below. (The pattern of a halftone does not become clearer when we magnify it so that the individual spots of ink become visible.) And nature is organized in levels because hierarchic structures - structures of Chinese boxes - provide the most viable form for any system of even moderate complexity *(IP: Simon (77))*."

"The argument in this paper has been that expanding social systems are entirely a part of nature and that their ultimate elements are no different from those composing the more easily visible physical world. Their inevitable expansion carries the emergence of higher levels of hierarchy, and these must

be recognized as real dissipative structures that will take on their own behavior. In the present case, the lesser components lose their autonomy of action; they lose the ability to respond individualistically to an unstructured environment because they now confront one that is structured. In the nature of social structure, they become subordinated to the larger expanding dissipative structure that encompasses them.

Thus, not only the individual vehicles, but also the expanding hierarchy of vehicles, will grow and decline in conformance with some known principles. We need to delineate the energy processes involved and identify the control and work roles of the various component structures as they operate in, take form, and contribute to the larger environment and the emerging structures therein. If we do this, I believe it may be possible to understand better the alternatives open to them. I am not suggesting that we can eliminate the indeterminism in all complex processes, but I suspect that there are consistencies in these emergent structures that, coupled with the fact that we are the "molecules" that compose them, suggest a potential for understanding emergent social dissipative human structures in a manner that may not be possible in physical, chemical, or genetic structures."

"There are many problems that confront us in understanding the emergence of these structures; let me mention only two. First, we have little comprehension of the circumstances of when and where such higher structures emerge. It may be argued that the process is essentially indeterministic and that it can occur through the re-channeling or rearrangement of energy within a system (i.e., it need not require additional inputs from the outside) and, therefore, may be the result of an entirely unpredictable fluctuation within. It may also be argued that the process can only occur with any stability through the increase of the energy output of the substructures and, thus, might be reducible to a deterministic theory. Second, we do not know much about the immediate evolution of an emerging structure, whether its appearance requires some specific sequence of steps or stages of formulation. For example, I would tend to argue that the emergence of the larger industrial, capitalist world structure, to which Britain made such an important contribution in the late nineteenth century, is still an uncentralized, coordinated arrangement. As such, it would have to be regarded as essentially amoral, incapable for the moment of making decisions as to what was best for itself. I would also argue, however, that the direction was towards higher-level centralization within that structure that would result in its own morality, displacing that of the separate nations and firms operating within it. Thus, the experiments with world organizations during the twentieth century reflect attempts to seek a more centralized order, as do the many regional bloc arrangements. Given these arguments, it follows that, of the two suggested explanations of the emergence, I would be inclined toward the second, that the emergence was the result of increasing energy and, therefore, was to some degree deterministic" (3).

I show in this study, that this is indeed the case for the (State-)System.

31.6. Application (1): Expansion of European control

Another clue to the expansion of the core (Europe) to the non-core, is the expansion of control of European states, of the earth's land. According to Tilly, "European states held political control over approximately 7 percent of the earth's land in 1500, 35 percent in 1800, and 84 percent in 1914" (91).

Interpolation, of these three data-points - assuming a smooth increase during the period 1500-1914 - gives the result shown in figure 31.8.

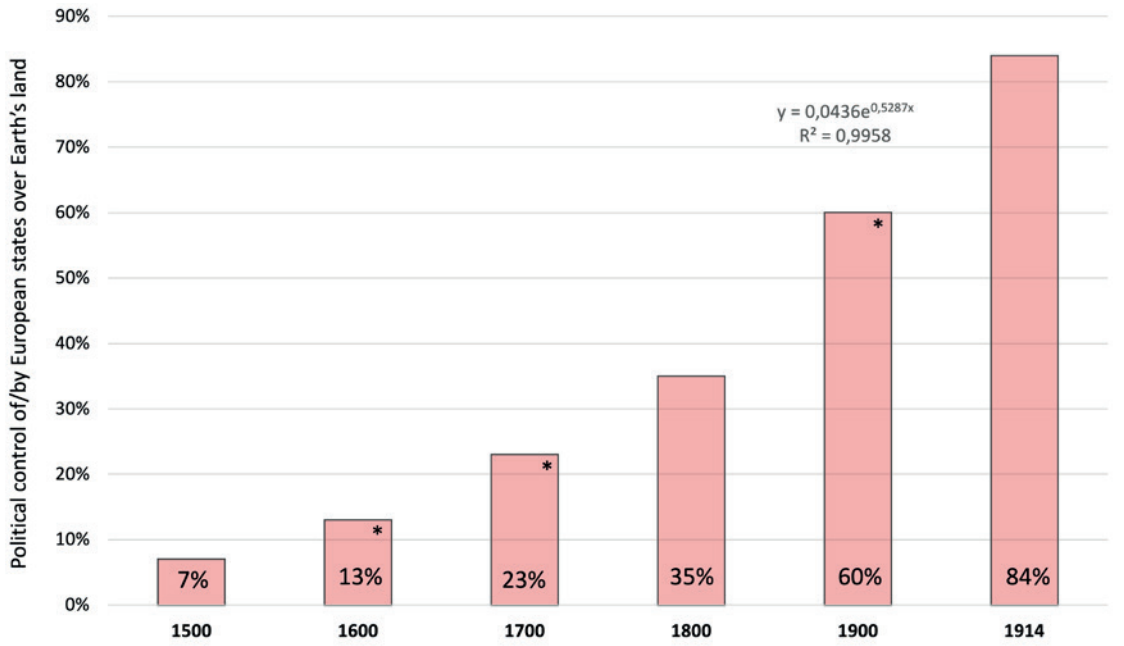


FIGURE 31.8: Exponential increase of political control of European states of Earth's land (1500-1914). * means the data is acquired through interpolation. The trend can be best described with an exponential function, with = 1.00. The correlation coefficient of both datasets {1500, 1800, 1914)} and {7%, 35%, 84%} is 0.92.

The observation that the political control of European states grew exponentially, is consistent with the exponential expansion of the core to the non-core.

The expansion (of control) not only concerned territories, but also the actual political control in colonies European states acquired; over time, control increased from superficial trade-relationships to full political control/exploitation of colonized territories.

Part VI

Introduction

In Part VI, I discuss the 2nd FTS which emerged after the (first) phase transition was accomplished in 1945. However, as I explain, initially, the global (State-)System produced a 2nd exceptional period from 1945 until 1989; better known as the Cold War. Although there are some differences between the 1st and 2nd FTS's and the 1st and 2nd exceptional periods, the consistency of the (State-)System is remarkable.

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32. Start-up of the 2nd FTS
33. Abnormal war dynamics during the 2nd exceptional period (1945-1989)
34. Resumption of chaotic non-systemic war and assessment of the current cycle (1945-....)

32. Start-up of the 2nd FTS

32.1. Introduction

During the period 1480-1945, the EMIS in the (State-)System, was regulated by the 1st FTS, a dissipative structure that was accompanied by four accelerating cycles and was instrumental in accomplishing a phase transition with two effects: Full aggregation (stage 3A) of the European State-System (the core), and simultaneous merging of the core and non-core into a global State-System. Consequently, the dynamics of the System 'scaled up' and the core of the System - the former European State-System - achieved thermodynamic equilibrium (albeit with a delay until 1989); inequalities (barriers) were eliminated in the core. In this state of thermodynamic equilibrium in the former core, free energy (military capabilities) could no longer perform useful work; the Second Law enforced uniformity (a process the United Kingdom chose to abolish (Brexit)). In Europe there were no longer differences in energy kinetic states; kinetic energy (military capabilities)/ KA had become obsolete as a useful regulator.
Analysis of war-data reveals that after an intermediate period - a 2nd exceptional period (1945-1989) - the global (State-)System resumed chaotic non-systemic KA in 1989, and is now producing a 1st KA/war-cycle at a global scale; analyses also suggests that the global (State-)System is producing a 2nd - global - FTS, with an identical aim as its predecessor, but at a different scale: To achieve thermodynamic equilibrium in the global State-System.
In this chapter, I discuss the initial start-up of the 2nd FTS, following the phase transition (1480-1945). Several conditions, impacted on the start-up of the 2nd FTS, including: the (initially) dysfunctional mode-coupling of the 2nd FTS, caused by intense rivalries between the United States and the Soviet Union (1945-1989), which is related to the vacuum the phase transition had produced in the (former) core. The 2nd FTS also had (and has) to develop a suitable environment to ensure EMIS-regulation and its sustainment.
This short chapter only provides an overview; these subjects will be discussed in more detail, in the chapters that follow.

32.2. Problematic start-up

This study shows that the emergence and sustainment of a dissipative structure - a FTS - require several conditions, including: A thermodynamic state FFE, mode-coupling, the organization of the (State-)System in hierarchically organized clusters (consisting of societies/states that already have achieved homeostatic control), drivers (population growth etc.) and a certain interplay between competing thermodynamic potentials that can serve as an 'engine'.
It seems that not all conditions were immediately met in 1945, and that some time (until 1989), was required for the 2nd FTS to become fully 'operational': Start-up of the 2nd FTS was in particular hindered by

the intense rivalries at a global scale between the United States and the Soviet-Union, which impacted on the mode-coupling of the global (State-)System, and consequently on the ability of the global (State-) System to regulate EMIS-flows efficiently.

32.3. Analysis of war-data

Analysis of war-data concerning the period 1945-2018, shows that it is possible to identify two distinct periods: A period from 1945-until 1989, and a period that started in 1989.
During these two distinct periods, the properties of non-systemic KA/wars were fundamentally different: During the period 1945-1989 (designated as the 2nd exceptional period, better known as the Cold War) non-systemic KA/wars was highly suppressed, while starting in 1989, the (State-)System resumed chaotic non-systemic KA, but now at a global scale.
Analysis of war-data also shows that the global (State-)System reached a tipping point in 2011; this is the tipping point of the 1st global KA/war-cycle (1945-....).
From 2011 onwards, the global (State-)System is in the HCR of the 1st global RSP (1945-....), and entropy started (and still is) accumulating in the global (State-)System.
The 1st global order (the United Nations, 1945-....) has become increasingly dysfunctional and the order no longer reflects the actual distribution of power and influence in the global System.
Despite the distortions caused by the 2nd exceptional period (1945-1989), a fully operational 2nd FTS is now in place and regulating EMIS-flows at a global scale. I assume that the purposes of the 2nd and 1st FTS are identical: To achieve thermodynamic equilibrium of /in respectively the European and global State-System.
The 2nd global FTS can be considered an enlarged "specimen" of the 1st FTS (1480-1945). Through the phase transition - and by utilizing and developing the non-core in the process - a 2nd FTS and a global State-System could (1941-1945) replace the 1st FTS and the European State-System. This process involved: (1) The destruction of the European State-System (1939-1945) and 1st FTS; (2) the creation of a 'vacuum' in the (former) core (Europe); (3) the filling of the vacuum by the non-core, and (4) a process of recovery (1945-1989) that 'delayed' the start-up of the 2nd FTS until 1989.
Although, the 1st FTS had during the transient period (1480-1945) created an enlarged specimen of itself through a process of expansion, there is one - probably very significant - difference between both FTS's: the 2nd (global) FTS – at least at this stage – still lacks a suitable environment - an environment equivalent to the non-core of the 1st FTS - that allows for the exchange ("dumping") of excess-entropy.
As I explained in the previous chapters, the non-core (the rest of the world) was essential as a 'supercharger' of the process of aggregation in the core (Europe), and essential for EMIS-regulation of the European State-System (1480-1945). The 2nd FTS also needs a suitable environment to be able to sustain its operation. Efforts to colonize space - which started at the inception of the 2nd FTS (1945) - can be considered attempts of the 2nd FTS to create a suitable environment, required for the sustained and accelerating dynamics of the 2nd global FTS.
This subject - the need for a suitable environment - I discuss in the next chapters.

32.4. Phases in the development of the System

It is possible to distinguish four phases in the development of the System, when the 2nd exceptional period is taken into consideration as an intermediate phase: See table 32.1 and figure 32.1.

TABLE 32.1: Phases in the development of the (State-)System. This table shows the four phases that can be distinguished in the development of the System.

	Phase	Timings	Remarks
I	An unorganized and increasingly unstable state.	< 1480	Start of an uncoordinated process of aggregation and expansion of European societies/states.
II	An organized state involving a core (Europe) and non-core, regulated by the 1st FTS (a dissipative structure) that was instrumental in a phase transition resulting in the full aggregation of the core and merging of the core and non-core. i.e. the globalization of the (State-)System.	1480-1945	The actual transition to a global State-System took place during the 4th systemic war (1939-1945, the Second World War), the final stage of the phase transition (1480-1945).
III	An intermediate phase: The 2nd exceptional period (Cold War).	1945-1989	Required for recovery and start-up of the 2nd FTS.
IV	The 2nd FTS is fully operational: Resumption of chaotic non-systemic KA/war dynamics.	> 1989	The 2nd FTS is in the process of producing a 1st KA/war-cycle.

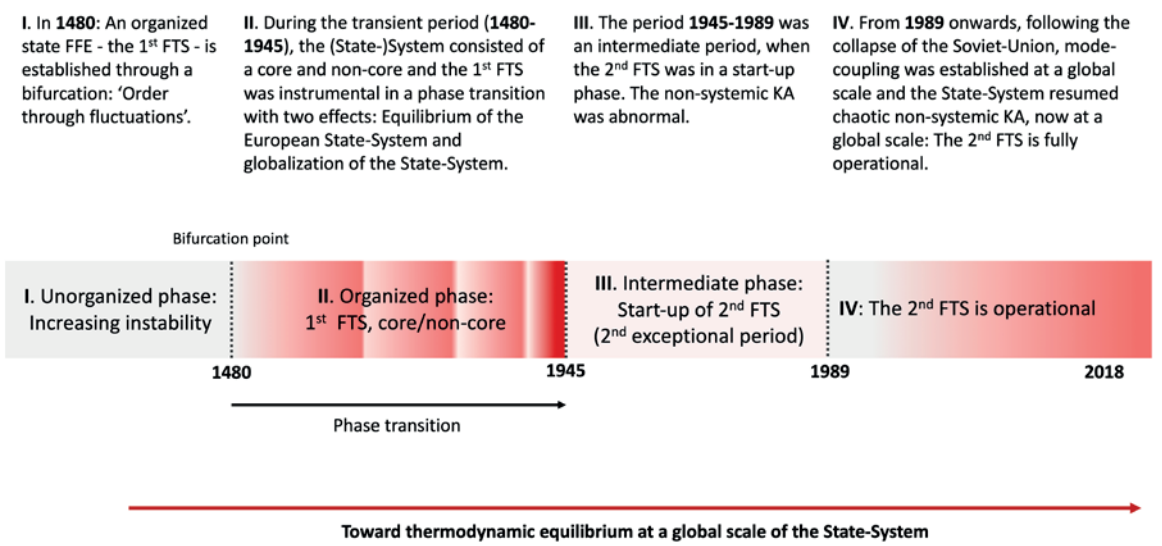


FIGURE 32.1: Phases in the development of the (State-)System.

32.5. Application (1): Same dynamic, but different order

It is important to keep the distinction between the deterministic and contingent domains of the (State-)System in mind. In above paragraphs, the deterministic properties of the (State-)System and their development were discussed. What social and political events and developments accompany the (highly) deterministic flows of energy and entropy in the contingent domain - and what political order is implemented - is as long as the Second Law and related principles that apply are obeyed not relevant.
The Second World War (1939-1945) was the contingent appearance of the 4th systemic KA/war of the 1st FTS; the United Nations order is the contingent appearance of the order of the 1st RSP of the 2nd FTS.
The contingent appearance of the 4th systemic war (the Second World War, 1939-1945) and the 1st global political order it produced (the United Nations order) could have been different, assuming that the alternatives would fulfill the thermodynamic requirements (obey the S-imperative). An aggregated order - a unified Europe - would also have been achieved with a German - fascist - order, or a Soviet-controlled communist order, assuming that these orders would have been able to acquire the necessary stability after Germany or the Soviet Union had acquired physical control over Europe.
Such a scenario could have unfolded if for example the United Kingdom would not have been able (or willing) to withstand German aggression, the United Kingdom had agreed upon a settlement with Germany, the United States would have refrained from intervening in Europe, the Allied landings in Normandy (6 June 1944) had failed, or the Soviet Union had reached the Atlantic coast in 1944, etc.
The outcome was a result of the interplay between probabilistic and deterministic factors in the (State-) system; and a combination of these factors will also determine the outcome of a next systemic KA/war.

33. Abnormal war dynamics during the 2nd exceptional period (1945-1989)

33.1. Introduction

During the transient period (1480-1945), the 1st FTS produced four accelerating war-cycles and accomplished a phase transition of the European State-System (core) to thermodynamic equilibrium (aggregation stage 3A).
Analysis of war-data shows distortions of the non-systemic KA during the period 1657-1763, during the RSP of the 2nd cycle (1648-1815), of the otherwise very regular and consistent *chaotic* non-systemic KA dynamics, during other RSP's of the 1st FTS. These distortions - the abnormal periodic war dynamics during the 1st exceptional period (1657-1763) - were discussed in chapter 30.
In this chapter, the abnormal war dynamics during the 1st cycle (RSP) of the 2nd (global) FTS (1945-....) are discussed. The abnormal non-systemic KA started in 1945 and stopped in 1989. I refer to this period as the 2nd exceptional period, better known as the Cold War.
In this chapter, I discuss various subjects related to these abnormal dynamics, including: Their cause and effects, the similarities and differences with the abnormal KA/war dynamics during the 1st exceptional period, and what (further) insights these abnormal KA/war dynamics during the 2nd exceptional period reveal about the now global (State-)System.

33.2. Recapitulation

During the (1st) transient period (1480-1945), the 1st FTS was instrumental in a phase transition of the European State-System to thermodynamic equilibrium; the 1st FTS was accompanied by four accelerating cycles. The critical point of the European State-System was reached in 1939: At that point the core (Europe), produced infinite amounts of entropy and KA. The European State-System consequently collapsed, and the phase transition entered its last stage; the 4th systemic war (the Second World War, 1939-1945).
The phase transition had several effects: The European (State-)System – the core - reached full aggregation (stage 3A) and the core (Europe) and a non-core ('the rest of the world') of the System simultaneously

merged into a global State-System. The non-core achieved equivalent status with the (former) core, and European states lost control over their non-core territories (colonies); the non-core societies adopted sovereign state-structures.

By means of the 4th systemic war, the first global order - the United Nations (UN) - was implemented, of which all societies with state-structures (that met the UN-requirements) could become 'member'.

Although the preconditions for full aggregation of the core, the merging of core and non-core and full equivalence of non-core societies/states were fulfilled, the actual implementation - institutionalization - of these fundamental changes still had to be accomplished and cost time.

Although through the destruction of the European State-System, barriers were eradicated that had hindered the accomplishment of thermodynamic equilibrium (full aggregation) in the core, the phase transition (1480-1945) had (also) created a vacuum in the core. It was problematic for European societies to fulfil their basic requirements and to ensure their survival, because of the destruction caused by the KA.

The vacuum that was created in Europe, was 'filled' by the United States and the Soviet Union: Western European states were physically occupied - and controlled - by the United States, while eastern European states were controlled by the Soviet Union.

As was the case with the three preceding systemic KA/wars, the 4th systemic war was also used by the most dominant Great Powers to establish a favorable order (but now at a global scale), that contained and embedded certain privileges for them in particular. The new configuration of the (State-)System was institutionalized through the United Nations order. The dominant Great Powers acquired permanent membership of the Security Council of the United Nations, including a veto-right, and ensured a (a later stage) 'legal' monopoly over the possession of nuclear military capabilities in the (State-)System. The scale of the (self-)destruction caused by the 4th systemic war in Europe (the former core), but also in Japan, gave the two most dominant Great Powers extra leverage to shape the (State-)System - and their spheres of influence – to secure and promote their own requirements and interests.

The state of the (State-)System – especially of the former core - in combination with the dominant positions of the United States and the Soviet Union and their rivalries, affected the functioning of the global (State-)System and the ability of the (State-)System to (immediately) produce a working 2nd FTS, with a global reach. The rivalries between the United States and the Soviet Union - supported by the respective societies/states these two dominant Great Powers controlled - quickly escalated, and (full) mode-coupling could consequently not be established. The (State-)System got stuck in an intermediate - an ossified - state, in which KA was suppressed. The intermediate period (1945-1989), allowed for the recovery and (further) reconfiguration of the (State-)System, and the establishment of the components of the 2nd (global) FTS. This intermediate period - when KA was suppressed, and the global State-System was ossified - I refer to as the 2nd exceptional period.

The moment the Soviet-Union collapsed in 1989[1], the global State-System was no longer dominated by the intense rivalries between the Soviet Union and the United States, and the (now global) (State-) System resumed chaotic non-systemic KA. Analysis of the war-data confirms this.

I assume that the purpose of the 2nd FTS is identical with the purpose of the 1st FTS: To (in case of the 2nd FTS) achieve thermodynamic equilibrium - a state of homeostasis - at a global scale of the State-System, via the most efficient path.

1. I assume the Soviet Union collapsed in 1989, a state of affairs that was eventually formalized - implemented - in 1991.

TABLE 33.1: War data: 1945-2018, (based on Levy (no's 115-119), Sarkees et al. (no's 120-128), and other resources (no's 125-134)). The wars marked in blue (numbers 115-123), occurred during the 2nd exceptional period (1945-1989). This data-set includes an extension of the war data of Levy (48) (numbers 124-134). To ensure consistency and avoid bias, I have used Levy's definitions for Great Powers, Great Power war, and battle-deaths, in my interpretation of the data-sets compiled by Sarkees et al. (68) and data from numerous sources; however, validation of the dataset is required. Sarkees qualifies the Intervention in Bosnia in 1995 by the United States and NATO, including Great Britain and France, (War no. 125) as a phase in an intra-state war (The Bosnian-Serb Rebellion of 1992-1995). This intervention, also referred to as 'Operation Deliberate Force,' qualifies - I assume - as a war involving Great Powers. Sarkees classifies the 'Soviet Quagmire of 1980-1989' as an 'extra-state war.' Because this war meets Levy's requirements, I added it to the data-set. Wars no's 116-123 took place - constitute - the 2nd exceptional period (1953-1989) and are shaded in grey. If the First and Second Chechnya War (respectively periods 1994-1996 and 1991-2003) qualify as interstate wars needs validation: These wars cause distortions in the circular trajectories in phase state. However, if excluded, their exclusion does not impact on the outcome of the assessment and predictions. The 'War of Afghanistan' (no. 129) is arguably still ongoing, although France's involvement ended in 2012 and Great Britain's involvement ended in 2014. The Russian-Ukraine War (no. 133) includes the annexation of Crimea by the Russian Federation (20 February - 20 March 2014) and the Russian military intervention in Ukraine (ongoing since 20 February 2014). GP: Great Powers, Fr: France, GB: Great Britain, SU: Soviet Union. The data for the remaining wars (no's 127-134) were collected from: War no. 129: "Afghanistan: Fatalities by year", icasualties.org 9 September, retrieved 14 September 2013; www.defense.gov/casualty.pdf, retrieved 29 June 2016 (through Wikipedia, retrieved 21 August 2016). War no. 130: "Fact Sheets/Operations Factsheets/Operations in Iraq: British Fatalities", Ministry of Defence of the United Kingdom, archived from the original on 11 October 2009, retrieved 17 October 2009 (through Wikipedia, retrieved 21 August 2016). War no. 132: retrieved 12 August 2016 (through Wikipedia, retrieved 21 August 2016). War no. 133: "Nuland Claims 400-500 Russian Soldiers Killed in Eastern Ukraine". Sputnik News.

No.	War	Dates	Duration (Years)	Extent (No of GP's)	Severity (in BCD)	Size (Fraction)	GP's
115	Korean War	1950 - 1953	3,1	4	954.960	0,67	US, China, Fr, GB
116	Russo-Hungarian War	1956 - 1956	0,1	1	7.000	0,17	SU
117	Sinai War	1956 - 1956	0,1	2	30	0,33	GB, Fr
118	Sino-Indian War	1962 - 1962	0,1	1	500	0,17	China
119	Vietnam War	1965 - 1973	8,0	1	56.000	0,17	US
120	Sino-Vietnamese Punitive War	1979 - 1979	0,1	1	13.000	0,17	China
121	The Soviet Quagmire	1980 - 1989	9,0	1	40.000	0,17	USSR
122	Falklands War	1982 - 1982	0,3	1	255	0,17	GB
123	Sino-Vietnamese Border War	1987 - 1987	0,1	1	1.800	0,17	China
124	Gulf War	1990 - 1991	0,7	3	402	0,5	US, GB, Fr
125	The First Chechnya War of 1994-1996	1994 - 1996	2,8	1	4.000	0,17	Russia
126	Intervention in Bosnia	1995	0,1	3	27	0,5	US, GB, Fr
127	War for Kosovo	1999 - 1999	0,2	3	2	0,5	US, GB, Fr
128	The Second Chechnya War of 1999-2003	1999 - 2003	4,2	1	5.000	0,17	Russia
129	War of Afghanistan	2001 - 2014	13,2	4	2.955	0,67	US, GB, Fr, Germany
130	Iraq War	2003 - 2011	8,7	2	4.676	0'33	US, GB
131	Intervention in Libya	2011 - 2011	0,6	3	0	0,43	US, GB, Fr
132	War for Syria	2011 - ongoing	7	5	20	0,71	US, GB, Fr, Iran, Russia
133	Russian-Ukraine War	2014 - ongoing	6	1	450	0,14	Russia
134	Iranian Intervention in Iraq	2014 - ongoing	4	1	11	0,14	Iran

For the analysis of the 2nd FTS, I make use of the data-set of Levy (48) - which concerns the period 1495-1975 - which I complemented until 2018, by making use of other data-sets, but by using the same selection-criteria Levy used to compile his data-set. See table 33.1.

33.3. Differences between the 1st and 2nd exceptional periods

I assume that when in 1945 the phase transition (1480-1945) was accomplished, the conditions allowed for the emergence of a 2nd global FTS, but that some time was required for the global (State-)System to 'settle itself and get all components in place and functioning.

The start-up was hindered by the intense rivalries between the United States and the Soviet Union (1945-1989), that were related to the vacuum the phase transition (1480-1945) had produced in the former core (Europe): An intermediate period - a 2nd exceptional period - was unavoidable, during which the former core (Europe) could recover, the components of the 2nd FTS could be developed and implemented, and the intense rivalries between both super powers could be (and had to be) resolved (from the perspective of the Second Law).

The start-up of the 2nd FTS included the formation of a functioning constraint, the organization of EMIS flows that accompanied and sustained the 2nd FTS, and the establishment of global mode-coupling; processes that were temporarily hindered by the ossified state caused by the intense rivalries.

The phase transition (1480-1945) had brought the global (State-)System into a state that produced entropy at a very high rate; this entropy could however not be used or effectively regulated, because there was no effective mode-coupling.

I assume that this combination of circumstances - a vacuum in Europe, the physical control by two states (the United States and the Soviet Union) of the former core, both (partially) located in the (former) non-core of the (State-)System, the temporary absence of a functioning dissipative structure (the 2nd FTS, with a global reach), etc. - caused a 2nd exceptional period, during which European (former core) states could recover, non-core societies (former colonies) could establish sovereign state-structures and the components of a 2nd FTS could be 'constructed'. The intense rivalries between both super powers hindered the establishment of a functioning global FTS.

Following the phase transition (1480-1945) and globalization of the State-System (accomplished in 1945), the same thermodynamic potentials control/direct (and still control) the dynamics of the (now global) (State-)System: The global System is (like its European predecessor) pushed to maximum entropy-production, while the global State-System is governed by the MEP-principle that pushes the global State-System to zero entropy (a thermodynamic state of the global State-System that is still in the future[2]). However, during the 2nd exceptional period, the interplay between competing thermodynamic potentials and their extremization, could not (yet) result in the establishment of effective mode-coupling at a global scale of the (State-)System.

2. Explorative calculations based on the corrected model of the 1st FTS show that a state of thermodynamic equilibrium of the global State-System is reached in 2187 (59). However, as was the case for the 1st phase transition (1480-1945), this phase transition can only be accomplished if the (global) State-System is destroyed, during the final stage (2185-2187), the 4th systemic KA/war of the 2nd FTS. The question is, if a viable non-core is established at that point, that can fill the vacuum that is then created at a global scale. That will probably be the case, otherwise the 2nd FTS, could not have been sustained until 2187.

The outcome was an intermediate period, when the global State-System was ossified, but the global System and its components could also mature into a fully functional FTS, at a global scale. This process of maturing included the recovery of European states, and the empowerment of non-core societies by establishing sovereign state-structures in the former non-core.
There are similarities and differences between the 1st and 2nd exceptional periods, respectively during the periods 1657-1763 and 1945-1989: In both cases, the intense rivalries between two dominant Great Powers and the subsequent reduction in degrees of freedom (n = 2) played an important role, in producing abnormal non-systemic KA. But a fundamental difference is that in case of the occurrence of the 1st exceptional period there was already a functioning FTS in place, while in case of the 2nd exceptional period, this was not yet the case.
This ossified thermodynamic state (a) during the 2nd exceptional period, impacted on the social and political dynamics in the contingent domain of the global (State-)System: The entropy-level was exceptionally high but could not be adequately regulated. Consequently, during the 2nd exceptional period (1945-1989) - in efforts by societies/states to harness the high levels of entropy (tensions, uncertainty) - there was a tendency for radicalization of ideologies and points of view in/by societies/states
The ideologies – communism and capitalism/democracy - were used - and required - by societies/states to cope with - harness - the high levels of entropy the State-System generated and 'pushed' into societies: Through these ideologies societal uncertainty and possible (internal) stability were controlled and the accompanying (increasing levels of free energy (military capabilities)) could be channeled. Ideologies are equivalent with control and low entropy.
These ideologies also provided for both 'blocks' - West and East, respectively dominated by the United States and the Soviet Union, and their respective societies/states - the justification to amass huge amounts of free energy (military capabilities): These ideologies served a clear thermodynamic purpose and were instrumental in achieving compliance of the)State-)System and its components (societies) with thermodynamic principles that applied during the intermediate period (1945-1989).

33.4. Analysis of abnormalities during the 2nd exceptional period

I use a 'normal' (undisturbed) KA/war-cycle - consisting of a RSP followed by a critical period - as a reference to identify abnormalities during the 2nd exceptional period, an approach I also used for the analysis of the abnormal KA/war dynamics during the 1st exceptional period (see chapter 30).
Normally, a KA/war-cycle consists of a RSP followed by a critical period. During RSP's, the (State-) System maintains a steady state, by responding to entropic perturbations with *chaotic* non-systemic KA (R1-dynamics). However, at a certain point - the tipping point of the RSP - non-systemic KA becomes increasingly inhibited by the network-effect. From the tipping point onwards, entropy-regulation becomes problematic and entropy starts accumulating in the (State-)System. The accumulation accelerates a process of nucleation of VC's, enables autocatalysis (entropy-accumulation generates more entropy through self-reinforcement) and causes the VC's to percolate the (State-System).
It is just a matter of time and the (State-)System becomes critical, collapses and produces systemic KA/war. During the systemic KA/war the accumulated entropy is used to upgrade the order of the (State-) System, and to implement a next (upgraded) RSP. See figure 33.1.

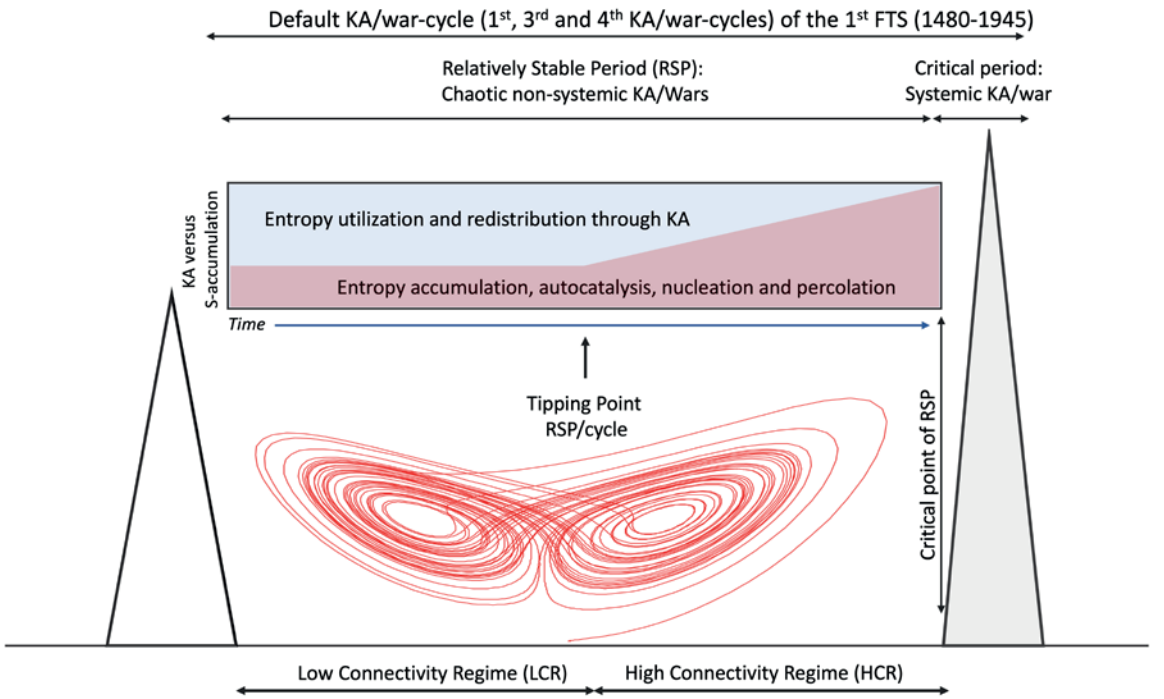


FIGURE 33.1: A default KA/war-cycle.

The 2nd exceptional period was predictable, when the results of the analysis of the abnormal KA/war dynamics during the 1st exceptional period (1657-1763) are taken into consideration: Intense rivalries between two dominant Great Powers impact on the (State-)System's degrees of freedom and nature of the emerging non-systemic KA.

In 1989, the moment the Soviet Union collapsed, the number of degrees of freedom increased (n > 2), and chaotic non-systemic KA/wars resumed in the (now global) (State-)System. The resumption of chaotic non-systemic KA/war dynamics in 1989 marks the end of the 2nd exceptional period and the emergence of a fully operational 2nd global FTS, as was the case for the 1st FTS, when in 1763, the rivalries between Britain and France were resolved and the (State-)System resumed chaotic non-systemic KA. This switch to chaotic non-systemic KA in 1989, can also be determined by fundamental changes to the trajectories in phase space of KA/war-dynamics, at the time.

The abnormal non-systemic KA during the 2nd exceptional period, will probably also impact on the performance and efficiency of the 1st global cycle (1945-....) and 2nd FTS: The normal development of the 2nd FTS was hindered, because VC's with fractal structures could not form and percolate the (State-) System. The moment the (State-)System resumed its default chaotic KA in 1989, it was only period of time, before the (State-) System reached the tipping point of the cycle in 2011, (assuming the war-data is accurate).

Based on the analysis, the 1st cycle of the 2nd FTS has developed as follows: See figure 33.2.

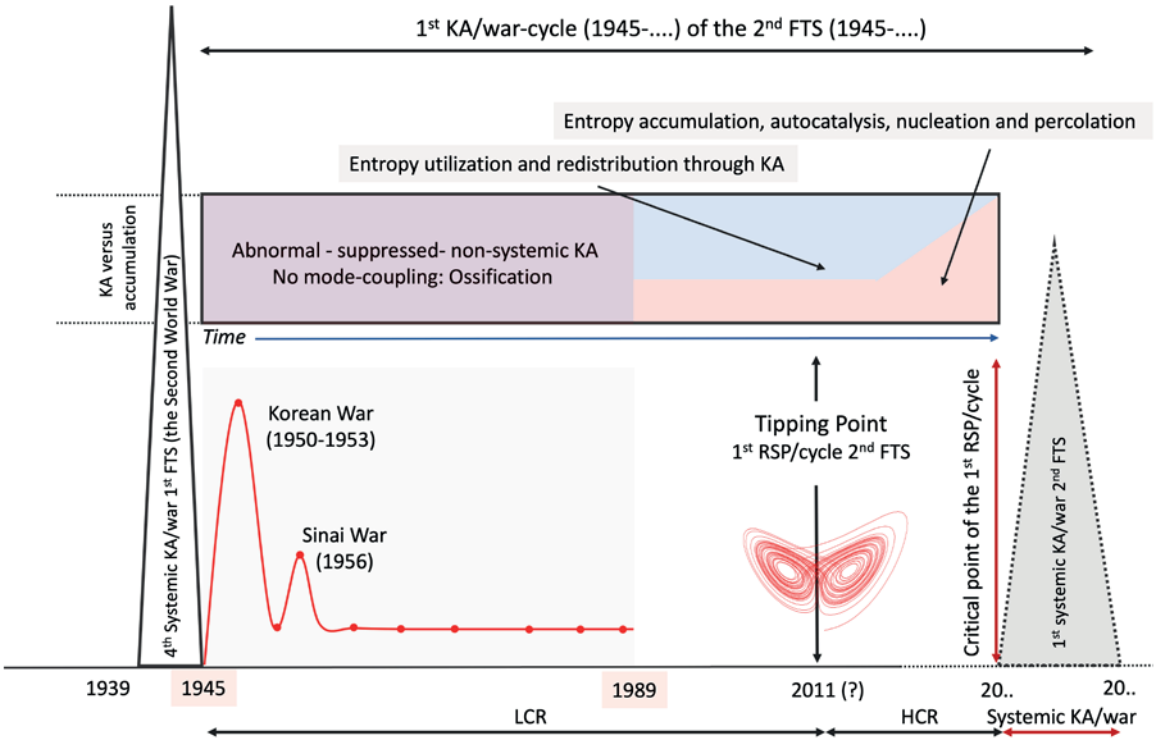


FIGURE 33.2: Abnormal war dynamics during the 2nd exceptional period (1945-1989), during the 1st cycle (1945-....) of the 2nd FTS (1945-....).

The following abnormalities can be identified, which I discuss in the next paragraphs: See table 33.2.

TABLE 33.2: Abnormalities of non-systemic KA/wars during the 2nd exceptional period (1945-1989).

Abnormality	Remarks
A limited number of KA/wars outside of Europe (the former and recovering core).	Europe was the focal point of the intense rivalries between the United States and the Soviet Union. The non-systemic KA/wars the (State-)System produced occurred (mostly) outside of Europe.
A small average size of KA/wars	The average size of non-systemic KA/wars was small.
The non-chaotic nature of the KA/war dynamics.	Analysis of phase state shows that the KA/wars the (State-)System produced were not chaotic in nature.
The Korean War, 1950-1953.	The large size of the Korean war - the involvement of a significant number of Great Powers - at the early stage of a new KA/ war-cycle is exceptional. There was no FTS-control.

(Quantitative) analysis reveals the characteristics of the abnormal non-systemic KA during the 2nd exceptional period (1945-1989).

33.5. Non-systemic KA/war frequencies and KA/war-sizes during the 2nd exceptional period

In below table some quantitative characteristics of the two distinct periods during the 1st cycle (1945-....) of the global (State-)System are shown. See table 33.3:

TABLE 33.3: Properties of two distinct periods during the 1st cycle of the 2nd FTS.

	1945-1989 (2nd exceptional period)	1989-2018 (Chaotic)	1945-2018
Number of KA/wars	9	11	20
Duration of period	44	29	73
KA/war-frequency	0,20	0,38	0,27
Average KA/war-size (fraction)	0,24	0,39	0,32

To make sense of these figures, they can be compared to the KA/war-activity during the RSP's of the four preceding cycles produced by the 1st FTS. See table 33.4:

TABLE 33.4: Properties of the four RSP's of the 1st FTS.

	1st RSP (1480-1618	2nd RSP (1648-1792	3rd RSP (1815-1914)	4th RSP (1918-1939)
KA/war frequency	0,37	0,24	0,17	0,05
Average KA/war size (fraction)	0,39	0,39	0,31	0,71

The KA/war frequency during the period 1989-2018 is almost double the KA/war frequency of System, during the 2nd exceptional period: 0,38 versus 0,20 respectively. The average KA/war frequency of the RSP of the 1st global cycle is up to 2018: 0,27.
In figure 33.3, the size-development of non-systemic KA/wars is shown: The Korean War (size) is clearly an anomaly: Overall are the sizes of non-systemic KA/wars during the 2nd exceptional period, not only small but for the last six (out of nine) events also very stable (their size = 0,17, equivalent with one Great Power participating, in these wars)

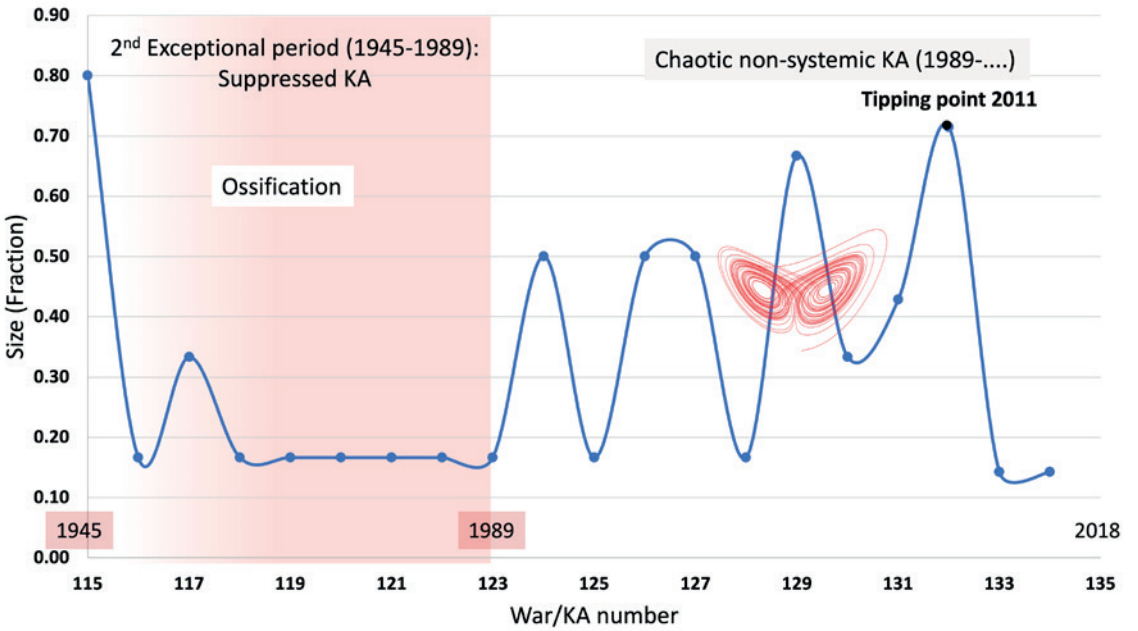


FIGURE 33.3: Sizes of non-systemic during the period 1945-2018.

33.6. Trajectories in phase space

Not only the frequency and sizes of non-systemic KA/wars changed dramatically the moment the Soviet Union collapsed and mode-coupling was established in 1989, but also the (nature) of the trajectories in phase space: These trajectories became circular again, indicative for the chaotic nature of the non-systemic KA/war dynamics of the (State-)System.

The shift to the chaotic regime of the R1-dynamics, ended the state of ossification (1945-1989), and the 2nd (global) FTS became fully operational. The change gave a strong impulse to the process of global (economic) globalization ("the interaction between people, companies, and governments worldwide" (96)) as well, and to the (further) unification (aggregation phase 3B) of Europe (through the European Union, e.g. the Treaty of Maastricht in 1992).

In figures 33.4 until 33.7, the changes in phase space are shown.

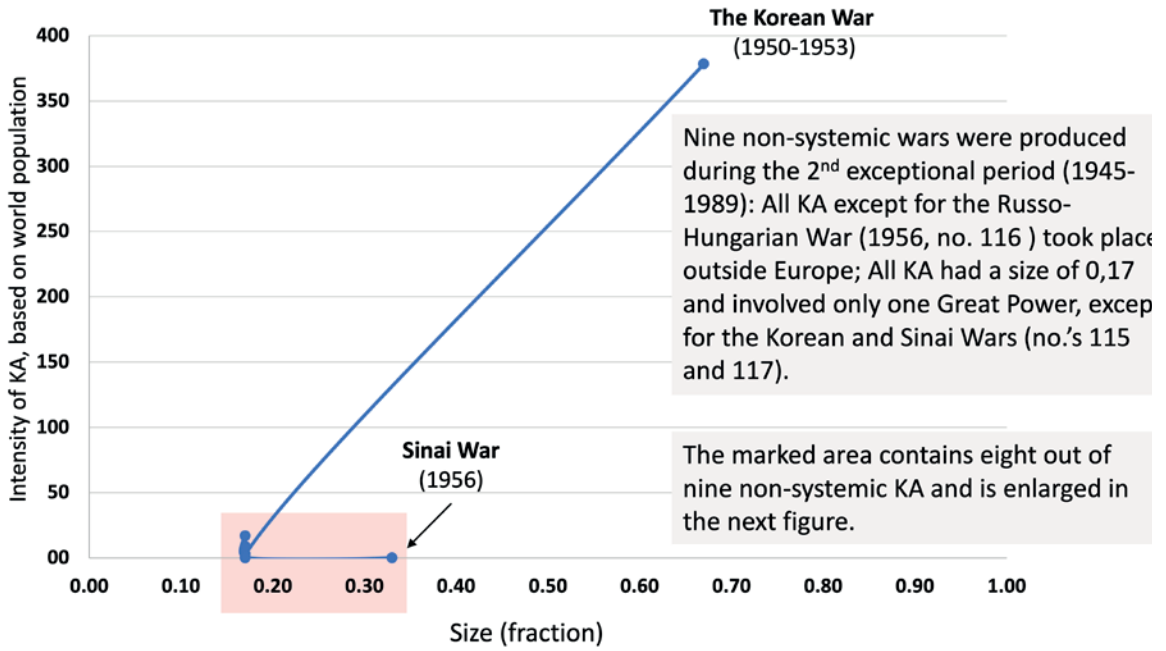


FIGURE 33.4: Trajectories in phase space 1945-1989. This figure depicts the trajectories in phase space of non-systemic KA/wars 116-123 during the 2nd exceptional period (1945-1989): x-axis: Size (fraction), y-axis: Intensity (based on world population). The sizes of these wars are very subdued (except for wars no's 115 and 117 (respectively the Korean and Sinai Wars), only one Great Power was involved, and typically occurred outside of Europe (except for war no. 116, the Russo-Hungarian War, 1956-1956).

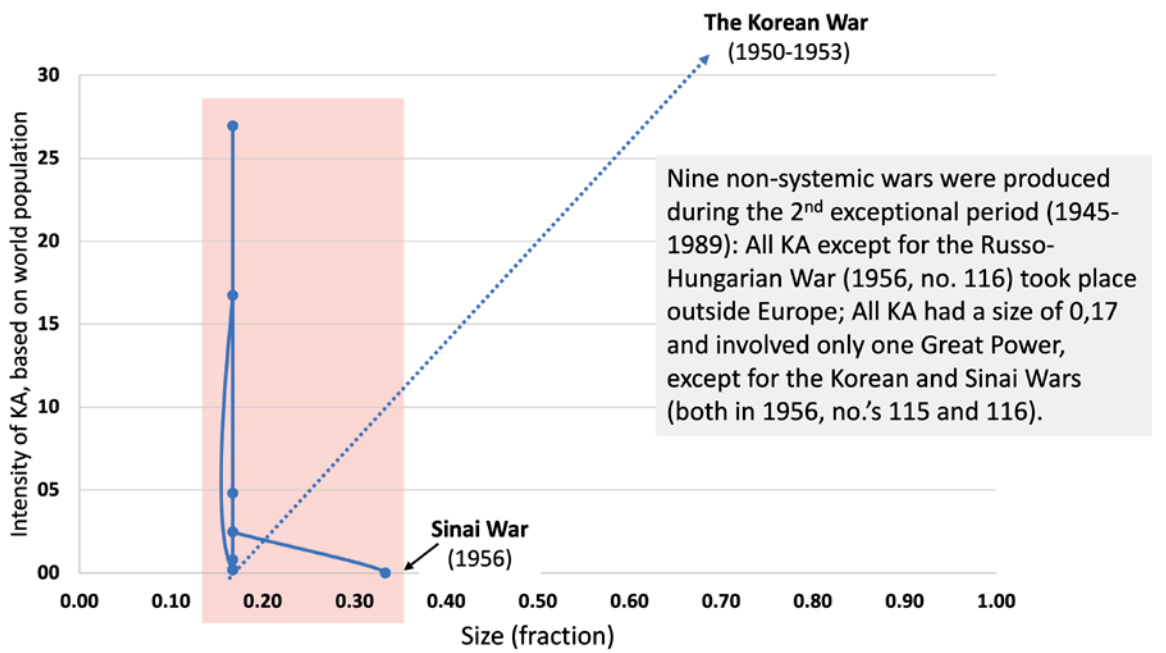


FIGURE 33.5: Trajectories in phase space enlarged: Korean War (1950-1953) excluded. This is an enlarged version of the previous figure.

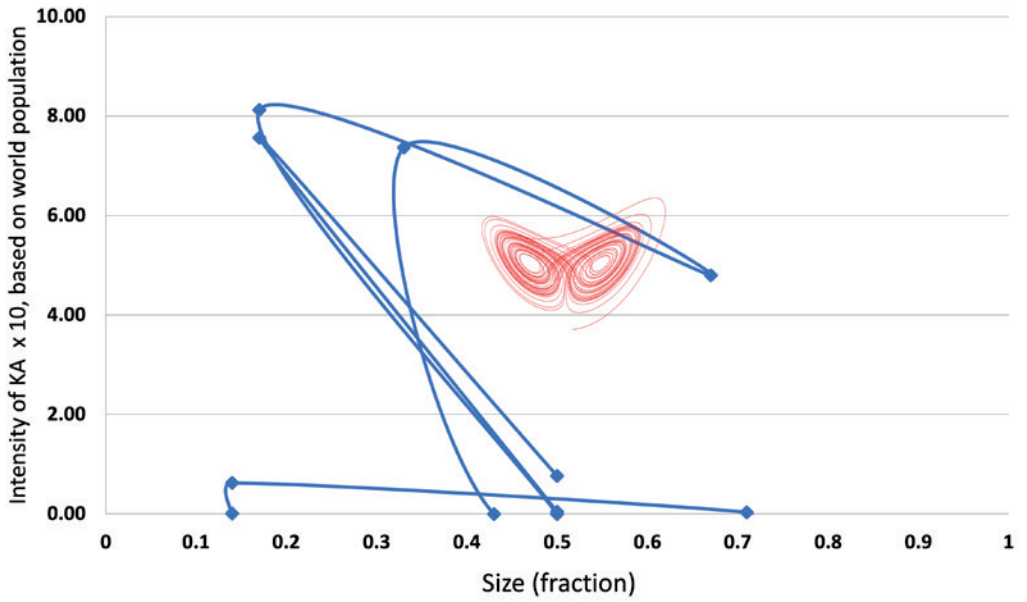


FIGURE 33.6: Trajectories in phase space 1989-2018. This figure depicts the trajectories in phase space of non-systemic KA/wars no.'s 124-134 from 1989 to 2018. The size of these wars is now more variable: The orbit-like trajectories in state-space point to the chaotic nature of these war dynamics.

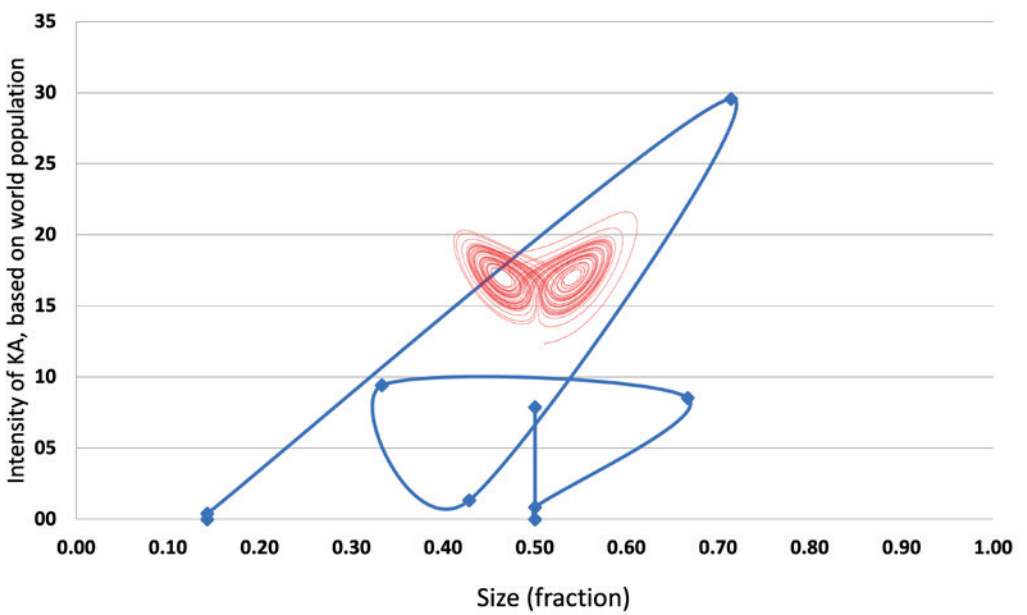


FIGURE 33.7: Trajectories in phase space 1989-2018, Chechnian Wars (No's 125 and 128) excluded. This figure depicts the trajectories in phase space of non-systemic KA/wars no.'s 124-134 from 1989 to the t 2018, however in this figure the First and Second Chechnya War respectively, during the periods 1994-1996 and 1999-2003 are excluded and the orbits (circular trajectories) are consequently more pronounced. The question is if these two wars actually qualify as interstate wars. Exclusion of these two wars from the analysis, does not impact on assessments and predictions.

33.7. The Korean War (1950-1953)

The Korean War (1950-1953), the first non-systemic KA/war the globalized (State-)System produced, seems to be an exception in two respects: (1) It was an exceptionally large non-systemic KA/war at the start of a new RSP (with a new upgraded and recently implemented order in place) and (2) it was furthermore an exception on the otherwise suppressed KA during the 2nd exceptional period (1945-1989). In these two respects the Korean War was an 'isolated' event.

Both these anomalies point to the absence of coherent and coordinated system-behavior, as was the case before the 1480-bifurcation; there was no (balanced) mode-coupling at this early stage of the globalized State-System.

The intense - and still intensifying - rivalries between the United States and the Soviet Union and their respective allies, contributed to these 'malfunctions'. It can be argued that the Korean War further intensified the already intense rivalries and pushed the global (State-)System into an ossified state (until 1989).

33.8. Interpretation of abnormal non-systemic KA (1945-1989)

Following the phase transition and globalization of the (State-)System in 1945, a functioning 2nd (global) FTS was not immediately in place and the intensity of the rivalries between the two dominant Great Powers - the United States and the Soviet Union - accelerated sharply. The two Great Powers and their respective allies (especially) faced off in Europe (the former core), where they had filled a power vacuum. The stalemate – the deadlock - contributed to the increasing production of entropy (tensions and uncertainty) and "stocks" of free energy (military capabilities) in the (State-)System that could not be put to use, to accomplish meaningful work. The outcome of the resulting extremely strong gradient, in combination with the limited number of degrees of freedom (n = 2) of the (State-)System, was that mode-coupling - required for FTS-regulation - could not be established, until 1989: Further development of the global (System-)System was also blocked; he global State-System was in an ossified state.

As discussed, mode-coupling is responsible for the establishment of long-range correlations between (initially) localized perturbations (interactions) (66), and the S/T-field, the collective dimension. Mode-coupling is required for macroscopic behavior: Mode-coupling enables coordinated EMIS-flows in the (State-)System.

The degree of mode-coupling is a function of the constraint and of the gradient (and force) the constraint produces. Because of the intense rivalries between the United States and the Soviet Union during the period 1945-1989, balanced mode-coupling could not be immediately established, following the phase transition (1480-1945). Furthermore, were at that stage, (former) core states not yet recovered, and had still (former) non-core societies to establish state-structures and to 'join' the global State-System as equivalent members. These processes - the 'construction' of the components of the 2nd FTS - required time.

During the 2nd exceptional period (the Cold War, 1945-1953) - as was the case during the 1st exceptional period (1657-1763) - 'local' issues did not exists: All issues were connected and consequently subjugated

to the overarching rivalries between the United States and the Soviet Union; the resulting constraint produced too strong a force on the now global (State-)System, and coherent EMIS-flows were consequently hampered and distorted.
The large size of the first non-systemic KA/war - the Korean War (1950-1953) - of the 1st global cycle (1945-....), and the series of small kinetic events/wars that followed, in combination with the low non-systemic KA frequency (1945-1989), but extremely high entropy and stocked free energy (military capabilities), point to the absence of a functioning 2nd FTS, and are manifestations of the dysfunctional state of the System during that period.
It is also not a coincidence that eight of the nine non-systemic KA/wars (except for the Russo-Hungarian War in 1956, no. 116) took place outside of Europe.
As I explain later, the lack of balanced mode-coupling in fact blocked a kinetic event (war) involving the United States and the Soviet Union: A 'Third World War' was blocked by the ossified State-System, also because societies and states obeyed the MEP-Principle that served as a thermodynamic potential (typically during RSP's), to which state-structures and their institutions are 'conditioned', during RSP's of cycles. The institutionalization of these thermodynamic potentials and stability principles, prevented a Third World War from breaking out. This is one of the main insights this research provides: The (State-) System and its components (societies and states, etc.) are organized in accordance with thermodynamic potentials and stability principles that apply: State-structures and the State-System are - represent - institutionalized thermodynamic principles, to which the System and societies are conditioned (with their responses and expectations).
The (State-)System and the (not yet fully operational) 2nd FTS, prevented a Third World War the occurrence of a "Third World War", during the period 1945-1989.
Only a malfunction in the (State-)System could have triggered a 'Third World War'; the resulting KA/war would probably have been system-sized, but could not have resulted in an upgraded order, the (State-) System was not in a critical condition (apart from the damage that would have been inflicted by such a war).
The moment the Soviet Union collapsed in 1989 (caused by internal social economic imbalances as a consequence of the demands and challenges on the Soviet state, and its lack of regulatory capabilities), rivalries and entropy(-production) decreased in the (State-)System and balanced mode-coupling was established.
The end to the intense rivalries and the (State-) System; a reduction that is also referred to as the "peace dividend".
The response of societies and states shows how they had conditioned themselves to the (exceptional) conditions during the Cold War; including social scientists like Fukuyama and Pinker (respectively (32) and (60))). It was just a matter of time before the chaotic non-systemic KA/wars, would dominate international developments and relations (again).

33.9. Consequences of the 2nd exceptional period

During the period 1945-1989, the global (State-)System was in an ossified state, and its development was restrained. Development of the (State-)System requires exploration and innovation, a 'process' in which chaotic non-systemic KA/wars (as discussed in previous chapters) play an essential part.

Whereas during the 1st exceptional period (1657-1763) the (State-)System produced high amounts of entropy and KA, during the 2nd exceptional period, the exceptional high amounts of entropy that were produced only resulted in the accumulation of massive amounts of free energy (military capabilities). The constraint that was produced through the intense rivalries - and the absence of a functioning 2nd global FTS - suppressed non-systemic KA/war.

Although the development of the global (State-)System - and the development of the global State-System to thermodynamic equilibrium - was stopped in its tracks and full utilization of the global System's potential was not yet possible, through this particular state of the (State-)System, societies/states in the former core (Europe) could recover from the destruction caused by the 4th systemic war (the Second World War, 1939-1945), sovereign state-structures could develop in the former non-core, and in Western Europe (the societies/states under control of the United States) an (institutional) infrastructure could be built that could eventually (following the collapse of the Soviet Union in 1989) absorb Eastern European societies and states, in an enlarged European political structure (aggregation phase 3B).

Given the fact that a 2nd global FTS is fully operational since 1989 and is producing a 1st KA/war-cycle, the question is what the impact is of the 2nd exceptional period (1945-1989) on the development of the 1st global KA/war-cycle and the 2nd FTS.

The 1st exceptional period (1657-1763), caused inefficiencies (an overproduction of entropy and KA), caused a delay of 13 years in the development of the 2nd cycle (1648-1815) and 1st FTS (1480-1945), and caused a distortion in the release ratio of the 2nd cycle: Significantly more non-systemic KA in terms of BCD took place during the 2nd RSP (1648-1792), than during the critical period (systemic KA/war, 1792-1815) that followed.

If these effects are indicative for the consequences that can be expected of the 2nd exceptional period, it is to be expected that there will be inefficiencies; probably a delay in the development of the 1st global KA/war-cycle, and a distortion of the release ratio of the 1st cycle (1945-....) of the 2nd FTS (1945-....).

It can be expected that the 2nd exceptional period delayed the development of the 1st cycle (1945-....) and 2nd FTS (1945-....) for several years; it is however not clear how much this delay is, and probably there is now (since 1989) some catching up taking place.

The question is if backlog caused by the suppressed KA/war dynamics during the 2nd exceptional period, results in a more severe systemic KA/war that will eventually be produced when the RSP of the 1st cycle/RSP reaches its critical point: The more extreme non-systemic KA during the 1st exceptional period (1657-1763), resulted in a less severe 3rd systemic KA/war (1792-1815); It should not come as a surprise that a more suppressed 2nd exceptional period (1945-1989), then produces a more severe 5th systemic KA/war.

The resumption of chaotic non-systemic KA/wars in 1989 and the development of the RSP will be discussed in the next chapter.

33.10. A Third World War during the period 1945-1989, was not possible from a thermodynamic perspective

Despite the fact that during the 2nd exceptional period (1945-1989), the global (State-)System was not even close to criticality - VC-clusters were not (sufficiently) formed, there was no autocatalysis and percolation - the (State-)System could also not produce any significant non-systemic KA/war, including a system-wide kinetic event. The configuration did not allow for such dynamics, as I already explained in the previous paragraph.

In this paragraph, I further explain this impossibility from an evolutionary perspective and from the perspective of thermodynamic principles, which societies/states - being products of these principles – are conditioned to obey and have institutionalized.
Human behavior - including the behavior of decision makers of states - follows (obeys) the thermodynamic requirements that are applied to/imposed on societies and states by the laws of thermodynamics and related principles that apply.
Humans and social systems are fully adapted to and conditioned by these imperatives: Humans and social systems, including the values and norms that underpin these systems and their cultures, political processes they generate, etc. are evolutionary products of – shaped by - these physical laws; aspects of these laws are internalized and institutionalized, also in for example the H-imperative. Our existence is based on obeying these laws and our survival on the ability to use them to our own (species) advantage, within the contingent latitude that is available.
The control - the constraints - that emerges from these laws and how these laws shape human life and our thinking and (inter)actions - despite our self-image of autonomy and free will - should on second thought, not come as a surprise. Obviously, the law of gravity has also shaped and constrained the evolution of our body and (consequently) of our mind and the physical structures humans (can) build.
We attribute the prevention of a 'Third World War' during the Cold War to human rationality and to an element of luck (chance). However, this study shows that during the 2nd exceptional period (the Cold War), the (State-)System could not have generated 'significant' KA/war, because KA/war was 'blocked' - suppressed - because of the absence of mode-coupling, and an (resulting) ossified state of the (State-) System. We - humans as products of these laws - ensured 'by definition' that these constraints were obeyed, as was the case during the transient period (1480-1945).
During the 2nd exceptional period, the supercharged constraint and the force that was consequently generated, made mode-coupling impossible, and the (State-)System could not produce any KA/war: Local perturbations (issues) were suppressed by the constraint and could not be amplified; furthermore, non-systemic KA/war was not a functional response to maintain equilibrium. The institutions and (social) mechanisms - representations/manifestations of the Second Law and related principles that apply - complied. Non-systemic KA/war had no purpose under those circumstances and was not utilized.
The fact that humans - the human mind, cultures, societies - can accommodate these processes and (can) attribute them to their autonomous decisions - without any (serious) second thoughts - shows nature's ingenuity: Our lack of understanding (knowledge) is compensated by our ability for collective deception.
From this perspective, ideologies and doctrines make sense: Ideologies and doctrines are instrumental in forming and shaping a collective dimension through which we can coordinate and shape our (collective) (inter-)actions. If these ideologies and doctrines become at a certain point inefficient or obsolete, they will be corrected by the (dysfunctional) dynamics they generate.
However, as I mentioned, only a "malfunction" could probably have triggered a "Third World War", but this has not happened: Effective structures and instructions were in place to avoid malfunctions in the system, including a number of fail-safes. These instructions and fail-safes can also be considered "extensions" of thermodynamic principles that applied, during the Cold War (the 2nd exceptional period).
The accurate execution of thermodynamic principles that were successfully enforced during the transient period (1480-1945) by the 1st FTS - of which the accurate timings of systemic KA /wars and other regularities are remarkable manifestations - was (not surprisingly) continued.

However, now - following the 2nd exceptional period (1945-1989) - the state of the global (State-)System is fundamentally different: Mode-coupling and a 2nd FTS are established, KA is (again) an integral and functional response of the State-System (2nd FTS) to entropic perturbations and chaotic non-systemic KA has resumed. Furthermore, apart from their proliferation, are weapons of mass destruction not always under strict control of states. This - in combination with the failing of state-structures - obviously constitutes a dangerous state of affairs.

33.11. The 2nd exceptional period in a broader context: Seeding, cloning and destructive growth

In this paragraph, I place the 2nd exceptional period (1945-1989) and its function/purpose in a broader perspective. See also figures 33.8 until 33.12.

From a thermodynamic perspective, the 2nd exceptional period does make (not surprisingly) much sense, it was even unavoidable: It was an intermediate period that bridged the 1st (regional) FTS - a Europe-centric system - to the 2nd (global) FTS, responsible for the EMIS-regulation of the globalized (State-) System. The 2nd FTS - the global State-System - is a product of - an upscaled version of - the 1st FTS and emerged from the self-destructed core, and the empowered non-core.

The self-destruction of the European State-System was unavoidable and instrumental in the growth process of System, from a regional to a global system: Certain barriers had to be eradicated.

Through the expansion to and development of the non-core, the 1st FTS and the State-System ensured its growth and continuity: During the transient period (1480-1945), it had created a copy - an identical but global version - of itself. The process involved an intimate interplay between entropy - new possibilities that were generated - and energy, regulated by the 1st FTS. New possibilities were continuously generated through the production of entropy, possibilities were selected with the help of chaotic non-systemic KA and free energy was put to use to realize favorable new possibilities. The selection process was determined by thermodynamic imperatives: The Second Law selected the most efficient path to thermodynamic equilibrium. However, these constraints still allowed for certain choices (latitude) in the contingent domain.

During the 2nd exceptional period (1945-1989), the vacuum the self-destruction of the European State-System had produced was 'filled' by the two Great Powers (the United States and the Soviet Union) that were well established in the non-core, and had used the 4th systemic war (the Second World War, 1939-1945) to their advantage. The United States and the Soviet Union served as connecting pins - links - between the former core and non-core. This linkage ensured the actual merging of the former core and non-core.

During the 2nd exceptional period, 1945-1989, the ossified state of the (State-)System caused the suppression of KA/war, but states in the (State-)System still produced free energy - military capabilities - at an accelerating rate; this energy (capabilities) was "stocked". The competition between the United States and the Soviet Union increasingly became a contest in economic power and between the ideologies that "underpinned" the respective super powers. Eventually the escalating competition undermined the legitimacy of Soviet state and caused its collapse in 1989/1991.

The (nature of the) growth process of the (State-)System that ensured its continuity - a combination of processes of KA, aggregation, expansion and empowerment, regulated by a FTS, resulting in its own destruction, and

upscaling - I refer to as destructive growth. During the transient period (1480-1945), the European State-System experienced a phase transition to thermodynamic equilibrium directed by the 1st FTS: It caused the European State-System's (self-)destruction, but the 1st FTS had also ensured that a non-core was developed, that could absorb the self-destructed core. Growth and continuity of the (State-)System also involve birth, death and reproduction, so to speak.

The upscaling of the System from a regional to global scale can be considered a form of reproduction - a biological process - through which offspring - a modified version - of the parent-system is produced. Reproduction is a fundamental feature of all known life. The form of reproduction of the System is cloning: The System has created an identical copy of itself, albeit at a larger scale.

The United Kingdom's colonies in North America and the independence of the United States in 1776 can be considered seeds that were planted by the United Kingdom - by the core of the System (Europe) - in the non-core. This particular 'seed' found a fertile breeding ground in the (State-)System (1480-1945): The System was to a high degree - decisively - shaped by the United Kingdom, also with the help of the PBMP-mechanism. The PBMP-mechanism - in combination with certain properties (capitalist economic model, synergetic geopolitical features, etc.) of the United Kingdom - had enabled the United Kingdom to become the most powerful Great Power in the European State-System, with a defining impact on successive orders that were created, during the transient period (1480-1945). The United States had (has) the same basic features and was for that reason able to optimally 'profit' from the successive British orders that were established during the period 1480-1939.

The geopolitical features of the United Kingdom in the European State-System (1480-1945), are to a high degree identical with the geopolitical features of the United States in the current global State-System.

Through the "seeding" of colonies that formed the basis for the United States, cloning was ensured: The Europe-centric System (1480-1945) - with the United Kingdom as its most dominant state - produced an enlarged - identical - copy of itself, with a British spin-off at its center.

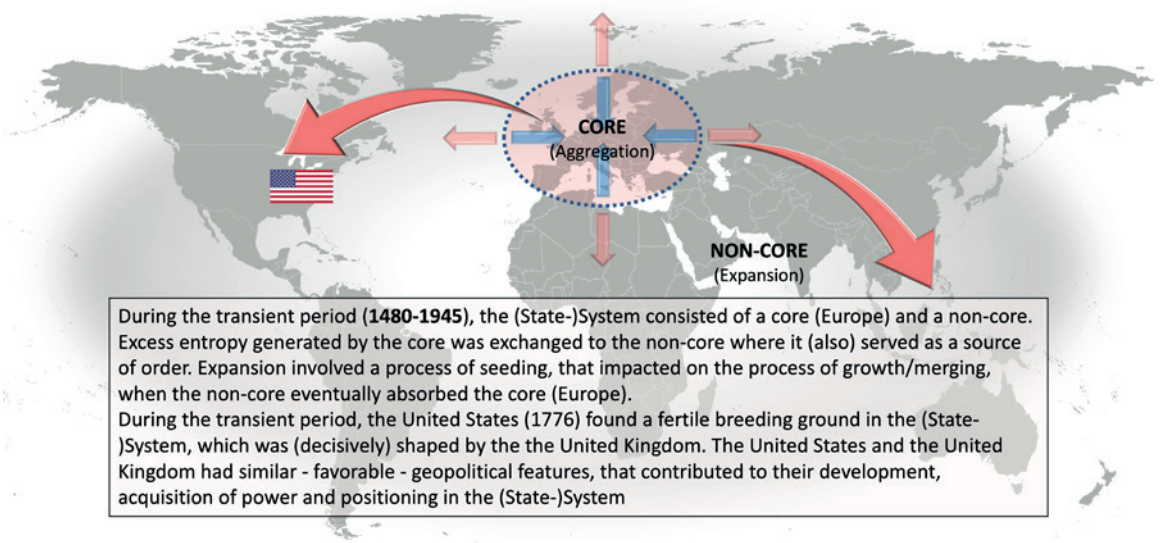


FIGURE 33.8: Expansion and seeding during the transient period (1480-1945).

Continuity of the (State-)System - including an enlarged specimen of the 1st FTS - was ensured through this process of seeding and cloning.

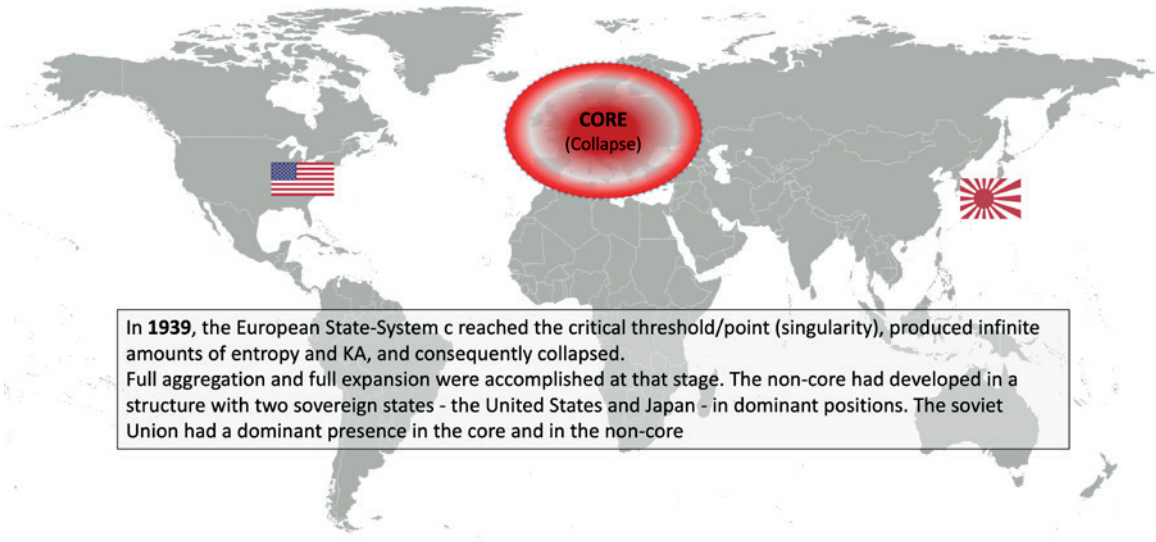


FIGURE 33.9: Development of the non-core and collapse of the core (1939).

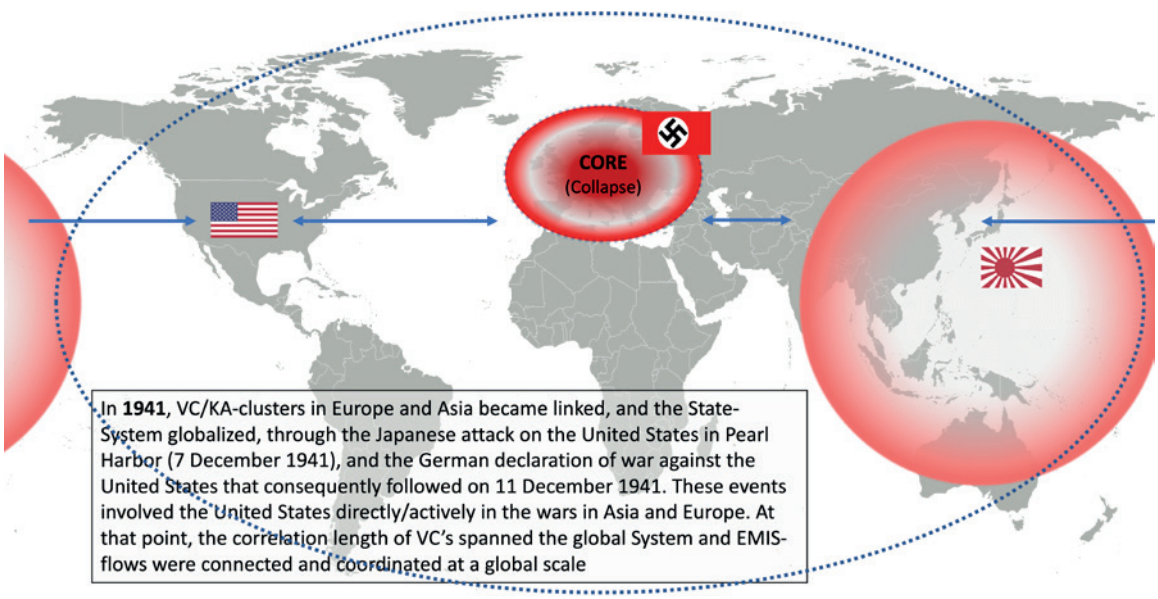


FIGURE 33.10: Globalization of the State-System in 1941.

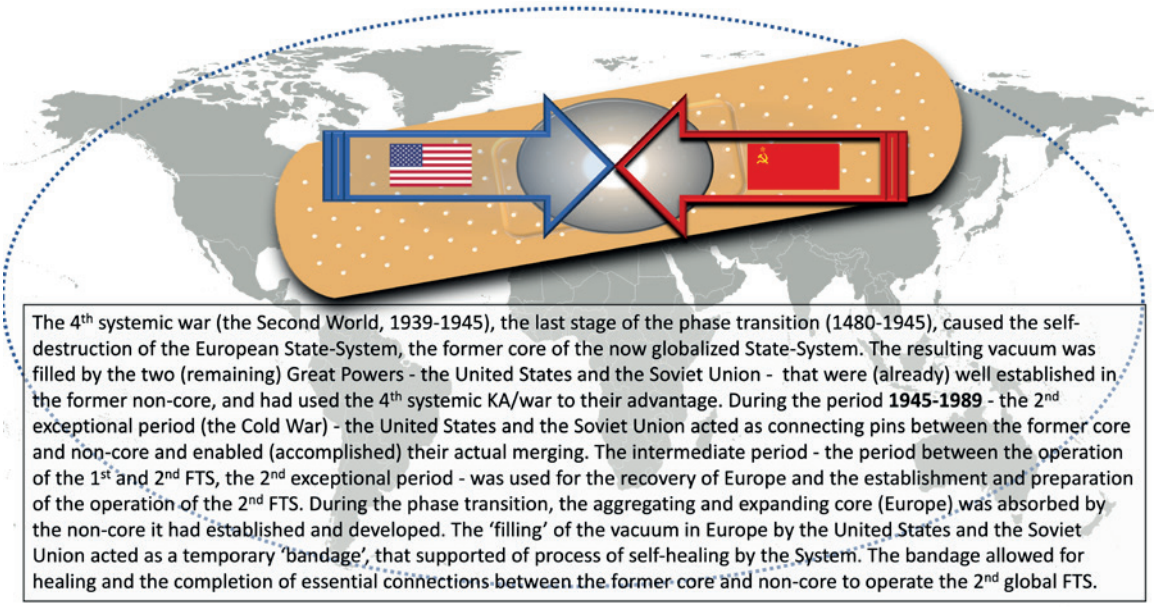


FIGURE 33.11: Healing and merging through a temporary 'bandage; the 2nd exceptional period (1945-1989).

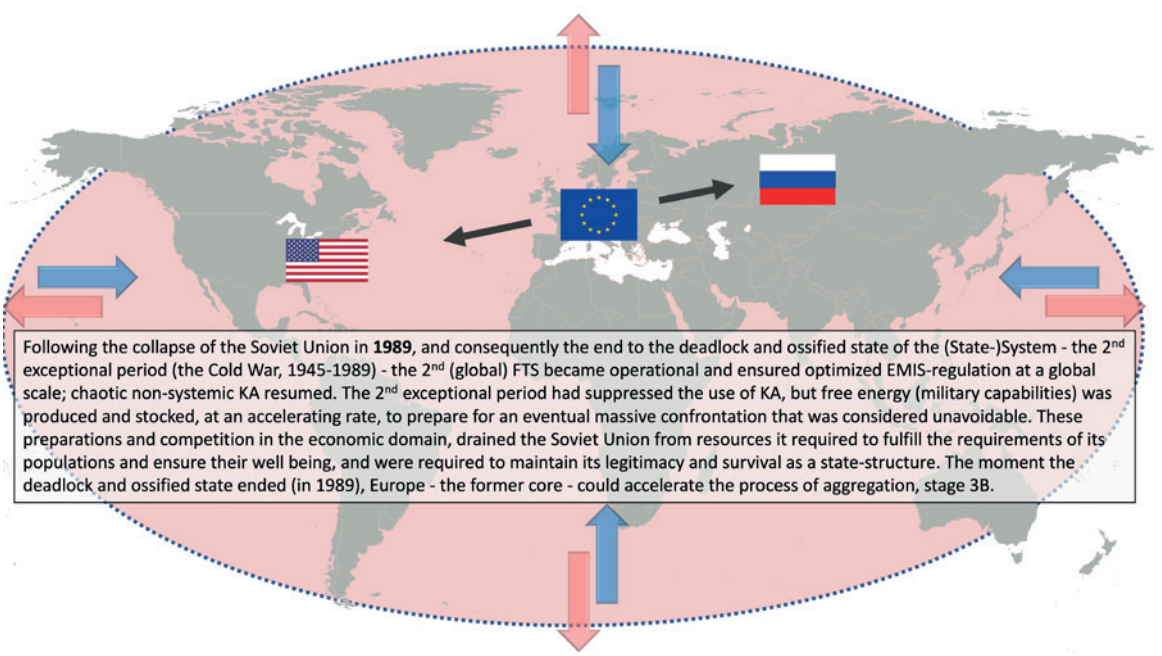


FIGURE 33.12: The 2nd FTS (1989) becomes operational.

I define destructive growth, as a form a growth in which destruction is functional - required - to ensure continuity of a (social) system. In case of the (State-)System, six stages and accompanying processes can be distinguished in the process of destructive growth: (1) growth and aggregation of a core; (2) growth and development of a non-core enabled by EMIS-exchanges between core and non-core; (3) destruction of the core on completion of the growth (aggregation) process; (4) absorption of the core by the non-core and (5) a process of 'healing' when the destructed core is repaired and processes and structures are formed and allowed to mature, to ensure the proper functioning of a globalized - scaled-up - System. Further growth, based on this model, requires (6) that the 'upscaled' System, "finds"/selects and develops its own non-core to ensure it can grow and develop, and to ensure the next non-core can eventually take control of the vacuum it will produce through its self-destruction.

33.12. Application (1): Healing of the System required a shut-down

In this chapter I introduced the term self-healing. Dissipative structures - organisms are also dissipative structures - have an ability for self-healing, a subject I will discuss later in more detail.
This not only is a very useful property, but also a valuable perspective to better understand what happened during the 2nd exceptional period (1945-1989), and what the purpose was of this intermediate period for the (State-)System and its continuity: During the 2nd exceptional period (1945-1989), the (State-)System temporarily shut done to allow for the 'healing' of the damage done to the former core (Europe) and for the establishment and maturing of structures and processes to support the operation of the 2nd FTS. The ossification of the (State-)System can also be considered self-healing.

33.13. Application (2): Interaction between domains

The intense rivalries between the United States and Soviet Union - and the resulting decrease in the number of degrees of freedom - resulted in the suppression of non-systemic KA/wars during the 2nd exceptional period (1945-1989), as was the case during the 1st exceptional period (1657-1763). The 2nd exceptional period also demonstrate the interaction between the contingent and deterministic domains of the (global) (State-)System. The occurrence of this reduction in degrees of freedom, directly following the phase transition and globalization of the System, prevented the immediate start-up of a 2nd global FTS, but allowed for a process of recovering and maturing of essential components of a 2nd FTS.

33.14. Application (3): Properties of abnormal and normal (chaotic) non-systemic KA

The differences between of abnormal - suppressed - non-systemic KA during the 2nd exceptional period (1945-1989) and default - chaotic - non-systemic KA are summarized in table 33.5.

TABLE 33.5: Different properties of chaotic and suppressed non-systemic KA.

Chaotic - normal/default - non-systemic KA	Suppressed - abnormal - non-systemic KA during the 2nd exceptional period (1945-1989)
Degrees of freedom > 2.	Degrees of freedom = 2; consequently, are less dynamic modes (and trajectories in phase space) available to the (State-)System.
Intrinsically unpredictable.	Highly suppressed and predictable (low frequency, low size).
More constrained in size and severity, than periodic KA (during the 1st exceptional period).	Very constrained in frequency and size; consequently, also no exploration of state space, and no formation of VC's with fractal structures required for a critical condition and upgrade through systemic KA/war.
Enables the nucleation and percolation of VC's with fractal structures and the development of the (State-)System towards criticality.	Hinders the development of VC's and the (State-)System's development.
Ensures optimality and efficiency.	Causes inefficiencies and delays in the operation of the FTS and development of the global System.

33.15. Application (4): The re-emergence of entropy

In preceding chapters the capacity of VC's to store entropy was discussed; and the need for entropy-regulation and the requirement for the (State-)System to obey the Second Law and related principles that apply, were discussed. The information storage capacity of VC's gives the (State-)System a memory; history matters.

The question is if and how - and on what scale - stored tensions (entropy) could re-emerge - be re-activated - in the (State-)System, and what the possible effects could be.

After a period of consolidation, following the collapse of the Soviet Union in 1989, Russia 're-emerged' as a dominant player in the global (State-)System and it seems that Cold-War issues and tensions - stored entropy - are "re-activated". These 'stored' tensions (entropy) also impact on the current process of VC-formation and nucleation. It is not (yet) clear if the stored entropy - which was not put to use during the 2nd exceptional period (the Cold War) - can add to the KA of the (State-)System at a later stage of development of the 1st cycle, i.e. contribute to the (increased) severity of a next systemic KA/war, to compensate for the suppressed non-systemic KA/wars during the 2nd exceptional period (1945-1989).

33.16. Application (5): Enhanced sensitivity during LCR's

It seems no coincidence that the 2nd exceptional period also took place during the LCR of the RSP, a subject I already discussed. I assume that LCR's are more vulnerable to distortions than HCR's: Once the RSP has reached the tipping point, the network-effect causes the RSP to become more stable and the

autocatalysis of VC's (which involves a positive feedback mechanism) contributes to the sustainment of chaotic (n > 2) dynamics of the (State-)System. Once the HCR of a RSP is reached, it is 'easier' for the RSP to maintain an undisturbed course to the critical point of the RSP.

33.17. Application (6): A suitable environment - non-core - is required for humanities survival

An essential feature of a dissipative structure - including an FTS in case of the (State-)System - is the availability of a suitable environment, the structure can exchange entropy and energy with. The "rest of the world" - the non-core of the System - constituted the environment of the core; of the 1st FTS and the European State-System, during the transient period (1480-1945). The 1st FTS was a 'regional' FTS, while the 2nd FTS is a dissipative structure with a global scope. The 2nd FTS also needs a suitable environment (non-core). It is no coincidence, that the exploration and colonization of space started, at the inception of the 2nd FTS, in 1945.

From a conceptual point of view, the exploration and colonization of the rest of the world had the same function for the 1st FTS, as the exploration and colonization of space has for the 2nd FTS.

The sustainment of the 2nd FTS requires a suitable environment to ensure EMIS-exchanges. When the environment (non-core) is fully developed it can replace - absorb - the global State-System, once it self-destructs, during the final stage of the next (2nd) phase transition. If we cannot escape the second (global) war-trap - the 2nd FTS - and cannot develop a non-core that can act as a scaled-up replacement, not only the global (State-)System, but also humanity will self-destruct.

34. Resumption of chaotic non-systemic war and assessment of the current cycle (1945-....)

34.1. Introduction

In 1989, when the Soviet-Union collapsed, mode-coupling became balanced and the 2nd FTS became fully operational. In this chapter, I discuss the resumption of chaotic non-systemic KA/wars in 1989, the development of the 1st global cycle and the current struggles in Europe.

34.2. The tipping point of the 1st cycle of the 2nd FTS

Analysis of war-data confirms - as was to be expected - that the moment the 2nd FTS became fully operational in 1989, the 1st (global) cycle of the 2nd FTS was in the LCR of the RSP. It was also to be expected that the average size of chaotic non-systemic KA would increase, as well as the non-systemic KA/war frequency. Data-analysis confirms these developments. See figure 34.1.
Data-analysis confirms the significant increase in the KA/war-frequency from 0,20 KA/wars per year during the period 1945-1989 to 0,38 KA/wars per year, during the period 1989-2018. For the period 1945-2018, the KA/war-frequency was 0,27, a number that resembles the KA/war frequency of the two first RSP's produced by the 1st FTS.
It is possibly no coincidence that the KA (war dynamics) of the 1st RSP, 2nd FTS (up to 2018) matches the kinetic activity of the early RSP's of the 1st FTS; it could suggest that the characteristics of 2nd FTS (1945-....) match the characteristics of the 1st FTS (1480-1945).
The fact that the Great Power status dynamics have also resumed, since 1989.
Analysis of war-data confirms that the average sizes of non-systemic KA/wars indeed started increasing once the 2nd exceptional period came to an end in 1989 (see figure 34.2). This analysis shows that the RSP of the 1st global cycle reached the tipping point in 2011, when the average size started decreasing as a consequence of the network-effect, as was the case during the RSP's of the cycles of the 1st FTS (1480-1945). This means that at this stage (since 2011) entropy - tensions and issues - is accumulating in the (State-)System.

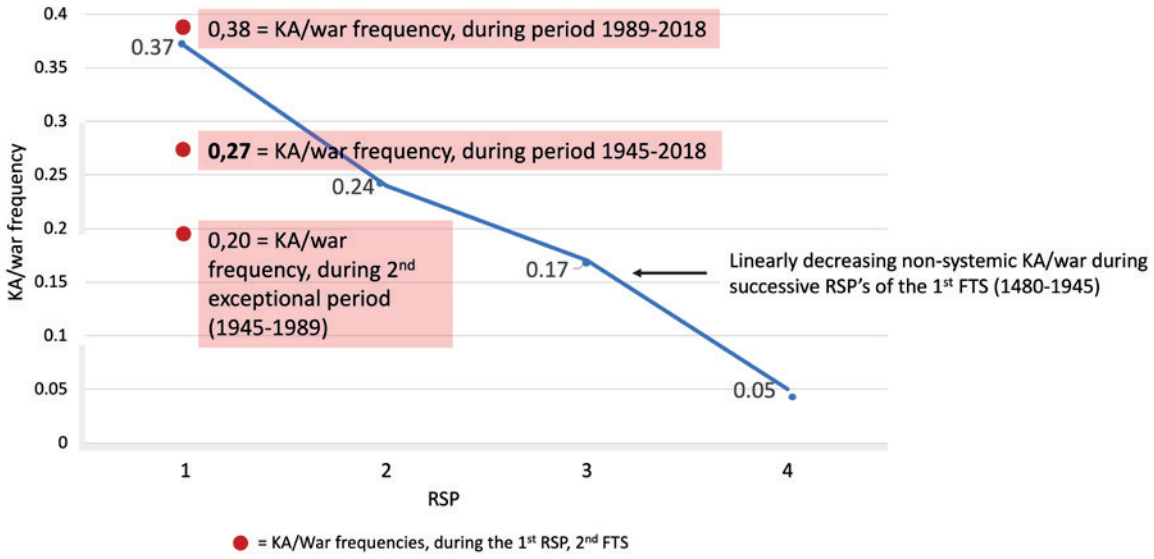


FIGURE 34.1: Development of the non-systemic KA/war frequency during the period 1945- 2018. Three periods and corresponding KA/war frequencies can be distinguished: A distinction is made between the 2nd exceptional period (1945-1989), the period 1989-2018, and the overall period (1945-2018); the KA/war frequencies during these respective periods are shown with red dots. These frequencies are in the range of the non-systemic KA/war-frequencies of the 1st and 2nd RSP of the 1st FTS.

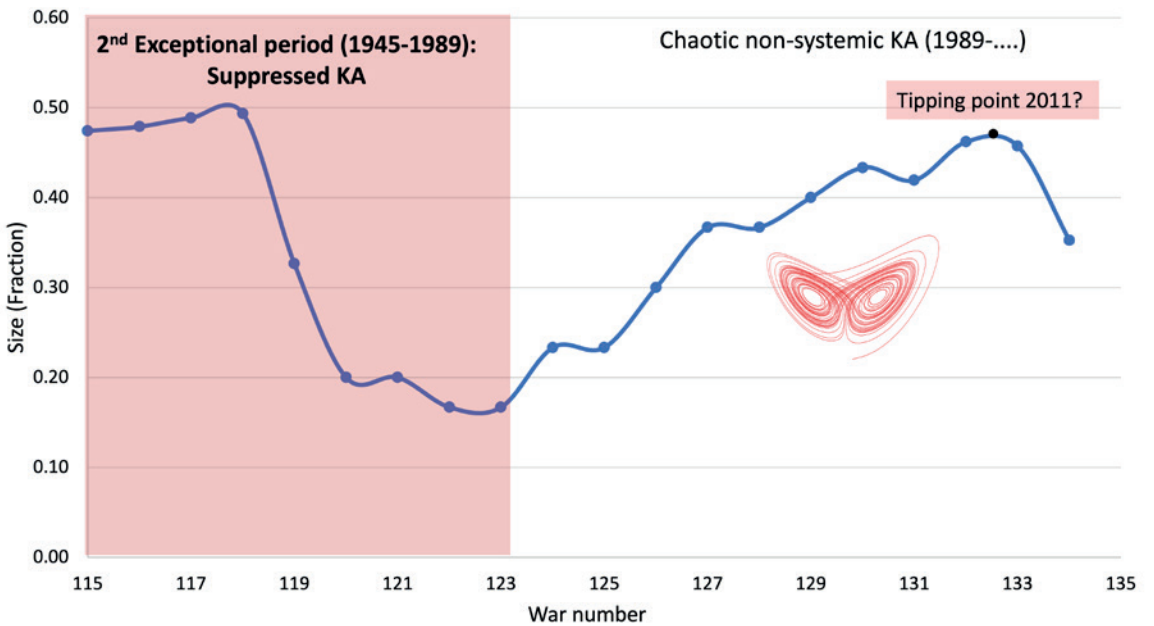


FIGURE 34.2: Development of the average size of non-systemic KA/wars during the period 1945-2018. This figure shows the moving average size (based on size in terms of fraction, of five successive wars) of the wars no's 115-134. The maximum involving the first four observations (values) can be attributed to the sizes of the Second World War (the 4th systemic war, 1939-1945) and the Korean War (1950-1953) and the lag-effect typical for moving averages.

As is typically the case during HCR's of RSP's, entropy is also pushed into societies because kinetic regulation is increasingly restricted in the (State-)System, see figure 34.3. The increased social and political volatility in - but also between - societies/states that can now (2019) be observed, is consistent with the assumption that the RSP has reached its tipping point, and entropy is accumulating.
The entropy powers the process of autocatalysis and VC-formation in the (State-)System; VC's increasingly percolate the (State-)System and issues become increasingly connected and entangled, a process that contributes to the stability of the RSP in its final stage (and explains non-systemic KA 'fades away').
The observation that the tipping point was reached in 2011 and that the (State-) System is presently (2019) in the HCR of the RSP, is consistent with its behavior in the contingent domain, it 'explains', for example: that (1) the 11 September 2001, attacks on the United States, did not - and could not - trigger a 'world war' (a systemic KA), because the (State-)System was not in a critical condition, and not sufficiently charged (with entropy), but still in the LCR of the cycle; (2) the (State-)System enabled the Afghanistan and Iraq-wars (respectively in 2001 and 2003, no's 129 and 130)), but (3) there was much more reluctance (especially by the United States), to commit itself to an intervention in Libya (no. 131); inhibitory behavior that is related to the network-effect. Furthermore, is presently (2019) a feature of the (State-) System, that issues and tensions are accumulating, and that they cannot be solved anymore. The fact that since 2011 the average size of KA/wars is decreasing, and social and political volatility and international tensions are increasing, can be attributed to the network-effect (since 2011).
Once the VC's percolate the (State-)System, the (State-)System becomes critical and produces a systemic KA/war, to upgrade the order of the System and to lower the (State-)System's energy-state.
The upgraded order and a lower energy-state allow for a new steady state (RSP), and further growth and development.

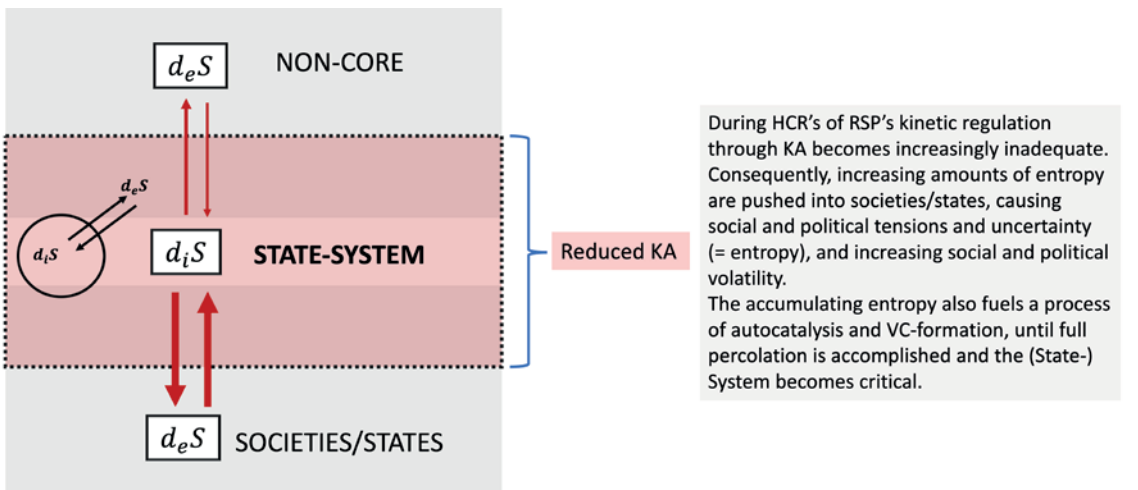


FIGURE 34.3: Increased influx of entropy during HCR's. This figure depicts entropy-regulation during HCR's of RSP's. Because of the network-effect, increasing amounts of entropy (tensions, uncertainty, etc.) are pushed into societies, which consequently develop more volatile social and political dynamic, which are manifestations of efforts to harness and utilize this entropy (and the new possibilities it offers). The level of dissatisfaction and fear increase in societies and fuel more extreme ideas; entropy and fear stimulate radicalization. Through these mechanisms, the (State-)System ensures its 'components' (e.g. societies and states), are also psychologically prepared for a systemic kinetic response.

34.3. Critical point of the 1st RSP/2nd FTS

Although the effects of the 2nd exceptional period cannot be calculated at this stage, it is possible - by using the model of the 1st FTS (1480-1945) as a reference - to estimate when the 1st RSP/2nd FTS reaches the critical point.
Assumption are that the war-data is correct and that the same ratios that apply to the (model of the) 1st FTS also apply to the 2nd global FTS. These ratios include e.g. the shortening of the life-span of successive RSP's, but also the number (four) cycles a 2nd FTS will produce. This has to be confirmed. I assume that the moment the moving average of the size of non-systemic KA/wars drops to circa 0,2 (following the tipping point), the RSP has reached the critical point, as was the case during RSP's of the 1st FTS. The data and model suggest this could happen in the year 2020 (+/- 2 years), assuming - as I mentioned - that data and assumptions are correct. However, if the data is not correct, criticality of the (State-)System will still be a matter of time.
This estimate suggests that the entropy level in the (State-)System is high at this stage. The accumulation of tensions and issues that have become increasingly linked and the current social and political volatility point in that direction, as I mentioned. Furthermore, the United Nations order has become increasingly dysfunctional and the five permanent members no longer reflect the actual distribution of power and influence in the (State-)System. The fact that KA/war activity is now more subdued (at a global scale), is consistent with the increasing stability of the (State-)System caused by the network-effect (during HCR's).

34.4. Europe is "stuck in the middle" and vulnerable

This study shows that the 1st FTS was instrumental in a phase transition of the (State-)System during the transient period from 1480-1945. The phase transition had two main effects: Full aggregation (stage 3A) of the core (Europe) and the simultaneous merging of core and non-core into a globalized State-System. The final step of the phase transition took place during the 4th systemic war (the Second World War, 1939-1945).
In this paragraph, I discuss the current state of affairs of the process of aggregation in Europe (the former core) and tendencies of political structures - of the European Union - to fragment.
Following the phase transition (1480-1945), the vacuum the self-destructed European State-System had produced, was 'filled' by the United States and the Soviet Union, who took control over respectively heavily damaged western and eastern European societies/states.
Although, aggregation stage 3A was reached, full aggregation had still to be accomplished.
As I explained in the previous chapters, through a combination of conditions, the global State-System was 'ossified', during the period 1945-1989; balanced mode-coupling was not possible due to the intense rivalries between the United States and the Soviet Union.
During this intermediate period - the 2nd exceptional period - the (State-)System produced massive amounts of entropy, that could not be regulated through non-systemic KA: The 2nd FTS was not yet fully operational.

The moment the Soviet-Union collapsed in 1989, balanced mode-coupling was established and the 2nd global FTS became fully operational. The end of the Cold War (1989) - the end to the ossified state of the global (State-)System - gave a strong impulse to the process of economic globalization and the (further) unification of Europe (institutionalization of aggregation stage 3B).
However, it was also a matter of time before Europe - which required time to accomplish full aggregation stage 3B - became subject to the forces generated by the constraint of the 2nd global FTS, which magnifies fault lines in the not yet completed European structures (aggregation stage 3B).
At present, member states of the European Union, but also the European Union itself (as a political institution), are in a vulnerable position, 'stuck in the middle', so to speak: Member states have selectively transferred state powers and responsibilities to the European Union, while the European Union itself is not yet fully developed. Nor are authorities and responsibilities fully aligned and optimized: The authority and responsibilities that are transferred often lack coherence.
The current state of affairs causes inefficiencies, delays and ineffectiveness; consequently, the authority - and to a degree the legitimacy - of states and the European Union are questioned by the European populations.
European states and the European Union are highly preoccupied with this unhelpful state of affairs and its consequences, including the British intention to leave the European Union (Brexit).
The processes of fragmentation - disaggregation - are enhanced by the centrifugal forces applied through the 2nd global FTS. Current developments - the process of fragmentation, the inadequacy of effective (administrative) structures in Europe and the fact that 'Europe' is stuck in the middle - raise the question if the accomplishment of a full-fledged, functional and effective European Union requires another systemic KA/war to be accomplished; not (necessarily) in Europe, but at a global scale. It should be reminded, that KA was instrumental in achieving aggregation (stage 3A) in Europe and in the globalization of the State-System.
As I explained, because of the divergence of the correlation length of the (State-)System during critical periods - the fact that the System becomes 'fluid' during critical periods, so to speak - makes systemic KA/war very suitable for societies/states to interactively design, select and implement upgraded orders.

34.5. From a directed to a centrifugal force

The upscaling of the (State-)System from a core/non-core to a globalized State-System, respectively regulated by the 1st and 2nd (global) FTA, was accompanied by a dramatic shift in the force that was applied in/on the (State-)System: Whereas the 1st FTS (1480-1945) applied a directed force at Europe - the 1st FTS was about achieving thermodynamic equilibrium in the core (Europe) - the 2nd global FTS (1945-...) applies a force at the global State-System, in order to achieve thermodynamic equilibrium at a global scale. See figures 34.4 and 34.5.
This global force has the effect of a centrifugal force on Europe - it tears the European Union apart, because fracture lines are amplified, and shared interest are not yet (sufficiently) institutionalized - while Europe is still in a precarious and vulnerable process of achieving full aggregation stage 3B.
The centrifugal force also finds points of application at societal/state level and increasingly at community and individual level, through e.g. social media that allow for unrestrained information exchange, and the creation of (virtual) communities: The (accelerating) process of empowerment contributes to the detrimental effects of the global force that is now applied by the 2nd FTS.

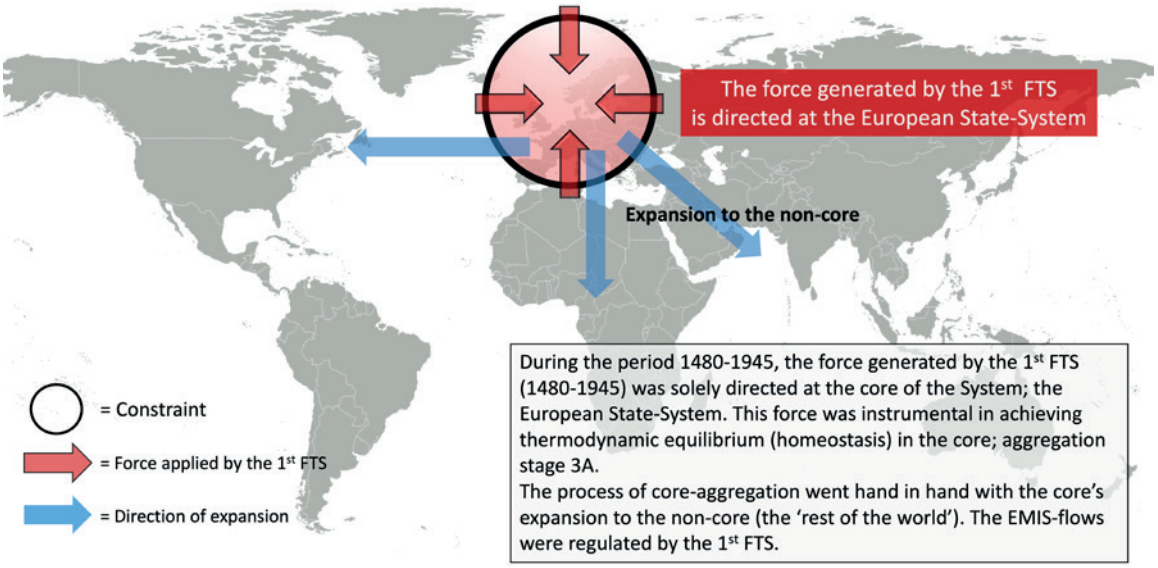


FIGURE 34.4: The 1st FTS applied a force to the European State-System (1480-1945).

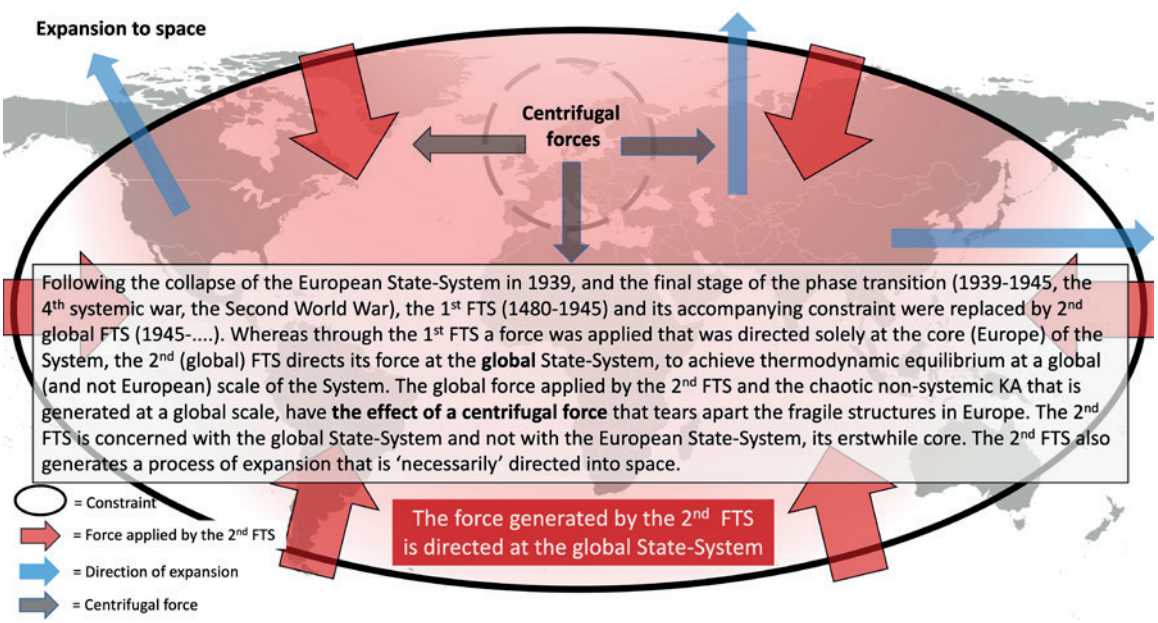


FIGURE 34.5: The 2nd FTS applies a force to the global State-System (1945-....).

34.6. Application (1): Brexit should not have come as a surprise

Brexit is a dramatic effect of the change of force caused by the phase transition (1480-1945); The 2nd FTS applies a force at the *global* State-System, and the chaotic non-systemic KA (which resumed in 1989) operates at a global scale. These changes are not without impact.

In Europe, the United Kingdom has always been - also figuratively - an 'outlier' state, that during the transient period (1480-1945) cunningly exploited its advantageous geopolitical position. The United Kingdom was geographically 'isolated' from the European mainland and ensured it had open (unrestrained) access to the 'open' seas'. The United Kingdom was able to decisively shape events and the balance of power in Europe. Apart from France, is the United Kingdom the only Great Power that was able to maintain Great Power status during the entire transient period (1480-present).

Through the PBMP-mechanism the United Kingdom (more than France), was able to have a decisive impact on shaping successive orders, during successive systemic KA/wars, the 1st FTS produced. The (State-)System increasingly reflected - and promoted - British interests. It can be argued that the European State-System during the transient period increasingly became a British system; a system that (especially) reflected British values and interests.

However, the United Kingdom, became - so to speak - the victim of its own success. British power and influence were based on a very extensive - world-wide - network of territories (colonies) it controlled in the non-core. However, the division between a core and non-core was unsustainable: The merging of the core and non-core and the decoupling of non-core territories from the core-controllers was a matter of time, as was the aggregation of the core. These transitions were dictated by the laws of thermodynamics and related principles that applied.

The finale stages of the processes of aggregation and globalization during the 4th systemic war (the Second World War, 1939-1945) required the (fundamental) repositioning of the United Kingdom in the (State-)System. This process was cunningly managed by the United States president, at the time - F.D.R. Roosevelt - at the time. Roosevelt cunningly used the existential threat the United Kingdom faced in Europe (Germany in 1940/1941), to acquire leverage over the United Kingdom, to reconfigure the globalizing (State-)System, in support of American interests. The United States guaranteed the United Kingdom's survival, under the condition that the non-core territories (colonies) it controlled would acquire full sovereignty and equivalence in a global order that would be established. By promoting democracy and providing markets to American economic capabilities that were (further) developed and 'unleashed' during the Second World War, a firm base was established for American economic expansion after the war.

The Atlantic Charter, issued by Roosevelt and Churchill on 14 August 1941, is the policy statement which defined the Allied goals for the post-war world. Roosevelt's vision was encapsulated in this document. The Charter stated the goals of the war: "no territorial aggrandizement; no territorial changes made against the wishes of the people (self-determination); restoration of self-government to those deprived of it; reduction of trade restrictions; global cooperation to secure better economic and social conditions for all; freedom from fear and want; freedom of the seas; and abandonment of the use of force, as well as disarmament of aggressor nations. Adherents of the Atlantic Charter signed the Declaration by United Nations on 1 January 1942, which became the basis for the modern United Nations" (96).

The fact that the United Kingdom and France both acquired a permanent seat in the Security Council of the United Nations, also supported American interests; it ensured that the United States had its strategic

partners embedded in the institutions that represented the upgraded order. The United Kingdom and France both acquired a position of power and influence in the new (first) global order (the United Nations order), while they were - it can be argued - seriously weakened the moment their colonial empires were dismantled.

But by providing the United Kingdom and France with privileges - including permanent seats and veto-rights in the Security Council, and (at a later stage) the legal right to develop and possess military nuclear capabilities - the Great Power status of these states was extended, and the American dominance in the global order assured (at least for the time being).

Despite the United Kingdom's dismantling of its empire, the United Kingdom left an impressive legacy: A European and global order which were mainly shaped by the United Kingdom with the help of the PBMP-mechanism. Because the United States was a British spin-off (clone) that took over the dominant and prominent 'role' of the United Kingdom when the core and non-core of the (State-)System merged into a global System, some continuity was ensured.

It is noteworthy that the geopolitical positions of the United Kingdom and the United States - respectively during the 'European' State-System (1480-1945) and the global System (1945-....) - are fundamentally identical: Both fulfilled a pivot function in the respective systems and there are other parallels, as well: Both the United Kingdom and the United States exploit(ed) similar strengths: Their capitalist (expansionist) economic models, their relative isolation (and reduced vulnerability), the ability to operate on strategic outer lines and their open access to the seas/oceans; only the scale differs.

During the Cold War (the 2nd exceptional period, 1945-1989), the United Kingdom (and France to a degree), could still manifest itself as a prominent Great Power, especially because of its '(legal') possession of nuclear capabilities, which was considered a valuable asset in the stand-off with the Soviet-Union.

On the other hand, in (Western) Europe prevailed a harsher reality for Britain: The United Kingdom's status was now equivalent with (all) other European states, a (painful) reality that was formalized in the rules that underpinned the European Economic Community (EEC, of which he United Kingdom eventually became a reluctant member in 1973).

The United Kingdom's 'degradation' and transition were very abrupt and its (relative) decline became increasingly exposed, during the period following the collapse of the Soviet Union (1989). Furthermore, nuclear capabilities proliferated and were no longer unique capabilities of the "privileged few".

The United Kingdom's frustrations for being "downgraded' in the European Union to an equivalent status with for example Luxembourg (no offense), while it had dominated the European State-System for more than 400 years, were further magnified when the European Union became increasingly bogged down in internal discussions related to the (increasingly) laborious transition to a full-fledged European Union (aggregation stage 3B).

The United Kingdom's status is furthermore increasingly challenged by rising Great Powers, that can rightfully claim more participation in the United Nations' order, because of their population size and increasing economic power (I refer to for example, India, Brazil and Indonesia), an issue that also (further) undermines the United Nations that explicitly promotes democratic values and human rights.

Thus, it should not come as a surprise that a centrifugal force produced by the 2nd FTS and the chaotic nature of non-systemic KA, at a global scale, found 'useful' fault lines and fissures in the problematic relationship between the United Kingdom - a traditional outlier in Europe - and the European Union. The centrifugal force amplifies fundamental differences.

The British exit (Brexit) from the European Union can be considered an act of frustration, that is based on the misconception that irreversible processes (not only from a thermodynamic perspective) can be reversed and that the United Kingdom can still secure a prominent Great Power status. Brexit will not have the desired effect: It will (predictably) weaken the United Kingdom, that can no longer profit from the synergy that can be exploited in and through the European Union.
The European Union will also be damaged. Brexit has no winners, but at least, it (again) shows the obvious to all involved - to the United Kingdom, European states and the European Union - that the connectedness of Europe - mutual dependencies - require intense cooperation and that state-structures and renationalization only diminish synergetic effects, to the detrimental of all involved.

34.7. Application (2): Comparison of the 1st and 2nd FTS

The 1st and 2nd FTS are both dissipative structures the System produced FFE. Their basic structure and operating principles are the same. I assume that the 2nd FTS (1945-....) will also accomplish a phase transition that will drive the global State-System to thermodynamic equilibrium, via the most efficient path, as did it predecessor - the 1st FTS - for the European State-System.
The most fundamental differences between both FTS's are summarized in table 34.1.

TABLE 34.1: Differences between the 1st and 2nd FTS.

Differences	1st FTS (1480-1945)	2nd FTS (1945-....)
Scope	Regional: Europe	Global
Inception phase	The 1st FTS emerged from an increasingly unstable condition of the System in Europe (< 1480), through a bifurcation in 1480.	The 2nd FTS emerged after the 1st FTS had accomplished a phase transition (1480-1945).
Purpose	To achieve thermodynamic equilibrium (social homeostasis) in the European State-System, in accordance with the Second Law and related principles.	To achieve thermodynamic equilibrium (social homeostasis) in the global State-System, in accordance with the Second Law and related principles.
Final stage of the phase transition	The final stage of the phase transition (1939-1945), involved the self-destruction of the European State-System) and the creation of a regional vacuum.	The final stage of the phase transition (1945-....), will cause the self-destruction of the global State-System and will create a global vacuum.
The absence of a non-core	During the transient period (1480-1945), the core (Europe) exchanged excess entropy to the non-core (the environment of the core; the "rest of the world)" to sustain the 1st FTS. During the actual transition (globalization) the non-core absorbed the self-destructed core.	A suitable environment - a non-core - must be developed and exploited by the 2nd FTS, to sustain its operation and supporting processes, and to ensure that at a certain point, the self-destructed global State-System can be absorbed by a larger entity.

The fundamental differences concern the inception of the 1st and 2nd FTS, and differences related to scale - regional versus global - and the possible absence of a physical environment, which is required for the exchange of entropy and the sustainment of the 2nd FTS.
A dissipative structure requires entropy exchange with its environment to ensure it can be sustained: Not coincidentally, the inception of the 1st FTS and the expansion of the core to the non-core - colonization - were synchronized.
It is also no coincidence that space exploration started during the inception-phase of the 2nd FTS. The Mercury, Apollo and Sputnik programs of respectively the United States and the Soviet Union in the 1950's and 1960's, are equivalent with the voyages of discovery by Columbus and Vasco da Gama cs. in the 15th and 16th century.
From a thermodynamic perspective these explorative voyages serve the same purpose: As enablers for the creation of suitable non-cores - environments - that enable entropy-exchange, and eventually ensure that the self-destructed core can be absorbed into a larger entity, that ensures continuity/survival.

Part VII

Introduction

In the previous chapters the functioning of the 1st and 2nd FTS were discussed, as well as the 1st and 2nd exceptional periods.
In this part, I will first discuss the highly optimized performance of the 1st FTS, then I will make a comparison between the thermodynamic characteristics of a heat engine and the FTS, which can - the analysis shows - also be considered a “kinetic” engine that drives the development of the (State-)System.
Finally, I discuss some observations about FTS-regulation, in general, and have a closer look at the interplay between the S- and H-imperative.

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36. The FTS depicted as a “kinetic” engine
37. FTS-regulation
38. The interplay between homeostatic- and FTS-regulation

35. Fractality and optimization

35.1. Introduction

During the transient period (1480-1945), the European State-System - supported by a process of expansion to the non-core - was driven to thermodynamic equilibrium by the 1st FTS via the most efficient path. Numerous regularities in the dynamics of the (State-)System and in the (development of) certain properties, point to the optimality - efficiency - of the process that are involved.
During the transition (1480-1945), the 1st FTS was responsible for the regulation of EMIS-flows, a process that involved the (re-)distribution of energy, matter, information and entropy (EMIS), at and between various levels of the (State-)System and between its multiple components.
Numerous processes and structures in the European (State-)System had fractal properties, which is indicative for the highly optimized performance of the 1st FTS.
In this chapter, I discuss 'fractality', the presence of fractal structures in the (State-)System, during the transient period (1480-1945).

35.2. Fractals

Fractals are objects whose dimensionality is between that of a point (R = 0) and a line (R = 1), or a line and a surface (R = 2), or a surface and a volume (R = 3); such objects are topological manifolds referred to as fractals (66). Also, attractors exist in three-dimensional phase space, other than fixed points, or closed curves of bounded two-dimensional surfaces, but with fractal dimensions (66). "The corresponding object in three-dimensional space consists of an infinity of sheets such that a section taken transverse to the sheets is a Cantor set" (66). Self-similarity - similarity at different scales, scale invariance - is a property of fractal structures. These fractal objects are often referred to as strange attractors, that constitute the models describing the onset of chaotic, turbulent-like behavior (66).
So-called power laws (power functions) - which abound in nature - are functions concerned with self-similar - fractal - properties. A simple power function is: $\boldsymbol{f(x) = cx^{\alpha}}$. "If $\boldsymbol{x}$ is rescaled (multiplied by a constant, then $\boldsymbol{f(x)}$ is still proportional to $\boldsymbol{x^{\alpha}}$, albeit with a different constant of proportionality" (75).
Fractals are ubiquitous in physical systems, in nature (e.g. biological systems) and social structures: Systems (networks) consisting of regularly interacting nodes (for example, cells in biological systems or states in the System) optimize their dynamics and structures by crystalizing in fractal structures (12, 14, 41, 42, 95). This is especially the case if these interactions concern distribution (processes) of physical resources, energy, or information.

As I mentioned, chaotic dynamics typically have fractal attractors and their properties can often be best described with power functions ("chaos generates power laws"). However, the presence of power laws cannot by definition be attributed to chaotic behavior; other mechanisms also generate power laws: e.g. critical phenomena (properties, various distributions near critical points).
Not surprisingly, this study shows, fractals structures (power laws) are also ubiquitous in the (State-) System. That is not surprising, because the (default) non-systemic KA during RSP's is chaotic in nature, and - as this study shows - the State-System is in a transient period and nearing a critical point ('1939'); fractality can be expected.

35.3. The origin of fractals in the (State-)System

The question is, why fractals are formed, and what purpose these structures have. Research in biological and social systems (like cities) point to the optimality in distribution that can be accomplished through fractal structures. Jensen suggests that "that the principle of lowest energy selects these fractal structures" (41).
Bettencourt et al. (13) observe, in relation to fractals: "Highly complex, self-sustaining structures, whether cells, organisms, cities require close integration of enormous numbers of constituent units that need efficient servicing." "To accomplish this integration," Bettencourt et al. continue, "life at all scales is sustained by optimized, in some cases space filling, hierarchical branching networks (*IP: that means structures with fractal properties*), which grow with the size of the organism as uniquely specified approximately self-similar structures." "Because these networks, e.g. the vascular systems of animals and plants, determine the rates at which energy is delivered to functional units (cells), they set the pace of physiological processes as scaling functions of the size of the organism."
Bettencourt et al. point to the clues these self-similar distribution networks provide to develop a predictive theory of biological and social structures: It is the "self-similar nature of resource distribution networks, common to all organisms, that provides the basis for a quantitative, predictive theory of biological structure and dynamics, despite much external variation in appearance and form." Fractional exponents of power laws contain important clues about the process/dynamic they describe, and what trade-offs are involved (75).
"From this perspective, it is natural to ask whether social organizations also display universal power law scaling for variables reflecting key structural and dynamical characteristics." This line of thought is at the basis of a study of Bettencourt et al.: "*Growth, innovation, scaling, and the pace of life in cities*" (13). Further research related to power laws generated by the System, will reveal valuable insights into the functioning of the System.
West et al. also point to the relationship between selection and optimization. According to West et al. "Natural selection has tended to maximize both metabolic capacity, by maximizing the scaling of exchange surface areas, and internal efficiency, by minimizing the scaling of transport distances and times" (95).



FIGURE 35.1: Fractal structures in nature. (Source photo tree: IP, source photo river systems: Centre National Détudes Spatiales, swot.cnes.fr).

Arguably, the (State-)System and its components (including the State-System, societies, states) also require close integration and 'efficient servicing', and that the numerous fractal - self-similar - distribution networks that can be identified in the System, fulfil this purpose, in accordance with the principal of lowest energy.

I assume that these fractal structures - self-similar distribution networks in the (State-)System - are the outcome of a selection process, consistent with observations of e.g. West et al. and Kauffman (42). The existence of these fractal networks is also consistent with the hierarchical structure of social systems, as defined by Simon; Simon also observed that hierarchical structures have evolutionary advantages (77).

Fractal structures are produced by fractal processes, and vice versa; the fractal structures we observe (also in the System) are - so to speak - "carved out" by processes with self-similar properties.

The (State-)System in Europe, as we now know it was carved out by the processes generated by the 1st FTS, during the transient period (1480-1945); the fractal nature of the (State-)System and the fractal properties of the FTS-processes are related; they are two sides of the same coin.

During the transient period, through the 1st FTS, the performance of the State-System was continuously optimized, in accord with requirements of the Second Law and related principles that apply. In 1939, when the critical point - the singularity in finite time - was reached, the European State-System reached (near) zero entropy and was highly optimized.

At that point (1939), military organizations and capabilities of European States, and of the United States and Japan - tasked with the distribution of kinetic energy (KA) in the (State-)System - had implemented highly identical fractal organizational structures, which is - I argue - indicative for their efficient servicing of societies/states and the (State-)System.

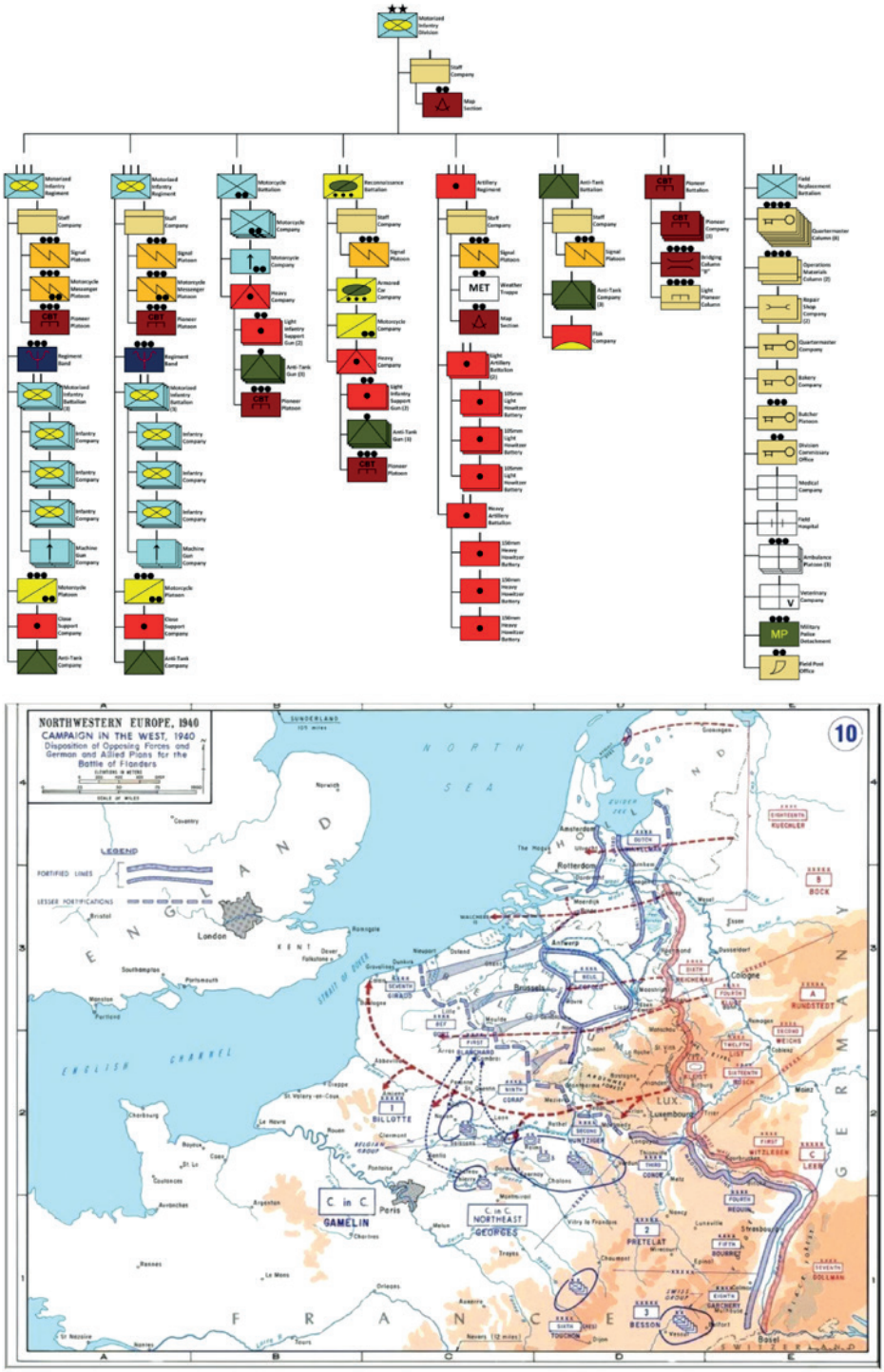


FIGURE 35.2: Fractal structures in the System: Optimal distribution of kinetic energy. Top: The organization of a German motorized infantry division in 1941 (https://en.wikipedia.org/wiki/List_of_German_divisions_in_World_War_II); bottom: French war plan (the Dyle Plan, Plan D), 1940 (https://en.wikipedia.org/wiki/French_war_planning_1920%E2%80%931940). The fractality of structures and processes is evident.

The presence of identical - fractal - military organizations in the System, also shows that societies/states used identical selection criteria, to decide on the structure of their military capabilities; Societies/states in the European State-System were (and still are) subject to the same selection forces.
At the start of the 4th systemic war (the Second World War, 1939-1945), the (fractal) organizational structures of German and American infantry divisions, for example, were highly identical.

35.4. Distribution of kinetic energy in the (State-)System

In this paragraph, I show that the 1st FTS (1480-1945) contains 'perfect' fractal structures if a fourth level of dynamics is taken into consideration, and if the 1st FTS would not have been distorted during the period 1657-1763 (the 1st exceptional period).

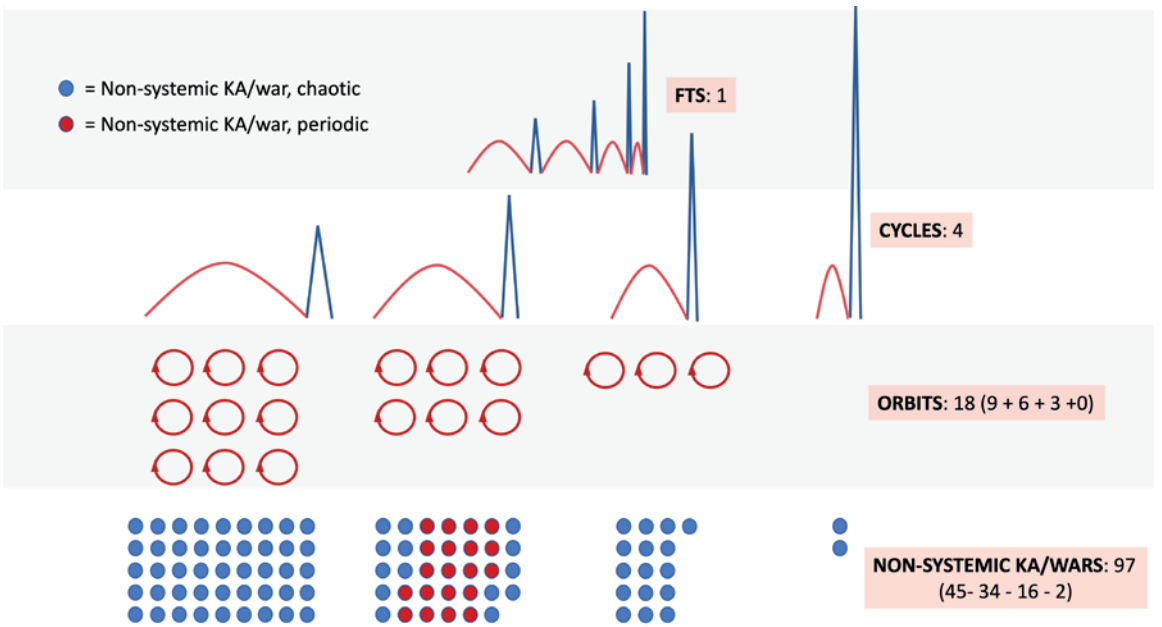


FIGURE 35.3: The 1st FTS is a fractal distribution system.

It is possible distinguish four 'levels' of dynamics in the (State-)System: (1) the 1st FTS itself, consisting of (2) four cycles, that generated (3) in total 18 orbits (assuming chaotic non-systemic KA were not distorted during the period 1657-1763) and (4) 97 kinetic events.
In pervious chapters, I discussed that orbits - orbital trajectories - can be identified in phase-space (when phase space is defined the intensity and size of non-systemic KA/wars), and that these orbits are a hallmark of chaotic dynamics, produced by a fractal (strange) attractor.

It seems that there is more to these orbits; it seems that these orbits make up a separate level of dynamics (at least in the deterministic domain). Why this is the case and what it means, in the contingent domain, is not clear and requires further research (Are non-systemic KA/wars that make up a single orbit concerned with the same issues in the contingent domain?).

The very regular orbits the 1st FTS produced during the 1st RSP (1480-1618) of the 1st FTS, possibly provide some clues: During the 1st RSP, the FTS produced nine orbits that constituted a damped oscillator, as discussed in chapter 26.

I assume that each consecutive orbit - consisting of a number of non-systemic KA/wars - can be considered a 'coordinated' response of the 1st FTS to a perturbation to re-establish equilibrium in the RSP. The oscillations suggest that these corrections (these responses) were produced with a time-delay, causing over-corrections (overshoots), that than triggered counter-corrections that were also delayed. The dampening of successive KA-oscillations - that eventually faded away shortly before the (State-) System became critical again and produced a systemic KA/war - can be attributed to the increasing local stability of states during high-connectivity regimes.

The supposed fractality of the FTS-process is based on the assumption that the 1st FTS would have produced 18 orbits in total during the transient period (1480-1945), if the 1st FTS would not have been distorted during the 1st exceptional period (1657-1763), during the 2nd cycle (1648-1815). The 'theoretical' number of 18 orbits in total - six orbits during the 2nd cycle if the 1st FTS would not have been distorted - is based on the following observations:

Two perspectives suggest that the 1st FTS would have produced 18 orbits in total, if the 1st FTS would not have been distorted during the 2nd cycle, both 'calculations' are based on interpolation of available data, and on the assumption that properties of the (State-)System develop regularly (an assumption that finds strong support in this study): (1) Interpolation of the series: 1 (FTS) - 4 (cycles) - X (orbits) - 97 (non-systemic events), suggest that X = 18; (2) interpolation of the number of orbits and orbit-like structures during respective cycles, of the series: 9 (1st cycle) - X (2nd cycle) - 3 (3rd cycle) and 0 (4th cycle), suggest that X = 6, bringing the total to 18, which is consistent with the outcome of the first perspective.

To check the outcome (18 orbits in total, 6 during an undistorted 2nd cycle), I also determined the number of non-systemic KA/wars, per average cycle, and if a number of six matches the average (see also figures 35.4 and 35.5).

During the 1st RSP (1648-1792) of the 2nd cycle (1648-1815) there were also two periods - before and after the 1st exceptional period (1657-1763), when the non-systemic KA was chaotic in nature, from 1648 until 1657 and from 1763 until 1792. During these short chaotic periods - analysis shows - the 1st FTS produced one orbit-like structure (1648-1657) and one orbit (1763-1792). That means that the twenty wars that were produced during the 1st exceptional period (1657-1763) had to fit in six minus two orbits is four orbits; that is five wars per orbit.

It is possible to check if the number (5 wars/orbit) fits in the patterns: Based on the available data and the 'reconstruction' of the 2nd cycle, it is possible to determine the number of non-systemic KA per orbit for each cycle: 5,0 wars/orbit during the 1st cycle (45/9), 5,7 wars/orbit during the 2nd cycle (34/6) and 5,3 wars/orbit during the 3rd cycle (16/3) (the 4th cycle produced two wars, but no orbit)s. The number calculated for the period 1657-1763 (5 wars/orbit) fits in the overall pattern.

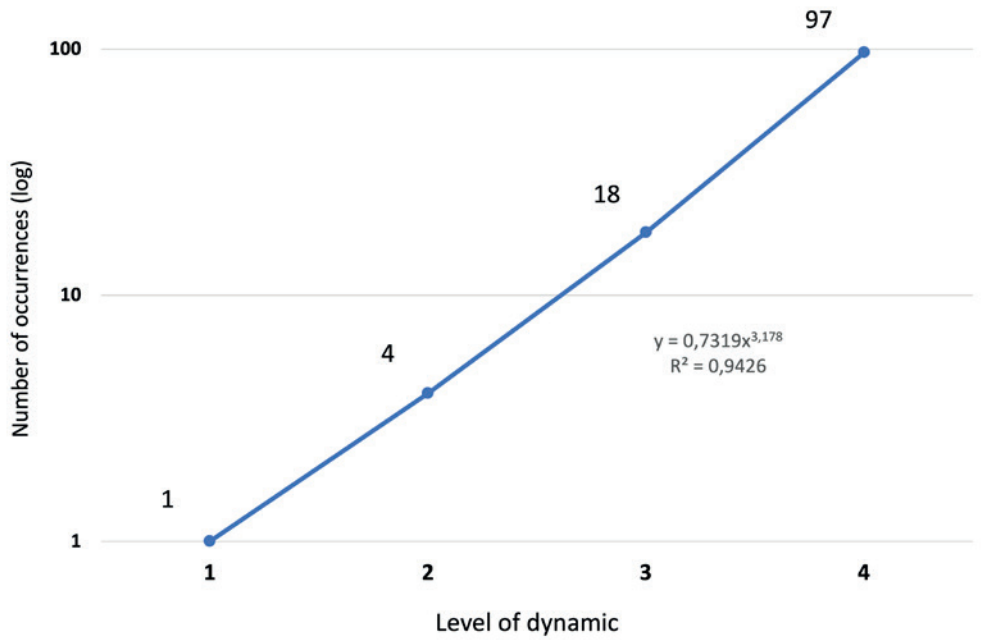


FIGURE 35.4: Number of orbits per cycle of the 1st FTS, based on a reconstruction of the 2nd cycle.

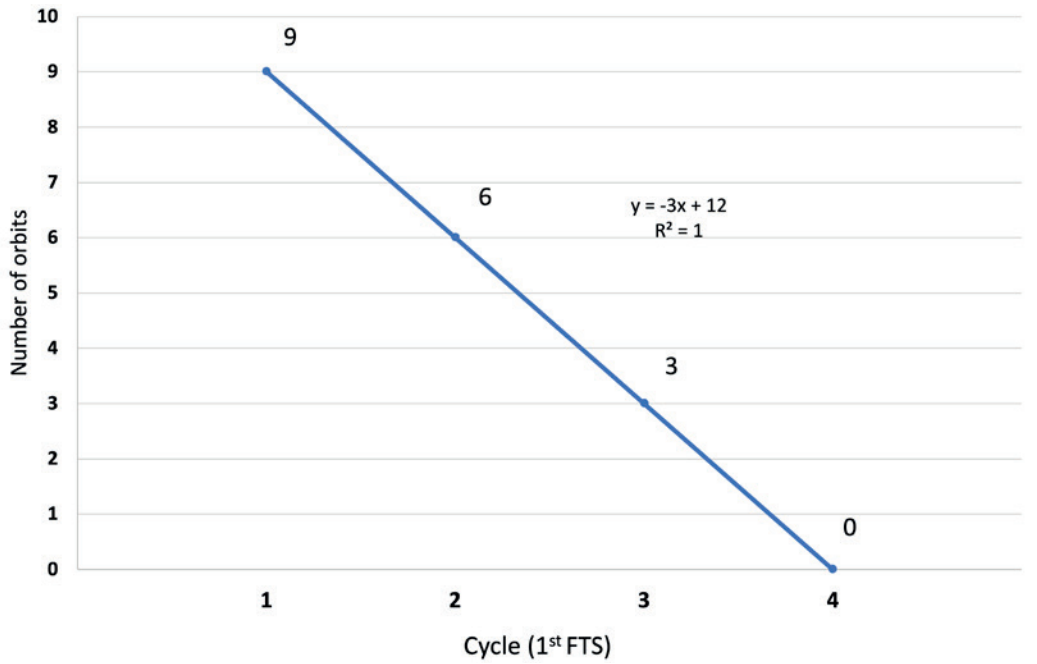


FIGURE 35.5: The 1st FTs is an optimized fractal distribution structure. This figure shows the number of occurrences at the four levels of dynamics: 97 non-systemic KA/wars (nine expansion wars excluded), 18 orbits (number established through interpolation), four cycles and one FTS, during the period 1480-1945. The distribution qualifies as a Zipfian distribution. The equation and R^2 refer to the accompanying trendline, a power law.

35.5. The State-System as a distribution network/system

As discussed in the previous paragraphs, fractal structures are related to criticality (critical phenomena), to chaotic dynamics and point to optimization (processes). Fractals are about distribution.
The State-System can be considered a distribution network/system. The European State-System was the structural component of the 1st FTS. The evolution of the configuration of the State-System, during the transient period (1480-1945), reflects the distribution and processing of EMIS-flows in the System.
In this paragraph, I discuss several cases 'where and why' power-law distributions - implying fractality - can be found in the dynamics and structures of the System, what this could mean, and how these distributions are in some cases related.

a. *War sizes*. The size-distribution of KA can be described with a power laws / Zipf-distribution: when size is defined as the number of casualties (67) and when size is defined as the fraction of Great Powers actively involved in Great Power wars, see figure 35.6.
I assume that these distributions can be attributed to the fact during the transient period (1480-1945), the State-System is increasingly near equilibrium, and experiences a phase transition that involves chaotic dynamics FFE (R1-dynamics). During the transient period, EMIS is constantly produced and redistributed, in compliance with the laws of thermodynamics and related principles that apply.

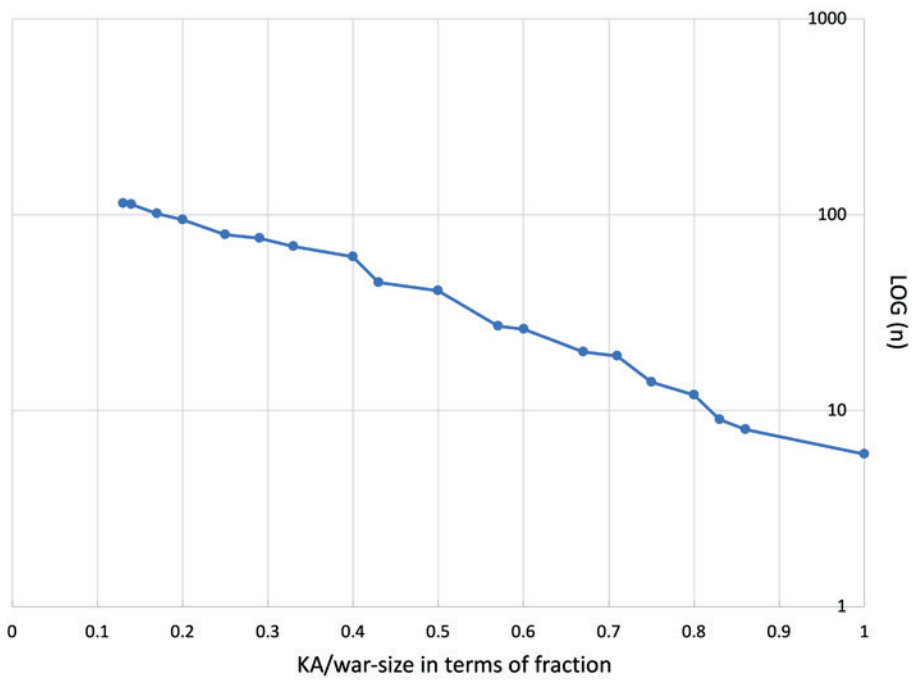


FIGURE 35.6: Zipf-distribution of KA/war-sizes in terms of fraction, during the transient period (period 1495-1945, data from Levy (..)). Non-systemic KA/wars during the 1st exceptional period and expansion wars are included.

b. *State structures*. During the transient period (1480-1945), the anarchistic (State-)System developed from a system consisting of a large number of loosely connected and various types of units, into a highly connected system with circa 25 highly standardized states, that were 'organized' to produce and deploy increasing amounts of kinetic energy, at accelerating rates.
   In the article titled "*Hierarchical organization of cities and nations*" observe that geographical and demographical data show "that the nation population and nation area distributions obey power laws" (50). Malescio et al. show that this is the case for all nations of the world, including Europe. As I mentioned, I argue that the fractal State-System in Europe was carved out by the 1st FTS, during the transient period.
   The increasing fractality of the State-Structure (over time) - and of supporting/related processes and structures - contributed to the optimization of EMIS-regulation. The fractal structures can be considered the outcome of continuous 'trade-offs' made by the FTS, that also involved the competing thermodynamic potentials and their extremization: maximization of entropy-production by the System and minimization of entropy-production by the State-System.
c. *Military organizations and capabilities*. During the transient period (1480-1945), military organizations increasingly adopted fractal organizational structures, indicative for the increasing optimization of the distribution of kinetic energy in the (State-)System, through states, the State-System and their military capabilities.
   In case of military organizations, organizational structures at (numerous) levels of organization are to a large extent self-similar: Each level consists of (mostly) three self-similar substructures. There is self-similarity in organizational structures, as well as in capabilities that are available at different levels of organization; see figure 35.7.

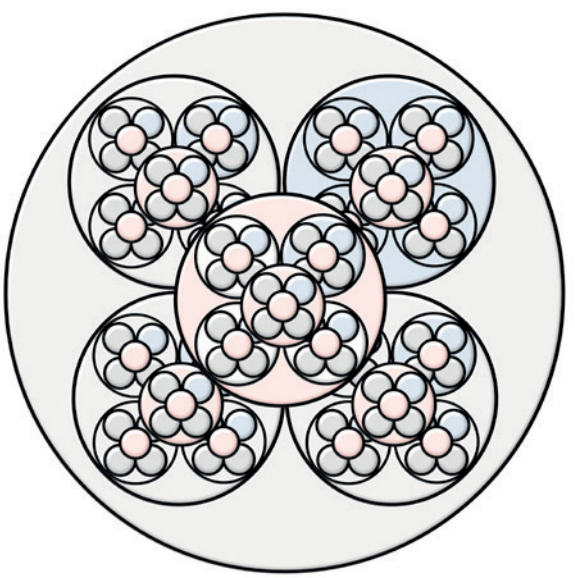


FIGURE 35.7: A schematic representation of the fractal structure of military organizations.

Military organizations put kinetic energy to use, in response to threats - possibilities (entropy) - that are considered threats - to the society/state they represent.

During the transient period (1480-1945), the production of entropy and KA continuously accelerated. Systemic KA was produced with an increasing rate and magnitude. Systemic KA became increasingly 'total' and required the full 'mobilization' of societal resources. The State-System (core) became increasingly 'kinetic' and societies became increasingly dependent on state-structures that could maximize the development, production and use (deployment) of kinetic energy (military capabilities) to ensure their survival.

War-fighting capabilities - and preparations - were constantly improved and increased in scale. 'On the battlefield' - where kinetic energy (military capabilities) are deployed - military organizations must reconcile and optimize a number of contradictory demands.

Military organizations must for example strike an optimal balance between the concentration of sufficient and decisive amounts of kinetic energy (military capabilities) and the risks concentration poses for destruction by the adversary: An optimal balance between concentration and dispersal must be achieved, to ensure accomplishment of the mission, and survival of the own military organization.

The span of control, defined as the number of military subunits that a commander can effectively control, is another factor that contributes to the emergence of fractal military organizations; military organizations must also ensure optimal distribution information.

Optimization of the span of control also requires balancing and trade-offs to achieve optimum results. In case the maximum achievable span of control is not utilized, the available resources (energy) and organization (structure) are not used to maximum effect and the organization has unnecessary communication links and probably too many hierarchical levels/layers (52).

TABLE 35.1: Rank order of Great Power participation in non-systemic wars (expansion wars excluded), at least involving two Great Powers. (n = 63, data from Levy (48)).

Rank	Great Power	Number of wars
1	France	35
2	Austrian Hapsburg/Austria/Austria-Hungary	26
3	England/Great Britain	25
4	Spain	24
5	Ottoman Empire	14
6	United Hapsburg	9
7	Russia/Soviet Union	9
8	The Netherlands	6
9	Prussia/Germany/West Germany	6
10	Sweden	3
11	Italy	1

On the other hand, if the maximum span of control is exceeded, the control system is saturated: information distribution is not efficient, and the accuracy of information is consequently negatively affected, which negatively affects 'situational awareness' and the quality of decision-making.

d. *Great power participation in Great Power wars*. The distribution of the participation of Great Powers in Great Power wars, is also related to the distribution of kinetic energy and KA, in the (State-)System. Table 35.1 specifies the involvement of Great Powers in non-systemic KA/wars (expansion wars excluded) that involved at least two Great Powers during the transient period (1480-1945). In total it concerns 63 non-systemic KA/wars.

e. *Duration of non-systemic KA/wars*. The duration of non-systemic KA/wars, is yet another property of the (State-)System, related to the distribution of kinetic energy and KA, in the (State-)System, during the transient period. In this case the distribution can also be described with a power law or Zipfian distribution, consistent with the assumption that the (State-)System produces fractal structures, to ensure efficient energy distribution. See table 35.2 and figure 35.9..

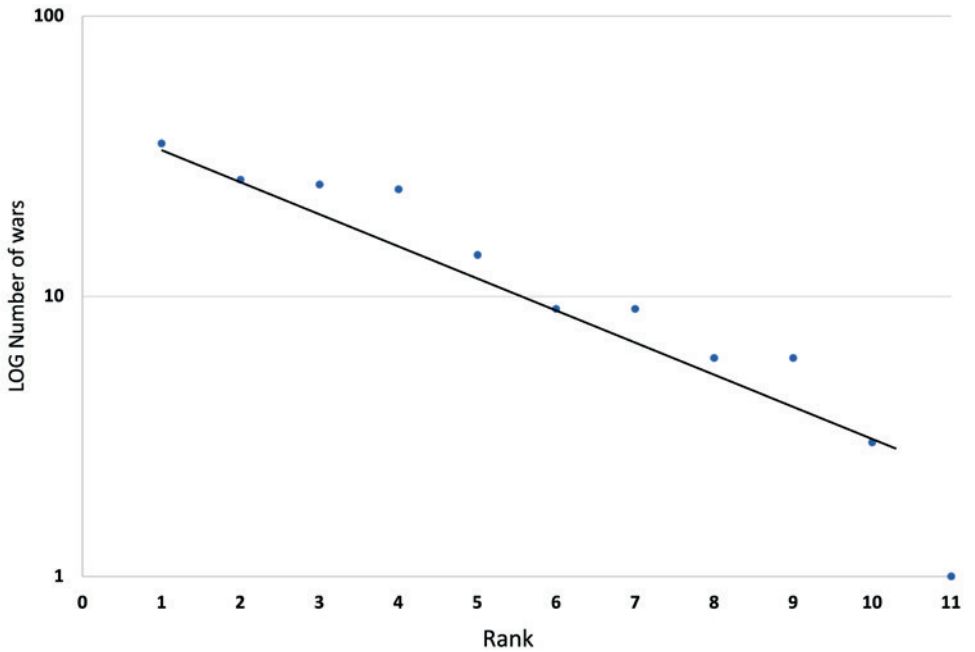


FIGURE 35.8: Rank order of Great Power participation in non-systemic wars (expansion wars excluded), at least involving two Great Powers (period 1495-1945. (n = 63, based on data from Levy (48)). The distribution approximates a Zipfian distribution, (59).

TABLE 35.2: Distribution of the duration of non-systemic KA/wars (expansion wars excluded) involving at least two Great Powers (period 1495-1945). (n = 63, based on data from Levy (48)). The figures in the second row (0-1, 1-2, etc.) are the brackets I used to determine the duration distribution: 1-2 for example, stands for wars with a duration of 1 until 2 years.

0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
8	8	8	11	2	5	5	3	1
9-10	**10-11**	**11-12**	**12-13**	**13-14**	**17-18**	**19-20**	**21-22**	
3	2	2	1	1	1	1	1	

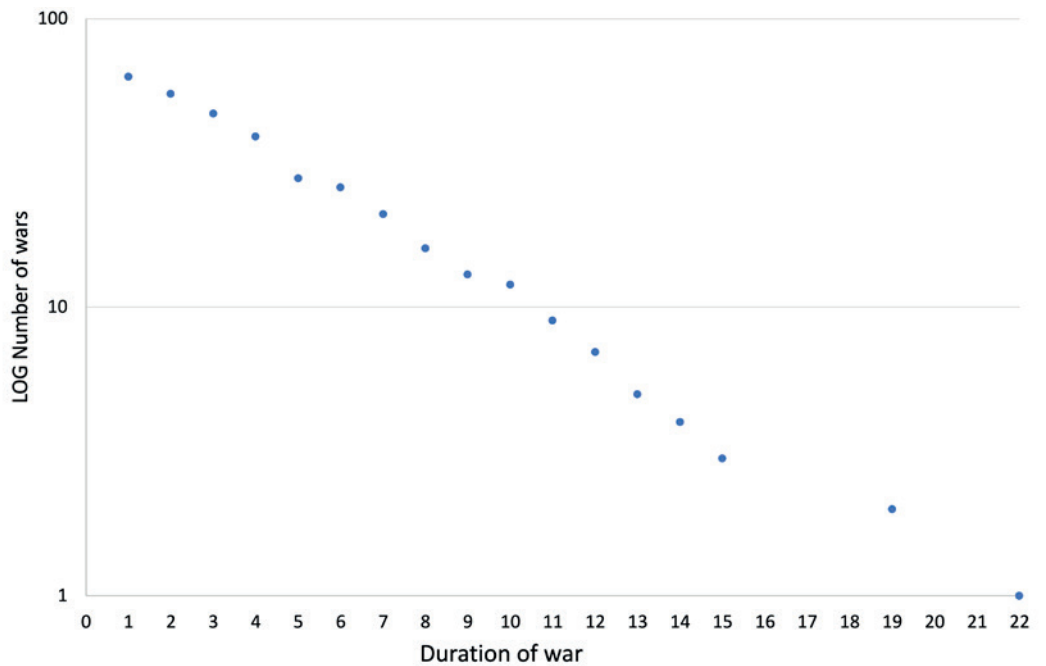


FIGURE 35.9: Cumulative distribution of durations of non-systemic KA/wars (expansion wars excluded), at least involving two Great Powers (period 1495-1945). The figures on the x-axis concern the duration of wars, based on above table. (n = 63, based on data from Levy (48)). This is distribution approximates a Zipfian distribution.

35.6. Application (1): 'Principles of war' and war theories optimize the use of military power (kinetic energy)

During critical periods, states deploy and 'counter deploy' kinetic energy on a system-wide scale, in efforts to submit other states to one's will and create favorable bargaining positions regarding the design and implementation of upgraded order. At the same time as states inflict destruction on certain (selected) states and their societies, they intensively cooperate with other states in alliances; not only to achieve 'maximum' destruction and hedge risks, but also to (collectively) design and implement favorable upgraded orders.

During systemic KA/wars the (State-)System consists of a mix of cooperative and conflicting clusters that have fractal structures, I assume (further research is required).

Because of risks involved and scarcity of resources, states want to complete systemic KA/wars as fast as possible, obviously with favorable results. Systemic KA/wars not only involve the risk of unfavorable outcomes e.g. through their destruction by other states, but also the risk for internal unbalances as a consequence of the singular focus of a state on security requirements, during a systemic KA/war. Ignorance of other requirements can cause internal imbalance and even collapse.

War-fighting has to be effective and efficient and requires optimization of the distribution of kinetic energy. Optimization is achieved through fractal structures of military organizations and of their capabilities, and through the application of principles that guide the deployment of kinetic energy.

On the battlefield, military organizations follow certain 'principles of war' to achieve maximum effects with minimal risks, using minimal amounts of resources. On the battlefield numerous conflicting demands must be reconciled. On the one hand, the principles of war advocate decisive and offensive action and concentration of force, but on the other hand, economy of force (to ensure sustainability), and security and protection must also be ensured, to avoid destruction by the enemy. These principles contradict each other - so to speak - and must be reconciled by 'flexibility' and 'unity of command'.

It is important to note that the principles of war - including military doctrines, like Clausewitz's theory 'On War' (22) - that apply to the use of military capabilities (kinetic energy) in the contingent domain, also are products of the 1st FTS. These doctrines and principles serve the 1st FTS, by providing guidelines and offer justification for the use of kinetic energy. The principles of war are manifestations of the Second Law and related principles in the contingent domain.

35.7. Application (2): Suboptimality of military capabilities

The highly optimized structure of military capabilities also explains the inability of 'armies' to fight wars against 'organizations' that apply different (distribution) structures and principles, as for example the wars in Vietnam (1965-1973), Afghanistan (2001-....), Iraq (2003-....), Syria (2014-....), etc. show. State-armies are organized and optimized to fight other state-armies; they are products of the 1st FTS and European State-System. This simple fact also explains why the Gulf War (1990-1991) - a 'classic' war between armies - was a short and simple war: "Armies fought with armies", with identical distribution structures.

However, despite this obvious observation, the United States drew the wrong conclusions from the Gulf War: Success was attributed to the 'overwhelming force' that was put to use against its adversary (the

Iraqi army). The success was mistakenly 'translated' in the 'Powell doctrine', and 'overwhelming force' was considered a formula and precondition for success in war, and not the organizational structures of military capabilities, and their control by state-structures.
This doctrine led to the so-called '*shock-and-awe*' type of warfare applied during the invasion of Iraq in 2003: The massive use of kinetic energy directed at selected targets; also intended to achieve a psychological effect by showing overwhelming force and superior kinetic capabilities and their destructive power. However, this war - based on the Powell-doctrine - quickly and very predictably evolved into a war between the army (and the armies of coalition partners like the UK) and the Iraqi population; a war an army is not designed for, cannot fight and cannot win: The kinetic capabilities that are put to use cannot accomplish any sensible work, but only cause (more entropy), including collateral damage. The damage done to the Iraqi society - the infuse of entropy - served only as fuel for the (continuation of the) the war. The typical response of armies - not being aware of their fundamental shortcomings and the mismatch of capabilities that cannot turn out to their advantage - is to apply more kinetic energy and cause more destruction: 'If you have only a hammer then every problem looks like a nail'.

35.8. Application (3): Adjustment of the State-Structure to minimize entropy-production

In the State-System, smaller states fulfill an important role in regulating relations (EMIS-exchanges) between Great Powers and can be helpful in minimizing the production of tensions (entropy). Smaller states can form 'buffers' between rival Great Powers. The creation - emergence - of Belgium in 1830 as a sovereign state, is an interesting case in point. Belgium was created with the explicit aim to structurally decrease tensions that tended to build up in the State-System and could threaten the System's status quo (the continuity of the RSP). According to Morgenthau (54): "The outstanding example of a buffer state owing its existence to the balance of power is Belgium from the beginning of its history as an independent state in 1831 to the Second World War".
The creation of Belgium can be considered a 'correction' by Great Powers of the time, to the 3rd RSP that was implemented following the 2nd systemic war (1792-1815, the French Revolutionary and Napoleonic Wars). I assume that the addition of Belgium as an independent state to the State-System contributed to the (further) 'fractalization' of the State-System's.
This measure (the addition of Belgium to the State-System) was consistent with the principle of minimization of entropy-production that applies to the State-System, and (again) shows how these thermodynamic principles are (unknowingly) 'obeyed' in the contingent domain of the System.

36. The FTS depicted as a "kinetic" engine

36.1. Introduction

In this chapter, in order to get a better understanding of the operation of the 1st FTS, and of its performance and efficiency, I analyze the operation of the 1st FTS by considering the FTS as an engine (a "kinetic engine") and by making comparisons between a heat engine and the 1st FTS/European State-System, from a classical thermodynamic perspective. This analysis produces some interesting insights in the workings - and efficiency - of the 1st FTS and the European State-System.
The comparison of the 1st FTS and European State-System with a heat engine, requires of course a simplification of the actual (much more complicated) state of affairs.

36.2. Similarities between an engine and the FTS-turbine

The analysis shows - confirms - that the FTS can be considered an "engine", a turbine, which accomplished work on behalf of the System, and (unavoidably) produces entropy, during the process.
There are some interesting similarities between the 1st FTS when this structure is depicted as a turbine, and a for example a heat engine. The FTS also accomplishes work; the work that is accomplished involves a force, and the physical displacement - ordering - of energy and matter, for example. The work the 1st FTS accomplished, during the transient period (1480-1945) concerned the transformation of the European State-System: The accomplishment of thermodynamic equilibrium in the European State-System.
Societies/states, the non-core of the System ("The rest of the world") and the physical environment, can be considered the environments of the European State-System, during the transient period (1480-1945). The (European) State-System was an open system and the work $\boldsymbol{W}$ of the 1st FTS was done on the System itself.
During the operation of the 1st FTS entropy $\boldsymbol{S}$ (equivalent with heat $\boldsymbol{Q}$, in case of an engine) was transferred to its environment(s). In case of the 1st FTS, the formula $\Delta \boldsymbol{U} = \boldsymbol{S} + \boldsymbol{W}$
Applies ($\boldsymbol{U}$ is the internal energy of the system concerned), when the (constant) energy input made available to the State-System (by extraction of resources and energy from its environment (and several drivers), is not taken into consideration.

The 1st FTS 'turbine', produced four accelerating cycles during its life-span (the transient period, 1480-1945). It is important to note that in case of the (State-)System FFE, entropy triggers KA, and that entropy (as a source of order FFE), is equivalent to (potential) energy. The FTS-turbine runs on entropy; entropy is its fuel.

36.3. Four phases in the process of transformation

When an "engine-perspective" is applied to the (State-)System, it is possible to distinguish four phases in a cycle of the FTS-turbine:

1. A *balancing phase*, during the LCR of RSP's of cycles: A certain amount of work (EMIS-regulation) is done on the (State-)System itself to ensure its smooth operation by maintaining the status quo. The (State-)System evolves towards the tipping point, when the network-effect 'kicks in'; the work includes some physical changes to the (State-)System; the work that is accomplished also includes the exchange of energy and matter (besides entropy and information).
2. A *charging phase,* during the HCR of the RSP's of cycles: A certain amount of work (EMIS-regulation) is still done on the (State-)System itself to ensure its smooth operation by maintaining the status quo; due to the network-effect, entropy now accumulates in the (State-)System; the work includes some physical changes to the system; the work done includes the exchange of energy and matter, (besides entropy and information).
3. *A design phase,* during the upgrade of the order during critical periods through systemic KA/war; the upgrade of the order also concerns work done on the (State-)System; the upgrade includes a physical transformation of the (State-)System and the exchange of energy and matter (besides entropy and information).
4. An *implementation and settlement phase*, during the upgrade of the order during critical periods through systemic KA/war, involving the utilization and redistribution of entropy to the environment of the State-System.

In case of the application of kinetic energy (KA/war), there are also (unintended) energy changes in the surroundings: $\Delta \boldsymbol{S}$. $\boldsymbol{S}$ generated by the FTS is equivalent with e.g. collateral damage ($\boldsymbol{Q}$, heat, in case of an engine). Collateral damage has a physical component (unintended destruction and suffering) and an abstract component, the undermining of values., etc.
In figure 36.1, the characteristics of a KA/war-cycle in terms of entropy-production and kinetic energy-use (KA) at four specific points during a cycle are schematically shown: (1) at the start of a new RSP, (2) at the tipping point, (3) at the critical point of the war-cycle, and (4) during the critical period (systemic KA/war). After a cycle is completed, the FTS does not return to its initial condition, the State-System has evolved (toward - in the direction of - thermodynamic equilibrium).
The four respective "points" (properties of the (State-System) evolve as follows, during successive RSP's of cycles: (1) the KA is the same, near zero; the entropy-level increases, (2) the KA decreases during successive RSP's, while the entropy-production increases (the increased robustness of successive RSP's hinders kinetic responses), (3) the KA is the same, near zero, while the entropy level increases significantly, and (4) the KA and entropy increase significantly during successive critical periods.

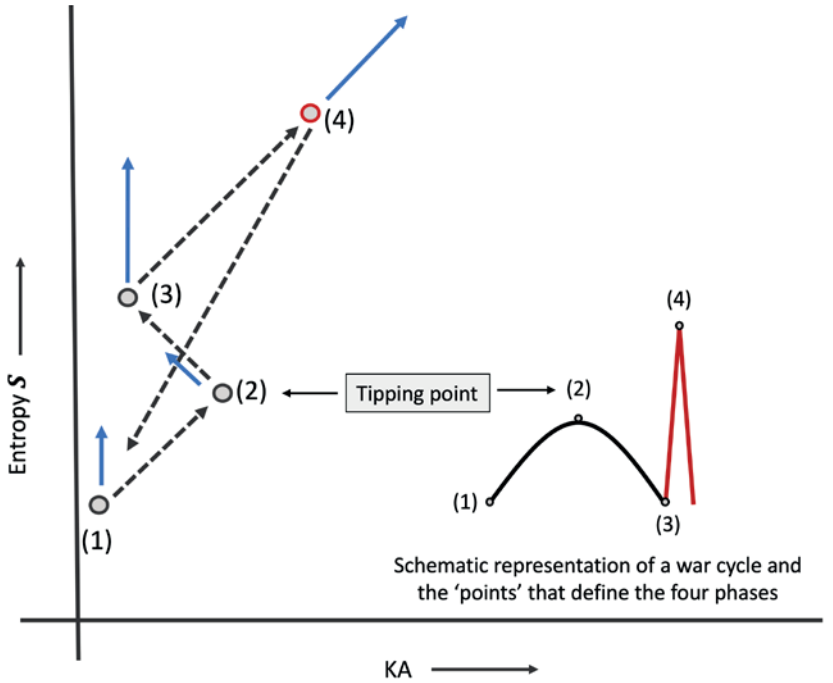


FIGURE 36.1: The development of properties at four points during cycles.

As I explain in this study, in case of the (State-)System (FFE) there is a close relationship between entropy (-production) and KA of the (State-)System, in efforts of the 1st FTS to neutralize and redistribute entropy. Entropy is a source of order: "entropy powers the FTS-engine/turbine" and it can be considered its 'fuel'. Carnot observed in reference to heat engines that "Wherever there exists a difference of temperature, motive force can be produced" (44, 55). In case of social systems (including the System) a similar principle applies: Wherever there exists an entropy gradient (different tension levels, anxieties in social systems) new possibilities are available, a social force can be produced and there is potential for social change.

The existence of gradients in a system means that the system is not in equilibrium (and vice versa). The standard response of a system is to (re-)establish equilibrium; this process involves forces and flows (as discussed): Gradients always produce forces and flows.

If the gradient is not sustained, equilibrium is re-established through forces and flows; the gradient(s) are erased and the FTS-turbine - in case of the (State-)System - comes so to speak to a halt. To maintain a force and EMIS-flows (as happened during the transient period) a gradient must be sustained. In case of the (State-)System, population growth and its effects (like increasing interactions between growing communities and societies) sustained the gradient that powered the FTS (see also chapter 21).

36.4. The Comparison of steam-cycles in a power plant a war-cycles of the 1st FTS

Ness discusses the workings of a stationary power plant that generates electricity by expanding steam through a turbine (55).
The operation of such a plant contains four primary devices in the power cycle. In this paragraph, I discuss the workings of a power cycle, and compare its primary devices and the functions they fulfil with the workings of a war-cycle, as part of the "FTS-turbine". See also table 36.1 and figure 36.2.

TABLE 36.1: Comparison between a steam engine and the FTS, based on a classical thermodynamic perspective.

	Power plant		FTS
	Primary device	**Function**	**FTS equivalent**
1	Boiler	A *boiler* converts liquid into steam at a high pressure and a high temperature. Heat input ($\boldsymbol{Q_H}$) is required from a high-temperature source. Function: Transformation of resources into (free) energy.	Societies transform resources into free (kinetic) energy (military capabilities). Function: Transformation of resources into (free) energy (entropy (tensions) serve as a catalysator in the process).
2	Turbine	The steam powers a *turbine* which drives an electric generator. Work $\boldsymbol{W}$ can then be accomplished by the electricity generated by the generator. Function: Transformation of energy into work.	The kinetic energy is put to work during *KA/ war, in response to entropic perturbations and entropy accumulation,* respectively during RSP's ($\boldsymbol{W_{RSP}}$) to maintain the status quo, and during critical conditions to upgrade the order ($\boldsymbol{W_{UPGRADE}}$). The FTS also functions as a turbine. The work $\boldsymbol{W}$ contributes to the process of aggregation and expansion. Function: Transformation of energy into work.
3	Condenser	Steam expands through the turbine, provides the motive power to drive the turbine and exhausts at a low pressure and enters a water-cooled condenser; the steam condenses and the heat $\boldsymbol{Q_C}$ is removed. Function: Exchange of heat (to the environment) and recycling of degraded energy (entropy, $\boldsymbol{S}$).	KA is regulated by the FTS. The KA also generates entropy which is extracted from the System by the solutions that are selected and implemented through the KA; the process is regulated (neutralized and redistributed) by the FTS, which - so to speak - also serves as a condenser. Function: Exchange (to the environment) and recycling of degraded energy (entropy, $\boldsymbol{S}$).
4	Pump	The liquid condensate is then pumped into the boiler where it is re-vaporized. Function: Ensuring continuation of the process.	The FTS ensures that continuity and change are balanced, (further) population growth, recovery of destruction caused by KA (self-healing), and further development are enabled, in order to ensure the most efficient path to thermodynamic equilibrium of the State-System. Function: Ensuring continuation of the process. Various self-reinforcing loops, regulated in concert by the FTS, serve as pumps; the underlying urge to survive is the basic driver.

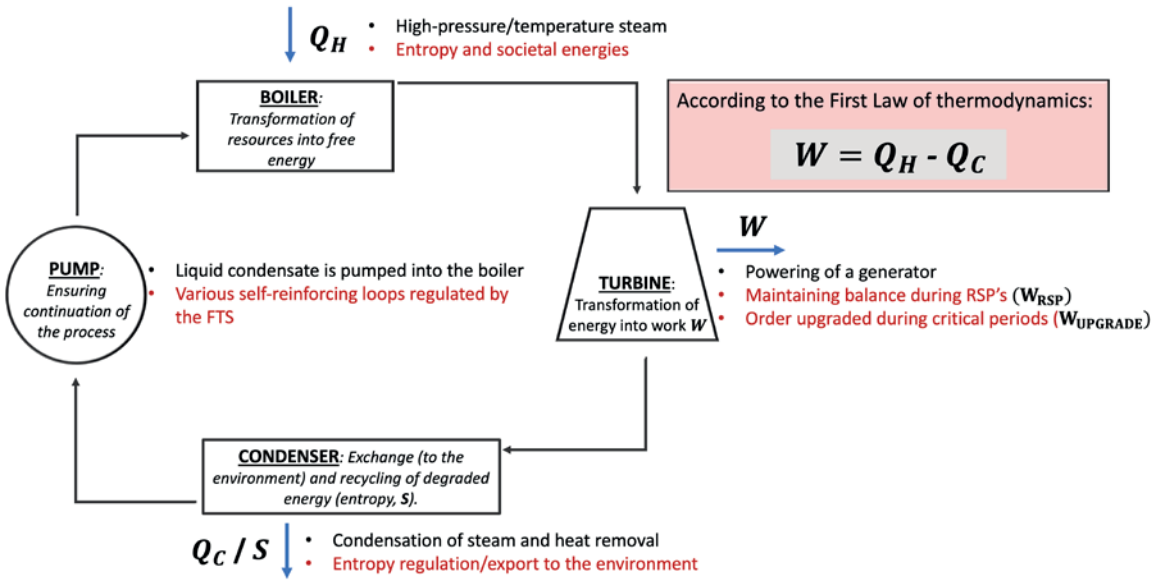


FIGURE 36.2: Comparison between a steam engine and the FTS-engine, based on a classical thermodynamic perspective (55). This figure is a schematic depiction of a steam- and KA/war-cycle. There are some fundamental similarities, it should however be reminded that the FTS is a FFE-structure and that its operation is based on its relationship and interactions with its environment(s). For each 'device' the function is shown; for the FTS-cycle in red.

It is now possible, to derive several relationships between variables involved in the KA of the (State-) System.

$$KA_{Cycle} = \sum E_{Kin} = F = pS = W_{Tot} + S_{environment}$$

$$W_{Tot} = W_{RSP} + W_{Crit}$$

KA is the sum of the kinetic energy that is put to use by states involved in the KA/wars (= $\sum E_{Kin}$); the kinetic energy E_{Kin} is the free energy F of the State-System. KA is triggered by the (State-)System and regulated by the FTS: KA is a system-response, triggered by entropic perturbations during RSP's, and by entropy-accumulation in case of Systemic KA (systemic KA/war during critical periods), that has accumulated during the HCR of the preceding RSP.

I assume that a relationship exists between the entropy produced by/in the (State-)System FFE and a certain amount of entropy that is then in response transformed by societies/states into free energy F (military capabilities). The factor p expresses the relationship between the entropy produced by the (State-)System and the proportion that is transformed into free energy F.

$S_{environment}$ is the entropy that is produced through the KA and is exported to the environments of the State-System.

Through the energy that is put to use, Work W is accomplished: During RSP's W_{RSP} to maintain the existing order (balance, status quo), and during critical periods W_{Crit} to upgrade the existing order.

The work accomplished in the non-core is included in the terms W_{RSP} and W_{Crit}.

If the basic equation that applies to steam engines - $\boldsymbol{W} = \boldsymbol{Q}_{\boldsymbol{H}} - \boldsymbol{Q}_{\boldsymbol{C}}$ - is also applied to the State-System (which is a simplistic presentation), then $\boldsymbol{W} = \boldsymbol{F} - \boldsymbol{S}_{\boldsymbol{environment}}$.

TABLE 36.2: Work in/on the core and non-core involving KA. In this table, an overview is given of (categories of) work the 1st FTS accomplished during the transient period (1480-1945).

	Work category	Purpose
1	Utilization and redistribution of entropy in the core, during RSP's.	To ensure efficient EMIS regulation; preserving the existing order; maintaining the status quo.
2	Aggregation of societies/states in the core during RSP's and critical periods.	Merging of societies and states, development of a new hierarchical level to improve EMIS-regulation; includes physical reconfiguration of the State-System to ensure territorial control.
3	Designing and implementing upgrades of orders of the core, during critical periods.	To ensure and improve EMIS-regulation; to balance continuity and change to ensure the most efficient path to thermodynamic equilibrium.
4	Expansion of the core to the non-core.	To support EMIS-regulation, by exchanging entropy; to acquire resources and power and influence; consolidation of structures established in the non-core.
5	Development of the non-core by autonomous non-core interactions and dynamics.	Conform (1) and (2).
6	Globalization of the System, through the merging of the core and non-core.	To ensure and improve EMIS-regulation; to balance continuity and change to ensure the most efficient path to thermodynamic equilibrium.

The development of the release-ratios of successive cycles of the 1st FTS shows that the division of work between RSP's (non-systemic KA/wars) and critical periods (systemic KA/wars) was very strictly organized and regulated, but that the 1st exceptional period (1657-1763) caused a distortion and inefficiencies.
The development of the release-ratios show that increasingly less work was done during successive RSP's, and that increasingly more work was accomplished during successive critical periods. Not only was there a shift in the distribution of work, but the amount of work increased (acceleratingly) at the same time.

36.5. Fundamental limits: There is no impact of technology and strategy on the efficiency of the FTS and of the (State-)System

Analysis of the workings of the "FTS-engine", from the perspective of a heat engine, and the fact that the laws of thermodynamics apply to both engines, provides us with some very useful insights: Arguably, Carnot's theorem can also be applied to the FTS/State-System.
Carnot "analyzed the fundamental processes that underlie heat engines, engines that performed mechanical work through the flow of heat and realized that there was a fundamental limit to the amount of work generated from the flow of a given amount of heat. Carnot's great insight was that this limit was independent of the machine and the manner in which work was obtained: it depended only on

the temperatures that caused the flow of heat" (44). In other words: The efficiency of Carnot's engine is only a function of temperature. "Further development of this principle resulted in the formulation of the Second Law of thermodynamics" (44).
Carnot's discovery that the *reversible* engine produces maximum work amounts to the statement that its efficiency is maximum. This efficiency is independent of the properties of the engine and is a function only of the temperatures of the hot and the cold reservoirs; this is Carnot's theorem (44).
This means that *irreversible* processes - like social interactions and work that is accomplished on the (State-)System by the 1st FTS, for example - can never achieve maximum efficiency: A certain degradation of energy, production of entropy (in the transformation processes involved) is unavoidable in these processes (as is the case in all natural processes, including heat engines).
In accord with Carnot's theorem, I argue that the maximum efficiency the FTS can achieve is independent of the properties of the technology and strategies that are applied during KA/war but is a function of certain thermodynamic properties of the dynamics (transformation processes) taking place. I argue that the maximum amount of work cycles of the FTS can accomplish is a function of the entropy-gradient the FTS - the State-System - can develop and maintain.
This conjecture is consistent with two observations regarding the 1st FTS and the KA/war dynamics of the (State-)System: (1) The very regular amount of energy (in terms of BCD) that was put to use during successive cycles of the 1st FTS, and (2) the fact that technological innovations and military strategies did not have any impact on the (thermodynamic) properties and performance of successive KA/war-cycles, during the transient period (1480-1945). Technology and strategy do matter in case of separate KA/wars in the contingent domain (how they are fought, in some cases who will succeed or not), but do *not* impact on the efficiency and performance of KA/war dynamics of the FTS.

36.6. Efficiency of cycles of the 1st FTS

The work that is accomplished by the heat engine discussed in above paragraph is $\boldsymbol{W} = \boldsymbol{Q_H} - \boldsymbol{Q_c}$. When the fraction $\boldsymbol{\eta}$ of the heat $\boldsymbol{Q_H}$ is converted into work $\boldsymbol{W}$, $\boldsymbol{\eta} = \boldsymbol{W}/\boldsymbol{Q_H}$ is the efficiency of the heat engine.
Since $\boldsymbol{W} = (\boldsymbol{Q_H} - \boldsymbol{Q_c})$, in accordance with the First Law, $\boldsymbol{\eta} = (\boldsymbol{Q_H} - \boldsymbol{Q_c})/\boldsymbol{Q_H} = (\mathbf{1} - \boldsymbol{Q_c}/\boldsymbol{Q_H})$.
"Carnot's discovery that the reversible engine produces maximum work amounts to the statement that its efficiency is maximum. This efficiency is independent of the properties of the engine and is a function only of the temperatures of the hot and cold reservoirs "(44), respectively $\boldsymbol{Q_H}$ and $\boldsymbol{Q_c}$.
"If for example the ratio $\boldsymbol{\eta}$ is 0,54, then 54% of the heat added is converted into work. And the remaining 46 percent of the heat leaves the engine as heat" (55).
The question is if these insights can also be used to better understand the workings of the FTS - that, as I showed, can be considered an engine as well - despite some obvious and significant differences (e.g. that the State-System is a system FFE).
I now assume that the population size of the core of the System (Europe) - the most basic driver of the (State-)System - was (and still is) a measure for the entropy that is produced by the (State-)System, during the transient period (1480-1945), and that the entropy that is produced in the (State-)System FFS can be considered equivalent to potential energy that is available to the (State-)System FFE.
The entropy - tensions, uncertainty - in the (State-)System trigger a process of transformation of societal energies into kinetic energy (military capabilities), a process that is regulated by the state.

Furthermore, I consider BCD's - produced during cycles - a measure for the kinetic energy (military capabilities) that was put to use during the cycles.
I define the efficiency of a cycle, as follows:

$$\eta_{Cycle} = 1 - \sum Severity_{Cycle} / Population\ size\ at\ the\ critical\ point$$

Despite some similarities in the equation, this is a different perspective on efficiency; it concerns the System FFE.
$\sum Severity_{Cycle}$ is the total number of BCD, produced during a cycle. BCD is a measure for the kinetic energy that is put to use. ***Population size at the critical point*** is the European population size (in case of the 1st FTS), the moment (1618, 1792, 1914 and 1939), the cycle (RSP) reached its critical point (start of the systemic KA/war).
$\eta_{Cycle} = 0{,}90$ means that the efficiency of this cycle is 90%, and that 90% of the European population - containing 90% of the potential energy - was transformed - configured - into a new upgraded order, at the expense of 10% of the population that was used - put to work - as kinetic energy, in the process of transformation (the work that had to be accomplished).
also means that 10% of the population is used in the transformation process (to accomplish work).
The KA generated by using kinetic energy (BCD), to ensure equilibrium during RSP's of cycles, and upgrades during critical periods, also results in civilian casualties (deaths), and damage to infra-structure etc. Part of the casualties is intentional (like caused by the bombing of cities, like London and Dresden, during the Second World War), part is unintentional, and can be considered entropy, that is generated through the KA.
From a thermodynamic perspective on KA/war-dynamics, there is a fundamental difference between military and civilian casualties: Whereas, military deaths (BCD) are a measure for the energy that is utilized (and the work that is accomplished), civilian casualties can be considered "heat" (an unintended "by product" of KA/war).
As Carnot shows, the maximum amount of work obtained by a heat engine is independent of technology that is applied but depends only on the temperature difference that caused the flow of heat (44); in other words, on the temperature gradient the machine establishes.
I argue that, in case of the (State-)System, the maximum of work obtained by the FTS is independent on the technology and strategies that are used in the KA/wars (in the process) but depends only on the entropy-gradient the FTS establishes and sustains between the System (S_s) and the State-System (S_{ss}); this gradient determines the flow of kinetic energy/KA in the State-System: $W = f(S_s, S_{SS})$.
The 1st FTS can be considered an adaptive "engine" that continuously kept its performance optimized, by maximizing the gradient ( ), to ensure the most efficient path to thermodynamic equilibrium of the State-System could be accomplished, in accordance with the Second Law and related principles: During the transient period (1480-1945), the 1st FTS achieved maximum efficiency, except for the 2nd cycle (1648-1815), when non-systemic KA was temporarily distorted during the 1st exceptional period (1657-1763).

36.7. The consistently high efficiency of the 1st FTS

It is now possible to calculate the efficiency of the four cycles that accompanied the 1st FTS. Not only is the question what efficiency was achieved during successive cycles, but also if the same efficiency was achieved, as I expected.

TABLE 36.3: Total severity (BCD) of cycles as proportions of the population size (core, Europe), at the critical points of cycles/RSP's (based on data used from Levy (48)).

Cycle	Year	Population size (in millions)	Actual 1st FTS (BCD/pop size in %)	Corrected 1st FTS (BCD/pop size in %)
1	1618	115	2,59	2,64
2	1792	195	3,87	2,95
3	1914	450	1,87	1,94
4	1939	525	2,47	2,19

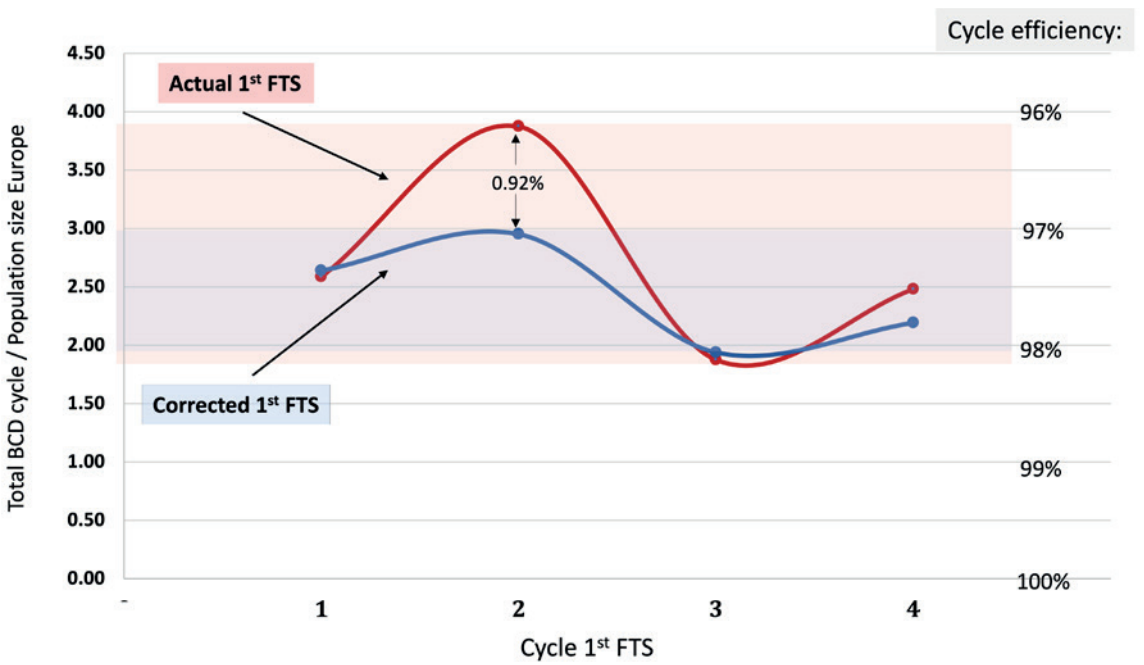


FIGURE 36.3: Efficiency of cycles, 1st FTS (1480-1945).

The analysis shows that the efficiencies of the four cycles of the 1st FTS were within a range of 96-98% for the actual, and between 97-98% for the corrected 1st FTS. See also figure 36.3.
The efficiency fluctuated only marginally, and not surprisingly, the abnormal KA/war dynamics during the 1st exceptional period (1657-1763), caused an inefficiency of the 2nd KA/war-cycle. If the corrected 1st FTS, is used as a reference, and the globalization effect that contributed to the total KA of the 4th cycle (to the 4th systemic KA/war, the Second World War, 1939-1945) is not taken into consideration, the efficiency of the 1st FTS improved.
This analysis confirms that the 1st FTS was a highly efficient and a well-tuned "engine".

36.8. Application (1): The ingenuity of the FTS

The analysis and calculations in this chapter, reveal the ingenuity of the 1st FTS: Its ability, to continually optimize its operation - including the KA/war-dynamics - to ensure the most efficient path of the European State-System to thermodynamic equilibrium, in accordance with the Second Law and related principles that apply.
During the transient period (1480-1945), the entropy-production and KA of successive cycles, accelerated continuously and very regularly: At the same time as the System's entropy- and kinetic energy production and their use accelerated, the European State-System was driven to zero-entropy; a state the State-System reached in 1939, and caused its collapse.
The 1st FTS used the increasing gradient ($\boldsymbol{S}_s - \boldsymbol{S}_{SS}$), to apply an increasing force on the European State-System, to breach barriers and accomplish thermodynamic equilibrium. During the process, the 1st FTS succeeded in sustaining a 97/98% efficiency. See also figure 36.4.

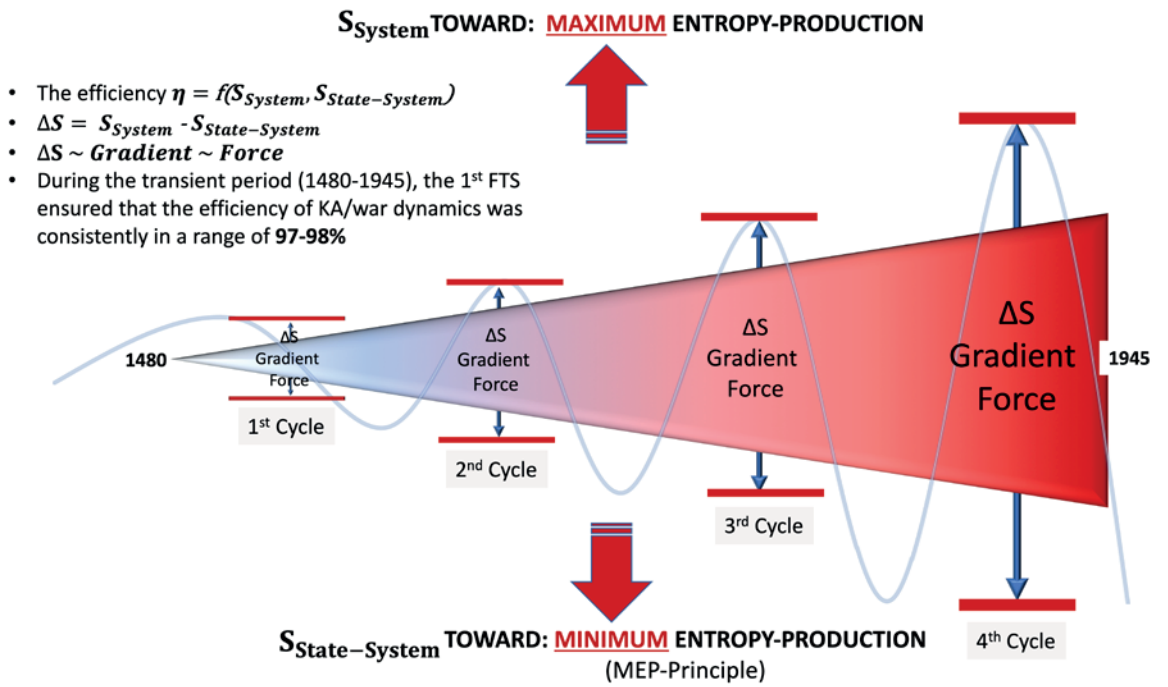


FIGURE 36.4: The 1st FTS ensured consistent efficiency (97-98%) during the transient period (1480-1945).

36.9. Application (2): Technology and strategy have no impact on the KA/war dynamics of the (State-)System

The analysis discussed in this chapter, provides us with very important insights in the nature of KA/war dynamics, and the operation of the FTS: Although factors as technology and strategy impact on the conduct of a (specific) war and can be decisive in its outcome in political and social terms - that is in the contingent domain - they do not impact on the KA/war dynamics of the (State-)System: The efficiency of the KA/war dynamics - the efficiency of the FTS - is only determined by the level of entropy of the System S_s, and of the State-System S_{ss}; by certain thermodynamic properties.

This basic fact - the determination that Carnot's theorem also applies to the "FTS-engine" - explains why major technological innovations and their application - like the steam engine, the railways, the telegraph, the tank and nuclear capabilities - did/do not impact on the KA/war dynamics of the (State-)System during the transient period (1480-1945): The properties of the KA/war dynamics of the (State-)System are determined by laws of physics, and in particular by the Second Law and related principles.

37. FTS-regulation

37.1. Introduction

The FTS regulates EMIS-flows in the (State-)System, in compliance with the Second Law and related principles; including competing thermodynamic potentials and their extremization which contribute to the dynamics and development of the (State-)System.
In case of EMIS-regulation by the FTS, four closely related - interacting and complementary - processes can be distinguished, as discussed in preceding chapters: The processes of KA, aggregation (of the core), expansion to the non-core - essential for the sustainment of the FTS - and empowerment.
Regulation of EMIS-flows serves an overcharging purpose: various purposes: To accomplish thermodynamic equilibrium of the State-System via the most efficient path.
In this chapter, I again address the subject of EMIS- regulation of the (State-)System through the FTS and apply the insights that were presented in preceding chapters.
Below model (see figure 37.1) - discussed in chapter 19 - serves as a reference.

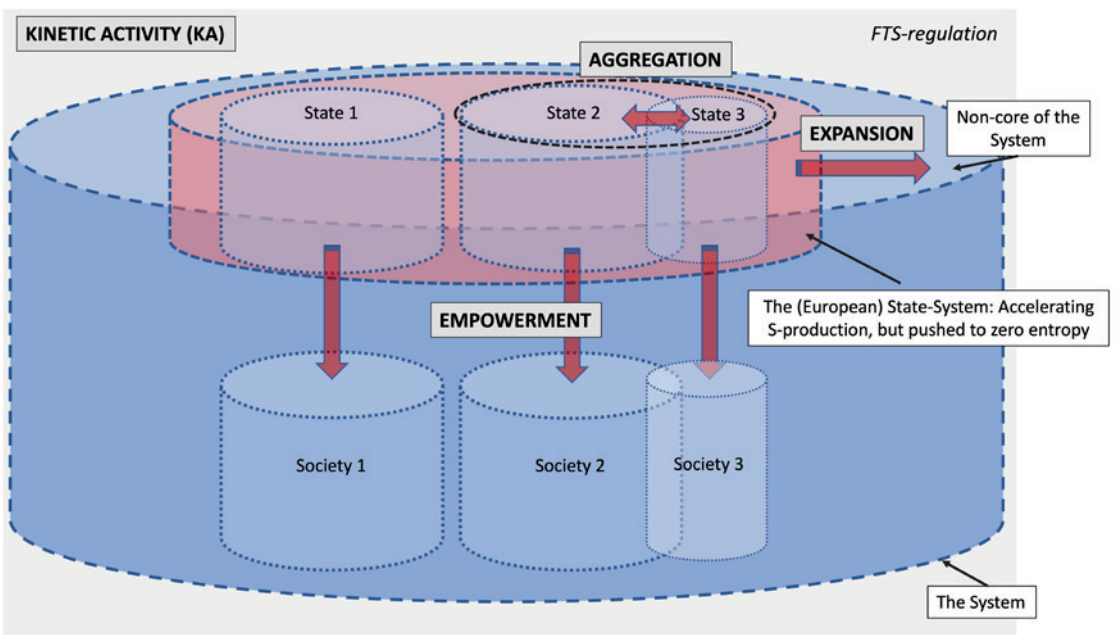


FIGURE 37.1: A model of the (State-)System.

The focus in this chapter is in particular on the (need for the) availability of suitable environments for ordered systems (like societies/states and the State-System), to ensure excess entropy can be 'dumped' in - exchanged to - to these environments, and an viable entropy-balance can be maintained in the ordered system (between order and disorder).
During the transient period (1480-1945), the European State-System had two environments, it depended on and could utilize, until they reached their "limits" (in 1939): It could exchange/push entropy to the non-core and to societies/states.

37.2. Increasing irreversibility and the essence of regulation

With respect to biosystems Toussaint observes that "As biosystems grow and develop, they should increase their total dissipation, and develop more complex structures with more energy flow, increase their cycling activity, develop greater diversity and generate more hierarchical levels. As a corollary to this general statement, biosystems which do not increase their total dissipation, are organisms dedicated to death, like observed during the aging of any biosystem. Species which survive in ecosystems are those that funnel energy into their own production and reproduction and contribute to autocatalytic processes which increase the total dissipation of the ecosystem while at same time surviving within the constraints of their changing environment. In a broad class of biosystems, stress and aging have similar thermodynamic properties and suggests common underlying principles" (92). I argue that these requirements also apply the (State-)System and to its growth and development; the European (State-)System - through the 1st FTS - continuously (and necessarily) increased its total EMIS-dissipation, developed more complex structures (in the contingent domain), increased its entropy- and energy-production, and increased its cyclic activity, etc.
The increasing entropy-production during the transient period (1480-1945), was an essential 'part' of this dynamic.
The European State-System, can be considered the structural appearance - representation - of the 1st FTS; the State-System can be considered a distribution system/network, as e.g. discussed in chapter 35
During the transient period 1480-1945, entropy-production necessarily accelerated and the performance of the 1st FTS - the vehicle of growth and change - was continuously adapted - and upgraded - to ensure adequate regulation (see preceding chapter).
England (28) also discusses the need for increased dissipation and work absorption to support growth and development, albeit from a different perspective.
As explained, entropy-production is a measure for the irreversibility of processes: England explains: "the more statistically irreversible a spontaneous process is (that is, the more likely you are to go from X to X than the reverse, under a given set of arbitrary non-equilibrium driving conditions), the greater the minimum amount of total entropy increase required" (28). Furthermore, England argues that "the more irreversible the macroscopic process, the more positive must be the minimum total entropy production" (27).
According to England, a relationship exists between exponential growth (i.e. in population dynamics) and the highly irreversible nature of these (population) dynamics (27). This is - this study shows - also the case for the (State-)System, that was driven by exponential population growth, which initiated a series of irreversible (closely related) processes of KA, aggregation, expansion and empowerment. See figure 37.2.

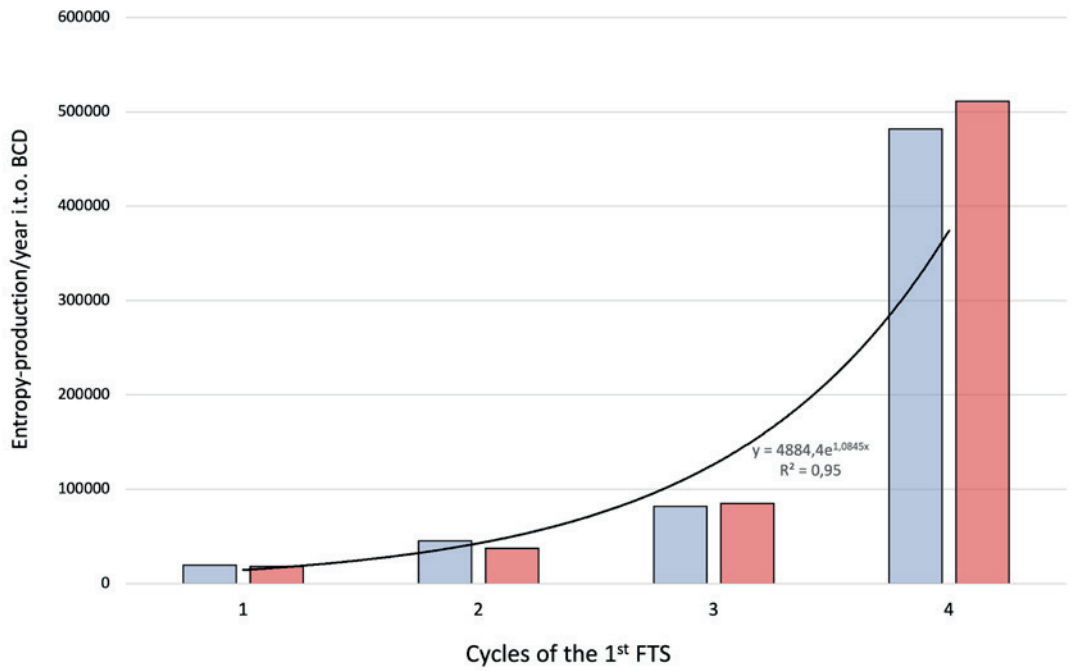


FIGURE 37.2: Entropy-production per year, during successive cycles of the 1st FTS. Actual 1st FTS in blue; corrected 1st FTS in red, (period 1495-1945, based on data from Levy (48)).

Obviously, also a relationship exists between entropy(-production) and free energy (at last $\boldsymbol{E} = \boldsymbol{F} + \boldsymbol{S}$), and work ($\boldsymbol{W}$). England observes: "Greater irreversibility must be powered by more of the work done on the system being dissipated rather than stored in the system (...) Increasing irreversibility carries a cost in dissipated work energy: Thus, extra energy is expended on growing systems, in response to an increase in irreversibility of processes" (28).

During the transient period, exponential population growth, increasing irreversibility, accelerating entropy-production, increasing free energy use, and work that was accomplished on the 1st FTS and European State-System, went hand in hand. Through the increasing irreversibility of the (State-)System, the present looked - and looks - increasingly different from the past.

In reference to the assemblage of nanostructures, where an external drive is applied, England observes: "different configurations of the system are not going to be equally competent to absorb work from that drive" (28). Work-absorption is related to the configuration of the system concerned (that is exposed to the external drive). This is also the case for the (State-)System, and its components (e.g. societies/states). The 1st FTS and the European State-System, continuously reconfigured (adapted) themselves, to the effects of exponential population growth and increasing entropy-production, to ensure it could absorb the work that was necessary to accomplish the phase transition, in accordance with the Second Law and related principles that applied.

The fact that the phase transition was eventually accomplished (1945), and the efficiency of the 1st FTS was consistently high (within a range of 97-98%) during the transition process (1480-1945), show that the 1st FTS and European State-System were very effective in absorbing the necessary work.

Certain societies/states - which also constitute 'building blocks' of the FTS - were more competent in absorbing work - and put it to their own use - than others; I point to Great Powers, who were able to exploit the PBMP-mechanism to their own advantage to support their own EMIS requirements (deterministic domain) and their interests (contingent domain).
According to Kondepudi et al. (44), the entropy of a system - e.g. a fluid - is a function of its total energy $\boldsymbol{U}$, volume $\boldsymbol{V}$ and molar amounts $\boldsymbol{Nk}$ of its constituents (44). A similar relationship also exists in case of the (State-)System, FFE, when entropy and free energy can be considered equivalent.
I assume that the total entropy-production of the (State-)System, depends on various factors/conditions, including: The (State-)System's distance from equilibrium, population size, the degree of compartmentation (the number of states), and its 'volume' (size, degree of expansion to the environment/non-core). The exact relationship between these variables is not (yet) determined.
As mentioned, sustainment of the FTS and State-System required continuous regulation by the FTS. In case of the FTS/(State-)System, regulation is determined/shaped by several (pre)conditions, including:

- $\boldsymbol{dS = d_iS + d_eS \geq 0}$;
- The accomplishment of thermodynamic equilibrium via the most efficient path;
- The interplay between competing thermodynamic potentials and their extremization: Minimization of the entropy-production of the State-System (because the MEP-Principle applies), which concerns $\boldsymbol{d_iS}$ and simultaneous maximization of the entropy-production of the System (which concerns $\boldsymbol{dS}$);
- The need of coupling of energetically unfavorable KA/wars to energetically favorable societal processes, as discussed.
- Through the gradient and force that are generated/sustained, the (State-)System generates EMIS-flows (forces and flows are related) that are configured by the FTS in accordance with the Second Law and related principles, and underpin the processes of KA, aggregation, expansion and empowerment;
- These processes determine and shape social and political evolution and developments in the contingent domain.

In this respect, it is useful, to point to the concept of a 'focal condition', a determinant of a directive correlation, that impacts on the evolution and development of the (State-)System and its components. Thermodynamic equilibrium of the State-System can be considered the focal point. According to Miller, a directive correlation "is characteristically found between processes in living systems and in their environments. Variables in them are so "geared" or interrelated that, within certain ranges, they will at a later time only bring about the focal condition. Such a situation requires that there was some prior state of affairs which gave rise jointly both to the processes in the system and to those in its environment (*IP: in case of the System, that is the FTS*). Feedback is one way such joint causation can be accomplished. Sommerhoff believes that this sort of process explains such phenomena of living systems as adaptation of individuals and species to their environments, coordination and regulation of internal system processes, repair of systems after trauma, and various sorts of behavior including learning, memory, and decision making. For example, one cannot distinguish between products which are put out by a system and wastes which are excreted without knowing the purpose of the system internally and its related goals in the supra-system". (53).

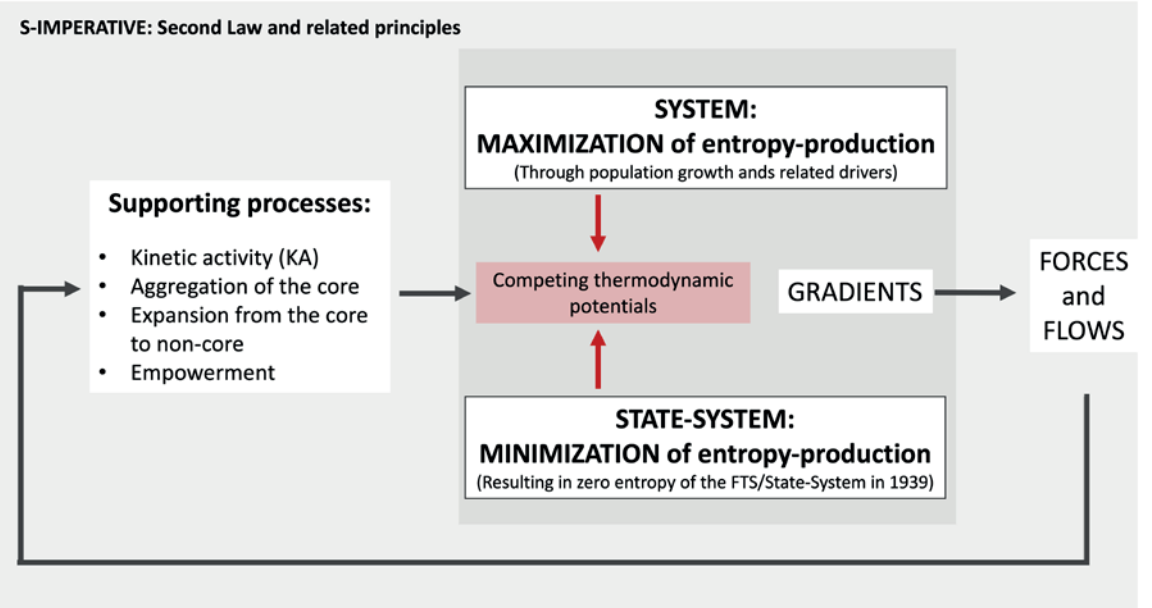


FIGURE 37.3: Competing thermodynamic potentials power(ed) the FTS. The accelerating entropy-production and kinetic activity of the (State-)System, during the transient period (1480-1945), can be attributed to the interplay between competing thermodynamic potentials that applied to the System and the State-System (a subsystem of the System). Through their extremization - a process regulated by the FTS - gradients, forces and flows were generated and could be sustained. The flows that were generated involved four interacting and complementary processes: the processes of KA, aggregation of the core, expansion of the core to the non-core and empowerment. The 1st FTS was accompanied by four accelerating cycles (R2-dynamics), that pushed the European State-System to thermodynamic equilibrium.

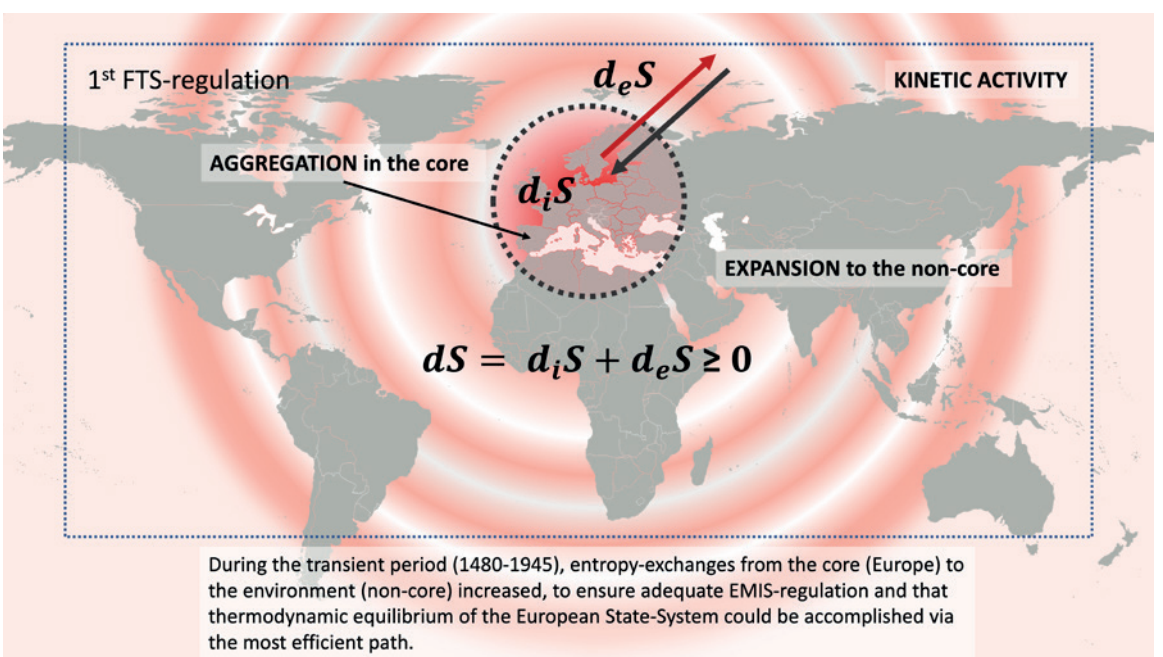
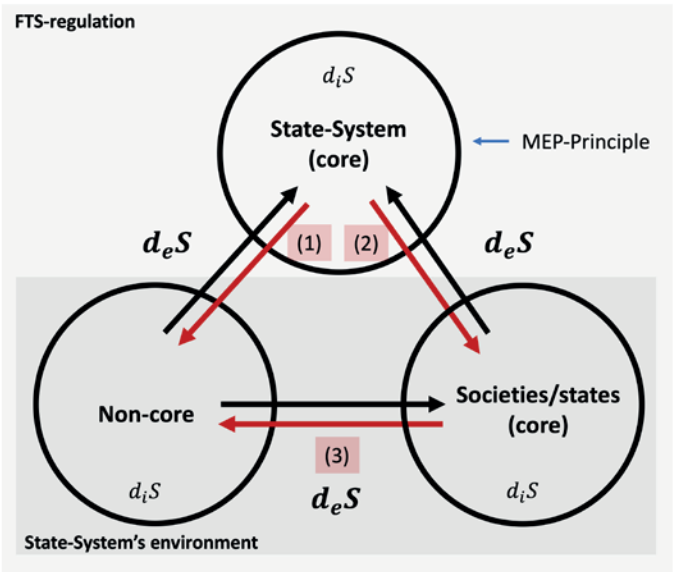


FIGURE 37.4: EMIS-regulation during the transient period (1480-1945).

According to the Second Law:

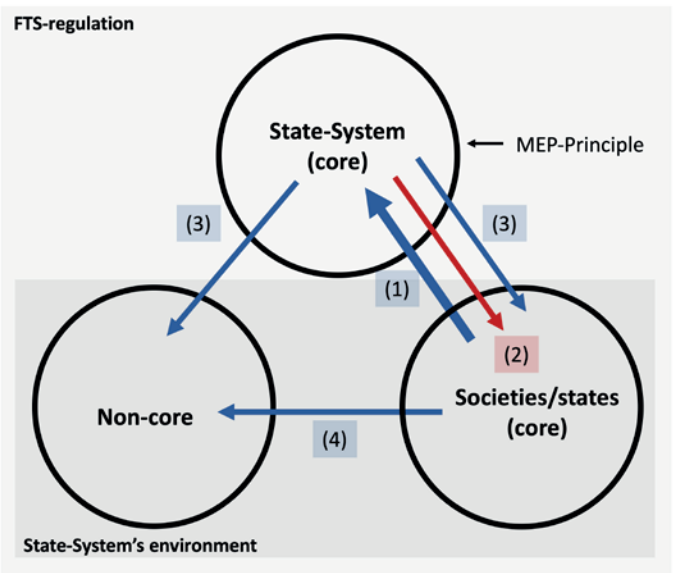
$$d_iS_{State-System} + d_iS_{Societies/states} + d_iS_{Non-core} + \Sigma d_eS \geq 0$$



Schematic and simplified depiction of **entropy-flows** regulated by the 1st FTS, during the transient period (1480-1945):

- Entropy-flows (1) and (3) are the main drivers of the process of expansion of the core to the non-core.
- Entropy-flow (2) contributes to the process of empowerment in societies/states.
- The MEP-Principle applies to the State-System and drives the process of aggregation (core).

FIGURE 37.5: Schematic representation of entropy-flows regulated by the 1st FTS, during the transient period (1480-1945).



Schematic and simplified depiction of **(kinetic) energy-flows** regulated by the 1st FTS, during the transient period (1480-1945):

- (1): The State-System extracts kinetic energy from societies; entropy influx (2) serves as a catalysator in the transformation process of "societal-energies" into kinetic energy (military capabilities). The FTS (State-System) utilizes the energy.
- (3): Kinetic energy is applied by the FTS/State-System through KA/war, a process that involves the S/T-field. The kinetic energy that is applied in the non-core concerns expansion wars.
- (4): A limited amount of kinetic energy is applied by core-states in the non-core, but does not involve the S/T-field

FIGURE 37.6: Schematic representation of energy-flows regulated by the 1st FTS, during the transient period (1480-1945).

37.3. Relationships between processes

Through the 1st FTS, a gradient - and consequently forces and flows - generated four interacting and complimentary processes that were involved in a phase transition of the (State-)System (1480-1945), with two related effects: Thermodynamic equilibrium of the European State-System (core), and the upscaling of the State-System to a global scale.
The four processes interact and are complimentary. The four processes ensure the coherence of the FTS, and ensure thermodynamic equilibrium is accomplished via the most efficient path.

TABLE 37.1: Processes generated and sustained by the 1st FTS, to support entropy-regulation.

Process	Application	Purpose
KA	State-System	During RSP's: To maintain equilibrium (the status quo). During critical periods: To upgrade the order of the (State-)System.
Aggregation	Core	Merging of societies/states; increase in entropy and increase in free energy potential (> mixing).
Expansion	Non-core	Exchange of entropy, to drive FTS; increase in entropy (> volume). Although the exchange of entropy to the environment, can be considered a form of "dumping", the "degraded" energy that is "dumped" (exported) can (possibly) be (partly) utilized in the environment.
Empowerment	Societies/states	Increase in entropy; improved utilization of opportunities; improves societal (entropy) coping.

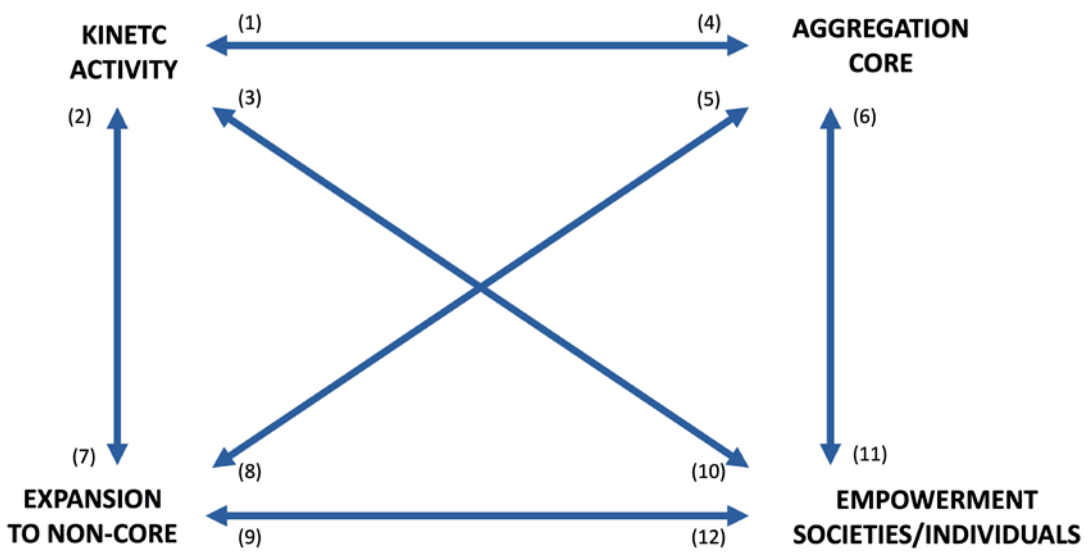


FIGURE 37.7: Interacting and complementary processes.

TABLE 37.2: Various interrelationships between processes.

	KA	Aggregation	Expansion	Empowerment
KA		(1) KA contributes to aggregation by providing stability to societies/states, during RSP's and reconfiguring the State-System and its components, during critical periods.	(2) KA contributes to expansion, by accomplishing control over non-core territories.	(3) KA contributes to empowerment, by forging shared identities.
Aggregation	(4) Aggregation contributes to KA, by increasing the potential to generate free energy.		(5) Aggregation contributes to expansion, by enabling and sustaining the FTS.	(6) Aggregation contributes to empowerment by adding to the diversity - and thus opportunities - of the aggregated structures.
Expansion	(7) Expansion contributes to KA, by optimizing EMIS regulation and making resources available.	(8) Expansion contributes to aggregation, by enabling and sustaining the FTS.		(9) Expansion contributes to empowerment by adding to the diversity- and thus opportunities, of the structures involved.
Empowerment	(10) Empowerment contributors to entropy-utilization in societies/states e.g. to enhance kinetic potential.	(11) Empowerment contributes to aggregation, by exploiting economies of scale and scope that are/come available, in the core.	(12) Empowerment contributes to expansion, by exploiting economies of scale and scope that are/come available, in the non-core.	

37.4. The relationship between aggregation and expansion

For their operation and sustainment, dissipative structures require continuous EMIS-exchanges with their environments: Excess entropy needs to be "dumped" in - exchanged to - the environment, to ensure a certain order can be maintained in the system itself.

During the transient period (1480-1945), the European State-System had two environments: Societies/states and the non-core (the rest of the world).

A close relationship exists between the processes of aggregation in the core, and expansion of the core to the non-core. As discussed in chapter 15, "When a system begins to exchange entropy with the exterior, then, in general, it is driven away from equilibrium and the entropy-producing irreversible processes begin to operate" and "systems that exchange entropy with their exterior do not simply increase the entropy of the exterior but may undergo dramatic spontaneous self-organization" (44).

This is the mechanism that can also be observe in the (State-)System, where a process of entropy-exchange from Europe to non-European territories started before the bifurcation in 1480 and helped drive the System increasingly further FFE.
In 1480, these developments and dynamics triggered a bifurcation in the core and through "dramatic spontaneous self-organization", the FTS emerged; the FTS subsequently organized and optimized the processes of expansion (entropy-transfer to the environment), aggregation and empowerment.
Expansion to the non-core not only served as an 'outlet' for (excess) entropy produced in the core, but also provided access to resources and eventually markets in support of economic development in the core (Europe).
The processes of aggregation and expansion worked as 'communicating vessels', so to speak: They were subject to the same forces that were generated by the FTS. The processes of aggregation and expansion both increased exponentially during the transient period: Population growth in the core (and related drivers), the push of the European State-System to zero entropy (through the MEP-Principle that applied to the European State-System), the process of aggregation and the process of expansion of the core to the non-core, were mutually supporting and dependent processes - they supported each other - under direction of the 1st FTS.
As mentioned before, organized aggregation of the core and organized expansion (colonization) started at the same time, around 1480; while both processes also stopped during the last stage of the phase transition (the 4th systemic war, the Second World War, 1939-1945). At that point, the core had reached full aggregation (stage 3A), while the process of expansion was also accomplished.
The synchronization of these processes can be explained by the 'unity' in EMIS-regulation accomplished by the 1st FTS: The processes of aggregation and expansion are integral - and closely related - components of the 1st FTS and can be considered two sides of the same regulatory-coin.
The processes of aggregation and expansion can also be understood as compensatory processes. Both processes - aggregation and expansion - allow for more entropy; respectively through mixing and an increase an in volume. Expansion to the non-core allows for the export of excess entropy generated by aggregation in the core, to the non-core; the environment of the core/State-System.
The accelerating production of entropy - of which the accelerating KA during the transient period was a manifestation - was accommodated - but also reinforced - by the processes of aggregation and expansion: Aggregation of the core required expansion to allow for the transfer entropy to the non-core. At the same time, the process of expansion also enabled aggregation through the input of energy from the non-core to the core: Through expansion, states extended their opportunities for exploitation. The interplay between these (and other) processes was orchestrated by the 1st FTS.
The working of communicating vessels - when open and connected (and thus communicating) vessels are subject to the same forces (gravity and air pressure) - can serve as a useful metaphor.
In case of communicating vessels, the liquid levels in the vessels will always be balanced. The same is the case for the connected processes of aggregation in the core and expansion in the non-core, that were powered and shaped by the same entropy(-production) in the (State-)System, subject to the same forces generated by the gradient and regulated by the 1st FTS.
The end of the process of aggregation - when full aggregation was accomplished - and the end of the process of expansion - when full expansion (full core-control over the non-core) was accomplished - were coordinated and coincided not coincidentally: The moment the core (the European State-System)

reached thermodynamic equilibrium (and the last barriers were eradicated), the non-core reached "full expansion", and control over non-core territories had to be transferred from core-states, to autonomous state-structures in the non-core. The now globalized State-System consisted of equivalent units.

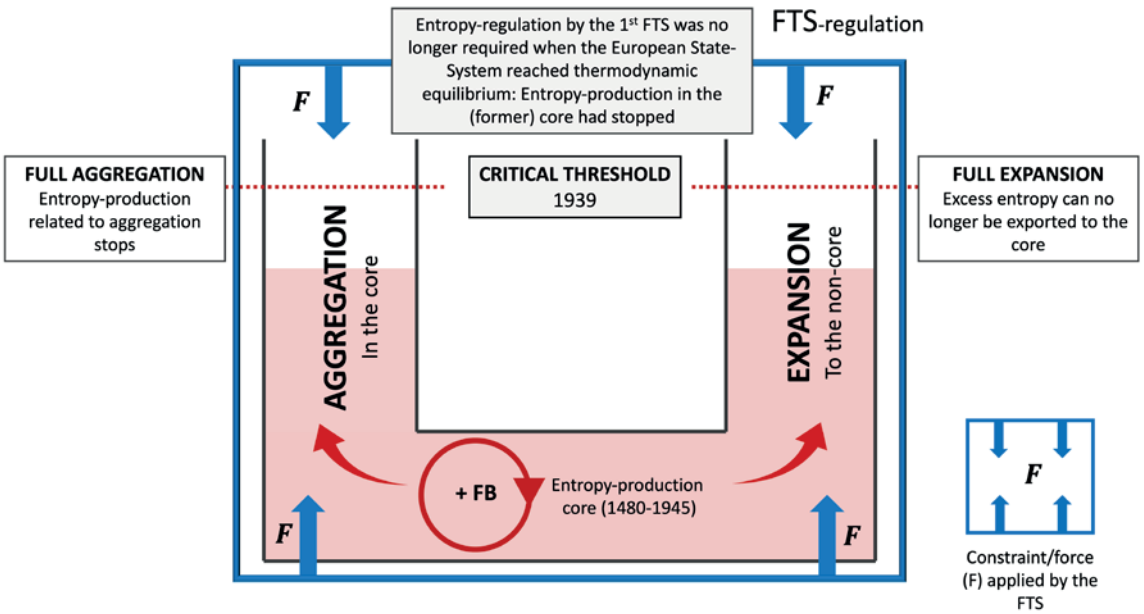


FIGURE 37.8: The interplay between the processes of aggregation and expansion depicted as communicating vessels. In the (State-)System processes with positive entropy-production compensate for the negative entropy production of other processes "in such a way that the total entropy production is positive, in accord with the Second Law" (44).

The logic of the transfer of control from core-states (European states) over non-core territories (colonies) to state-structures in the non-core (based on a blueprint of state-structures as they had evolved in Europe, during the transient period) once full aggregation and merging of core and non-core was accomplished, can also be explained from a thermodynamic perspective: The purpose of the 1st FTS was to accomplish thermodynamic equilibrium of the European State-System, and to ensure optimized EMIS-regulation (1480-1945), in order to utilize the most efficient path to the equilibrium state.

When the purpose of the 1st FTS was accomplished, the 1st FTS collapsed, including the need for regulation of EMIS-flows between core and non-core.

After 1945, when thermodynamic equilibrium was accomplished in the former core and the State-System was globalized, a 2nd FTS emerged (> 1945, fully operational in 1989) with the dedicated purpose to achieve thermodynamic equilibrium in the global State-System, via the most efficient path that can be made available.

During the 2nd transient period (1945-....), a process global aggregation - supported by a process of Expnasion to a "new" non-core - will be take place.

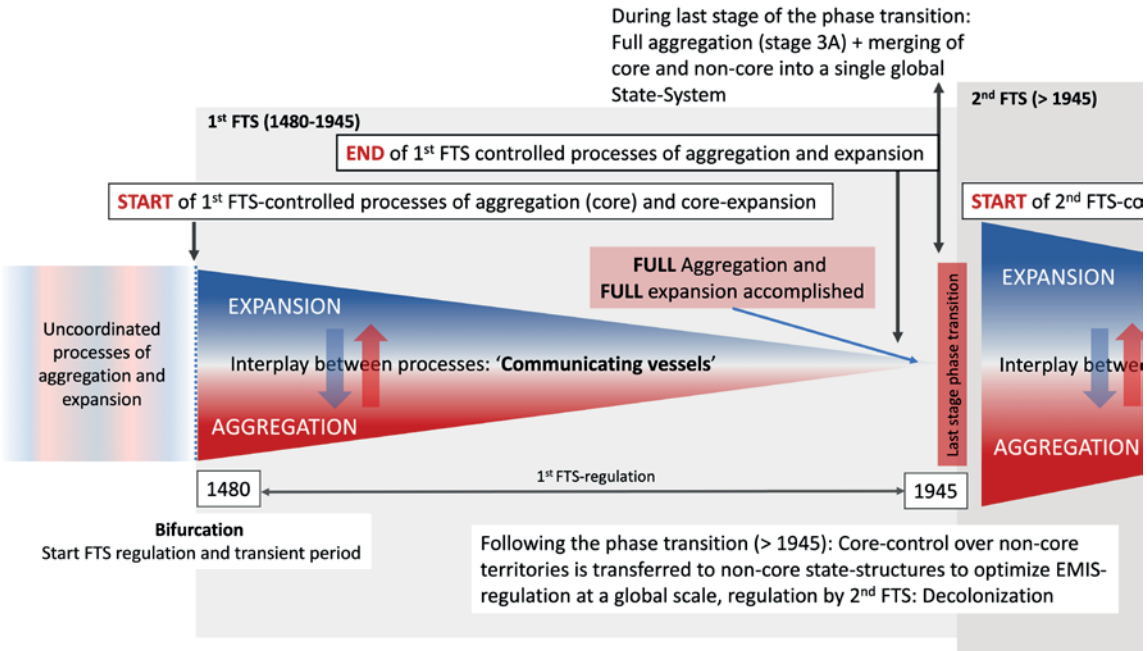


FIGURE 37.9: The interplay between the processes of aggregation and expansion. A schematic depiction of the interplay between the processes of aggregation and expansion, during the transient period (1480-1945).

37.5. The interplay between the processes of aggregation, expansion and empowerment

So far, I have focused on the processes of aggregation and expansion and their interplay. But a process of empowerment is also involved in entropy-regulation of the (State-)System: Empowerment also (like expansion and aggregation) deals with "compensation" of "excess" entropy(-production).

Empowerment in everyday speech refers to "measures designed to increase the degree of autonomy and self-determination in people and in communities in order to enable them to represent their interests in a responsible and self-determined way, acting on their own authority" (96). In daily speech, empowerment has a positive connotation; In this study empowerment is a neutral term - a state-function (property) of social systems, - that indicates the 'amount' of entropy 'in' social systems that is contained in and can be put to use by its 'parts'. More empowerment means that potentially more energy (and innovation) can be extracted from societies and the System; empowerment means more free energy can be made available for a variety of purposes.

From a thermodynamic perspective empowerment is concerned with the 'degrees of freedom' of individuals and communities etc. to shape their own environment and utilize entropy.

In case of increased empowerment, social systems at lower levels of hierarchical organization (as defined by Simon) can utilize their own possibilities (entropy); in case of increased empowerment there is more diversity, that can be effectively utilized and regulated.

Through empowerment, entropy (is) and can be exchanged (to lower levels of hierarchical organization), and energy at these levels can be utilized.
Voting rights are a manifestation of empowerment. More entropy and energy can be put to use. Societies/states vary in their degree of empowerment. Empowerment also affects homeostatic control and are mutually supporting.
Contrary to democratic societies/states are radicalized societies (like Germany in the 1930's and during the 4th systemic war (1939-1945, the Second World War) not empowered but in a state near 'zero-entropy': Their low entropy goes hand in hand with tight control, standardization, and the availability of 'concentrated' free energy with a high focus.
I assume that during the transient period, the degree of empowerment in societies in the core and non-core increased.
Empowerment played an important role in the development of the core and non-core of the (State-) System; through empowerment more possibilities could be shaped and exploited in support of the processes of aggregation and expansion. In case of the core, European states for example, improved the efficiency of the available kinetic potential (free energy, military capabilities) by increasingly employing smaller and/or more empowered units, that were 'pushed' to exploit local circumstances on the battlefield. Similar developments were taking place in other domains of societies.
In the non-core, empowerment was used to shape national identities, and push for autonomy. Aggregation and empowerment can also work at cross-purposes: when aggregation pushes for unification and empowerment for fragmentation. Empowerment must be harnessed to ensure social stability.

37.6. The final stage of FTS-regulation (1939-1945)

The combined processes of aggregation, expansion and empowerment, allowed for the scaling-up of the (State-)System: From a system consisting of a core that subjugated an expanding non-core, in support of its own development, to a system in which core and non-core were merged and had obtained an equivalent status.
A dissipative structure (the 1st FTS) regulated this transition process. The moment merging of core and non-core was accomplished a 2nd FTS with a global scope emerged and started regulating the now global (State-)System (fully operational in 1989).
Because the possibilities for global geographical (physical) expansion are now depleted, opportunities for expansion are now explored in space and in the abstract domain. Especially the opportunities for expansion in the abstract domain reinforce the process of empowerment.
The actual growth-mechanism in the final stage of the phase transition - the 4th systemic war (1939-1945, the Second World War) worked as follows: The moment full aggregation and full expansion were accomplished, the non-core - a product of the core - could fill the vacuum in the core (Europe), the systemic KA/war in the final stage of the phase transition (the 4th systemic war, the Second World War, 1939-1945) had produced.
Self-destruction of the core, and integration of the core in a larger 'body' it had created according to its own 'image' (it was in fact an enlarged 'copy' of itself), constitutes the growth mechanism of the (State-) System, FFE. The 1st FTS was instrumental in a process of kinetic growth, (as explained).

In figures 37.10 until 37.14, the interactions between the processes of aggregation and expansion are shown at five points in time: (1) Before the bifurcation took place in 1480, and the (State-)System still lacked macroscopic coherence, (2) in 1480, the moment the bifurcation took place and the 1st FTS - a dissipative structure - emerged, (3) in 1618, during the 3rd systemic KA (1618-1648, the Thirty Years' War), (4) during the 4th systemic war (1939-1945, the Second World War), when the phase transition was in its final stage, full expansion and aggregation were accomplished, and the (State-)System was in the process of merging the core and non-core, and (5) following the phase transition (1945), when the (State-)System had globalized and was regulated by a 2nd (global) FTS, an observation that is supported by war-data analysis.

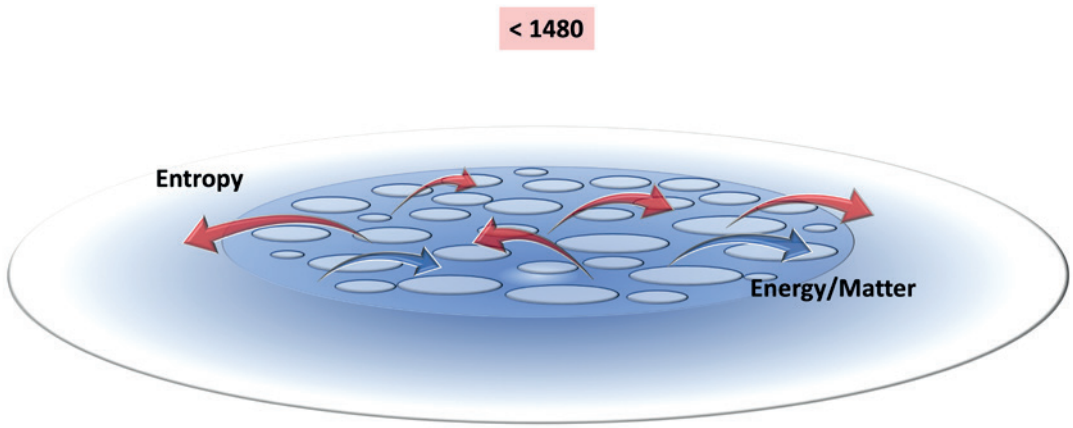


FIGURE 37.10: Interactions between the processes of aggregation and expansion, before 1480. At this stage entropy was already transferred in limited amounts, and without any organization and regulation, to what would become the non-core of the System.

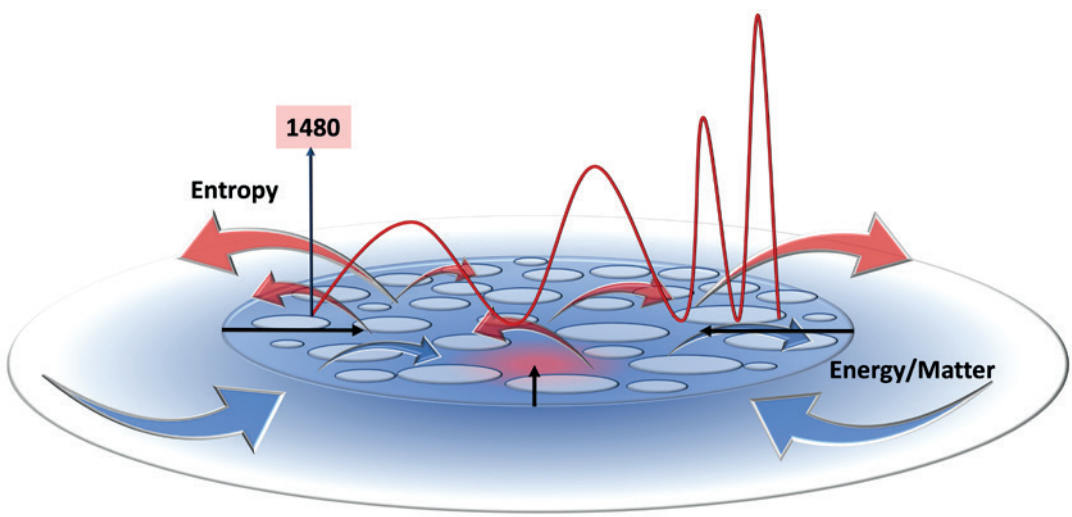


FIGURE 37.11: Interactions between the processes of aggregation and expansion, 1480.

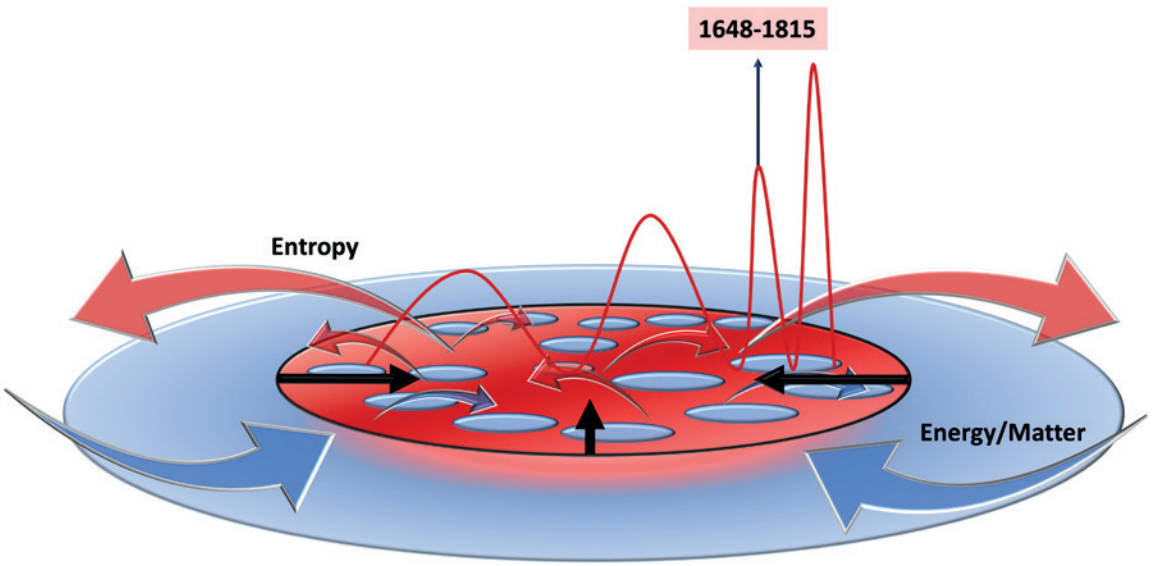


FIGURE 37.12: Interactions between the processes of aggregation and expansion, 1648-1815.

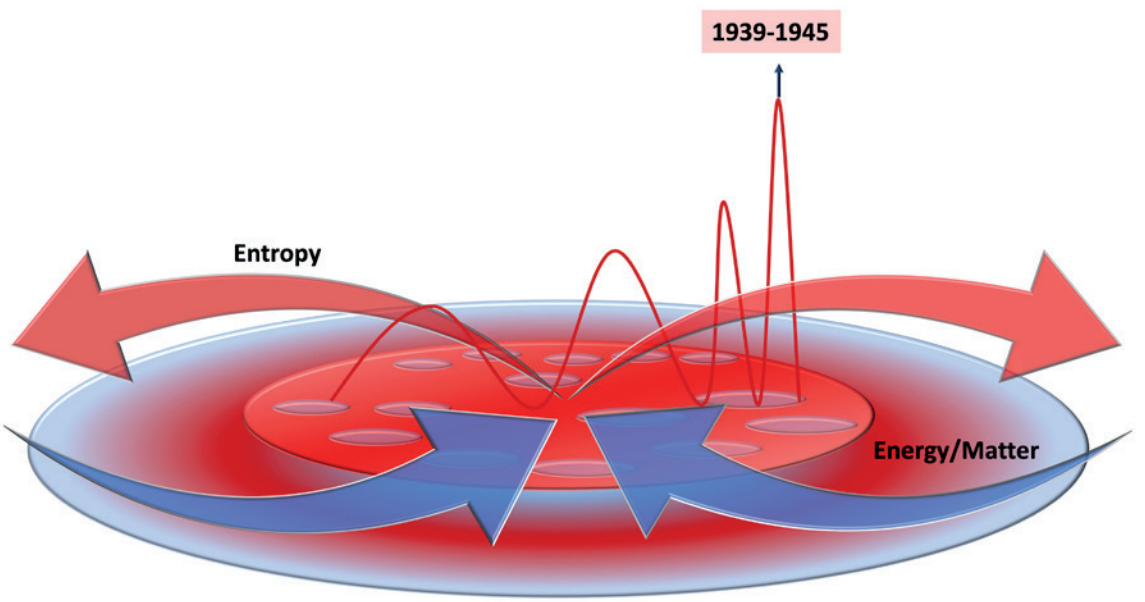


FIGURE 37.13: Interactions between the processes of aggregation and expansion, 1939-1945. During the 4th systemic war (1939-1945, the Second World War), when the phase transition was in its final stage, full expansion and aggregation (stage 3A) were accomplished, and the (State-)System was in the process of merging the core and non-core.

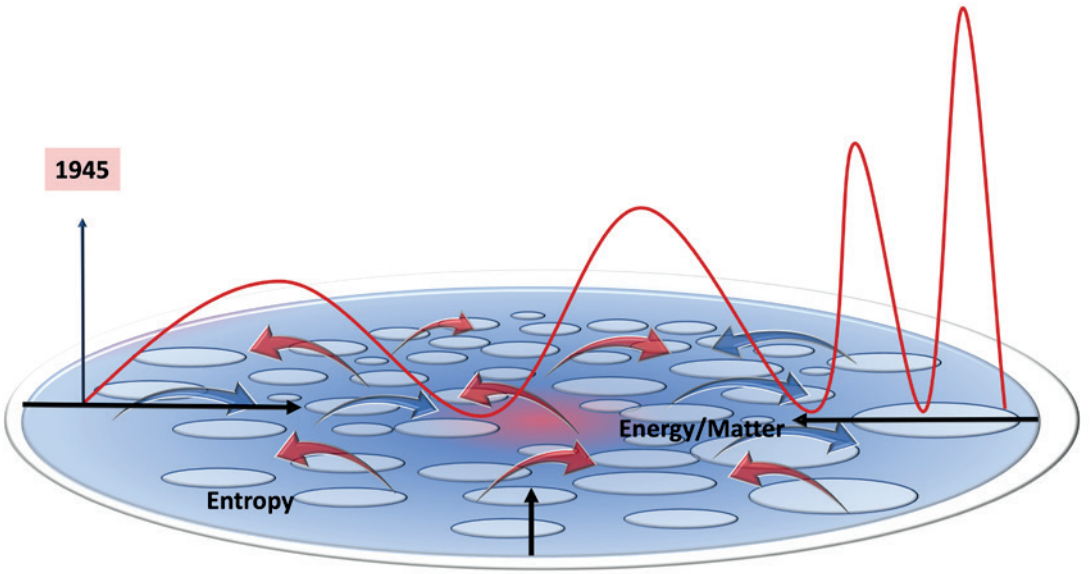


FIGURE 37.14: Interactions between the processes of aggregation and expansion, > 1945.

37.7. The need for a suitable environment

This study shows the intimate relationship of the processes of aggregation and expansion in the (State-) System: The processes of aggregation and expansion are inseparably linked and constitute two sides of the same regulatory coin. The processes of aggregation in the core ('unification of Europe') and expansion to the non-core (colonization) enabled and reinforced each other, during the transient period (1480-1945).

If a suitable environment - the "rest of the world" - would not have been available to Europe, the core of the System, exchange of entropy - i.e. the process of aggregation in the core based on KA (as we know it) - would not have been possible: The equation $\boldsymbol{dS = d_iS + d_eS \geq 0}$ - the Second Law of thermodynamics - would have been violated.

A process of aggregation requires expansion and for that reason an environment.

Expansion is a natural tendency of social systems: The irreversible processes social systems generate - in combination with the requirement to sustain its 'own' low entropy organization to survive - result in excess entropy(-production) that must be redistributed to a suitable environment.

The ability of the environment to "absorb" entropy determines the rate of entropy-production in/of its source (the core in this context). The development of territories in the non-core and of the non-core (itself) were driven by the need to ensure "maximum" entropy-exchange, at a societal-state level (European states created their own entropy-overflow capacity through control over non-core territories) and at the level of the core.

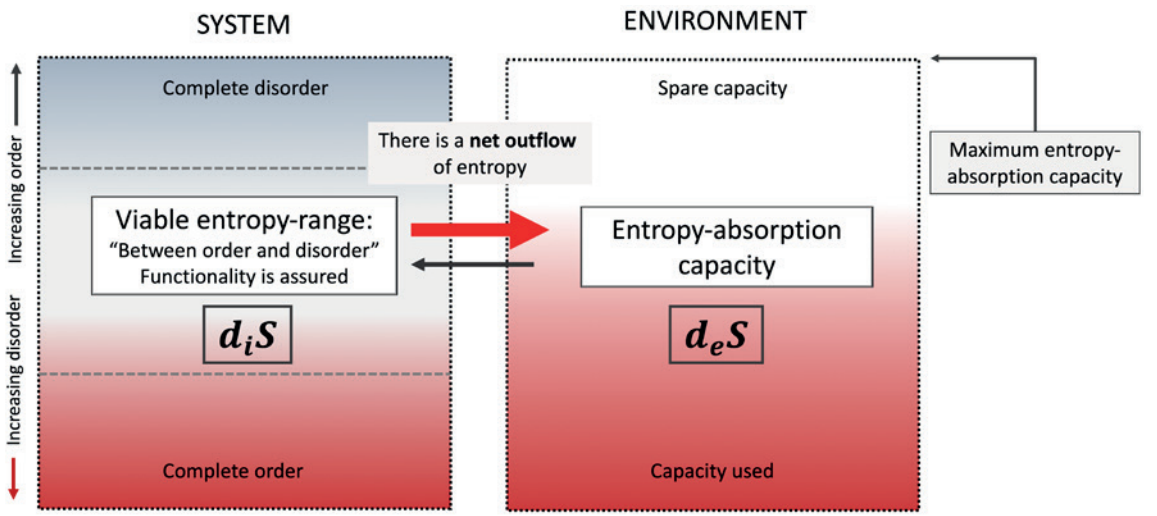


FIGURE 37.15: The entropy balance of a system (1): Entropy-absorption capacity is still available. The entropy-absorption capacity of a system's environment determines if entropy-producing (irreversible) processes can be sustained in the system, without causing disorder. Environments must be actively managed to ensure survival.

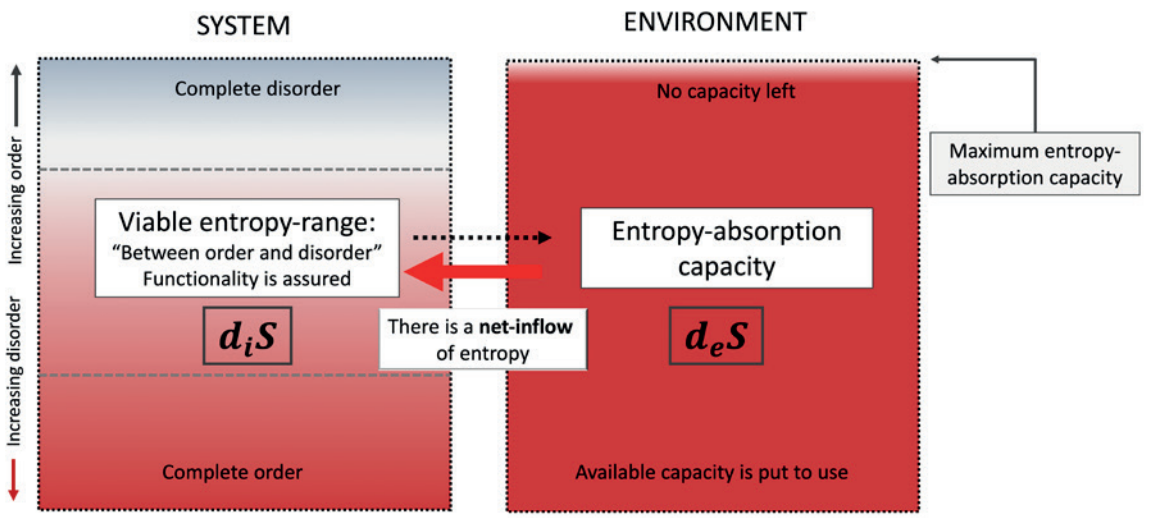


FIGURE 37.16: The entropy balance of a system (2): Entropy-absorption capacity is depleted. The maximum capacity is reached, and consequently 'non-disposable' entropy accumulates in the system and at a certain point there is also a net-inflow of entropy: Consequently, the order and functioning of the system are undermined, and the system can be pushed into another stability domain. During the transient period (1480-1945), the entropy-absorption capacity of the environment of the core (Europe) - the non-core of the System - was sufficient. The question now is, if the maximum entropy-absorption capacities of the environments that support the global (State-)System will at a certain point be exceeded (or already are).

The non-core (territories) at the same time served as an additional source of energy to power the process of aggregation in the core. The environment is a constraint in the process of aggregation, and social development in general. The potential of the environment of a social system to absorb entropy determines the rate of aggregation and social development it can accomplish.
Limitations to entropy-dumping also concern the operation and sustainment of the 2nd (global FTS (1945-....): The global population still growths at a significant rate.

TABLE 37.3: Population growth rates. This table shows the growth rate during successive periods of 50 years in Europe (1500-1950) and at a global scale (1900-2150) (data from United Nations Population Division and related sources).

Period	Europe (10^6)	Growth rate Europe	World (10^6)	Growth rate global
1500	84		458	
1550	96	14,3%	500	
1600	111	15,6%	580	
1650	118	6,3%	630	
1700	125	5,9%	682	
1750	163	30,4%	791	
1800	203	24,5%	978	
1850	276	36,0%	1.262	
1900	408	47,8%	1.650	30,7%
1950	547	34,1%	2.521	52,8%
2000	729		5.978	137,1%
2050	734		9.725	62,7%
2100	639		10.854	11,6%
2150	517		9.746	-102%

The associated increase in entropy-production needs an environment with sufficient entropy-absorption capacity, to be able to sustain the 2nd FTs and related processes, otherwise the Second Law $\boldsymbol{dS = d_iS + d_eS \geq 0}$ is violated.
The globalized (State-)System still lacks suitable a non-core. From a thermodynamic perspective, space exploration and exploitation can be understood as efforts of the 2nd (global) FTS to develop a suitable environment, to sustain its operation.
The question is if space exploration and exploitation - development of space as a suitable environment to export globally produced (also social) entropy to - can keep pace with the entropy produced by the 2nd FTS; a new "Age of Discovery" is required (this is (especially) paramount, when the limits our physical environment - e.g. the climate system - has reached to support human activity and growth, are taken into consideration).

If this - the development of a suitable environment(s) - cannot be accomplished - in other words, if entropy-production (d_iS) exceeds the absorption capacity of the environment - low entropy structures (social structures) will be damaged and become disorganized.

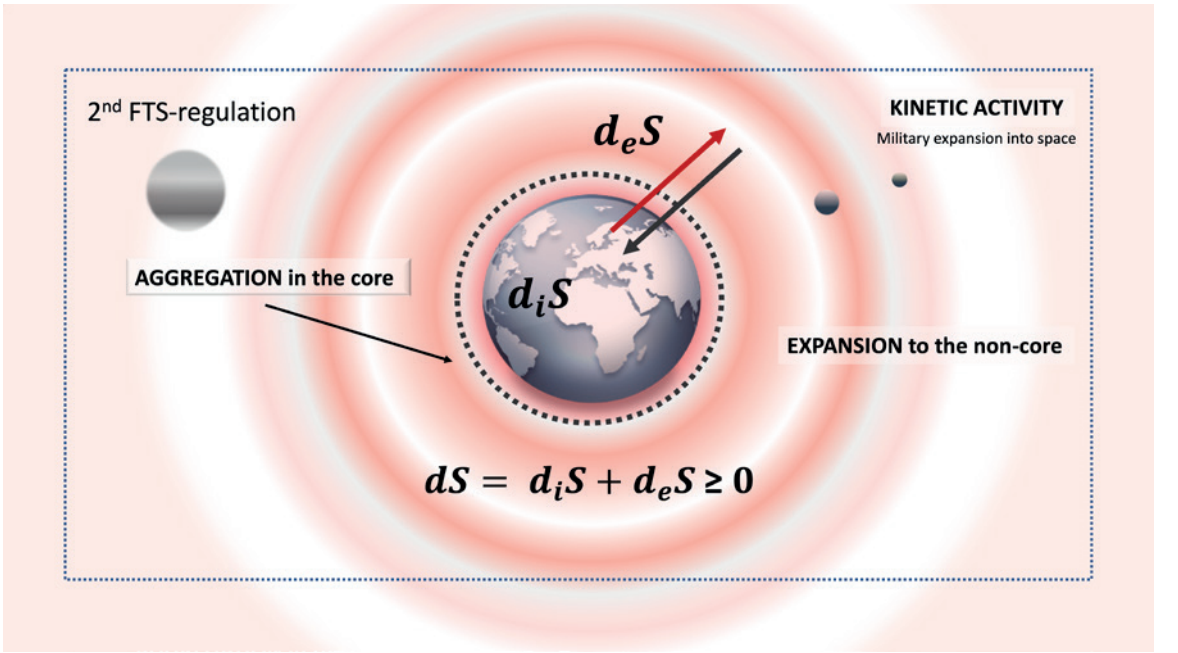


FIGURE 37.17: The essence of regulation, applied to the 2nd FTS (1945-....). To ensure that the order of the global (State-)System can be maintained, the (State-)System must exchange excess entropy with its environment. During the transient period (1480-1945), the non-core of the (State-)System constituted the environment of the core (Europe). Through the phase transition that was accomplished by the 1st FTS, the core and non-core merged, and the State-System globalized. Expansion and aggregation (evolution/development of social systems) are closely related. Aggregation of the core (Europe) and expansion to the non-core started in (around) 1480, the process stopped when full aggregation was accomplished in the core (Europe) at the end of the transient period. Aggregation and expansion enabled and reinforced each other. It is no coincidence that efforts to explore and exploit space coincided with the inception of 2nd - global - FTS in 1945. The question is if sufficient entropy-absorption can be ensured by suitable environments, to enable and support the processes of aggregation and development at a global scale of the (State-)System. Otherwise, the global (State-)System will be forced into another stability domain.

There are limited options available to humanity, including: (1) decrease of entropy-production, and alignment of entropy-production with the ability of the available environment(s) to absorb the excess entropy production, (2) create 'alternative' environments (can the abstract domain serve as an alternative?), (3) change entropy- (EMIS-)regulation (now there is emergent EMIS-regulation by the 2nd FTS, with a high dependence on KA). These options I discuss in more detail at a later stage.

This basic principle - the need for a suitable environment, to ensure: $dS = d_iS + d_eS \geq 0$ - also provides a practical framework to better understand the impacts of climate change: *Climate change and its effects are also related to the basic law:* $dS = d_iS + d_eS \geq 0$, that cannot be violated: The entropy - waste - produced

by humanity exceeds the entropy-absorption capacity of the physical environment (the biosphere, atmosphere, etc.) and impacts on (control) parameters of the climate- and Earth-systems that determine their stability: The climate- and Earth-system are forced into other stability-domains.

During the transient period (1480-1945), the (State-)System became increasingly irreversible, and entropy-production accelerated. It was just a matter of time, before environmental (that is non-core) limits to entropy-absorption would be reached. Given the physical limitations of the environment (non-core), the rate of expansion of the core to the non-core (see chapter...) determined the ability of the System to sustain entropy-producing processes in the core. As I explained, the processes of aggregation in the core and expansion to the non-core constituted a single process of growth, regulated by the 1st FTS.

In figure 37.18, the maximum potential for entropy-absorption of the environment (non-core) is shown, and how this variable developed over time, through expansion of the core to the non-core. Organized and synchronized expansion started in 1480 and was regulated by the 1st FTS; in 1939, the environment (non-core) reached the maximum entropy-absorption capacity.

The existence of a 'gap' - a difference - between the maximum entropy capacity of the (expanding) environment/non-core and the actually produced entropy, ensured that a certain order (lower entropy) in the core/Europe could be maintained and increased, without violating the Second Law*:*

$$dS = d_iS + d_eS \geq 0.$$

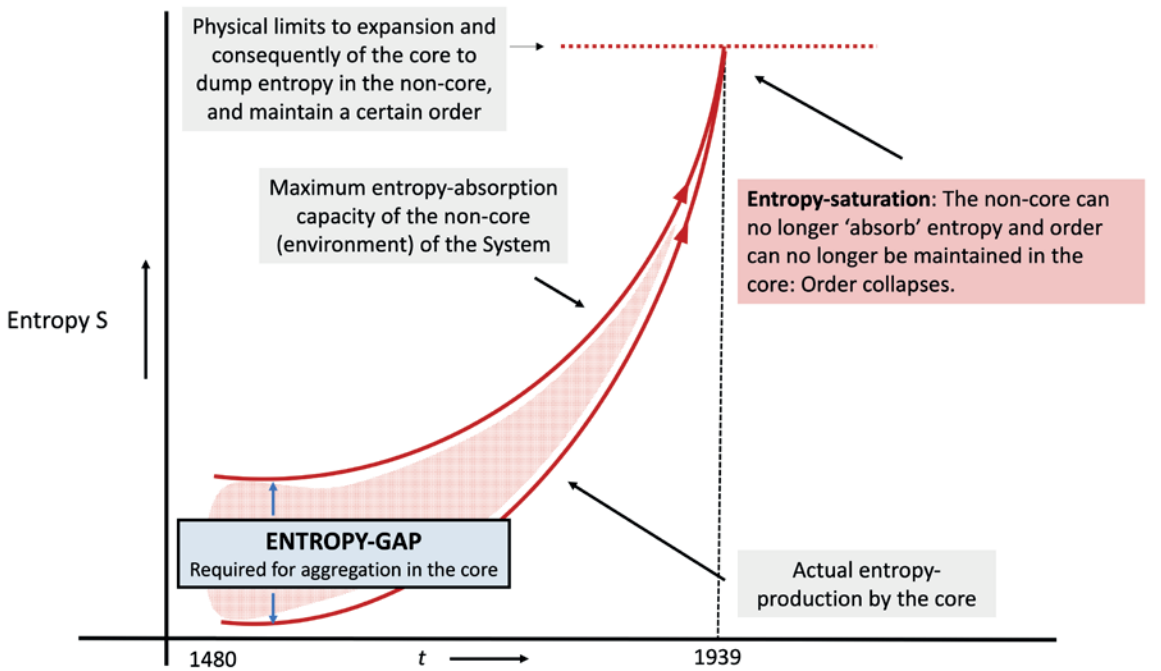


Figure: 37.18: Limits to development and order. Limits to expansion to the non-core, set limits to the ability to create and maintain order in the core.

Becomes of (physical) limitations, the increase in maximum entropy capacity (through expansion), could not keep pace with the accelerating entropy-production in the core, and eventually a limit was reached, in 1939.
Energy and entropy-regulation became problematic, once full colonization was accomplished. Entropy that cannot be dumped or re-utilized, will cause disorder in the system.

37.8. End to regulation

In 1939, the 1st FTS reached the singularity in finite time, and consequently collapsed. At that point, the state of the core of the System - the European State-System - was as follows:

- The European State-System produced infinite amounts of entropy and KA;
- The European State-System was maximum robust and fragile;
- The release ratio had reached 1,00; meaning that entropy could only be regulated through systemic KA/war;
- The European State-System had reached zero entropy, and was out of options;
- Great Power Status dynamics had died out;
- The entropy gap was zero ('closed'), and the environment was fully developed/exploited by the core;
- The European State-System had amassed enough activation energy to accomplish the final step in the phase transition to a state of thermodynamic equilibrium in the core.

It is also possible to understand the response of (State-)System in 1939, from an energetic point of view, as discussed. As explained, for a reaction - KA - to take place 'spontaneously', the KA must be energetically favorable, meaning that $\Delta \boldsymbol{G} < \mathbf{0} \wedge \Delta \boldsymbol{S} > \mathbf{0}$.
In 1939, for non-systemic KA, these conditions could be no longer satisfied: Entropy produced through non-systemic KA () could not be absorbed by the European State-System (because of the strong drive by the MEP-Principle), not by societies (that already experienced high tension levels), and not any more by the environment (non-core); consequently non-systemic KA was suppressed.
However, these conditions enabled a systemic kinetic response (R2-dynamics); the suppressed non-systemic KA (during the 4th RSP (1918-1939), in combination with the autocatalytic process of entropy-production and accumulation, caused a critical condition, and enough activation energy was generated that could be put to use to upgrade the order (and work means $\Delta \boldsymbol{G} < \mathbf{0}$). Through the systemic KA, the energy state of the System could be decreased (in accord with the Second Law).
Furthermore, through the phase transition, with its two complimentary effects - thermodynamic equilibrium of the European State-System (core) and simultaneous globalization of the State- System - the requirement $\Delta \boldsymbol{S} > \mathbf{0}$, could be satisfied again. The limitations imposed by the non-core (the fact that the non-core had reached its maximum entropy-absorption capacity, in 1939) could be made irrelevant, through a fundamental reconfiguration of the (State-)System.
Because the European State-System reached thermodynamic equilibrium, the MEP-Principle no longer applied to the core (it had lost its meaning), entropy became maximum (in the former European State-System), and free energy was pushed to minimum levels. The now global State-System was (and is) not

yet (near) zero-entropy, and at the (global) (State-)System started exploring and exploiting a next (level) non-core (space), to develop a suitable environment that can absorb entropy that is generated in the new core, the global State-System.
The upscaling of the System and its dynamics allow for a next level of growth and development; upscaling is required to ensure sufficient entropy-absorption capacity by a suitable environment of the (State-) System, to support a process of ordering (aggregation, etc.) taking place in the (State-)System.

37.9. "The 1st law of (social) evolution (development)"

The amount and rate of entropy a system can exchange to its environment - the entropy-absorption capacity of the system's environment - determines the system's rate of evolution/development/ aggregation. If the entropy-absorption capacity of the environment is exceeded - and the law $\boldsymbol{dS = d_iS + d_eS \geq 0}$ is consequently violated - the evolution/development of the system - its order - will be affected. A system's environment requires active regulation/management, because the
entropy exchanged to the environment affects the environment's entropy-absorption capacity. Exceedance of the entropy-absorption capacity of a system's environment is not without consequences and can cause a system's collapse. The entropy that cannot be exchanged to the environment damages the order (organization) of the system generating the entropy.
Given a projected growth/development path (goal) of a system, the entropy that must be exchanged to and absorbed by the environment can be calculated, and the suitability of the environment - and the feasibility of the projected growth (goal) - can be assessed.

37.10. Application (1): The purpose of barriers for entropy-regulation (1)

During the transient period (1480-1945), the (State)System and its components became increasingly connected and societies/states became increasingly interdependent. Population growth contributed to these developments. Because of the intensification of exchanges, increasing amounts of entropy were produced that required regulation to ensure a certain order in the (State-)System and in societies/states, could be created and maintained.
In their efforts to regulate and contain entropy, states established different types of barriers, including physical borders to 'guard' their territories. The development of national identities can also be considered efforts - methods - to regulate entropy, by introducing certain standards (embedded in values and norms) and physical recognition signs.

37.11. Application (2): The purpose of barriers for entropy-regulation (2)

Communities and societies build walls, not only in the abstract domain (e.g. ideological 'walls', borders between states) but also physical walls. Walls can be static or dynamic, and often involve the use of KA, to enhance their effectiveness. Examples of static physical walls include: The Chinese-, the Berlin-, and US-border walls, but also the Maginot and Siegfried Lines. These walls serve(d) as barriers to channel

EMIS-flows: entropy is FFE not only a source of order, but potentially also a source of disorder. Societies and communities regulate entropy-input, to ensure social homeostasis: Entropy is equivalent with new possibilities, that constitute threats and/or opportunities for societies. (Political) control requires barriers. Each society has (at least to a degree) a specific form of organization (low entropy), that is embedded in its internal institutions, laws, culture, values and norms, etc. Each state (society) actively regulates entropy to ensure organizational arrangement s ('low entropy structures') stay intact and stability is ensured.
Barriers in military operations serve to channel threats (entropy) and kinetic energy (KA).

37.12. Application (3): The origins of the French and American revolutions

In this chapter, the need for entropy-balancing and the requirement for entropy-absorption of environments for (social) systems was discussed. These requirements also apply to societies.
As discussed in chapter 30, during the 1st exceptional period (1657-1763), normal (chaotic) non-systemic KA was disturbed; a distortion that was caused by a temporary decrease in the number of degrees of freedom of the System that resulted in the emergence of a periodic window.
The periodic non-systemic KA/wars during the 1st exceptional period was less restrained, and the production of entropy and KA were more extreme. Because of its more extreme nature, the periodic non-systemic KA also lacked the ability to form VC's that also have the capacity to store entropy. I assume that the flows of entropy had to - and were - adjusted accordingly: More entropy was transferred (in)to societies/states in the core (Europe) and contributed to an acceleration in empowerment of societies; empowerment is besides aggregation and expansion another important entropy-distribution process in the (State-)System, regulated by the FTS.
The intriguing question is how this extra influx of entropy in societies - the accelerated empowerment - impacted on dynamics (events) and social development in the contingent domain: Did the excess entropy - the new possibilities and disorder - that was pushed into French society during the 1st exceptional period (1657-1763), reinforce and accelerate processes of empowerment in French society that in 1792 triggered the French Revolution and resulted in the (eventual) introduction of (more) democratic structures?
The same question can be asked in respect to the American Revolution (1765-1783) and the adoption of the declaration of independence from Great Britain in 1776: Is the American Revolution a consequence of the accelerating empowerment of British colonies in North America caused by the influx of excess entropy in these colonies caused by the accelerated production of entropy and distorted regulation caused by the abnormal non-systemic KA during the period 1657-1763?
It seems that these events could well be related to the redistribution of excess entropy during the 2nd cycle (1648-1815) through (accelerated) empowerment, to ensure compliance with the Second Law and related principles $\boldsymbol{dS} = \boldsymbol{d_iS} + \boldsymbol{d_eS} \geq \mathbf{0}$.
Further research is required to determine what the exact effects were on the entropy-balance of the System during the 2nd cycle, and how and where excess-entropy (new possibilities, and disorder) were 'exported to', and what the impact was on contingent dynamics.

37.13. Application (4): Democracy and societal entropy-regulation

Societies need to regulate their entropy(-production) to ensure a viable (that is intermediate) 'degree' of entropy is maintained, 'between order and disorder'.
States contribute to entropy-regulation of societies (internally as well as externally) to ensure the basic requirements of the respective societies they represent (govern) are fulfilled. Active entropy-regulation - regulation of tensions, new possibilities and (potential) disorder - is required in societies. The exact requirements for entropy-regulation of societies differ to a certain extent: A 'match' is required with the societies' specific needs and values, and cultures and identities. Consequently, governments differ in the amount of entropy, 'disorder' and information-exchange they allow, and consider desirable. Governments more or less serve the societies they regulate (control) and represent and are more or less able to enforce/impose rules and certain 'behavior' of its citizens.
During the transient period (1480-1945), the irreversibility of societies and the overall System continuously increased, and entropy in the (State-)System was regulated through the processes of KA, aggregation, expansion and empowerment.
Democracy is a system of government where citizens exercise power by voting. In case of democratic governance, citizens in societies are empowered to influence their environment, and contribute to the entropy-regulation of the social system they are part (member) of. In case of democratic governance, there is an active but regulated interplay between the society and its state; the state serves the society, while the society maintains the state, according to a mutually agreed upon protocol (laws).
Through democratic governance, entropy can be better regulated, opportunities can be identified, while at the same time stability and continuity can be maintained. Democracy balances continuity and change, by actively involving societies.
Through democracy, innovation potential is utilized, and resource exploitation can be (better) maximized.
Democracy is a form of societal entropy-regulation. Democracy was not invented during the modern era, but (re-)emerged during the transient period.
Democracy contributed to the entropy-regulation - the entropy-absorption potential - of the (State-)System.
Through the American and French Revolutions democratic governance was further promoted and reinforced as the preferred and most effective form of societal entropy-regulation of societies. Empowerment achieved through democratic structures, also contributed to the ability of societies to survive in an order that was regulated by the FTS, at least that is what the dominance of democratic structures that emerged in Europe (including the collapse of the Soviet Union in 1989) suggest.

37.14. Application (5): To maintain coherence FFE, EMIS flows must be maintained

Dissipative structures - including societies and the (State-)System - require sustained EMIS-flows - that involve their environments - to maintain their coherence and functioning. KA - war - is an essential energy flow to sustain the FTS. KA contributes to the coherence and functioning of the (State-)System.
Although wars in the contingent domain not necessarily contribute to constructive social and political developments, in the deterministic domain wars - KA - have a well-defined function.

38. The interplay between homeostatic- and FTS-regulation

38.1. Introduction

In this chapter, I discuss the interplay between the S (entropy)- and H (homeostatic)-imperatives, I explain that despite fundamental differences, both processes are complimentary and reinforce the process of aggregation.

38.2. Fundamental differences

There are several fundamental differences between FTS-regulation and homeostatic control. FTS-regulation is closely related to – "emerges from" - the S-imperative, which is grounded in laws of physics: The Second Law and related principles. Homeostatic control - homeostasis in social systems – is closely related to biological and social 'laws'; these laws are "subordinate" to laws of physics.

The primary purpose of homeostatic control is to resist a natural tendency of systems towards thermodynamic equilibrium (25), whereas the primary purpose of FTS-regulation is to achieve thermodynamic equilibrium of the State-System, via the most efficient path: Homeostatic control is dominated by negative feedbacks, while the FTS is subject to positive feedback.

The "homeostatic-imperative" (H-imperative) must be "obeyed" to ensure the maintenance of an organism's integrity. Damasio defines homeostasis as: "The natural process of life regulation orients living organisms so that they operate within the range of parameters compatible with life maintenance and flourishing. The heroic process of maintaining life requires a precise, herculean process of regulation, in individual cells as well as in whole organisms" (25). Whereas homeostatic regulation is about continuity, FTS-regulation is about change.

The H-imperative utilizes the opportunities the Second Law - $\boldsymbol{dS} = \boldsymbol{d_iS} + \boldsymbol{d_eS} \geq \mathbf{0}$ - provides: As long as entropy is exported (to an environment), low entropy structures - i.e. solutions that satisfy the H-imperative - can be maintained and further developed.

Furthermore, the H-imperative is able to utilize the available contingent latitude in the contingent domain of the (State-)System. Satisfaction of the H-imperative provides well-being and survival to its "users" (individual humans, communities and societies).

Another fundamental difference between the two types of regulation is that FTS-regulation can be considered top-down regulation, and homeostatic control as bottom-up regulation.

Laws of physics are superordinate to biological and social laws and impose certain constraints on social systems. The more flexible H-imperative must deal with these constraints but can also use them. Despite the deterministic nature of the Second Law and related principles, are this law and principles statistic in nature, and consequently plays probability an important role in the dynamics and structures these laws (help) produce: The dynamics and structures the FTS produce involve probabilistic and deterministic factors.

The latitude the Second Law provides - the indeterminateness of the Second Law - and the contingent latitude in the (State-)System, allow biological and social systems to produce an - it seems - 'infinite' myriad of solutions (processes, structures and artefacts), despite the imposed constraints. Furthermore, are the solutions the H-imperative generate not limited to the physical domain, but also include ideas, ideologies and values in the abstract domain, where they can be freely combined.

The interplay between top-down FTS- and bottom-up homeostatic regulation produces solutions that can satisfy the H-imperative and can contribute to the survival (changes) and well-being of its beneficiaries; this interplay also determines and shapes the process of social evolution (social evolution will be discussed in the next chapters). See figure 38.1.

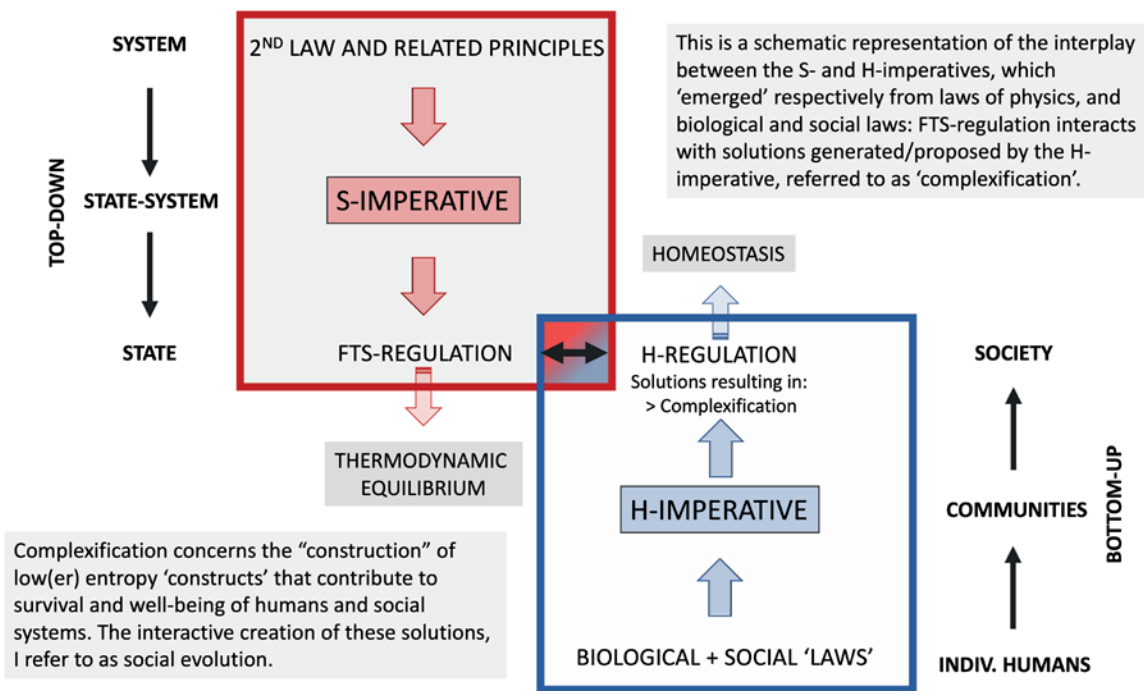


FIGURE 38.1: Interaction between the S- and H-regulation. This figure also explains how the deterministic domain (the footing of the S-imperative) interacts with the contingent domain (the footing of the H-imperative), and how top-down macroscopic dynamics and processes (generated by the S-imperative) are inseparably linked to bottom-up microscopic processes (generated by the H-imperative).

38.3. Complementarity in regulation and synergetic effects

A closer look at both regulatory processes and their interplay during the transient period (1480-1945), reveals that FTS- and homeostatic regulation are complementary, and that both processes contributed - reinforced - the process of aggregation, which was eventually accomplished by a phase transition (1480-1945).

The H-imperative promotes - reinforces - cooperation and aggregation (the merging of communities and societies). According to Damasio, "By breaking down isolation and bringing individuals together, the simple drive to socialize generates opportunities to improve or stabilize individual homeostasis" (25). Better solutions can be produced, by utilizing economies of scale and scope cooperation and aggregation offer to social systems. Survival (changes) and well-being can be enhanced through cooperation and aggregation. This is a bottom-up process, that also contributes to bottom-up entropy-regulation. According to Damasio: "homeostasis achieved the survival and flourishing of the individual and helped create the conditions for it to persist and reproduce" (25).

As discussed, a (macroscopic) process of aggregation is one of the regulatory processes (besides KA, expansion and empowerment) the 1st FTS generated. See figure 38.2 and 38.3.

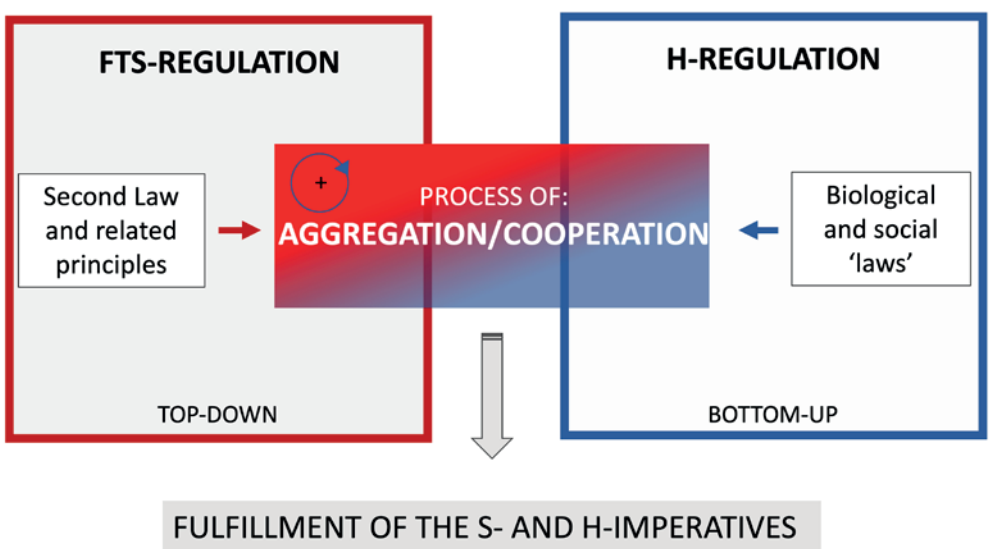


FIGURE 38.2: The process of aggregation/cooperation generated by the S- and H-imperatives links FTS- and homeostatic-regulation in the (State-)System.

Homeostatic- and FTS-control both reinforce the processes of cooperation and aggregation, and are shaped by a process of social evolution, in which entropy (new possibilities) are explored and exploited, by utilizing energy (e.g. social potential).

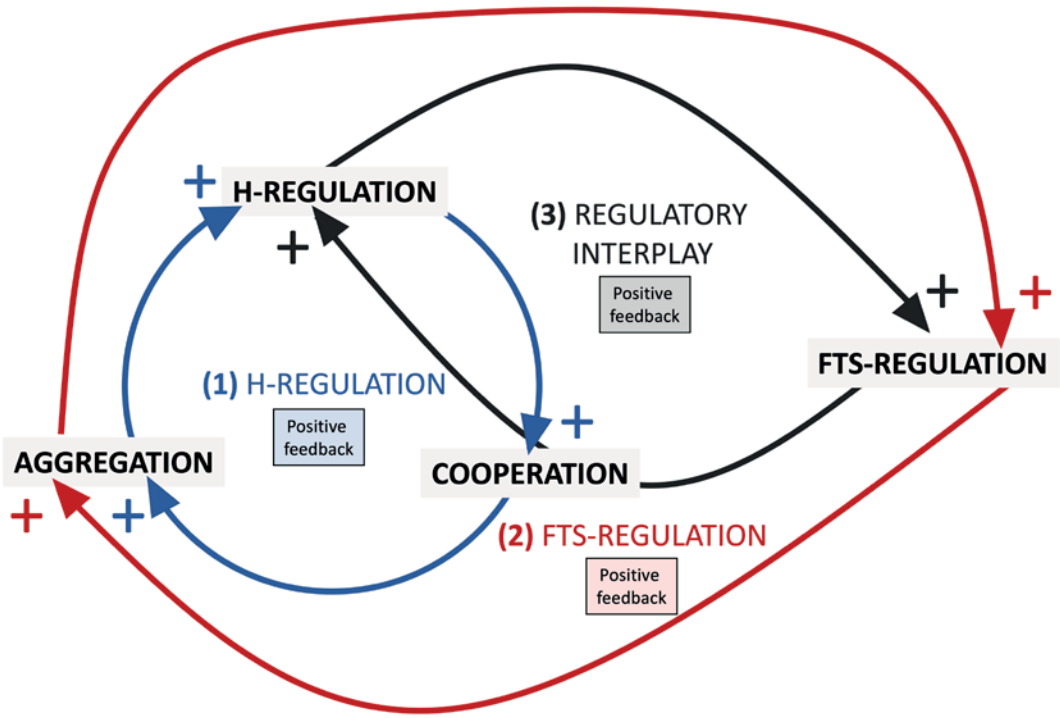


FIGURE 38.3: Causal loop diagram "regulatory interplay". This figure shows the variables that are involved in the interplay between H- and S-regulation in the (State-)System, and the relationships between these variables. Three closely related and mutually reinforcing positive feedback (reinforcing) loops can be distinguished: (1) H-regulation promotes cooperation, while cooperation contributes to the process of aggregation; aggregation offers new opportunities for H-regulation, through (new) economies of scale and scope that can be exploited; (2) FTS-regulation drives the process of aggregation, while aggregation further reinforces FTS-regulation; and (3) FTS-regulation (through aggregation) reinforces H-regulation, and vice versa. This causal loop diagram also explains how the deterministic domain (footing of the S-imperative) interacts with the contingent domain (footing of the H-imperative), and how top-down macroscopic dynamics and processes (generated by the S-imperative) are inseparably linked to bottom-up microscopic processes (generated by the H-imperative).

38.4. A continuous and self-reinforcing stream of innovations

Well-being and survival of social systems requires that both the S- and H-imperative are satisfied. Because of population growth and other drivers, entropy-production in the (State-)System accelerated during the transient period (1480-1945). These accelerating 'amounts' of entropy and the accelerating KA it resulted in, required continuous and accelerating FTS-regulation. Also, because increasing amounts of entropy were 'forced' into societies, societal adjustments were continuously required to ensure that homeostasis was maintained. Entropy is a source of order in FFE-systems like the (State-)System and societies. Through the interplay between FTS- and homeostatic-regulation - and to ensure that both imperatives were obeyed - the system - at all levels - responded with continuous adjustments and innovations. These

innovations also contributed to entropy-regulation, and not only concerned for example technological innovations but also abstract innovations - ideas and ideologies - that contributed to the harnessing of entropy.
Because the process of innovation itself also generated entropy, and because innovation can also be accomplished by combination ('novelty by combination'), the process was self-reinforcing. See figure 38.4.

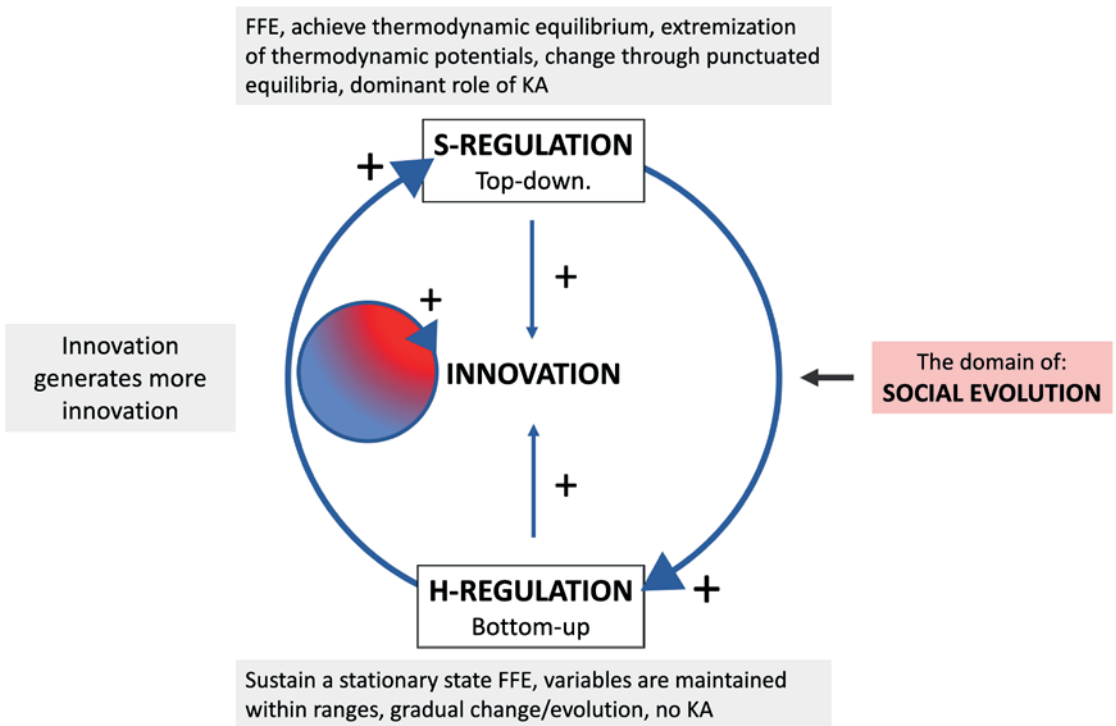


FIGURE 38.4: Through the interplay between FTS- and H-regulation an accelerating stream of innovations was (and still is) produced in the contingent and abstract domain.

38.5. The role of the state

The state fulfills a key role in the interplay between bottom-up homeostatic control, grounded in societies, and top-down FTS-regulation, grounded in the (State-)System. As discussed in chapter 12 the state acts as a linking-pin and functions as an intermediary: The state is responsible for maintaining homeostasis in societies, and for regulating interactions and exchanges with other societies and states in the anarchistic State-System, on which FTS-regulation is superimposed. The State is an intermediary

between a society - the state's inner environment - and a society's (external) environment, on which a society depends to ensure the society's basic requirements are fulfilled, and a certain well-being and survival are accomplished.
The FTS (also) applies kinetic energy - KA - to fulfill its regulatory functions. State's provide the kinetic energy and participate in KA, a process that is also regulated by the FTS.
Whereas kinetic energy and KA are functional in the regulation of the (State-)System, kinetic energy and KA are not functional in inter-societal processes, where KA can damage the fabric of societies and undermine homeostatic control.
In case of societal homeostatic control, minimization of societal kinetic energy and KA serve as a thermodynamic potential: The utilization of kinetic (free) energy in societies undermines homeostasis and destabilizes these societies. Kinetic energy and KA are strictly regulated in societies.
To be able to fulfill their intermediary - dual - role and to effectively regulate their internal and external environments, states have acquired a monopoly on violence: A monopoly on the use of kinetic energy to neutralize internal entropic perturbations (if required), and to participate in KA in the State-System, to ensure a favorable and supportive external environment is sustained.
Through the monopoly on kinetic energy (violence), civilians cannot engage in destabilizing KA, but states can - if required - utilize KA to control (societal) behavior. Furthermore, the monopoly on violence - centrally controlled - also provides efficiency benefits to the society and state.

38.6. Integrated mutuality

FTS-regulation is grounded in the Second Law and related principles and is a top-down process; homeostatic-regulation on the other hand, is grounded in biological and social 'laws' and constitutes a bottom-up process. A s I explained, both regulatory processes reinforce aggregation and cooperation, and produce(d) an accelerating 'stream' of innovations. These innovations include ideological, cultural and organizational 'solutions', that must satisfy both imperatives.
During the transient period (1480-1945), societies/states became increasingly dependent on the 1st FTS for their survival in the (State-)System; while the 1st FTS (and its structural component the State-System) became increasingly dependent on functioning societies to sustain its operation and ensure its own survival.
The regulatory processes of homeostatic control by societies/states and FTS-control by the (State-) System coevolved: There was increasing integrated mutuality: The FTS 'drew' on societies/states - by extracting entropy- and energy - and reciprocated the favor by sustaining them, as is the case for other complex life-forms. (25).

38.7. The switch from FTS- to homeostatic-regulation

At a certain point during the process of aggregation, the relationship between certain societies switched from FTS-regulation to homeostatic-regulation, based on intrinsic design-principles applied by the societies/states involved.

Two processes are involved in the merger (aggregation of societies/states): (1) the substitution of FTS-regulation - which includes regulation through KA - by homeostatic-regulation, which prohibits/inhibits the use of KA, and (2) the merging of two different forms - at least to a degree - of homeostatic control. This 'switch' requires the fusion/merging of the state-structures that are involved in the process, and a certain reconfiguration is required.
From a thermodynamic point of view, the switch in regulation can only be accomplished if the 'merger' is energetically favorable - $\Delta \boldsymbol{G} < \mathbf{0} \wedge \Delta \boldsymbol{S} > \mathbf{0}$ - and in the contingent domain, certain incomplementarities are - or can be - eradicated.
The merger means, that the societies/states involved must not only merge their homeostatic-control, which requires a process of fine-tuning, but also must redirect part of their kinetic potential. Whereas before the merger, the societies/states regulated their interactions and relationships - their EMIS-flows - under control of the FTS (which could result in amplification by the S/T-field), and if necessary, through KA; after the merger, the use of KA was no longer possible and desirable.
The merged homeostatic-control structures need to be designed and implemented - institutionalized - in the contingent domain of the System.
In case of a process of social fragmentation - of which Brexit is an example - the reversed process must be executed: (shared) homeostatic-control - which by definition requires a high degree of integration and fine-tuning - is replaced by FTS-control, which could involve at a certain point KA. The fact that FTS-control is re-imposed, means that the fragmented entities - and their relationships and interactions - also become subject to S/T-field amplification again, which can result in an intensification of entropy-production.

38.8. Application (1): Democracy is empowered entropy-regulation

There exist various forms of societal homeostatic control, which differ for example in the degree in which (internal) EMIS-flows are regulated, the state depends on repression (kinetic energy) to shape behavior, and the degree in which the population - society - is actively involved in homeostatic control. In case of democratic governance, the population is actively involved in societal regulation: Self-regulation - empowerment - is a hallmark of democracy.
Empowerment - freedom of action - means that society contains - and can contain - more entropy. In democracies, entropy can be utilized by the population as a source of (local) innovation and order.

38.9. Application (2): Repertoires of behavior

As is the case with other living systems, over time, societies/states - and the (State-)System they are integral parts of - produced certain repertoires of behavior in terms of competition, cooperation and conflict. States - 'representing' societies - do act according to these repertoires of behavior. These repertoires are much more limited than we want to belief; these are mostly highly automated responses. These repertoires are institutionalized, a process in which the FTS and the PDLI-mechanism were instrumental.
The repertoires of behavior include codes of conduct between societies and states and are inspired by the H-imperative. "Such codes have generally aimed at the reduction of risk and dangers for individuals

and social groups" and the utilization of opportunities; and have "resulted in a reduction of suffering and the promotion of human welfare. They have strengthened social cohesion, which is, in and of itself, favorable to homeostasis" (25). Risk reduction and the exploitation of opportunities are equivalent with entropy-regulation: The homeostatic- and FTS-regulation are inseparably linked.

38.10. Application (3): The other 'invisible hand' and the war trap

"Invisible hand" - a term used by Adam Smith - refers to the unintended social benefits of an individual's self-interested actions (96). The invisible hand captures Adam Smith's notion that "individuals' efforts to pursue their own interest may frequently benefit society more than if their actions were directly intending to benefit society" (96), a notion that is also used to justify free - unregulated - markets.
This study shows that a similar effect can be observed in the (State-)System, where the (State-)System benefits from the individual efforts of societies/states in pursuance of their own interests, in obedience of the H-imperative. These individual efforts generate entropy and KA, which is instrumental in the growth and development of the FTS and State-System.

Part VIII

Introduction

In this part, I focus on (social) evolution, by making use of the insights this study has produced.

According to Chaisson, "Where the environment is conducive and energy available, open systems capable of utilizing energy can sometimes *build more complex structures able to process increased energies*; the products often comprise an unresolvable mixture of efficiency, competition, and optimization (*IP: like societies/states and the (State-)System*).

What's more, the resulting complexity is not necessarily just an accumulation of more of the same; rather, increasing amounts of it can sometimes lead to distinctly new (emergent) phenomena. The complex objects seen around us are the macroscopic manifestations of fundamental fluctuations - that's largely chance (probabilistic factors) - arising on the microscopic level within unstable dynamical systems. A combination of non-equilibrium conditions and resultant system-environment gradients engender energy flows - that's largely determinism - not to achieve some predestined goal since evolution is not a movement toward any specific state, but to foster ordered forms consistent with the easiest way out of a difficult situation. In turn, via trial, error, and much feedback, evolution improves the management of energy flow with each substantial increase in organization, all in accord with a selection process that is quite natural, thereby rewarding and reinforcing those flow pathways able to draw greater rates of energy per unit mass." (20).

In this part, I show that similar mechanisms are at work in the (State-)System; including the interplay between chance and determinism, on the microscopic and macroscopic levels of the (State-)System.

Although, there are similarities between Chaisson's observations, there are also some differences: The State-System certainly does achieve some predestined goals, i.e. to achieve thermodynamic equilibrium - a very specific end-state - via the most efficient path. This predestined goal and the processes involved, concern the evolution of the State-System and set the stage for evolutionary processes in the contingent domain of the System.

In chapters 39 and 44, the focus is on social development and evolution. In chapter 39, I discuss a study by Chaisson with the title "Cosmic Evolution" (20). In this study, Chaisson discusses "an underlying, ubiquitous pattern" that penetrates "the fabric of all natural sciences (...) a sweepingly encompassing view of the order an structure of every known class of object in our richly endowed Universe", Chaisson refers to as "universal change" or "cosmic evolution" (20). A question is of the pattern Chaisson refers to can also be identified in the evolution of the (State-)System, and if his framework provides other insightful observations and clues to better understand the dynamics of the (State-)System.

In chapter 44, I discuss some 'key-features' of social evolution that can be identified with the help of Chaisson's study, insights in biological evolution and some of the results of this study.

In chapter 41, the fundamental differences of dissipative and designed structures are discussed that also impact on the (social) evolution of these different types of systems.

In the next chapter - chapter 42 - the interplay between individual and collective behavior is discussed, and especially how individual behavior and collective behavior become synchronized through the mechanism of "interacting self-fulfilling prophecies". In chapter 43, I discuss how social systems can become more volatile and can radicalize.

Finally, I discuss the "mechanisms of social evolution" in chapter 44 and present some developmental scenarios of the (State-)System, in chapter 45.

Contents

39. Universal change and selection
40. Social development and evolution: concepts and ideas
41. Dissipative and designed structures
42. The interplay between individual and collective behaviour
43. Social and political volatility and radicalization
44. Social development and evolution
45. Developments and scenarios

39. Universal change and selection

39.1. Introduction

In the study with the title 'Cosmic Evolution', Chaisson describes an "underlying, ubiquitous pattern penetrating the fabric of all natural sciences (20) a sweepingly encompassing view of the order and structure of every known class of object in our richly endowed Universe", Chaisson refers to as "universal change" or "cosmic evolution" (20). Cosmic evolution, "is the study of change, the vast number of developmental and generative changes that have accumulated during all time and across all space, from the big bang to humankind (...) cosmic evolution comprises the sum total of all the many varied changes in the assembly and composition of radiation, matter and life throughout the history of the Universe" (20).

"Cosmic evolution is a search for principles that subsume, and even transcend, Darwinian selection, a unifying law, an underlying pattern, or an ongoing process perhaps, that creates, orders, and maintains all structure in the Universe, in short a search for a principle of cosmic selection" (20).

According to Chaisson, "recent advances throughout the sciences suggest that all organized systems share generic phenomena characterizing their emergence, development, and evolution." Chaisson uses the "concept of energy flow as a measure of complexity among all organized systems, from elementary particles to cultured society" (20).

In this chapter, I try to determine if similar patterns can be determined in the (State-) System's evolution.

39.2. Universal change

Chaisson addresses the question what "the source of order, form, and structure is that characterizes all material things? How did (and does) order emerge from disorder, given that the Second Law of thermodynamics dictates the Universe to become increasingly randomized and unstructured?" (20).

Chaisson explains - also by making use of modern thermodynamics, as developed by Prigogine et al. - how the "theoretical destructiveness of thermodynamics (often called the "thermodynamic arrow of time" can be reconciled with the observed constructiveness of cosmic evolution (the "cosmological arrow of time")" (20). That question is also addressed in this study.

Chaisson observes that "We learned how the evident order and increasing complexity of the many varied, localized structures within the Universe in no way violate the principles of modern physics, which, prima facie, maintain that the Universe itself, globally and necessarily, becomes irreversibly and increasingly disorganized" (20); Chaisson refers to the Second Law of thermodynamics; $\boldsymbol{dS} = \boldsymbol{d_iS} + \boldsymbol{d_eS} \geq \mathbf{0}$.
According to Chaisson, evolution is another word for change, and "change is the hallmark for the origin, maintenance, and fate of all things, animate or inanimate". Cosmic evolution, "encompasses all change, on every spatial and temporal domain, large and small, near and far, past and future".
According to Chaisson a sequence of events - an arrow of time - can be identified, consisting of seven major construction phases in the history of the Universe: Particulate, galactic, stellar, planetary, chemical, biological, and cultural evolution, and changes "have generally been toward greater amounts of diversity and complexity" (....); the dynamic tide of ceaseless change" resembles an intricate web of step-by-step causality" in which the structures the Universe produced (including life), always "adapt to the prevailing physical conditions, whatever they may be, and eventually fill an entire spectrum of environmental niches with a variety of ordered types" (20).
Chaisson also argues that both chance and necessity have roles to play in all cosmic evolution, as is the case in the (State-)System: "Contingency - randomness, chance, stochasticity - pervades all dynamic (*IP: including deterministic change and necessity*) change on every spatial and temporal scale"; prediction (based on a Newtonian worldview) is not possible: "cosmic evolution predicts little of the future, yet strives to explain much of the past".
However, as I discuss in this study, despite the indeterminateness Chaisson refers to, the dynamics of the (State-)System - especially certain characteristics of the R2-dynamics of the 1st FTS, during the transient phase (1480-1945) - developed remarkably regular and predictably.

39.3. Increasing complexity: Different energy densities and expansion

Chaisson observes that over time, "material assemblages have become increasingly organized and complex, especially in relatively recent times", in an otherwise disordered and chaotic environment (20).
In figure 39.1,, the trend of increasing order, form, complexity, organization and information etc. is shown.
Chaisson distinguishes seven major construction phases (as I mentioned before), during three successive phases of the Universe. The three successive phases of the Universe are: (1) the radiation phase, when the (early) Universe was "flooded with pure energy whose radiation energy density was initially so high as to preclude the existence of any appreciable structures"; (2) the matter phase, that followed a phase transition ("about a hundred millennia after the origin of all things"), when "matter's energy density had overthrown the earlier primacy of radiation", and (3) the free energy phase, "some 12 billion years later (....) with the onset of technologically manipulative beings (on Earth and perhaps elsewhere)" when "the energy density contained within matter" became "locally dominated by the rate of free energy density flowing through open organic structures". See figure 39.2.
According to Chaisson, "Nature has, surely naturally and perhaps inevitably, managed to establish the environmental conditions conducive to the complexification of all known systems within an otherwise disordered Universe. Using non-equilibrium thermodynamics as the crux, I (*IP: that is Chaisson*) argue that "it is the contrasting temporal behavior of various energy densities that has given rise to those environments needed for the emergence of galaxies, starts, planets, and life".

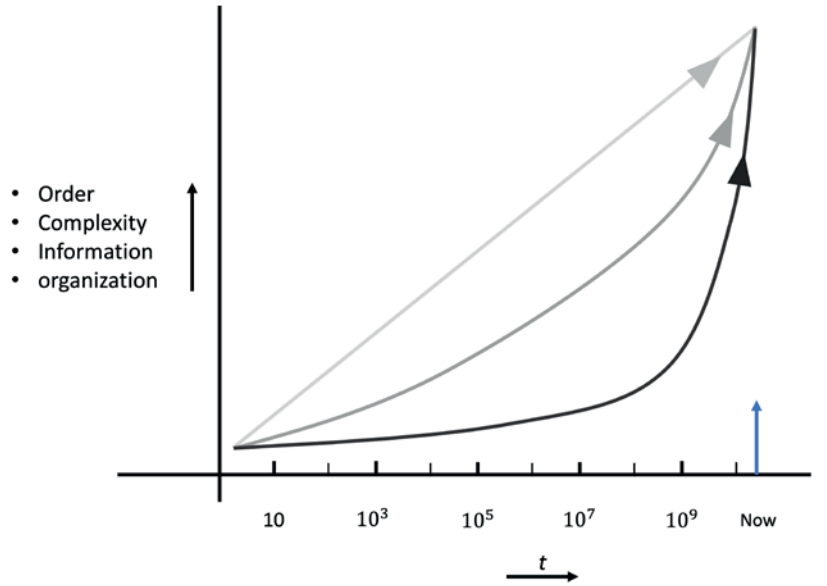


FIGURE 39.1: Different complexification trajectories. According to Chaisson, a general trend can be observed in the (rising) complexity throughout the history of the Universe. This diagram is a schematic representation of this trend: Three possible complexification trajectories are shown (based on Chaisson, (20)).

THREE PHASES
(Based on Chaisson)

Contrasting temporal behavior of various energy densities give rise to environmental conditions conducive to the complexification of all known systems.

Changes can be observed in dominant energy densities of the Universe, at least locally/temporarily.

Three phases can be distinguished:

1. Dominance of **RADIATION ENERGY** (0 - 100.000 years);
2. Dominance of **MATTER ENERGY** (100.000 - 12 billion years);
3. Dominance (at least on Earth) of **FREE ENERGY flowing through organic structures** (12 billion years - present).

FIGURE 39.2: Three successive phases of the Universe (20).

Chaisson explains that a general trend can be observed, but that "disorder occasionally gains the upper hand at isolated points in space and time" (for example, in case of the detonation of supernova, simplification of biological structures or the collapse of societies), but that "such decreases in complexity

are comparatively rare, implying that cosmic evolution is not some kind of random walk; *the general trend is demonstrably toward increased complexity with increased time*" (20). This is also the case for the System and its components (e.g. societies).
Chaisson explains that complexity is in ordinary discourse referred to as "a state of intricacy, complication, variety, or involvement, as in the interconnected parts of a structure; a quality of having many interacting, different components" (20).
Chaisson argues (20), that complexity itself "is insufficient to demonstrate the direction of evolution, at least not biological evolution" (20), and that the direction of (cosmic) evolution seems to obey the 'basic maxim' that "the collective efforts of living organisms tend to utilize optimally (per unit volume or mass) both their energy intake and their use of free energy by dissipative (dispersive) processes occurring within them. It is in this sense that biological evolutionary events have some temporal direction" (20).
In order to study complexity in quantitative terms, and to explain the general trend of rising complexity, Chaisson operationalizes complexity in two ways: (1) "as a measure of the information needed to describe a system's structure and function, and (2) as a measure of the rate of energy flowing through a system of given mass" (20).
According to Chaisson, "Organized systems of a physical, biological, or cultural kind everywhere apparently optimize (per unit volume or mass) the flux of energy passing through them. By "optimum" is meant an intermediate range in energy flow, below which the energy flow is too small to affect order, and above which is so large as to destroy order"
In this chapter, I determine the rate of energy that flowed through the (State-)System, during the transient period (1480-1945); I show that the rate of energy that flowed through the (State-)System accelerated during the transient period; The (State-)System obeys Chaisson's maxim, it seems.
This study shows that the process of aggregation in the core (Europe) and the process of expansion of the core to the non-core during the transient period (1480-1945), were closely related and (mutually) reinforcing processes. Chaisson also discusses the relationship between increasing order (complexification) and expansion: "that a necessary, though perhaps not sufficient, condition - a veritable prime mover - for the onset of such ordered structures (*IP: in the Universe*) is the expansion of the Universe itself" (20).

39.4. Shaping of evolutionary processes through the interplay between probabilistic and deterministic factors

Chaisson argues that in case of evolution, "there is no strict causality and predestination; the future is not implicit in the past, and the universe generates essential novelty" (20). Chaisson explains (for the Universe in general), "even if an initial set of conditions is known, the one and final state of some event" cannot be predicted (20): "Probabilities can be assigned to each of the possible outcomes if we are given the initial conditions, but the outcome is not fixed or predetermined" (20). However, although chance plays an (important) role in the dynamics and development of systems, chance is also "constrained" by laws of physics and produce "oddities in structure for which the a priori chances are slim.

According to Chaisson, "thermodynamics acts as a molecular sieve or probability selector - in effect, a mark of determinism - fostering certain chemical combinations and rejecting others, all the while guiding organization and order from amid some of the randomness and chaos" (20): Selective assembly is more of a rule than an exception (20).
According to Chaisson, evolution is a synthesis between determinism (necessity) and chance, and "biological natural selection acts as a 'sifting mechanism' - an 'editor' of sorts - permitting some species to thrive even while others perish. Chance admittedly provides the raw materials for biological evolution (...) but natural selection is a decidedly deterministic action that directs evolutionary change. The deterministic part can be considered a constraint - a physical, chemical or environmental boundary - that limits the role of chance; thus, we have evolution by 'constrained contingency'" (20). "In the production of variation chance dominates, while selection itself operates largely by necessity" (20).
I have visualized the application of this basic evolutionary mechanism to the European State-System, in figure 39.3.

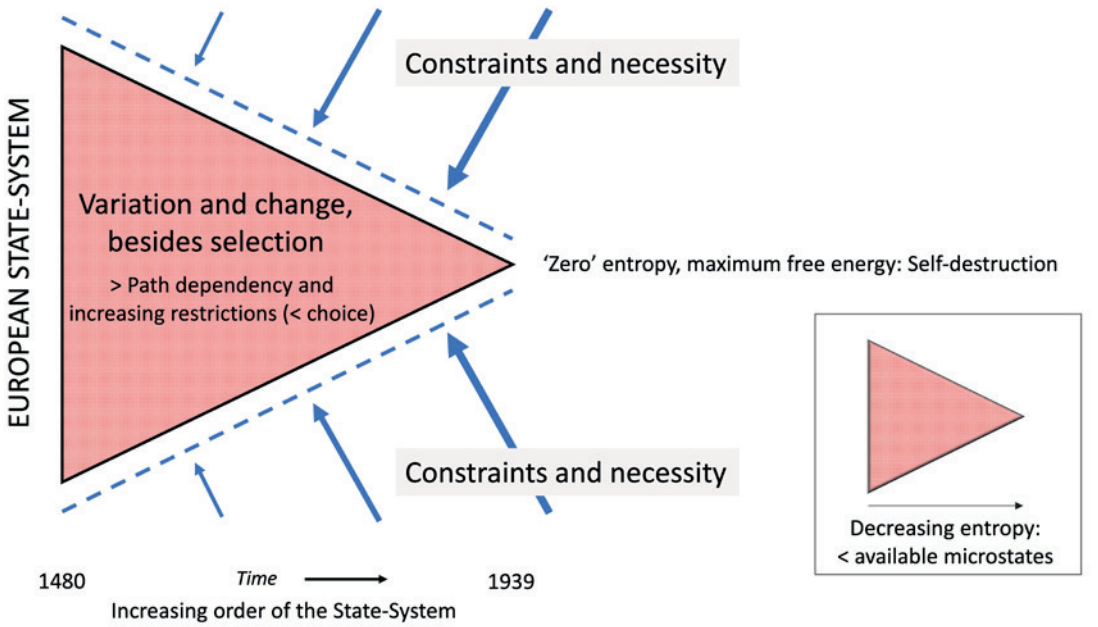


FIGURE 39.3: Constrained contingency of the State-System during the transient period, leading to collapse in 1939.

In case of the State-System there are some similarities with Chaisson's observations, but there is also a fundamental difference: Contrary to what Chaisson observes, in case of the State-System there was (and is) certainly a predetermined end-state: The State-System accomplished thermodynamic equilibrium via the most efficient path, during the transient period (1480-1945), meaning that full aggregation was achieved, and the environment (i.e. non-core) was also developed in the process.

However, despite the strict causality and predestination of the State-System and the fact that the future of the State-System was implicit in the past, there still was latitude for contingency, and the process can (still) be characterized as "evolution by constrained contingency": The strict causality of the development of the State-System went hand in hand with a certain interplay between probabilistic and deterministic factors, but still left latitude for contingency, at least until the State-System reached zero entropy in 1939. It is probably more to the point to consider the transition to thermodynamic equilibrium of the State-System as a process of (social) development - of growth - and not of social evolution per se; and that this process provides a context - a straitjacket - for social evolution of - and in - its components (societies and states).

39.5. Dissipative structures and universal change

"Life forms, in particular, are highly complex and intricate systems whose substantial order implies much hierarchical organization - structure gradually or episodically acquired by long periods of evolution. Lest life's order be neither created nor sustained, this organization must regulate an ample flow of energy (in the form of radiation, or matter, or both) into and out of living systems (...)" (20).

As discussed previously, according to Schrödinger: "An organism feeds upon negative entropy, attracting as it were, a stream of negative entropy upon itself, to compensate for the entropy increase it produces by living and thus to maintain itself in a stationary and fairly low entropy level". In the words of Chaisson: "Thermodynamics' Second Law strongly inhibits ordered structures in isolated systems" (20).

Given the usual course of thermodynamics leading toward equilibrium and a state of maximum disorder (20), living (ordered) systems must - at least temporarily, for the duration of their lifespan - ensure this order is maintained, which requires the input and regulation of EMIS: "From simple bacteria to complex humans, from aged stars to differentiated planets, ordered systems must emerge, in some cases be maintained, and yet still others be reproduced by means of a continuous exchange of energy with their surrounding environments" (20).

Chaisson explains: "The importance of free energy, available to go to work and potentially defeat entropy, though only locally and temporarily, cannot be overstated" (...) all these ordered objects - also referred to as dissipative structures - living and non-living - "more or less maintain their being by means of a regular flow of available energy from their outsides to their insides. The more complex and intricate the structure, generally the more energy intake (per unit mass) needed for sustenance (...)". "In the process, these structures can export some of their entropy (or dissipate some of their energy, hence their name) into the external environment with which they interact. Accordingly, order is created and often maintained by routine consumption of substances rich in energy, followed by a discharge of substances low in energy" (20).

Chaisson also observes, like Prigogine et al. that "fluctuations - random deviations from some average, equilibrium value of density, temperature, pressure, etc. also called 'instabilities' or 'inhomogeneities' - are common phenomena in Nature. They inevitably and stochastically appear in any system having many degrees of freedom. Normally, as in equilibrium thermodynamics, such instabilities regress in time and disappear; they just come and go by change, the statistical fluctuations diffusing as quickly as they

initially emerged. Even in an isolated system, such internal fluctuations can generate local, microscopic reductions in entropy, but the Second Law of thermodynamics ensures that they will always balance themselves out. Microscopic temperature fluctuations, for example, are said to be thermally relaxed." (20). Open systems cannot generate order, "evolve spontaneously to new and interesting structures" near equilibrium: A state far from equilibrium is required (as explained in previous chapters). If because of the increasing 'distance' of a system from equilibrium, fluctuations "become too great for the open system to damp, the system will then depart far from equilibrium and be forced to reorganize" (20), as was also the case for the (State-)System in 1480.

Chaisson explains the application of the Second Law FFE as follows (see also preceding chapters): "For open systems, then, the Second Law of thermodynamics must be reformulated. Specifically, we now recognize two contributions to the total entropy change of any event in Nature: One is the (normally positive) entropy production inside the system (*IP:* $\boldsymbol{d_iS}$) per se caused by irreversible events, such as friction, chemical reactions, or conduction of heat (*IP: or caused by interactions between societies/states in case of the State-System*); the other is the (always positive) entropy production in the environment (*IP:* $\boldsymbol{d_eS}$) caused by exchanges between the system and the outside world (*IP: In case of the State-System caused by exchanges between the State-System and its environments (societies and the non-core)*)" (20).

As discussed, $\boldsymbol{dS} = \boldsymbol{dS_{State\text{-}System}} + \boldsymbol{dS_{Environments}} \geq \boldsymbol{0}$. "For an open system, the entropic change caused by environmental interaction is always positive

(*IP:* $\boldsymbol{dS_{Environment}} > \boldsymbol{0}$), whereas the internal entropy change (*IP:* $\boldsymbol{d_iS} = \boldsymbol{dS_{State\text{-}System}}$) can be either positive or negative. The sign of the internal contribution (*IP:* $\boldsymbol{d_iS} = \boldsymbol{dS_{State\text{-}System}}$) to the total entropy change (*IP:* $\boldsymbol{dS}$) is generally undetermined and depends on the quality and rate of the flow of energy across an open system's boundary" (20). Provided that $\boldsymbol{dS_{Environment}}$ increases more than $\boldsymbol{dS_{State\text{-}System}}$ decreases, "the Second Law of thermodynamics is still obeyed in that the total entropy change $\boldsymbol{dS} > \boldsymbol{0}$, meaning that a system can become locally ordered at the expense of a global increase in entropy in the Universe beyond" (20).

"Accordingly, in principle at least, an open system can establish and sustain a negative entropy (or negentropy) change in relation to its environment, and during the course of evolution may reach a state wherein its entropy has physically decreased to a smaller value than at the start. Note that we are not stating that the rate of entropy growth merely becomes lessened or even reduced to zero. Under appropriate conditions, most notably a high-grade energy flow, the entropy itself within open systems can actually be reduced, i.e. $\boldsymbol{dS_{sys}} < \boldsymbol{0}$ (*IP:* $\boldsymbol{S_{State\text{-}System}} < \boldsymbol{0}$, *in case of the System*). For such a non-equilibrium state, order can be achieved within a system by means of the spontaneous emergence of organization" (20).

As explained previously, this is what happened in the System during the transient period (1480-1945), when the entropy of the State-System decreased (through application of the MEP-Principle) and consequently, the State-System became increasingly organized; while at the same time, the increasing entropy-production was redistributed by the 1st FTS, through e.g. the process of aggregation and expansion from the core (Europe) to the non-core.

"Furthermore, open systems can be prevented from reaching equilibrium by the regular introduction of fresh reactants and by the regular removal of the derived products. And some of such systems can be regulated to achieve a constant ratio of incoming reactants to outgoing products. The system then

appears to be in equilibrium because this ratio does not change over time. But in contrast with true equilibrium (where entropy is maximized), this kind of process continually produces entropy and dumps (or dissipates) it into its surrounding environment" (20).

In case of the (State-)System, new reactants are introduced through population growth, and in case of societies/states also through aggregation, mixing involved in aggregation. These new reactants contribute to the entropy and free energy of the (State-)System and societies/states.

Chaisson also argues that fluctuations - products of the interplay between change (randomness) and necessity (determinism) - can be considered the physical equivalent of system mutations, the stabilizing paths taken akin to natural selection (20).

This perspective also applies to the (State-)System, I argue: The State-System also stabilizes itself - and evolves - through the amplification of "selected" entropic fluctuations (perturbations) and of the issues these fluctuations contain (in the contingent domain).

The selection (process) involved in entropic fluctuations produced in the (State-)System, concerns the ability of these entropic fluctuations and the issues they contain to attract (more) entropy and energy from the S/T-field, at the expense of competing perturbations/issues. The process of selection - the allocation of energy and entropy - is regulated by the FTS, in accordance with the laws of thermodynamics and related principles that apply. The 'successful' perturbations/issues have been naturally selected by a physical process (regulated by the FTS) "that mixes a random initiator (*IP: random perturbations/events and issues in the (State-)System*) with a deterministic outcome" (20).

Amplification of certain fluctuations involves interaction between the entropic perturbation (the initial fluctuation/perturbation) and the S/T-field (as discussed in chapter 20), from which (more) entropy and energy is drawn.

"Such reorganizations generate a kind of 'dynamic steady state', provided the amplified fluctuations are continuously driven and stabilized by the flow of energy from the surroundings, namely, provided the energy flow rate exceeds the thermal relaxation rate. Global, coherent cycling is often the result, since under these conditions the spontaneous creation of macroscopic structures dissipates energy more rapidly than the ensuing, and damaging, heat can smooth out those structures. Furthermore, since each successive reordering causes more complexity than the preceding one, such systems become even more complex than the preceding one, such systems become even more susceptible to fluctuations. Complexity itself consequently creates the condition for greater instability, which in turn provides an opportunity for greater instability, which in turn provides an opportunity for greater reordering. The resulting phenomenon - termed "order through fluctuations" - is a distinctly evolutionary one, complete with feedback loops that drive the system further from equilibrium. And as the energy consumption and resulting complexity accelerate, so does the evolutionary process" (20).

In case of the (State-)System, an identical process can be observed. In case of the (State-)System entropy and energy are the sources of order FFE: Entropy offers new opportunities and serves as a catalysator for the transformation of societal energies in kinetic potential (military capabilities), while through energy (the kinetic potential, military capabilities) work is accomplished. EMIS-flows generated by the 1st FTS maintain its organization - coherence - FFE.

As discussed in the preceding chapters, in 1480, through a bifurcation, the System generated a dynamic steady state - regulated by the 1st FTS and European State-System, by means of chaotic non-systemic KA/war (R1-dynamics) - and fluctuations were effectively stabilized and regulated by EMIS-flows, that also involved the environment of the State-System (societies and the non-core). The FTS could be sustained

because the (accelerating) entropy-production in the (State-)System exceeded the relaxation that was accomplished by R1- and R2-dynamics. Through the coherent macroscopic structures of the dissipative structure (the 1st FTS), energy could be dissipated more rapidly; while at the same time the FTS ensured that accelerating amounts of entropy and energy were produced.

Highly ordered structures that emerge FFE, like the 1st FTS in case of the System (1480-1945), can only be maintained "through a sufficient exchange of energy with their surroundings (*IP: societies and the non-core in case of the State-System during the period 1480-1945*); only this incoming-outgoing energy flow can support the requisite organization for an ordered system's existence. The work needed to sustain the system far from equilibrium is the source of the order" (20).

It was a matter of time, before the 1st FTS produced - through the network-effect - a 1st systemic KA/war (1618-1648). During the transient period (1480-1945), the (State-)System produced four cycles. Systemic KA (the R2-dynamics) was instrumental in decreasing - lowering - the energy-state of the (State-)System and in upgrading its order, to optimize EMIS-regulation. During the transient period, enabled by the 1st FTS, complexity (as defined by Chaisson), increased.

Chaisson also observes that: "Cyclic behavior is typical of a dissipative structure that organizes (or reorganizes) itself in a way as to minimize the production of entropy", this is a disequilibrium process, Chaisson explains, that "not coincidentally, mimics the metabolism of many living organisms whose cycles transport energy" (20).

This is also the case for the (State-)System this study shows: During the transient period 1480-1945, the (State-)System tried to minimize entropy-production through cyclic R2-dynamics. However, these efforts failed - as I explained - because the 1st FTS - of which the R2-dynamics are an integral component - at the same time facilitated the accelerated production of entropy in the System (through population growth).

Chaisson observes that "non-equilibrium thermodynamics stipulate that radically different states can succeed one another with sudden abruptness, and adaptation to wholly new complex states even as these boundary conditions slowly change. The result, rare and catastrophic, might be violent climate change or major alteration in surface cycling of matter and energy, a largely deterministic (if not predictable) in terms of unchanging scientific principles guiding gradients, flows, drifts and cycles" (20). In case of the System, the State-System made some sudden changes to (radically) different states (e.g. in 1480, from unorganized to organized; in 1618, 1792 and 1914 when secondary bifurcations were produced, and in 1945, when the core made a transition to an equilibrium state), but these 'sudden' changes are not only explainable, but also highly regular and predictable: The 1st FTS was instrumental in accomplishing a phase transition, that followed a standard blueprint.

"A common solution to the dynamical-system equations governing non-equilibrium states is that of a 'bifurcation'. The fork diagram (...) illustrates such a twofold solution (*IP: See figure 39.4*), showing how a stable steady state can spontaneously break its symmetry upon entering a non-linear mode beyond some energy threshold (*IP: reached in 1480, in case of the (State-)System*). The result is two new, possible, dynamical steady states, only one of which a given system actually selects, depending partly on the system's history and partly on environmental fluctuations at the time of bifurcation. In non-equilibrium thermodynamics, the new states can result in whole new spatial structures at each bifurcation, much as in equilibrium thermodynamics when changing temperatures cause phase changes in various states of matter" (20).

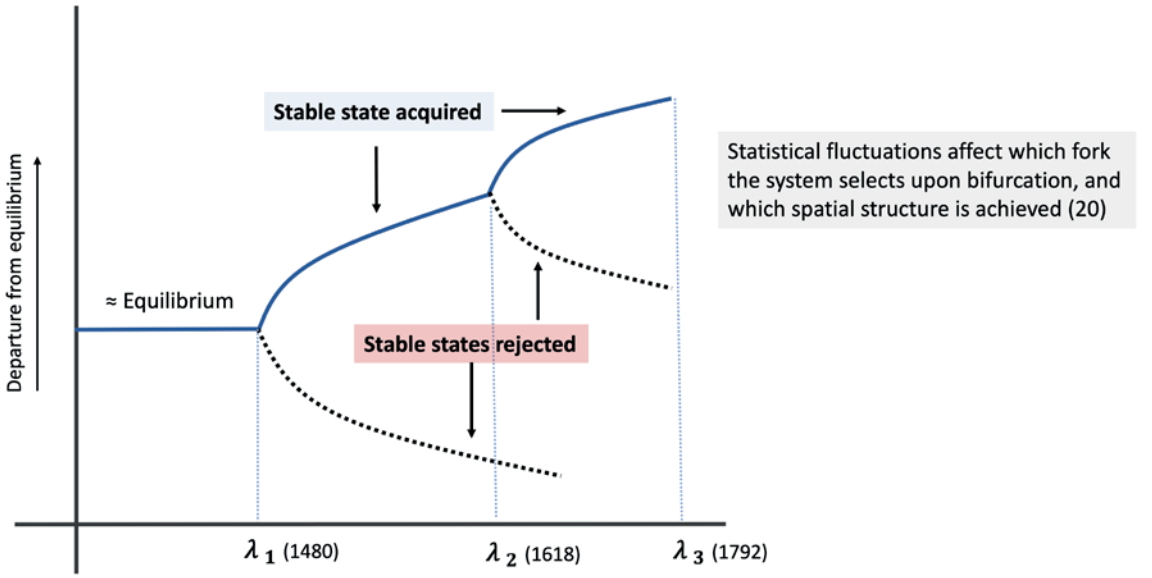


FIGURE 39.4: Bifurcation: Selection of a dynamic steady state (based on 20).

According to Chaisson: It is the (free) energy entering the system from the outside (*IP: The input/inflow of kinetic energy (military capabilities) from societies/states that constitute (together with the non-core) the environment of the State-System*) that helps create the conditions and engenders the changes (*IP: By putting the kinetic energy to work, through KA/war in the State-System*) needed to enhance the potential growth of complexity with time of the (State-)System.

"The interplay between random factors (at the bifurcation point) and deterministic factors (between bifurcations) - chance and necessity, again - not only guides the systems from their old states into new configurations, but also specifies which new configurations are realized. However, with statistical fluctuations triggering such events and the role of chance once more evident, the evolutionary trajectories are indeterminate, the new complex states unpredictable. Again, with evolution, we are not in the prediction business; cosmic evolution is an attempt to explain the rich ensemble of past events, whatever their convoluted, historical paths might have been" (20).

As I already explained, in case of the (State-)System, the process of evolution is somewhat different: There is a combination of (1) a process of growth and development of the State-System, to thermodynamic equilibrium - which also involves an interplay between probabilistic and deterministic factors (also in the deterministic domain) - and (2) a process of evolution (in the contingent domain): The first process imposes certain constraints on the second process and there is "increasingly constrained contingency", because of the drive to zero-entropy of the (State-)system through four reconfigurations, during the transient period (1480-1945). Whereas the state (configuration) of the State-System can be predicted, that is not the case for the System and societies.

39.6. Expansion and the creation of gradients

Chaisson distinguishes three (overlapping) phases in the evolution of the Universe: The age of radiation, matter and life, respectively. "Radiation surely dominated the first great era in cosmic history, and it is only from changes in radiation that matter has emerged" (20). "In this broad view, we are mainly concerned with the density of the energy contained in radiation so that it can be compared to the energy density of matter derived above" (20). As discussed in previous chapters, different densities imply the presence of gradients, forces and flows, and (potentially) contribute to complexification and social evolution.

During the Radiation Era: ".... the violent conditions of the primordial Universe guaranteed that the energy housed in radiation greatly exceeded that effectively contained in matter. (...) As soon as the elementary particles of matter tried to assemble into anything much more substantive, high-frequency radiation (...) destroyed them, thus precluding the existence of even the simplest structures we now call 'atoms' let alone any stars and galaxies" (20).

"For the first hundred centuries, radiation had reigned supreme over matter. (...) matter and radiation were intimately coupled to each other; thermalized and equilibrated. Particle symmetry reigned supreme. As the universal expansion paralleled the march of time, however, the energy housed in radiation decreased faster than the energy equivalently contained in matter (IP: and gradients consequently emerged). Matter and radiation thereafter began to decouple, their equilibrium unraveling and symmetry breaking, as an evolutionary event of first magnitude set in. (...) the charged elementary particles of matter clustered into more structured atoms. (...) matter, as it neutralized, finally gained some leverage in a Universe previously ruled by pure energy. "Once the Matter Era began, however, matter became atomic, the gas-energy equilibrium was destroyed, and a single temperature is no longer enough to specify the bulk evolution of the cosmos. Two temperatures are needed: one to describe radiation and another to describe matter" (20). "The establishment of a cosmic temperature gradient is the essential point (...) as the cosmos, on average departed gradually from its original equilibrium state" (20).

"(...) matter became the dominant constituent of the Universe" (20). The moment of uncoupling the "uniform, featureless state (IP: Dominated by radiation) was overthrown by one in which order and complexity were thereafter possible" (20) "(...) once the grand symmetry was broken, the thermal decline of matter exceeded, all the while its energy density decline lagged, the corresponding values of the radiation field - a curious result, yet one that enabled matter, in the main, to 'build things'" (20); the process produced gradients and flows, and the non-equilibrium state of the Universe allowed for construction. In the words of Chaisson: "The temperatures of matter and radiation went their separate ways once the quantities became fully decoupled at t » 100.000 years (...) a definite temperature gradient developed between radiation and matter in the expanding Universe, a clear manifestation of non-equilibrium conditions prevailing throughout" (20).

Chaisson shows that now - in the current (cosmic) epoch - the energy density of matter exceeds the energy-density of radiation, by several orders of magnitude, and that "matter is now in firm control (gravitationally) of cosmic changes, despite the Universe still being flooded today with radiation": Matter dominates radiation (20).

As mentioned, "The establishment of a cosmic temperature gradient is the essential point" (20), and "The result is a grand flow of energy between the two differentiated fields (*IP: radiation and matter*), and with it a concomitant availability of energy (for use in work) over and above the extant in the early, equilibrated Universe. Hence, the Matter Era has become increasingly unequilibrated over the course of time; the

expansion of the Universe guarantees it. Such non-equilibrium states are suitable, indeed apparently necessary, for the emergence of structure, form, or organization, of order! Thus, we reason that *cosmic expansion itself is the prime mover for the construction of a hierarchy of complex entities throughout the Universe*." (20).

A more or less similar evolutionary process occurred - and is still in progress - in the (State-)System; in which expansion also played an essential role in the creation of a state FFE, required for the emergence of the 1st FTS in 1480.

Until 1480, the (State)System was much more uniform - from a thermodynamic perspective - and symmetrical. However, in the period preceding the eventual bifurcation in 1480, increasingly more entropy and energy were produced, and the System became increasingly unstable. Gradients became steeper, and forces and flows became stronger; fluctuations became increasingly amplified. Eventually - through a bifurcation in 1480 - a dissipative structure emerged. These changes drove - and still drive - the energy-flows in the (State-)System and the processes of complexification and social evolution, that was initiated.

Expansion from the core - Europe - to the non-core (the rest of the world), played an important role in the dis-equilibration of the (State-)System, in the period before the bifurcation in 1480. Expansion served as an enabler, a 'kick-starter' for the 1st FTS: Expansion helped drive the System increasingly FFE and helped create the conditions for a bifurcation. The bifurcation then enabled the complexification of the (State-) System, during the transient period (1480-1945): Through expansion were gradients in the core and in the non-core - e.g. through rivalries between European states - (further) amplified, which contributed to the sustainment of EMIS-flows, necessary to maintain the 1st FTS.

Expansion means more entropy, more energy but also more and stronger gradients.

39.7. Decoupling of information

As Chaisson explained, during the process of cosmic evolution, matter gained increasing leverage over radiation and eventually emerged as the dominant constituent of the Universe: Matter and radiation uncoupled (20). According to Chaisson, we now live in the free energy phase, in which free energy dominates matter.

However, it can be argued as a follow-up to Chaisson's line of thought, that the human species - and their 'applications' (like social systems) - have gained increasing leverage over energy and matter through their ability to manipulate information: The domains of energy and matter on the one hand, and information on the other hand, are also decoupled. Humans are able to freely manipulate information - in what I name the abstract domain - and use abstract (information) concepts to utilize and shape energy and matter.

Not only matter and radiation became uncoupled at a certain point, as Chaisson explains, but arguably, also energy and matter, and information are (now) uncoupled, at least on Earth, in case of the human species, it seems.

The human species and social systems they create/form, are specialized in information processing/ control and in the ability to assess and utilize entropy, by manipulating energy(sources) and matter in the (State-)System.

The existence of an abstract domain (discussed in chapter 19), in which "decoupled" information can be freely manipulated and combined, can be attributed to the decoupling of information. In social systems differences in information density also drive and shape EMIS-flows[1]. Chaisson observes: (...) "the human being has learned to tinker not only with matter and energy but also with evolution" (20); humans can control not only their environments, but also genes, life itself (20).
Other biological species have not (yet) achieved information decoupling, and do not have an abstract domain they can (collectively) exploit: Humans and social systems differ in their information dominance; in their ability to utilize information to their own advantage.
Chaisson describes the change from the radiation to the matter age as a crucially important turning point in the cosmic evolution of the Universe; the moment information dominance was established (by the human species), can also be considered a crucially important turning point; at least in the evolution of/on planet Earth.
Given the ability of humans to process information and to utilize entropy and energy, information gradients - differences in available information (content), in information density, e.g. about the state/ configuration of a system - increasingly determine and dominate energy- and matter-flows in the (State-) System

39.8. Free energy rate density

According to Chaisson "it is the organized energy density that best characterizes the degree of order or complexity in any system, just as it was radiation energy density and matter energy density that were significant earlier in the Universe" (20).
Chaisson considers the free energy rate density a useful quantity to specify the order and organization of any system: The free energy rate density mimics the rise of complexity in systems (20); according to Chaisson: "The greater the perceived complexity of the system, the greater the flow of free energy density through that system, either to build it, or to maintain it, or both." (20). Accordingly, all systems can be compared on a fair and level spectrum. To biologists, this term is known as the metabolic rate (20).
The free energy rate density is expressed in units of energy per time per mass and denoted by the symbol $\boldsymbol{\Phi_m}$" (the units are erg $\boldsymbol{s^{-1}\, g^{-1}}$, $\boldsymbol{\Phi_m}$ is an energy rate (i.e. per unit time) density (i.e. per unit mass)) (20)
$\boldsymbol{\Phi_m}$ is considered by Chaisson a reasonable measure of the energy that is available to organize - create order in - a given amount of matter (20) Chaisson points to the relationship between the free energy rate density and its vital role in evolution: Evolution proceeds in such a direction, that the total energy flux through a system is optimized within the constraints that apply (20).
Chaisson quotes Lotka in reference to this observation: "(...) in the struggle for existence, the advantage must go to those organisms whose energy-capturing devices are most efficient in directing available energy into channels favorable to the preservation of the species. (...) In every instance considered, natural selection will so operate as to increase the total mass of the organic system, to increase the rate of circulation of matter through the system, and to increase the total energy flux through the system, so

1. Chaisson describes life as: "Life is an open, coherent, spacetime structure maintained far from thermodynamic equilibrium by a flow of energy through it (...) Life likely differs from the rest of clumped matter only in degree, not in kind." (20). Chaisson uses the term 'Life Era', and observes that when technologically intelligent life emerged, at least on Earth, whole new era (Life era) was heralded (20). In my study, I point to (possibility of) information uncoupling (from matter and energy) that took place, at that point.

long as there is presented an unutilized residue of matter and energy ..... and, so long as there remains an unutilized margin of available energy, sooner or later the battle, presumably, will be between two groups of species equally efficient, equally economical, but the one more apt than the other in tapping previously unutilized sources of available energy." (20).

The question is, if Chaisson's observations and assumptions also apply to the evolution of the State-System.

Analysis of war-data shows that when cycles are used as units of analysis, that during successive cycles: (1) the total energy flux in terms of BCD increased about linearly, but that the 2nd and 4th cycles caused a distortion (see figure 39.5), and (2) the energy flux of successive cycles per year increased exponentially (see figure 39.6).

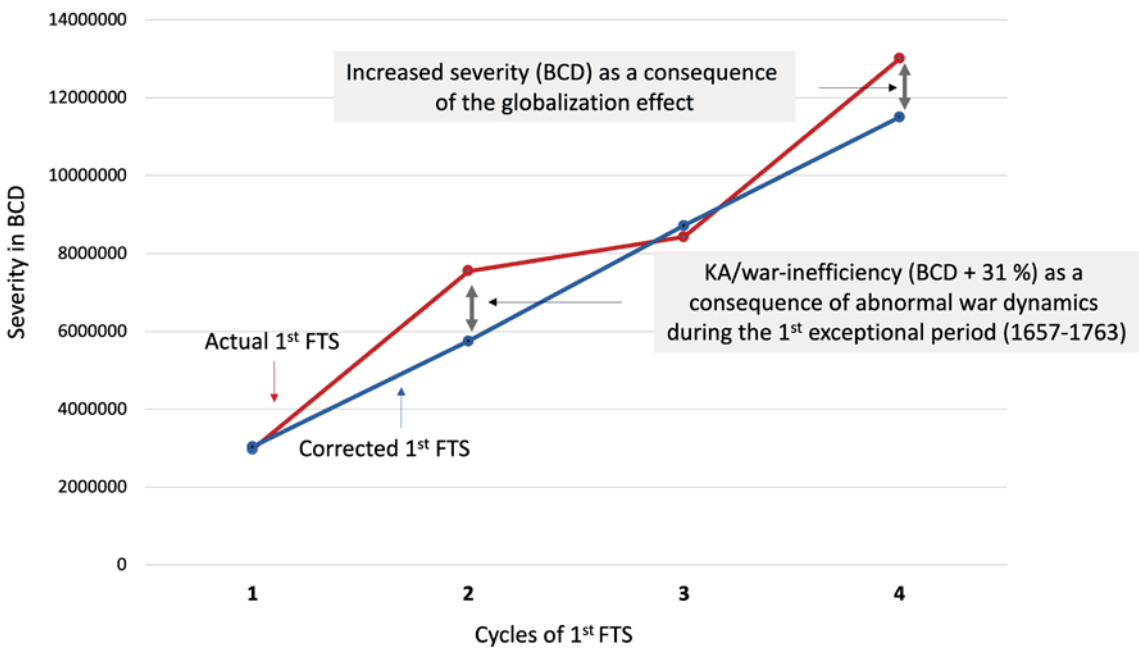


FIGURE 39.5: Total energy flux per cycle of the 1st FTS (1480-1945). (Actual 1st FTS: Red; corrected 1st FTS: Blue).

The free energy rate density (Φ_m), also includes the mass of the system. Point is, that the State-System is an organizational concept, and that it is problematic to assign a certain mass to it.

However, I have made some explorative calculations to determine Φ_m of the European State-System during critical periods, during the transient period (1480-1945. These explorative calculations are based on the following assumptions, I consider: (1) the severity of the systemic KA/war indicative for the energy-flux, (2) the duration of the systemic KA indicative for the duration of the process, and (3) the population size of the European State-System at the respective critical points (1618, 1792, 1914 and 1939) multiplied by a mass of 70 kg per individual, indicative for the mass of the European State-System. See table 39.1 and figure 39.7.

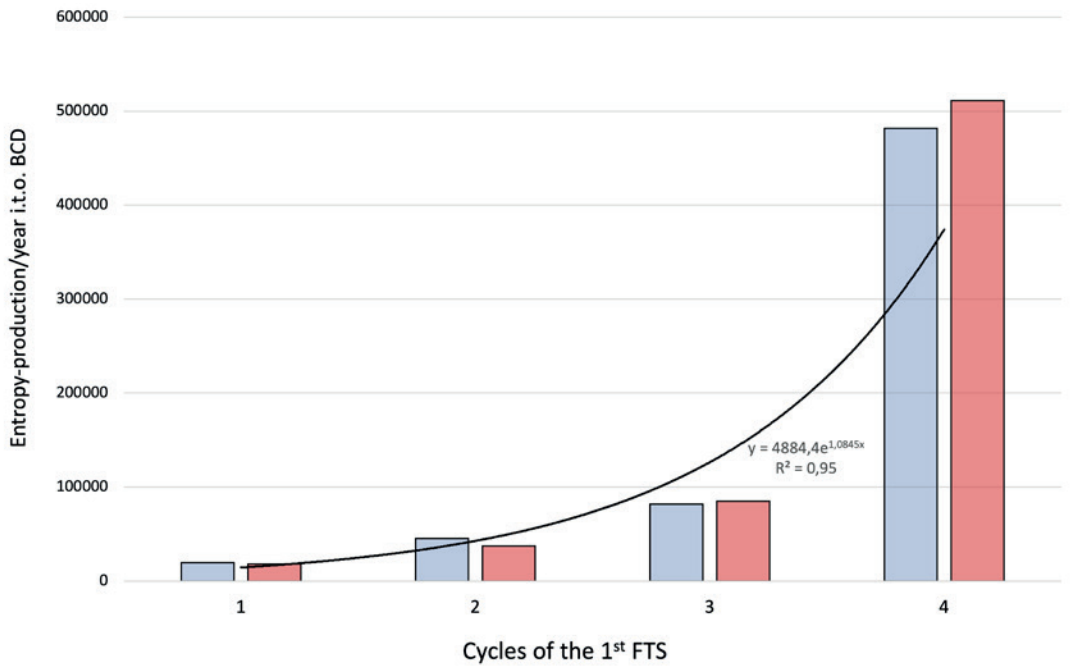


FIGURE 39.6: Exponential growth of the energy-flux per year, for successive cycles of the 1st FTS. (Actual 1st FTS: Red; corrected 1st FTS: Blue).

TABLE 39.1: Data used for explorative calculations of Φm of successive systemic KA, generated by the European State-System/1st FTS (1480-1945).

	Energy (BCD)		Duration		Mass (70 kg pp)		Φm (BCD as a measure for E)	
Sys.KA	Actual	Corr.	Act.	Corr.	Pop.size	Mass (kg)	Actual	Corr.
1	1.971.000	1.971.000	30	30	115×10^6	8.050×10^6	$8{,}16 \times 10^{-6}$	$8{,}16 \times 10^{-6}$
2	2.532.000	4.900.000	23	23	195×10^6	13.650×10^6	$8{,}06 \times 10^{-6}$	$1{,}56 \times 10^{-5}$
3	7.734.300	8.100.000	4	4	450×10^6	31.500×10^6	$6{,}14 \times 10^{-5}$	$6{,}43 \times 10^{-5}$
4	12.948.300	11.100.000	6	2.5	525×10^6	36.750×10^6	$5{,}87 \times 10^{-5}$	$1{,}21 \times 10^{-4}$

If the corrected version of the 1st FTS is taken as a reference, this analysis shows that the modified free energy rate density (Φ_m) of the European State-System, with BCD as a measure for energy (E), increased exponentially.

It seems that the evolutionary logic Chaisson referred to (i.e. Lotka), also applied to the European State-System: During the transient period (1480-1945), the System - through the State-System - achieved to increase its mass exponentially (I considered the total population of the core an adequate measure; populations can also be considered 'carriers' of energy), while the free energy density rate - the energy that was utilized - of the System also increased exponentially.

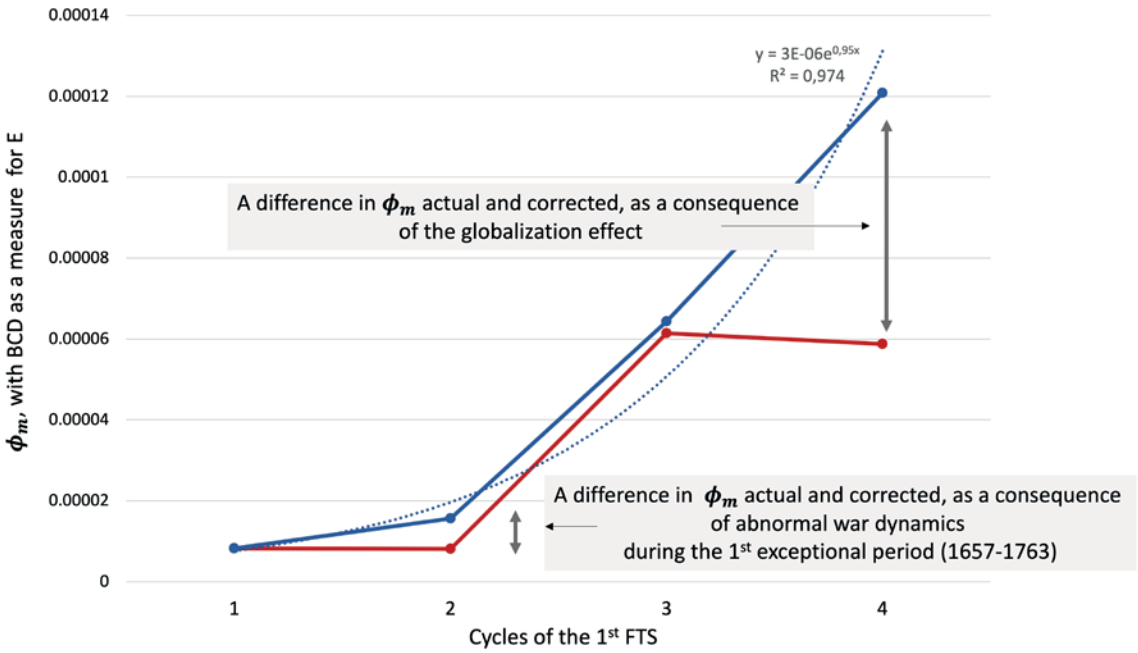


FIGURE 39.7: Explorative calculations of Φm of successive systemic KA, generated by the European State-System/1st FTS (1480-1945). This figure is a visualization of the data and results of calculations presented in above table. Especially there is a significant difference between Φm actual and corrected, which I attribute to the globalization effect: During the 4th systemic KA (the Second World War, 1939-1945) the European State-System made a transition to a global State-System.

According to Chaisson, the exponentially increase of the free energy rate density (Φ_m), is indicative for the exponential complexification - and ordering - of the system concerned: "Rising energy expenditure per capita has been the hallmark of cultural evolution (...)". Chaisson shows that the exponentially increase of the free energy rate density (Φ_m) is a property of a variety of inanimate and animate objects and systems in the Universe (20); it seems, that the (State-)System is no exception.

39.9. Cultural evolution and rising energy expenditure

Cultural evolution is equivalent with increasing complexification of/in the contingent domain of the (State-)System. According to Chaisson: By cultural evolution, we denote the changes in the ways, means, actions, and ideas of societies, including their transmission from one generation to another. "Human culture, in particular, is the sum total of human minds, often acting cooperatively over the ages. Foremost among the more utilitarian changes that helped make us cultured, technological beings were the construction and refinement of useful tools, the development and teaching of meaningful communication, the invention and practice of profitable agriculture, and not least the discovery and harnessing of controlled energy. All of these are essentially manufacturing advances that expend energy

to do work, decrease entropy at the locality of the cultural change, and more than compensate by increasing the entropy elsewhere in the world." ... "Cultural acquisitions spread much faster than genetic modification" (20). This definition is consistent with Damasio (25).

Chaisson observes: "... the increasing expenditure of energy has been an important factor in the emergence and development of humankind (...); cultural evolution occurs when societies alter their organizational posture in response to changes in the flow of energy through them, for it is increased organization that helps dynamically stabilize a far-from-equilibrium society" (20). According to Chaisson: "These increases in Φ_m values have been evolutionary, competitive processes in which selection has once again played a role (...)

.... people elected to concentrate their energy for greater efficiency", (...) and luxuries eventually became necessities (...). "Rising energy expenditure per capita has been the hallmark of cultural evolution (...)" and this fact "conforms to the widely observed principle of natural selection and the second law of thermodynamics (...)" (20).

Societies are voracious users of energy (20), and energy-flows were (and still) are regulated and sustained by the FTS. If the Φ_m cannot be maintained the pace of evolution and development in the contingent domain of the System - also necessary to sustain the population and ensure a certain well-being - (generated by the FTS) cannot be sustained.

According to Chaisson: "(...) all organized entities exist uneasily "on the edge" (...) it is "their dynamic steady-states that act as sources of innovativeness, creativity, and the very way that systems take advantage of chances to advance steadfastly along the scale of complexity" (20). The (State-)System needs disequilibrium and entropy- and energy-flows to maintain order, and to evolve and develop.

39.10. The relationship between expansion and the potential for order (information) in the Universe

Based on the relationships between order, disorder and (neg)entropy, it is possible to calculate the potential for order - the potential for information - of/in the Universe. The potential for order (information) is contained in (related to) the (increasing) difference between the temperature of radiation and matter, after decoupling, guaranteed by the expansion of the Universe (20). "After decoupling (...), the potential for the growth of information rose steadily as T_m and T_r diverged when the matter and radiation steadily departed from equilibrium (...) (20).

"The very expansion of the Universe, then, provides the environmental conditions needed to drive order from chaos; the process of cosmic evolution itself generates information. (...) We can nonetheless identify the essence of the development of natural macroscopic systems - ordered physical, biological, and cultural structures able to assimilate and maintain information by means of local reductions in entropy - in a Universe that was previously completely unstructured." (20).

However, because of the statistical nature of the processes involved, "the growth of order is not a foregone conclusion" (20), there is potential order - potential information - "realized only should Nature take advantage of the newly established conditions for the development of systems" (20).

"More decoupling" means that the Universe is driven further from equilibrium and results in steeper temperature gradients (between the temperature of radiation and matter), and a greater potential for

order and information in the Universe. In this respect, Chaisson points to the "seemingly paradoxical yet wholly significant result for the scenario of cosmic evolution: In an expanding Universe, both the disorder, S, and the order, I, can increase simultaneously; a fundamental duality, strange but true." (20).
Based on these insights and the energy that was consumed by the (State-)System, during the transient period (1480-1945) - which is equivalent with a certain degree of order - it must possible to 'calculate', (about) how much energy(-flux) is required to produce a certain degree of order at a global scale of the System, given a certain population size (apart from how that order, 'crystallizes in the contingent domain (e.g. what social and political solutions are selected) through the interplay between probabilistic and deterministic factors).

39.11. Evolutionary potential

In this paragraph, I (again) address the relationships between order, energy and entropy, from a (more) evolutionary perspective, and introduce the term 'evolutionary potential'.
Arguably, from a thermodynamic perspective, the evolutionary potential of a social system depends on four factors/conditions:

- The difference - the gap - between the actual entropy of/in the State-System ($S_{Actual\ State\text{-}System}$), lower than maximum, because of the order established in the core) and the maximum possible entropy of the System ($S_{Maximum\ System}$) that would have been achieved had equilibrium been restored (the FTS ensured from did not happen) continuously increased;
- The gradient richness of the social system;
- The availability and entropy-absorption capacity of a suitable environment to maintain the dissipative structure (discussed in chapter ..);
- The effectiveness and efficiency of the dissipative structure to regulate EMIS-flows.

During the transient period (1480-1945), the gap ($S_{Maximum\ System} - S_{Actual\ State\text{-}System}$), increased, and the free energy (potential) in the State-System could build up; a buildup that was also supported by barriers in the (State-)System, and could (and was) put to use (at a later stage), for the (further) evolution and development of the (State-)System. Free energy "is not energy as such, rather newly rearranged energy thereafter available for use in the course of evolution" (20).
The state of nonequilibrium - caused by the gap - produced a gradient-rich environment that provided a fertile ground for social evolution and development (in the contingent domain), and at a certain point - 1939 - the European State-System generated strong enough free energy flows (KA) to destroy the European State-System, and to enable the establishment of a State-System at a global scale.
In case of the System FFE - as I mentioned before - entropy- and free energy are - so to speak - equivalent: Entropy in fact serves as a catalysator in the process of (societal) energy-rearrangements. Free energy (military capabilities) of states (and its availability in the State-System), is extracted from entropy - tensions - in the System and in societies; free energy is rearranged entropy - military capabilities are rearranged societal entropy and energies - that is used to neutralize a (particular)gradient in the (State-) System, in accordance with the Second Law.
The potential for order is contained in the 'distance' from equilibrium ($S_{Maximum\ System} - S_{Actual\ State\text{-}System}$) and the further from equilibrium, the stronger the gradient, the stronger the flows and forces, and the

greater the free energy-potential, and potential for order. The ability of a social system (ordered structure) to regulate EMIS-flows - to 'handle' free energy and to select opportunities (contained in entropy) - determines the ability of the social system (ordered structure) to sustain its order, achieve a certain well-being and ensure survival; the ability to regulate EMIS-flows determines a social system's evolutionary potential. However, as I explained in chapter ..., to create and maintain order, a suitable environment (to exchange entropy to) must be available, and the availability of a suitable environment also determines the evolutionary potential of a (social) system.

The increasing drive FFE of the State-System, during the transient period (1480-1945), provided the System with increasing potential to create order, and explains the acceleration of a series of - related - developments (order creation, complexification) in the physical, contingent and abstract domains of the System, including: Expansion from the core (Europe, the State-System) to the non-core, the introduction of social and political innovations (political and military ideologies and doctrines), the scientific revolution and Enlightenment, and technological innovations. See figure 39.8.

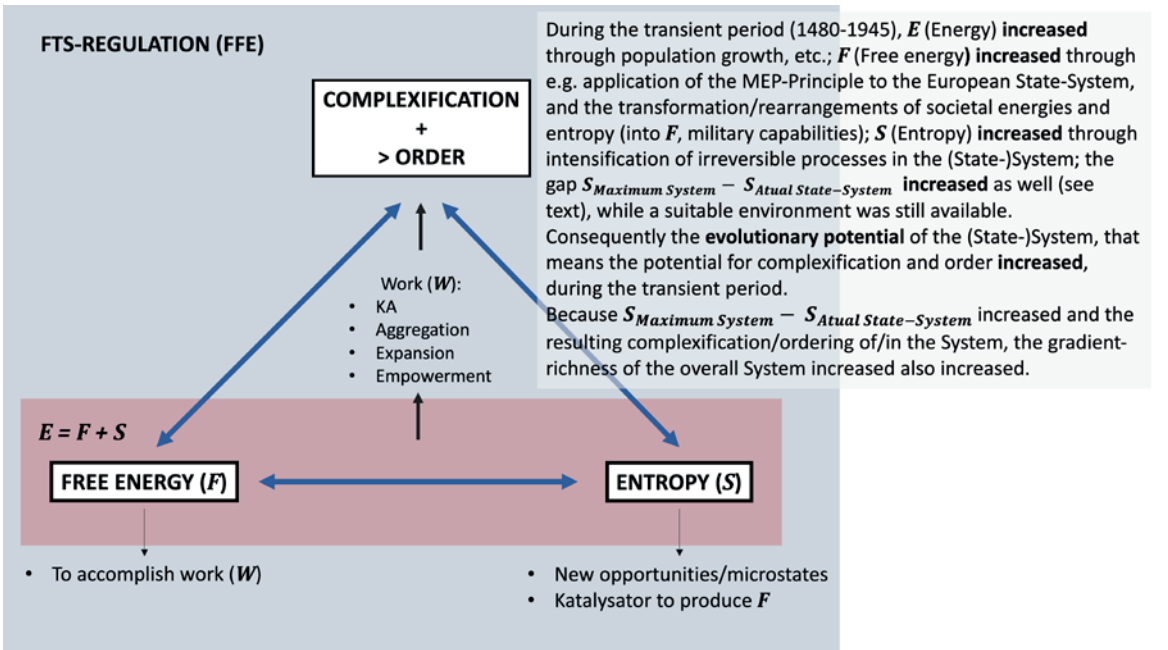


FIGURE 39.8: The relationships between free energy, entropy and complexification/order. The gap $S_{Maximum\ Systeme} - S_{Actual\ State-System}$ and the gradient-richness contribute to the evolutionary potential of the (social) system: Gradient-rich conditions and energy flowing through open, nonequilibrium systems are conducive to the growth of complexity (20).

39.12. Application (1): Enhanced robustness and enhanced fragility

Chaisson explains: "With complexity comes variety and biodiversity, thereby enhancing opportunities for organisms to increase their chances for survival and reproduction. Yet with complexity comes specialization and vulnerability as well, for each part of a complex system has a particular job it must do, implying that viability, or fitness, might inversely correlate with complexity. (...) complexity and its inevitable specialization might well carry disadvantages" (20).

"The notion that complex systems are more prone to extinction does not, however, preclude an evolutionary drive toward complexity, recognizing that, although many will be engaged, few will be selected to travel new routes toward robust energy rate densities; genetic mutations (that's chance) occasionally produce organisms a bit more efficient than other members of a species in utilizing available energy (that's determinism), thus making those organisms better able to survive" (20).

40. Social development and evolution: concepts and ideas

40.1. Introduction

In the previous chapter, 'universal change' (also referred to as 'cosmic evolution'), a framework proposed by Chaisson (20), was discussed; foremost a thermodynamic perspective on change and evolution.
Analysis shows that in case of the State-System – as is the case for a variety of other structures in the Universe – an (exponential) increase in the energy density rate can be observed during the period 1480-1945. According to Chaisson's ideas, this increase points to the increasing complexification of the (State-) System.
In chapter 39, several principles and mechanisms that underpin the process of 'universal change' were discussed.
In this chapter, I elaborate on chapter 39, and explore how the terms evolution and development are applied in biology, especially in evolutionary and developmental biology, and ecology: The biological sciences are much more advanced than the social sciences and can serve as valuable references. *Evolutionary biology* is the subfield of biology that studies evolutionary processes; *developmental biology* is the study of the process by which animals and plants grow and develop, and is concerned with e.g. the questions of differentiation, the organization in functional structures and growth and reproduction (35); *ecology* is the scientific study of the interactions that determine the distribution and abundance of organisms (interactions among organisms and their environment) (45). See figure 40.1.
Although evolutionary and developmental biology and ecology do not provide concepts that can be adopted without any 'modification'; their (scientific) approach to change - evolution, development and growth - is helpful in identifying key-features of social evolution and development.

40.2. Evolution

The term "evolution is often used to describe the process by which ideas, designs or plans, and animate and inanimate objects change over time into different forms. Things that emerge, unwind, develop, spread out, or appear in succession or series are all said to evolve". Applied to biology, evolution describes genetic changes that occur in organisms over time. It is distinct from maturational changes that occur during development or in organisms that have metamorphosis". "In some contexts - most conspicuously when discussing "human evolution" - the term often acquires an implicit sense of progress such that

later forms are assumed to be more complex and sophisticated than their primitive ancestors. In other contexts, "evolution" connotates a sense of adaption, such that evolved forms are better suited to coping with the demands of their environment" (57).

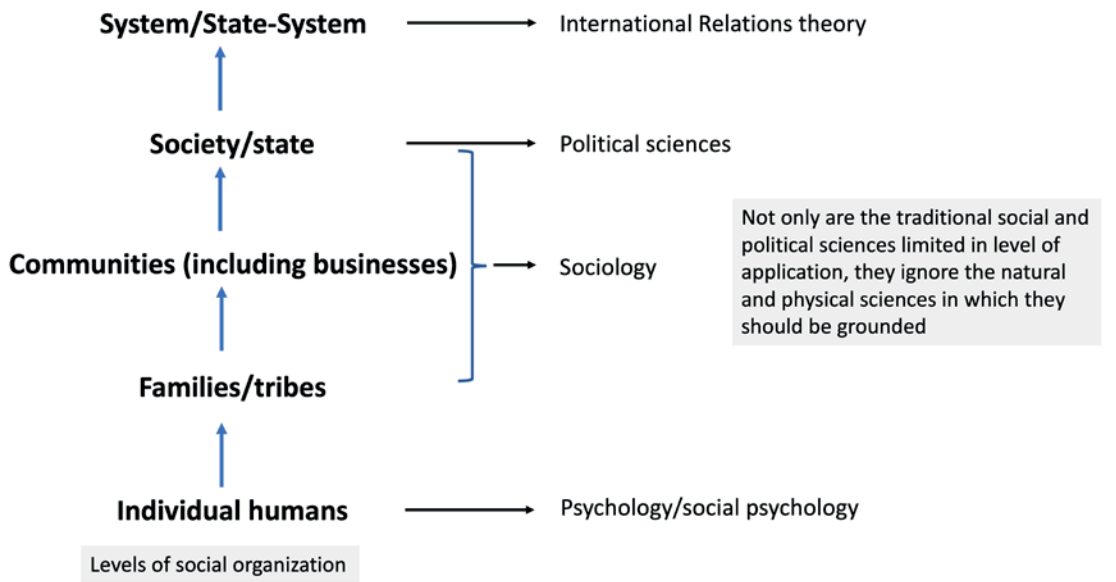


FIGURE 40.1: The limited scope of social and political sciences. The social and political 'sciences' lack the scientific foundation of the biological sciences, and mostly have a very specific scope: International Relations theory "attempts to provide a conceptual framework upon which international relations can be analyzed" (96); Global studies are described as "the interdisciplinary study of political, economic, legal, ecological and cultural interconnectedness. Predominant subjects are politics, economics and law on an international level" (96); Political science "is a social science which deals with systems of governance, and the analysis of political activities, political thoughts, and political behavior. It deals extensively with the theory and practice of politics which is commonly thought of as determining of the distribution of power and resources" (96) and sociology "is the scientific study of society, patterns of social relationships, social interaction and culture" (96).

In evolutionary biology, the term evolution - and related terms as adaptation - have a very precise meaning. In evolutionary biology, evolution is defined as "change in the heritable characteristics of biological populations over successive generations. These changes are driven by evolutionary processes such as natural selection and genetic drift acting on variations produced by mutations, genetic recombination and gene flow, resulting in biodiversity at every level of biological organization, including the levels of species, individual organisms, and molecules" (96). Evolution concerns change in the heritable characteristics of biological populations and is driven by evolutionary processes that act on variations. Although evolution is a largely random process, much of evolution can be understood as optimization, whereby the optimum - the ideal organism - is defined relative to constraints on what is possible (11).

To be able to speak of evolution and selection as defined in evolutionary biology, there has to be reproduction. Kauffman makes in this respect a distinction between evolving complex systems and

coevolving complex systems; social systems are complex systems: "We can make a rough distinction between evolving complex systems and coevolving complex systems. In the former, the components of the system do not replicate, and hence selection cannot act directly on them. Instead, selection acts only on the system as a whole. In the latter, the components of the system replicate, and so selection may act on the level of the parts of the system as well as on the system as a whole" (42).
Key features of the current understanding of genetics and evolution include (11):

- Deoxyribonucleic acid (DNA) is a molecule that carries the genetic instructions used in the growth, development, functioning and reproduction of all known living organisms and many viruses. DNA interacts with the cell and the environment to determine the phenotype, the composite of an organism's observable characteristics or traits. The DNA is involved in the determination of the timing of gene expressions within the cell, the response to the outside world, and the development of morphology and behavior (11*).*
- Populations evolve: A species is not a single homogeneous unit: It is population of diverse individuals. A species evolves as the proportions of different kinds of individuals within it change, rather than in abrupt, discontinuous transitions (11). A definition of social evolution must specify what change - of what subjects - it is concerned with: Concepts used in evolutionary biology could possibly be applied to 'populations' of societies and states, but not to the development of the (State-)System. Populations of (State-)Systems do not exist.
- Evolution does not progress toward a goal. Populations evolve in response to change variations and to their changing environment. This leads to erratic change and to diversification, rather than progress toward any particular and point (11). Contrary to populations (in evolutionary biology), the State-System evolves to a very clear goal: Thermodynamic equilibrium.
- Although many processes shape evolution, all adaptation is caused by natural selection; it alone creates complex, functioning organisms (11). "All other processes tend to degrade what has been built up by natural selection, simply because these processes act at random with respect to function" (11). Thus, natural selection is a key mechanism of evolution and is the most important evolutionary process; the differential survival and reproduction of individuals due to differences in phenotype. Although there are many causes of evolutionary change, only natural selection can lead to adaptation - that is, to the complex and finely tuned structures that allow organisms to survive and reproduce in diverse environments. Organisms are not designed for their present way of life; rather, their ancestors accumulated variations that were favorable for reproduction (11). In case of the System, other mechanisms - other than natural selection - also lead to changes in characteristics of states and societies, like thermodynamic potentials that determine and shape social interactions.

These key features of biological evolution raise the question if it is possible to identify key features of social evolution. I discuss this subject later in this chapter.

40.3. Information and evolution

Avery argues that "The prehistoric genetic evolution of modern humans, as well as their more cultural evolution can be understood in terms of a single theme: information. The explosively rapid development of our species can be thought of as a continually acceleration of information" (6). The change from

molecular information transfer to cultural information transfer marked a dramatic shift to a higher mode of evolution: "Human cultural evolution began only an instant ago on the time scale of genetic evolution. Already it has completely changed the planet" (6).

The distinction between thermodynamic and cybernetic information is also relevant from an evolutionary perspective: "the evolutionary process consists in making many copies of a molecule or a larger system, and these undergo random mutations. After further copying, natural selection preserves those mutations that are favorable. It is the thermodynamic information that drives the copying process, while the selected favorable mutations (*IP: e.g. values in social systems*) may be said to contain cybernetic information" (6). The capacity of the human species and of social systems to exploit - process - cybernetic information allow them to recombine and store information, to communicate, to create knowledge, and to manipulate and (re)shape their environment: Humans and social systems are able to purposively exploit the interface between the physical and abstract domains.

"New methods for the conservation and utilization of information were the driving forces behind the explosively accelerating evolution of human culture" (6), and human and societal preferences can work as selection mechanisms.

The increase in population size is (also) related to information storage capacity: With "the increase in population size, the storage capacity of information increased exponentially, as well as interaction between (divers) information carriers" (6).

"The rapid accumulation of scientific knowledge made possible by paper and printing was quickly converted into the practical inventions of the industrial revolution. In the space of a few centuries, the information explosion changed Europe from a backward region into a society of an entirely new type, driven by scientific and technological innovation and by the diffusion and accumulation of knowledge" (6).

As I explained, there is (also) a connection between free energy and information, which has an important role in creating order in the (State-)System; Information-containing free energy is needed to produce the order which is characteristic of social systems: From an evolutionary perspective, the FTS can also be thought of as a process in which cybernetic information is converted into social order. During the process of social evolution, information is preserved, transmitted, and shared between increasingly complex communities and societies, the whole process being driven by an input of energy, and regulated (in case of the System) by the FTS.

KA/War can also be considered an exchange of information, as a form of communication: The kinetic energy that is put to use by a society/state is intended to maintain or make changes to the existing order and therefore must carry (cybernetic) information. Whether the communication is effective depends on various factors and conditions.

40.4. Entropy and evolution

Energy, matter, information and entropy are closely related, as I already explained.

In the previous paragraph, I have discussed the relationship between information and evolution. Besides energy and information – the ability to accomplish work, and the availability of information to act upon – entropy is required for evolution and development: Entropy is a source of order. Entropy is equivalent with (new) possibilities, microstates and variety. Possibilities - entropy - need to be explored and

opportunities must be selected; this process requires energy and information. Georgescu-Roegen (34) speaks in this context of 'sorting', according to Georgescu-Roegen, all living systems must sort entropy for the purpose of preserving their lives. Humanity dramatically improved its sorting capacity - its capacity to exploit entropy - through what Damasio names the human species' cultural mind. According to Georgescu-Roegen, "evolution can be described as a progress of the entropic efficiency of life-bearing structures" (34).

40.5. Natural selection

"Natural selection is a mechanism that causes evolution. It occurs when some kinds of organisms in a population leave more offspring than other kinds of organisms; the result is that the kinds of organisms who leave more offspring will increase in frequency over time". "Natural selection will operate on anything that has the following three properties: Reproduction, inheritance and variation". Variation is undirected. "The population must show variation with respect to an attribute that influences reproductive success, or to be exact, what biologists call fitness" (57). Evolution is directed by natural selection.

"Natural selection explains two of the biggest facts about life: adaptation and evolution". "In relation to human thought as a whole, natural selection is probably more important as an explanation of adaptation. Adaptation refers to the way living creatures are adjusted (or designed) for life in their environments" (57). "Natural selection also produces evolution: when the environment changes, natural selection will favor a change in the organisms, too" (57).

Natural selection is the only known explanation for adaptation: All adaptation in case of evolution (as defined in evolutionary biology) is caused by natural selection: "Although there are many causes of evolutionary change, only natural selection can lead to adaptation" (11); "Only natural selection has a systematic tendency to build up the elaborate functions that are needed to maintain reproductive success" (11), that is to ensure fitness.

"Natural selection acts on phenotypes, the observable attributes of individuals". "Different genotypes give rise to different phenotypes, but not in a simple way": development is (also) affected by environmental factors (45). "Consequently, it is simpler to observe the effect of natural selection directly on the phenotype and to ignore the underlying genotype".

Three types of selection can operate on phenotypic characters: (1) In case of directional selection an extreme phenotype is favored, in case of (2) stabilizing selection, "phenotypes near the mean of the population are fitter than those at either extreme, and does the population mean value does not change" and in case of (3) disruptive selection, "the extremes are favored over the mean" (45). "Directional selection probably accounts for most of the phenotypic changes that occur during evolution" (45).

The net-result of selection is that organisms are adapted to their environment, and the diversity of biological forms can be considered a manifestation of adaptation by natural selection.

During the transient period (1480-1945), properties of state-structures were selected that enabled states to develop, produce and put maximum amounts of kinetic energy (military capabilities) to use, to ensure a certain societal well-being and survival in an increasingly competitive environment. This is an example of directional selection; directional selection accounted for most of the changes in characteristics of state-structures in the State-System.

During the transient period, state-structures converged on an increasingly identical 'phenotype' (despite differences in genotype (e.g. values, norms)): the state as we now know it: Centralized governance, a monopoly on the use of violence, control over a well-defined territory, etc.). This convergence - end-directed evolution - is related to the 'fitness' of societies, and a process of optimization under constraint.

40.6. Social force, affinity and social potential

(Also) from a thermodynamic perspective, it is important to identify the driving force that is responsible for social evolution and development: Social evolution and development also cause changes in the physical domain of the (State-)System and its components.
A similar question was also addressed in relation to chemical reactions, as Kondepudi et al. explain: "At a certain point, in thermodynamics the question had to be addressed what 'driving force' is responsible for chemical change, given that motion is explained by the Newtonian concept of force: "Why do chemical reactions occur at all and why do they stop at a certain point? Chemists called the 'force' that caused chemical reactions 'affinity'. This idea had to be further developed, and chemical affinity was founded on the concept of chemical potential" (44).
"In thermodynamics, chemical potential of a species is a form of energy that can be absorbed or released during a chemical reaction or phase transition due to a change of the particle number of the given species. The chemical potential of a species in a mixture is defined as the rate of change of a free energy of a thermodynamic system with respect to the change in the number of atoms or molecules of the species that are added to the system" (96).
These concepts can also be applied to social interactions and social change. In this study, I introduced the notion of social affinity, which is indicative for a social force.
In case of social systems, the social potential of a social system - e.g. a society/state - can be defined as the energy the social system can put to use during interactions with other social systems, due to the transformation of entropy into energy. The social potential of a social system in the (State-)System can be defined as the rate of change of entropy into a free energy (e.g. kinetic energy/military capabilities). More specific: The social potential of a society/state in the State-System during the transient period (1480-1945), is the entropy - tensions - the society can transform into kinetic energy (military capabilities) and can put to use during kinetic-interactions with other societies/states.
Unequal social potentials of societies/states - which imply to the existence of gradients - generate EMIS-flows and impact on EMIS-regulation by the FTS: When there is a force, there is an (EMIS) flow, and vice versa. Thus, when there are differences in social potential, there exist gradients and there are always forces and flows at play, and there is potential for change. Because Great Powers (by definition) have great social potentials, they produce significant forces and flows, that impact on the whole (State-)System.
The FTS - in accord with the Second Law and related principles that apply - always tries to eradicate gradients, and to achieve thermodynamic equilibrium of the State-System, via the most efficient path. Low entropy structures - like societies/states - can temporarily and locally create 'barriers' and stop or redirect forces and flows. In case different social potentials are (eventually) equalized, the underlying gradients are neutralized. In case of thermodynamic equilibrium of the State-System, the social potentials generated by states have become uniform, or are no longer considered 'relevant'. The fact that all societies/states in the European Union are now considered equal (following the phase transition), can

be attributed to the institutionalization of the equalization (or 'deactivation') of social potentials between member states of the European Union. Through the process of aggregation (1480-1945), social potentials between state-structures were eradicated.
The social potential of societies/states determines what potential social force they can apply on other social systems - including the (State-)System - in efforts to affect change. However, other factors also play a significant role in the change - work - that can eventually be accomplished, these factors include the phase of development of the RSP, and the responses of the FTS and S/T-field.
The Gulf War (1990-1991) and the War in Afghanistan (2001-present), are examples of respectively the effective and ineffective application of a social potential (through force, kinetic energy) by the United States: In case of the Gulf War, the entropic perturbation was effectively corrected, while in case of the War of Afghanistan, this was not the case.

40.7. Social fitness and optimization under constraint

In this paragraph, I do some suggestions to define the term "social fitness".
From a biological perspective, fitness of an individual is defined as the number of offspring it leaves after one generation or after some chosen time interval (11). "Natural selection arises from the systematic accumulation of inherited variations in fitness. If some characteristic (...) leads to increased fitness, then that characteristic will increase. Because random variations in fitness tend to cancel out, the systematic effects of selection will dominate in large populations" (11).
The concept of fitness needs some modification if it is meaningfully applied to social systems (societies): Social fitness can be considered realized social potential; in which (also) the state is instrumental (the fitness of a society is not necessarily identical with the fitness of the state that is responsible for its regulation; if not sufficiently aligned, they can be subject to different selection forces).
Contrary to biological species, is offspring - in terms of population size/growth - not an adequate measure for (social) fitness of societies/states. As I discuss later, population growth is especially a trait of fragile societies/states, where - it seems - the population tries to ensure its basic well-being and survival through their offspring, because the state cannot provide the necessary (basic) facilities.
In case of (social) fitness, it is instructive, to make distinction between a thermodynamic and contingent (social) perspective on social fitness and evolution; both concepts are related, and in both cases, there is optimization under constraint. 'Optimization under constraint' refers to the requirement to make sensible trade-offs between various factors and conditions, that impact on the process of evolution and on fitness; whereby the optimum is defined relative to constraints on what is possible (11).
Krebs names four major forces that constrain adaptation in real populations: (1) Genetic forces prevent perfect adaptation (because of mutations and gene flow), (2) continuously changing environments, (3) adaptation always is a compromise, because of the limited availability of time and energy, resulting in trade-offs, and (4) the presence of historical constraints and chance in small increments (45).
Similar 'forces' also constrain adaptation in case of societies/states; in case of societies and states, (certain) changes in their environment (which includes the State-System), the availability of time and energy, and historical constraints are to a considerable degree shaped and regulated by the FTS, in other words by the laws of thermodynamics and related principles that apply.

In case of a thermodynamic perspective on social fitness, the optimization under constraint concerns EMIS-regulation; the accomplishment of thermodynamic equilibrium via the most efficient path, in accordance with the Second Law and related principles.
In case of a contingent perspective on social fitness, the optimization under constraint is concerned with (social) well-being and survival. Social fitness includes the ability of a social system to utilize entropy and manipulate its environment to serve its interests, including other societies/states, the (State-)System, but also the physical environment.
The extent in which a society (state) is able to determine the terms for aggregation (with other societies/states) and is able to determine the arrangements that underpin upgraded orders, including the privileges that contribute to the safeguarding of its interests and the well-being of its population, can be considered measures for social fitness.
The concept of social fitness needs further study. It is important to keep in mind that fitness is not an absolute 'measure'.

40.8. Self-organization and evolution

The phenomenon of self-organization - when physical processes build complex structures in space and/or time, through often simple underlying rules - is essential for life (11), and also for the (State-)System: The State-System - which emerged in 1480, through a bifurcation - is an example of self-organization.
"Self-organization can lead to complicated and well-ordered patterns" as is also the case for the (State-)System, I show in this study. The phenomenon of self-organization shows that complicated structures - including dissipative structures in the System - can be produced without the aid of natural (social) selection. The State-System was not selected by societies/states, but an emergent structure, determined and shaped by the Second Law, and the constraints the Second Law imposed.
The patterns that are produced (can) impact on the process of evolution, including on the evolution of state-structures in the System: These patterns constitute developmental constraints and can shape living organisms: "(...) natural selection exploits self-organization to produce well-adapted organisms" (11).
The selection processes of state-structures (what is the optimal structure of a society/state? What structure ensures maximal social fitness?), also involves the 'exploitation of self-organized structures like the State-System: The PBMP-mechanism - through which dominant states produce orders that favor their specific characteristics and interests - is an example of the exploitation of self-organization.

40.9. Development

Gilbert et al. explain that development is the route via which an organism goes from genotype to phenotype, and it can be studied at any level of organization, from molecules to ecosystems" (35). Phenotype is defined as "the part of the genetic makeup of a cell, and therefore of an organism or individual, which determines one of its characteristics (phenotype)" (...) "genotype is one of three factors that determine phenotype, along with inherited epigenetic factors and non-inherited environmental factors" (96). Epigenetic factors are factors that produce "heritable phenotype changes that do not involve alterations in the DNA sequence" (96). The processes of development include fertilization,

cleavage, (...). According to Gilbert et al. are the processes "among the greatest sources of questions in science, questions such as: How do the various cell types - blood cells, neurons, pancreas cells etc. - form, and how do they become different from one another? How do cells become organized into functional organs? How do the organs know their correct size? (...) (35).
This perspective and related questions are also relevant for the development of the (State-)System: In case of the (State-)System there is a relationship between for example values and norms that shape and drive behavior and the characteristics of social systems, e.g. its ability to produce kinetic energy and responses.
In 1480, the 1st FTS emerged in Europe driven by population growth, but population growth does not explain why the 1st FTS - and the State-System and state-structures - emerged in Europe. Other regions have experienced - and still experience - the same population growth, but identical structures did not emerge; population growth is not a sufficient condition.
The question is what factors determine the phenotype, the composite of a social system's observable characteristics and traits? Are also epigenetic and environmental factors
at play, and what is the role of for example thermodynamic potentials that determine and shape social dynamics?

40.10. Other key-concepts

In this paragraph, I discuss two other concepts related to evolutionary and developmental biology and to ecology that could be of use to our understanding of social dynamics and for the development of a useful conceptual framework:

- Gradual and evolution by punctuated equilibria. Evolution often occurs gradually but can also occur in rapid bursts over short periods of time, with relative stasis after these punctuational bursts (82). In case of gradual evolution, evolution does not "jump from stage to stage". Rather it gets ever more fully orchestrated into hierarchically ordered, but semi-autonomous functioning levels" (40). In case of punctuated equilibrium, evolution comes in 'bursts. "Punctuated equilibrium involves two key propositions: First, that species undergo long periods of little or no evolutionary change; second, that these lengthy interval of stasis (i.e. equilibrium) are broken (i.e. punctuated) by relatively rapid speciation events" (82). In case of the (State-)System societies and states seem to evolve rather gradually, while the Sate-System develops through rapid bursts - supported by systemic KA - when the order of the State-System is upgraded: Systemic KA/wars punctuate RSP's, stationary periods.
- Coevolution. "Coevolution occurs when a trait of species A has evolved in response to a trait of species B, which has in turn evolved in response to the trait in species A. Coevolution is specific and reciprocal" (45). Each party in coevolutionary relationships exerts selective pressures on the other, thereby affecting each other's evolution (96). Coevolution is not (necessarily) about reproduction. Coevolution can drive major evolutionary transitions, not only between species, but also in the System. State-structures and the State-System coevolved in the core (Europe), during the transient period (1480-1945). The constraint (the collective dimension), and the process of aggregation in the (State-)System were integral parts of - instrumental in - this coevolutionary process, as well as the mechanisms of PDLI and PBMP. The 1st FTS, of which the European State-System was the structural component, exerted increasing selective pressures on the process of state-formation in the System,

through the processes of (accelerating) KA, aggregation, expansion and empowerment. Increasing KA was required to regulate the increasing entropy-production and to maintain the coherence of the 1st FTS/European State-System, during the transient period (1480-1945).

- For the survival of societies and states - their social fitness - the ability/capacity to produce and put kinetic energy (military capabilities) to use increasingly became the most important 'trait' - property - of societies states. The ability of states to produce and put kinetic energy to use and the ability of the 1st FTS to generate KA, were (developing) traits of coevolving states and the State-System.
- Not surprisingly, state-structures - structures that evolved and were selected because of their ability to generate kinetic energy and engage in KA , during the transient period (1480-1945) - generated a 2nd (global) FTS, following the globalization of the System (1945), and the adoption of state-structures as the only legitimate representative structures of societies in the 1st global order (the United Nations, 1945-....).

40.11. End-directed evolution

Biological evolution does not progress toward a goal; evolution is not end-directed. However, in case of the (State-)System this is not the case: While societies and the System evolve(d) more gradually and not to a specific goal (end-state), the State-System and states on the other hand, coevolved toward a state of thermodynamic equilibrium; the 1st FTS ensured that thermodynamic equilibrium of the core (Europe) was accomplished (involving a phase transition), via the most efficient path. From the perspective of evolutionary and developmental biology, the process - the transition of the State-System during the transient period (1480-1945) - can be (better) considered a process of development and growth. This process of development/growth of the State-System - which actively involve states - constitutes an evolutionary framework for societies.

From a thermodynamic point of view, the emergence of dissipative structures may be interpreted as end-directed evolution by which is meant "that the system may take several different paths but reach the same final state" (b2). "End-directed evolution is a familiar concept in thermodynamics; after all, according to the Second Law, systems evolve to states of maximum entropy or minimum Gibbs or Helmholtz energy. We might not know the mechanism or the path a system will take to its final extremum state, but we can be sure that it will reach that state. In this case, the final state is an equilibrium state in which there is no entropy production. It is possible that end-directed evolution may also be a property of far-from-equilibrium systems" (44).

This study shows that the development of the State-System indeed is end-directed: The State-System (the former core, Europe) reached thermodynamic equilibrium in 1945 (albeit the actual implementation was delayed until 1989, as explained). And the moment that thermodynamic equilibrium was reached in the (former) core (Europe), the State-System scaled-up to a global level. This process of development and growth has been discussed in the previous chapters. The 1st FTS (1480-1945) - the dissipative structure the System produced through a bifurcation in 1480 - was instrumental in this process.

Kondepudi et al. explain that "end-directed evolution has two aspects: the state to which it will evolve and the stability of that state".

Regarding the first mentioned aspect (evolution towards maximum entropy-production), it has been hypothesized that a nonequilibrium system will evolve to a state in which the rate of entropy production

is maximized. According to this hypothesis, the great diversity of behavior we see in organisms and the evolution of life is a result of nature evolving to states of an ever-increasing rate of entropy production" (44). Kondepudi et al. explain that "the maximum entropy production hypothesis is a subject of much debate: while many studies have indicated its validity, there are others that have indicated otherwise. Indeed, close to equilibrium, in the linear regime, we have seen that the rate of entropy production in minimized, not maximized. Yet, the hypothesis has been a useful tool to predict some far-from-equilibrium steady states. Perhaps there is a set of conditions that need to be fulfilled for its validity that has not yet been identified; perhaps there is a different principle, or more than one principle depending on the system being studied. Future studies will shed light on this line of thought" (44).

The (State-)System demonstrated the following behavior: During the transient period (1480-1945), entropy-production in the System was maximized - through population growth, the increasing interactions between societies and other related effects - while the entropy of the State-System (the regulatory system) was minimized (pushed to zero entropy through the MEP-Principle), at the same time. The process was instrumental in a phase transition, that resulted in the destruction of the European State-System and equilibrium in the core, and the simultaneous upscaling to a global State-System. In the former core, the entropy was now maximum, and entropy-production stopped.

The above-mentioned hypothesis that "the great diversity of behavior we see in organisms and the evolution of life is a result of nature evolving to states of an ever-increasing rate of entropy production" seems also to apply to the System".

Regarding the latter aspect (stability of the end-directed state), Kondepudi et al. observe: "This means that, when perturbed, the system will find a path to return to the end state. In other words, if the end state is perturbed due to a change in the environment, the system will find a means to restore the end state. The diversity of paths that the system is capable of taking to reach the end state may lead to interesting behavior, which resembles those we see in organisms. As an example, let us consider a spatial dissipative structure that is maintained by the inflow of energy/matter at one location. Let us further assume that the structure maximizes a thermodynamics quantity Y (such as the rate of entropy production) and its form depends on the location at which the energy/matter flows into the system. Now if the location of the energy/matter source is moved, the system is no longer in a state that maximizes Y. In response to this perturbation, the system will evolve to a new state in which Y is maximized. This type of end-directed evolution resembles the response of an organism to a change in the location of the source of its 'food'. To be sure, an organism is much more complex; nevertheless, studies of dissipative structures will give us thermodynamic principles on which the behavior of organisms are founded" (44).

Regarding the stability of the end state of the former core (Europe), the following can be observed: The former core (Europe) is in thermodynamic equilibrium. Entropy is maximized, and entropy-production and free energy (-production) are at the same time minimized. EMIS-regulation is now accomplished through homeostasis. The fact that there is no free energy (military capabilities) available for internal European use, and KA - as a (contribution to the) regulatory process - is replaced by a multitude of non-kinetic regulatory mechanisms, is a manifestation of a change in the thermodynamic potentials that now govern the former core (Europe). The 'new' thermodynamic potentials are institutionalized, a process (the perfection of the institutions of the European Union) that is still in progress. In case the (intra) European equilibrium is disturbed, the non-kinetic coordinating mechanisms correct the disturbance and equilibrium is restored.

40.12. Social evolution

In the previous paragraphs, I have discussed biological evolution and related concepts like natural selection and adaptation, to better understand (the process of) change(s) that took - and still take - place in the (State-)System. The concept of biological evolution does however not apply to the (State-)System. The changes that took - and still take - place in the (State-)System are especially concerned with the adaptation of social systems - societies - to their changing environment(s).

Other societies, states, the State-System and the physical environment constitute the environment(s) of a society. States as we now know them - with their specific characteristics - have emerged as the regulatory subsystems of societies responsible for (EMIS-)regulation of societies, including of their environments.

The adaptations that societies and states are required to make, to ensure their survival and the well-being of their populations, are 'imposed' by the FTS, a dissipative structure that itself is an emergent 'product' of the interactions between (the populations of) societies and states, and the laws of thermodynamics and related principles that apply.

Societies and states actively contributed to the emergence of the 1st FTS which constitutes an organized environment that then requires societies and states to adapt continuously to; there is an interplay.

This process can be considered a process of growth and development and has a clear direction: To achieve thermodynamic equilibrium - homeostasis - of the State-System; that is the overarching "goal". The process is highly optimized; there is optimization under constraint, and development by constraint. The laws of thermodynamics and related principles are the (origins of the) constraints that apply to the (State-)System, states and societies.

Social evolution can be defined as change in properties (characteristics) of social systems - societies in particular - that in the context of this study especially concern/impact on (in particular) the relationships of societies (through state-structures) with their environments, of which the FTS is a (very) significant part.

The FTS generated several closely related and highly structured processes - like the processes of KA, aggregation, expansion and empowerment generated by the FTS - that were (and still) are integral to the processes of social evolution and adaptation. Increased KA "demanded" by the 1st FTS during the transient period (1480-1945), forced societies to continuously improve their ability to produce and put KA to use. Because of the increasing scale of this existential challenge, states exploited ideologies to control and mobilize societies. Although natural selection as defined in biology does not apply to the (State-)System, the emergence of the 1st FTS - including the four supporting processes - involves selection, and selection forces, in which the S-imperative (the Second Law and related principles) serves as arbiter.

The term fitness as defined in biology (as the number of offspring a population leaves after one generation or after some chosen time interval) does not apply to the (State-)System, as I explained.

Although there was/is reproduction and growth of the population of societies, the process of 'reproduction' and growth of the State-System - from a European to a global State-System - was a fundamentally different process; it resembled a process of cloning, and includes the upscaling of the self-destructed (former) core, as I explained.

It is important to note, that the requirements to achieve social fitness, continuously evolve: The ability of societies to fulfill their basic requirements and survive are increasingly dependent on their ability to adapt to changes, including to changes in the physical environment - e.g. the climate - a factor that was until now mostly ignored.

These impacts are very significant and concern directly and/or indirectly the fulfilment of all basic requirements of individual humans and social systems. The question is how the damage to the carrying capacity of societies and the System - which includes the climate - and the increasing entropy that is consequently generated can be regulated by the State-System and 2nd FTS.

40.13. Some key features of social evolution

Based on the development of the (State-)System so far, it seems that certain key features of social evolution/adaptations can be identified, these key features include:

- *Coevolution*: The function of state-structures is to regulate societies. State-structures must continuously adapt to the changing requirements imposed on them by the FTS, which itself is a product of the multitude of (inter)actions between societies and states and must itself also constantly optimize its operation. The State-System is the structural component of the FTS. The FTS and State-System constitute the environment of societies/states.
- *Thermodynamic requirements*: The FTS - itself also a product of the Second Law and related principles that apply - determines interactively with state-structures what adaptations had (and have) to be made.
- *End-directed evolution of the State-System and convergence*: Adaptation of states and of the State-System are "orchestrated" by the FTS, in accordance with the S-imperative, to accomplish thermodynamic equilibrium of the State-System, via the most efficient path. Because state-structures are subject to the "same" FTS and selection forces, the development of these structures converge(d) on their ability to develop, produce and deploy kinetic energy: The transient period can also be considered a standardization process that also contributed to the process of aggregation.
- *Two selection forces apply to state-structures*: Properties of state-structures were selected that ensure maximum support to - and alignment with - the 1st FTS and optimize societal regulation; state have to strike a balance.

40.14. Social evolution: A tentative framework

In below framework (see figure 40.2), a tentative framework concerning social evolution in/of the System and its main components is shown.
The State-System and states are responsible for the EMIS-regulation of respectively the System and societies. The FTS regulates the (State-)System and societies/states, in accordance with the laws of thermodynamics and related principles that apply. Thermodynamic principles that apply determine the behavior - dynamics - of the State-System, including the adaptations that are required to ensure optimal functioning. Societies are regulated by states; there is homeostatic control in case of (functioning) states. In case of the System, societies and state-structures, the evolution/adaptation is gradual, while in case of the State-System there is development through punctuated equilibria: RSP's - stationary periods with little or no adaptations to the State-System - were periodically punctuated by systemic KA, when in short periods of time fundamental adaptations to the organization of the State-System were made.

Contrary to the evolution/adaptation of the System and societies, are adaptations to the State-System and states end-directed: The State-System is driven to thermodynamic equilibrium via the most efficient path in accordance with the laws of thermodynamics and related principles that apply; while states are forced to maximize their kinetic capabilities to satisfy the FTS, and to ensure the societies they represent can survive.

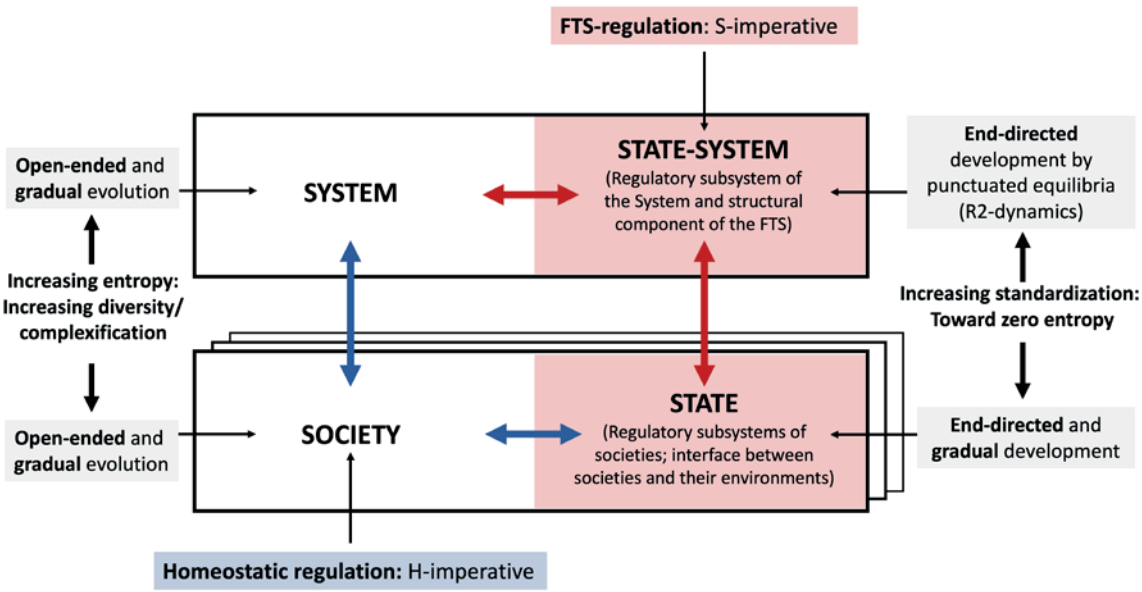


FIGURE 40.2: Relationships between components, regulation and evolution/development.

40.15. Application (1): Remarkable similarities in pattern formation

Although social evolution and selection have their own logic, the building blocks of social systems - the human species - are a product of ongoing biological evolution. Social evolution can be considered a process, that emanated/emanates - "shredded-out" -from the process of biological evolution.

Despite some differences, certain 'similarities' - consistency - between both evolutionary processes should not come as a surprise.

A closer look at pattern formation during the life-cycle of slime mold (amoeba, *Dictysostelium discoideum*) reveals some noteworthy similarities with pattern formation in the (State-)System, during the transient period (1480-1945): An amoeba is a type of cell or organism - which has the ability to alter its shape, in response to certain environmental stimuli, just like the (State-)System and societies.

Both living systems - the amoeba and the System - are relatively simple life forms, that seem to follow a more or less similar growth dynamic and survival 'strategy'. The explanation of the growth stages in this paragraph, is based on Kondepudi et al. (44).

Damasio (25) observes in respect to simple life forms: "Bacteria are very intelligent creatures; that is the only way of saying it, even if their intelligence is not being guided by a mind with feelings and intentions and a conscious point of view. They can sense the conditions of their environment and react in ways advantageous to the continuation of their lives. Those reactions include elaborate social behaviors. They can communicate among themselves—no words, it is true, but the molecules with which they signal speak volumes. The computations they perform permit them to assess their situation and, accordingly, afford to live independently or gather together if need be. There is no nervous system inside these single-celled organisms and no mind in the sense that we have. Yet they have varieties of perception, memory, communication, and social governance. The functional operations that support all this "intelligence without a brain or mind" rely on chemical and electrical networks of the sort nervous systems eventually came to possess, advance, and explore later in evolution. In other words, later, much later in evolution, neurons and neuron circuits have come to make good use of older inventions that relied on molecular reactions and on components of the cell's body known as the cytoskeleton—literally, the skeleton inside the cell—and the membrane."

The process of pattern formation (see figure 40.3) of the amoeba is as follows (44): In stage 1, the amoebas are at the unicellular stage. They move in the surrounding medium and they feed on such nutrients as bacteria and proliferate by cell division. Globally speaking they constitute a uniform system, inasmuch as their density is essentially constant. This stage is comparable to the developmental stage of the System before 1480.

If the amoebas are subjected to starvation, the individual cells do not die, but respond by aggregating toward a center of attraction (stage 2). Starvation is analog to a constraint that is applied to the system. Through the (process of) aggregation, the initial homogeneity is broken; space becomes structured. In case of the System, the structuring of space accelerated in 1480, through a dissipative structure that emerged through a bifurcation.

The resulting multicellular body, the plasmodium (stage 3), is capable of moving, presumably to seek more favorable conditions of temperature and moisture. The expansion of the System to the non-core can be considered as efforts of the core of the System (Europe) to find more favorable conditions to support its growth and development.

After this migration the body differentiates (stage 4) and gives rise to two kinds of cells, one of which constitutes the stalk and the other a fruiting body within which spores are formed. Eventually the spores are disseminated (stage 5) in the ambient medium, and if the conditions are favorable, they germinate to become amoebas and the life cycle begins again. In case of the System, stages (3), (4) and (5) took place during the transient period (1480-1945) and were shaped by the 1st FTS. As I explained, the independence of the United States can also be considered the result of the disseminations of spores (seeds) by the core (Europe) to the non-core of the System.

Pattern formation (stage 2) plays an important role in case of amoebas and in case of the System/ societies, when confronted with scarcity.

During the process of aggregation, amoebas periodically release signals through a chemical substance known as cyclic adenosine monophosphate (cAMP). Two types of dynamics are triggered by the release of cAMP: (1) the movement of amoebas to areas with a higher concentration and (2) a positive feedback

loop is switched on, causing an acceleration of the process of aggregation through increased signaling and interactions. The enhanced density of cells contributes to the (further) release of cAMP: More cells are attracted; more cAMP is released; it becomes an autocatalytic (self-reinforcing) process; a positive feedback loop dominates the dynamics of cells.

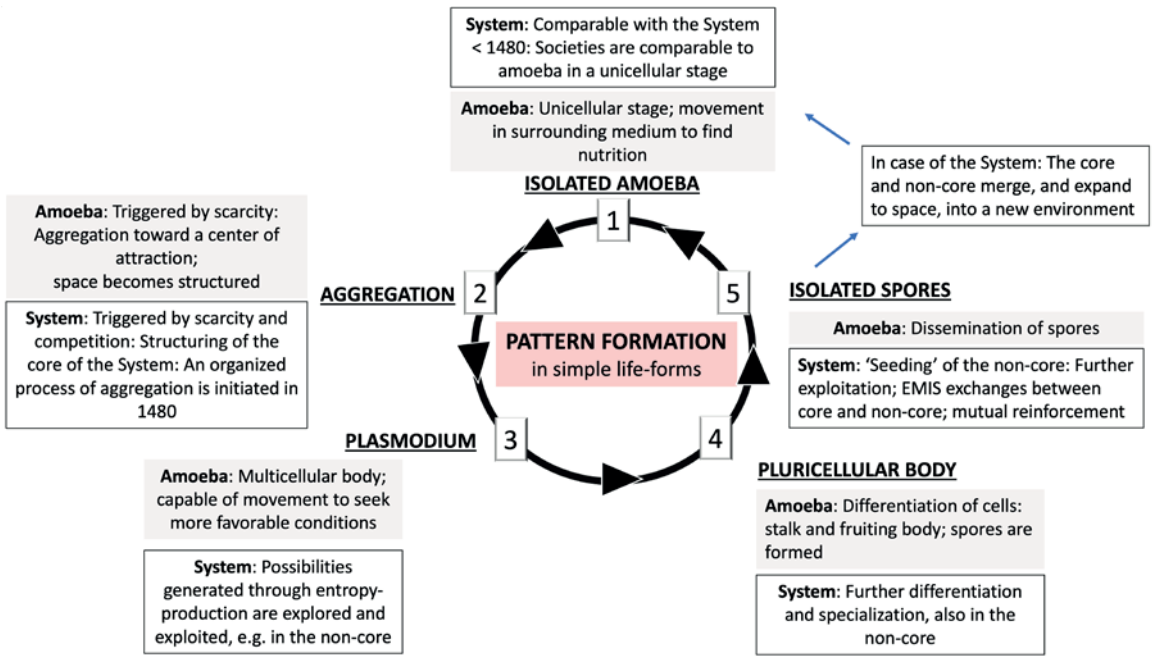


FIGURE 40.3: Pattern formation in simple life-forms. This figure shows some similarities between the (basic) growth dynamics of two simple life forms: Amoeba and the System/societies. When confronted with a constraint (scarce resources), both life forms aggregate, form an increasingly differentiated and 'capable' multicellular body (the State-System in case of human societies), exploit/utilize entropy, and expand by multiplication of their respective life forms and (further) exploitation of their respective environments (the non-core in case of the System); the cycle then repeats itself.

Identical dynamics and mechanisms can be observed in case of the (State-)System: Humans increasingly 'cluster' and their interactions and consequently EMIS-flows increase and intensify; aggregation contributes to the fulfillment of basic requirements and survival.

Referring to the developmental stages of amoebas, Kondepudi et al. explain: "Thus, the response to the starvation constraint gives rise to a new level of organization resulting from the concerted behavior of a large number of cells and enabling the organism to respond flexibly to a hostile environment" (44).

A similar mechanism is at play in the System, where (increasing) scarcity of resources (that constituted a constraint for the (State-)System, during the transient period (1480-1945)), gave rise to a next (global) level of organization that resulted from the concerted behavior of humans organized in societies and states, and enabled better (collective) responses to a hostile environment. See figures 40.4 and 40.5.

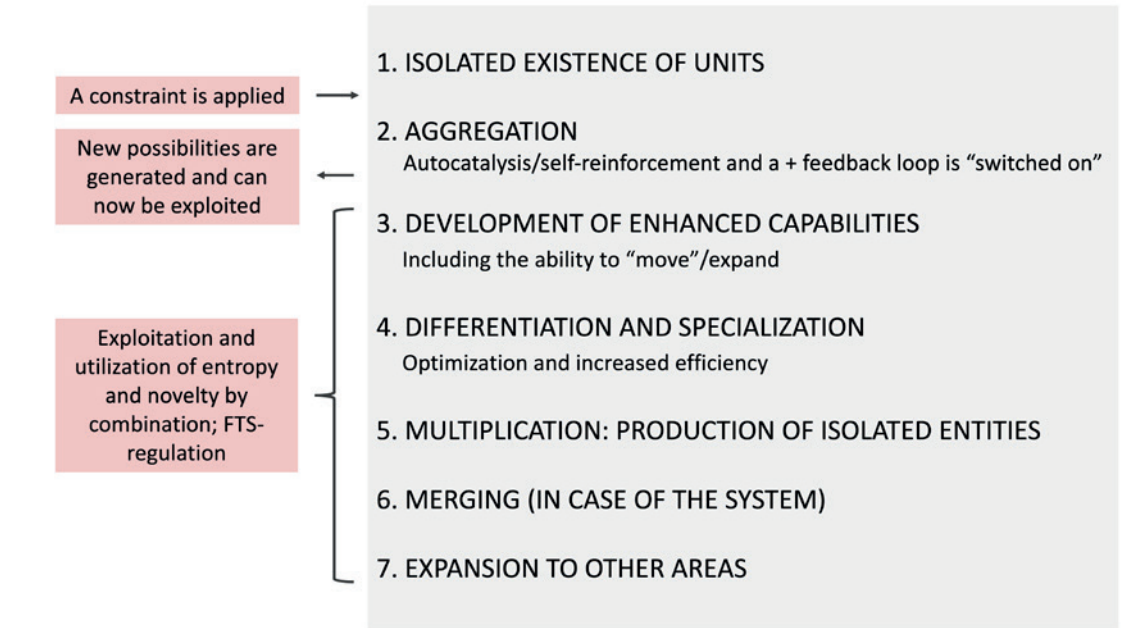


FIGURE 40.4: Basic growth dynamics of simple life forms. The basic stages in the growth dynamics of simple life forms are shown, amoebas and human communities/societies follow more or less identical stages.

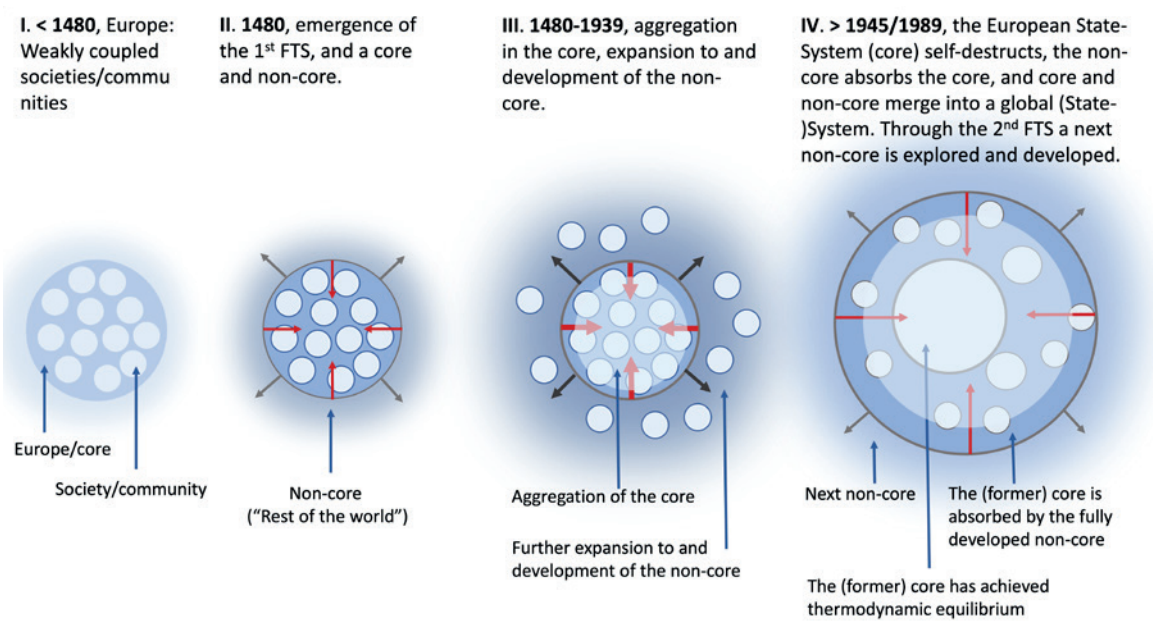


FIGURE 40.5: The phase transition (1480-1945) depicted as a process of biological growth and development. This figure depicts the phase transition as a process of biological growth; during the process, interactions/exchanges of the core (Europe) with its environment (the none-core) continuously intensified; the interactions contributed to the development of the non-core. In the final stage of the process, the core (self-)destructs and the (by then) sufficiently developed non-core absorbed the core. The (State-)System has grown/developed from a regional into a global "organism".

40.16. Application (2): The System depicted as a "superorganism"

Not only are there certain similarities between pattern formation during the life-cycle of amoeba and of the System, but also between the superorganismic organization of certain social insects and the System. Hölldobler and Wilson point to the existence of "major transitions of life, which proceeds from molecule through cell to organism, superorganism, and population, and finally to ecosystem" (38), and observe that "superorganisms - colonies of individuals tightly knit by altruistic cooperation, complex communication, and division of labor - find their highest expression in the insect world" (38). Social insects - like ants, bees, wasps, and termites - form superorganisms. These social insects live in colonies, which are "integrated tightly enough by its communication system and caste-based division of labor" and are called superorganisms by Hölldobler et al.: "The social organizations, however, vary greatly among the social insect species, and we can recognize different evolutionary grades of superorganismic organization. A "primitive" (less derived) grade is represented by several ponerine species (*IP: A subfamily of ants*), where members of the colony have full reproductive potential and there is considerable interindividual reproductive competition within each colony. Highly advanced grades are represented, for example, by the leafcutter ant genera Atta and *Acromyrmex* and the *Oecophylla* weaver ants, where the queen cast is the sole reproductive, and the hundreds of thousands of sterile workers occur as morphological sub-castes that are tightly integrated in division of labor systems. These societies exhibit the ultimate superorganism states, where interindividual conflict within the colony is minimal or nonexistent" (38).

The superorganism exists at a level of biological organization between the organisms that form its units and the ecosystems, such as a forest patch, of which it is a unit. This is why the social insects are important to the general study of biology.

"The superorganisms are the clearest window through which scientists can witness the emergence of one level of biological organization from another" (38) Social insects offer a "accessible connection between two levels of biological organization". These social insects form for example networks of cooperation and show, "how the division of labor can be crafted with flexible behavior programs to achieve an optimal efficiency of a working group".

Hölldobler et al. view the insect colony as the equivalent of an organism. I argue, that the System - not only societies - can (also) be viewed as the equivalent of a superorganism, which exhibits all the "key superorganism traits, such as castes, division of labor, and sophisticated communication" (38).

According to Hölldobler et al. several levels of construction can be distinguished in the construction of superorganisms: The first level of construction is sociogenesis, "the growth of the colony by the creation of specialized castes that act together as a functional whole". "Castes are created by algorithms of development, the sequential decisions rules that guide the body growth of each colony member step by step until the insect reaches its final, adult stage" (38). These specialists in the colony work "together as a functional unit" and are "guided by sets of behavioral rules that operate in the following manner. If in a given context the worker (*IP: One of the specialist roles*) encounters a certain stimulus, it predictably performs one act, and if the same stimulus is received in a different context, the worker performs a different act". The insects have "a repertory of a few dozen acts. The totality of these relatively spare and simple responses defines the social behavior of the colony" (38). "Nothing in the brain of a worker ant represents a blueprint of the social order" it acts deliberately on. "Instead colony life is the product of self-organization" (38).

In fact, in case of humans and social systems the state of affairs is not fundamentally different: Humans have at best, also only a very limited understanding of the workings and dynamics of social systems they are integral parts of; the organization of e.g. societies and the State-System are also products of self-organization.

Humans and social systems (like states) also respond to certain stimuli with predictable acts that are context dependent, as for example the exact timing of systemic KA/wars shows: During the transient period (1480-1945), the four systemic KA/wars the self-organized 1st FTS (State-)System produced started - unknowingly for us - at exactly the right time, and had very regular and consistent durations and severities. A change in thermodynamic potentials - the switch to a critical state - caused a fundamental change - a kinetic change - in human behavior to stimuli that would have been ignored (not have triggered a kinetic human response) during RSP's.

According to Hölldobler et al. "The superorganism exists in the separate programmed responses of the organisms that compose it". "The algorithms of caste development and behavior are the first level in the construction of a superorganism. The second level of construction is the genetic evolution of the algorithms themselves. Out of all possible algorithms, generating the astronomically numerous social patterns they might produce, at least in theory, only an infinitesimal fraction has in fact evolved (*IP: As is the case for behavioral norms in societies and in the (State-)System*). The sets of algorithms actually realized, each of which is unique in some respect to a living system (*IP: And Society*), are the winners in the arena of natural selection. They exist in the world as select group that emerged in response to pressures imposed by the environment (*IP: In case of societies/states, pressures imposed by the FTS/State-System on societies/states*) during the evolutionary history of the respective species."

According to Hölldobler et al. "Life is a self-replicating hierarchy of levels (*IP: Which is also the case for social systems*). Biology is the study of the levels that compose the hierarchy. No phenomenon at any level can be wholly characterized without incorporating other phenomena that arise at all levels. Genes prescribe proteins, proteins self-assemble into cells, cells multiply and aggregate to form organs, organs arise as parts of organisms, and organisms gather sequentially into societies, populations, and ecosystems. Natural selection that targets a trait at any of these levels ripples in effect across all the others". All levels of organization are primary and secondary targets of natural selection" (38). This is obviously also the case for the System, where the selection of the state with its 'strong' trait (ability) to produce and deploy kinetic energy, "ripples across" - shapes - societies states serve, and the State-System where states are integral parts of.

According to Hölldobler et al. "Biological hierarchies are reverberating systems within which, depending on the histories of the species and the environmental niches they occupy, social order may or may not evolve". It seems that this is also the case for societies/states in the System, in which social order may or may not (further) evolve, depending on the histories of these societies/states and if these societies/states can occupy 'positions' within the (State-)System; which to a high degree depends on their ability to regulate and utilize entropy and the PBMP-mechanism.

"The principal target of natural selection in the social evolution of insects is the colony while the unit of selection is the gene" (38). Arguably, the principal target of selection in the social evolution of the human species is (currently) the society, while the unit of selection are values and norms that underpin these societies/states.

"Because the traits of the colony are summed products of the traits of the colony members and those traits differ genetically among the members, as well as from one colony to the next, the evolution of the

social insects is grounded in the flux of changing gene frequencies across generations. The flux in turn reflects the complex interplay of behavior both by colonies and the individual members that compose them."

A similar logic also applies to the human species: The traits of a society can be considered the summed products of the traits of the members of the society concerned, and these traits - the values and norms that underpin them - differ among the members of the society, and from one society to the next; consequently the (social) evolution of social systems (e.g. societies) is grounded in the flux of changing values and norms across generations. In case of the (State-)System, the *processes of KA,* aggregation (mixing), expansion and empowerment - the four key processes that make up the FTS and are controlled and shaped by the FTS - determine and shape the flux of changing values and norms, and vice versa.

40.17. Application (3) The FTS serves as a template

The FTS - itself a product of the laws of thermodynamics and related principles - served (and still serves) as a template for social evolution and adaptation for the (State-)System, including of societies and states. The FTS not only provides constraints, but also opportunities, i.e. through a combination of probabilistic and deterministic factors, which impacts on the dynamics of the FTS and "choices" that are made in/during the process.

Through the KA that was generated (1480-1945), The 1st FTS established several defining 'milestones' in the development - the path - of the European State-System toward thermodynamic equilibrium in the core.

During the transient period (1480-1945), the 1st FTS and the European State-System constituted an increasingly close-fitting straitjacket, because of the European State-System's drive to zero entropy. States were forced into systemic KA with an increasing frequency and magnitude. The 1st FTS worked as an accelerating and eventually unsustainable treadmill. During the process the contingent latitude of the System decreased.

The chaotic non-systemic KA/wars during RSP's, also had (and still have) a decisive impact on the development of the (State-)System, e.g. on political processes and the structuring of military capabilities: Societies and states had to (and still must) cope with the intrinsic unpredictability's of chaotic non-systemic KA in the (State-)System.

The process the System and societies undergo - which started well before 1480 and is still in progress - can be best considered a process of growth and development, with for the (now) global State-System a clear purpose: Thermodynamic equilibrium, at a global scale. Contrary to the end-directed nature of this process, are the more gradual processes of evolution and development of/in societies and the System not progressing to a specific goal.

It can be argued that the processes of growth and development of the State-System towards global thermodynamic equilibrium, maximize the opportunities (entropy) of aggregating societies for further evolution e.g. novelty by combination. When eventually thermodynamic equilibrium - that is full-aggregation - is accomplished, there are no more barriers that limit the exploitation of opportunities in a global society.

A precondition for this developmental path is that the System does not destroy itself in the process, e.g. because a viable non-core (for the now global System) cannot be developed, or the System depletes the carrying capacity of its environment(s) in the process (e.g. the climate on which we depend).

40.18. Application (4): The evolution of self-organization dynamics: "The evolution of evolutionary processes"

A dissipative self-organizing system evolves along a coherent sequence of space-time structures (40), as the development of the State-System and 1st FTS (1480-1945) also demonstrate.
In this paragraph, I discuss anagenesis, the self-transcendence of evolutionary processes in the System: "The evolution of evolutionary processes" (40). In case of the (State-)System, there is also anagenesis through the interactions between societies/states that brought their own self-organizing dynamics into play.
Jantsch defines anagenesis as "the step-wise evolution of the dynamics of self-organization itself (*IP: "the evolution of evolutionary processes"*), bringing into play new levels of systems with their appropriate self-organization dynamics. It may be interpreted as self-transcendence in space-time (40).
Examples of anagenesis in macroevolution include coevolution of species in ecosystems as well as division of labor in human societies" (40). The development of subsystems in societies and of the State-System are also examples of anagenesis. Anagenesis and shredding out, a term used by Miller, concern (at least to a degree) similar phenomena.
Besides anagenesis, Jantsch distinguishes three other dimensional frameworks evoked by evolution (more generally by dissipative self-organization).
The other three frameworks are (40):

1. *Autopoiesis*. Autopoiesis of a structure is the self-renewal of a system maintaining a globally stable space-time structure. Over time (1480-1945), the State-System maintained a globally coherent structure, while 'parts' of the structure - human individuals - were continuously changing (renewed): We only join the structure for the duration of life. Institutions, ideas and paradigms, religions are other examples of autopoiesis.
2. *Ontogeny*. Ontogeny is the evolution of self-organizing space-time structures in a coherent way through changes in the dynamic regime, in other words the evolution of a system. It arises from dissipative self-organization which, in principle, defeats any structural permanency and may be interpreted as dynamic self-reference; not with respect to a single structure, but with respect to an evolutionary path of structures. Successive RSP's/cycles arose from the 1st FTS and are changes in dynamic regimes of the State-System and are an example of ontogeny. The evolution of ideas, paradigms, etc. are examples of ontogeny in the abstract domain.
3. *Phylogeny*. Phylogeny is the evolution of the knowledge (the dynamic programs or effective space-time information) employed in the self-organization of systems. It involves the interaction of dissipative self-organization dynamics with conservatively stored information. Examples range from gene pools and the corresponding emergence of biological variety to value sets and the corresponding socio-cultural evolution.

These frameworks also provide a useful perspective on the functioning and evolution of the (State-) System.

In the remainder of this paragraph, I further discuss *anagenesis*.
The dynamics of systems - including of the (State-)System - "may always be considered from two angles a microscopic one (processes occurring among constituents within the system (*IP: between societies/states in the (State-)System*)) and a macroscopic one (the system as a whole)" (40). In case of the System, the interactions between societies/states FFE find their correlate in the macroscopic FTS, which requires (as is the case for dissipative structures) the exchange of entropy and energy between the System (core) and its environment (non-core); which is a higher-order macroscopic view (namely of the System as a whole) (40).
Jantsch explains that "If the output of a system's self-organization dynamics enters again a self-organization configuration (a so-called hypercycle[2]), higher-level self-organizing structures may result. The level of the original dynamic system is thereby transcended. In this way, dissipative processes at different levels may be linked together and form a hierarchy involving several levels" (40).
"In a multilevel dynamic reality, each new level brings new evolutionary processes into play that coordinate and accentuate the processes at adjacent levels in particular ways. Therefore, reduction to one level of description is never possible. In order to understand self-organization and especially the phenomenon of life, it is necessary not only to recognize different levels, but also to understand the relations between them" (40).
Jantsch explains that (as is also discussed in the previous chapters) nonequilibrium is an intra-systemic condition for self-organization and evolution that reappears as an inter-systemic condition for symbiosis and coevolution.
Anagenesis - the self-transcendence of evolutionary processes - is related to symbiosis: "If the exchange between two self-organizing systems (*IP: two societies in this context*) includes the essential mutual use of transformation products or services we may speak of symbiosis" (40). In case of symbiosis, "each system sacrifices part of its individual autonomy and gains in exchange the participation in a superordinate system and a new level of autonomy with which this superordinate system establishes itself in the environment" (40).
In case of symbiosis, Jantsch explains, "self-organization becomes modified in such a way that it now plays simultaneously at two semantic levels, the level of the individual subsystems and the level of the overall system (...) symbiosis leads to the formation of hierarchical organization in which, however, the lower levels partially maintain their autonomy. Hierarchical complexity is gained at the expense of part of the subsystem's autonomy".
When the autonomy of the subsystem is totally abandoned, symbiosis may lead to the extreme of fusion (40). The superordinate system remains as the only self-organizing unit. In the domain of life, however, complete fusion is rare, Jantsch argues. Also, in case of endosymbiosis, "the joining of systems to form a

2. In chemistry, a hypercycle is an abstract model of organization of self-replicating molecules connected in a cyclic, autocatalytic manner (...). The hyper cycle is a cycle of connected, self-replicating macromolecules. In the hypercycle, all molecules are linked such that each of them catalyzes the creation of its successor, with the last molecule catalyzing the first one. In such a manner, the cycle reinforces itself. Furthermore, each molecule is additionally a subject for self-replication. The resultant system is a new level of self-organization that incorporates both cooperation and selfishness. (...) After formation, a hypercycle reaches either an internal equilibrium or a state with oscillating concentrations of each type of chain I, but with the total concentration of all chains remaining constant (96).

new one, the original semantic levels are usually maintained, giving rise to multilevel systems in which each level functions in a semiautonomous way. This guarantees a substantial gain in complexity" (40, see also: Simon (77)).
In case of the State-System (core), during the transient period (1480-1945), the joining of states eventually resulted in the establishment - at least in efforts to achieve this - of a single superordinate political structure (the European Union) that was/is supposed to replace regulatory of state-structures that were established at the societal level of organization.
According to Jantsch, if "we look at a symbiosis of processes instead (*IP: and not in structural terms*), we arrive at the notion of coevolution" (40).
"Full" coevolution - meaning "total adaptation" and fusion of structures - means that equilibrium is achieved. Equilibrium is equivalent with death and means an end to evolution; Dissipative structures - life - can no longer be maintained.
Through the phase transition the 1st FTS was instrumental in (1480-1945), total adaptation and aggregation were accomplished in the core of the System (Europe) which resulted in the death the European State-System (core): A European State-System no longer existed (and could no longer exist) in the core, the moment thermodynamic equilibrium was achieved; it had lost its purpose (1945, however, the intermediate period - the 2nd exceptional period (1945-1989) should be taken into consideration).
Evolution, self-organization, anagenesis, symbiosis (the mutually dependence of societies/states) and homeostasis are related; further study is required to determine the exact relationships between these phenomena in case of the (State-)System.

40.19. Application (5): The 1st FTS also served as a supercharger for scientific discoveries and innovations, and vice versa

During the transient period (1480-1945), positive feedback loops - (self-)reinforcing dynamics - dominated the (State-)System and were regulated by the 1st FTS. These dominant positive loops not only contributed to population growth, accelerating production of entropy and accelerating KA/war-cycles, but also to accelerated information processing, resulting in for example: Knowledge development, innovation and economic development. Innovation generated more innovation at an increasing pace. Innovation was required for adaptation and the fulfillment of basic requirements and survival of societies, in an increasingly competitive environment (State-)System, in which kinetic potential became the most decisive attribute (trait) of states.
Innovation can e.g. be accomplished by exploiting new knowledge and new opportunities, and also by novelty through innovation. Innovation ensures that suitable solutions are found to ensure well-being and survival. In a continuously changing System (environment) a lack of innovation, undermines adaptation and resilience, and survival changes.

40.20. Application (6): From near-decomposability to non-decomposability

During the transient period (1480-1945), the core of the System (Europe) developed from a collection of circa 300 diverse state(-like)-structures with a total population of circa 83 million, to a network of circa

25 standardized, well-defined and formalized structures, with a total population of circa 544 million, in which these structures - and the societies they regulated - had become highly dependent on each other for the fulfillment of their basic requirements their well-being and survival.
During the transient period, the near-decomposability of the (State-)System decreased, while the irreversibility of the (State-)System and entropy-production increased. As discussed in preceding chapters, this development constituted a fundamental contradiction at the heart of the System.
In 1939, the connectivity of the (State-)System - of societies and states in the core - reached a critical threshold and the State-System consequently produced infinite amounts of entropy that could no longer be effectively regulated. Infinite entropy-production generated infinite systemic KA, consequently the core of the System collapsed, and the final stage of the phase transition was accomplished by means of the 4th systemic war (the Second World War, 1939-1945). The phase transition had two effects: Thermodynamic equilibrium in the core (Europe, aggregation stage 3A), and simultaneous globalization of the State-System. Internally in Europe, state-structures no longer fulfilled a crucial role as connecting links between societies and their environments.
From the hierarchical perspective of Simon, the State-System was no longer nearly-decomposable, the increasing exchanges and interactions between societies and states - and the accompanying increase in entropy-production - undermined the (functioning of) autonomous hierarchical structures. Societies and states had become too connected, and the autonomy (sovereignty) of societies/states had to be 'sacrificed' through the imposition of an overarching structure that was more efficient in fulfilling the increasingly shared basic requirements: FTS-regulation was replaced by homeostatic control in the core, regulation through KA had become dysfunctional and self-destructive for the core.
The change in hierarchical structures - the dysfunctionality and abolishment of state-structures (at least some of their functions) - and the simultaneous establishment of an overarching state structure (the European Union), that had to deal with the now globalized State-System of which Europe (the former core) had become an equivalent part, caused - and still causes - some predictable confusion, and the new super-structure (the European Union) needs time to develop and to settle.
Foreign policy has (partly) become domestic policy, while security threats - which before 1945 for European states mainly originated in Europe - now originate in the former non-core. The European Union is still not capable - and equipped - to deal effectively with these new challenges.
Unconstrained exchanges and interactions are now possible in the former core (Europe), without barriers that are imposed by state-structures; new possibilities - opportunities and threats - can be explored and exploited. The eradication of barriers contributes to the maximization of entropy in the former core, in accordance with the current state of thermodynamic equilibrium.

40.21. Application (7): Quantitative growth leads to qualitative change

The emergence of the 1st FTS in 1480 and the phase transition the 1st FTS accomplished (1480-1945), show how quantitative growth - population growth - resulted in qualitative growth, through the utilization of entropy by the (State-)System's constituents. In case of the System purely quantitative growth led to qualitatively new choices and structures (65).

40.22. Application (8): Dissipative adaptation and the PBMP-mechanism

In the article "Dissipative adaptation in driven self-assembly" (28) England discusses the "challenge of predicting the path of arbitrary non-equilibrium evolution" in processes in which matter is driven by an arbitrary forcing field or externally imposed current in the presence of thermal fluctuations, by using thermodynamics (28).

The processes discussed concern biochemical reactions and thermodynamics that apply to these reactions and related processes. England observes that "once we have chosen our external drive, different configurations of the system are not going to be equally competent to absorb work from the drive" (28). Work absorption refers to "the extra energy expended on dissipated work during the construction of a given assemblage of matter", which "determines the maximum durability that this target structure (*IP: in case of directed self-assembly*) can have in the presence of thermal fluctuations at the same temperature; once we know how fast it was assembled and how much dissipation was catalyzed during that process, we can immediately estimate a timescale on which the structure is likely to fall apart spontaneously under the same conditions" (28) (*IP: this line of thought can also be used to determine the moment the global State-System, will self-destruct, in the 2nd FTS stays in control of EMIS-regulation*).

England discusses the speculative hypothesis that for "within a vast and diverse set of equally kinetically accessible states, the ones most likely to be outcomes of our particular scenario of driven evolution will have special histories of reliably high work absorption, meaning that all of likely stochastic paths carrying the system from $\boldsymbol{i}$ to $\boldsymbol{j}$ have exceptionally positive values for $\boldsymbol{W}$ (work)" (28). In other words, England speculates that in case of driven evolution by a forcing field (as defined by England in the example) the states "most likely to be outcomes of our particular scenario of driven evolution will have special histories of reliably high work absorption".

The reason this could be the case is that work absorption by a structure - a structure that has a history of absorbing more energy from the drive - is indicative for the adaptation of this structure to the drive: "(..) a structure that is chosen from a vast and diverse set for its likely history of atypically high work absorption may generally be the end product of antecedent structures that exhibited a well-matched relationship to the particular driving environment that enabled them to catalyze the absorption and dissipation of work with exceptional effectiveness" (28).

England continues: "The physical intuition behind this general expectation turns out to be surprisingly simple: The absorption of energy from a drive allows the system configuration to traverse activation barriers too high to jump rapidly by thermal fluctuation alone, and if this energy is dissipated after the jump, then it is not available to help the system go back the way it came. Thus, while any given change in shape for the system is mostly random, the most durable and irreversible of these shifts in configuration occur when the system happens to be momentarily better at absorbing and dissipating work. With the passage of time, the 'memory' of these less erasable changes accumulates preferentially, and the system increasingly adopts shapes that resemble those in its history where dissipation occurred. Looking backward at the likely history of a product of this non-equilibrium process, the structure will appear to us like it has self-organized into a state that is 'well adapted' to the environmental conditions. This is the phenomenon of dissipative adaptation" (28).

During the transient period (1480-1945), the 1st FTS regulated the EMIS-flows in the (State-)System and ensured that the European State-System was driven to thermodynamic equilibrium via the most efficient path. The 1st FTS included a force field, the S/T-field. The 'directed evolution' of the European

State-System to equilibrium, involved the (State-)System and 1st FTS, but also the components (states/societies) of the System. The (State-)System, states and societies co-evolved. 'Within' the most efficient path to equilibrium, various (contingent) configurations/versions of the State-System were possible. The State-System had to meet thermodynamic requirements, while political values that underpinned social orders were not relevant to the determinist domain. Certain states were more effective in influencing the path of the System than others. Great Powers by definition had impact on the dynamics and evolution of the System. However, there are also significant differences in the life-span of Great Powers: Only two Great Powers - France and the United Kingdom (48) were able to sustain their Great Power status during the transient period (1480-1945).

I argue that certain Great Powers could - and still can - sustain their impact on the path (direction of contingent evolution) of the System more effectively than others, because they were/are able to absorb more energy from the S/T-field, and put it to use (work) to their own advantage, e.g. by ensuring the order of the System is underpinned by values (privileges) that especially serve their positions of power and influence. These Great Powers are better adapted to the State-System (and vice versa). This mechanism, I refer to as the powerful-become-more-powerful (PBMP)-mechanism. This is a thermodynamic explanation for the working of this mechanism; its working can also be explained from a dynamical system perspective.

41. Dissipative and designed structures

41.1. Introduction

There exist fundamental differences between structures created by dissipative processes - like the State-System in Europe (1480-1945) - and human-designed machine-like structures.
In this chapter, I have a closer look at these differences: If we want to tackle the profound challenges humanity now faces - e.g. the effects of climate change and fragile states - we must not only better understand how social evolution works, but also how we can make certain changes, as far as this is possible at all. Social "evolutionary design rules" - and how they can be best applied - cannot be ignored.
Kondepudi et al. (44) explain the origin of the differences between structures created through dissipative processes and human-designed machine-like structures as follows: "The organization of a machine, its structure and function, comes from processes external to it. So, when we encounter a machine that we have never encountered before, taking it apart and analyzing how its components are made and arranged also gives us a way to build one – assuming we have the necessary external processes we call 'technology' (44). (...) Newtonian science, based on reversible laws, has put us on the path to the world of machines that we inhabit; a world that is very different from that of organisms. The difference, arguably, is the difference between reversible mechanics and irreversible thermodynamics" and, "(...) the processes that bring about an organism are not a part of our technology. Organisms are based on self-organization brought about by internal irreversible processes. The organization of machines comes from processes external to it, and ideal machines are reversible. We have not yet developed a technology based on irreversible processes and self-organization that can emerge from it": (...) and although "we have been analyzing the structure and organization of a living cell for well over a century, and although we have an immense knowledge of its makeup, all the way down to the molecular level, we do not know how to build a living cell or even one that vaguely resembles one" (44).
In this chapter, I discuss the differences between human-designed and self-organized organizational structures, and limitations of human-designed structures: Our understanding of these limitations - and how to deal with them - is still limited.

41.2. Dissipative versus designed structures

There are some fundamental differences between dissipative structures and human-made designed structures, like machines, computers and organizational structures. According to Kondepudi et al. "one may surmise that dissipative structures are more akin to biological organisms than are machines and computers" and that "the machine paradigm is inappropriate as a theory of biological organism" (44). Fundamental differences include:

- *Entropy exclusion versus entropy inclusion*. "Most designed structures are based on time-reversible mechanics". "The ideal designed structure does not include irreversible processes; for its best performance, entropy-generating dissipative processes must be minimized. In stark contrast, the very existence of dissipative structures depends on dissipative processes. Their mathematical description is based on irreversible thermodynamic processes. Their behavior is not time symmetric" (44). In case of the System, entropy is a source of order.
- *The origin of design: External (imposed) or internal (self-organized)*. "The structure of a designed structure originates from processes external to the system and so is its function: Every designed structure is designed to perform a specific set of functions, as are its components. In computers, 'machine intelligence' is, in fact, 'borrowed intelligence'; the algorithms that enable it to perform its function originate in processes external to the system".
  "In contrast, the structure in dissipative structures originates from processes within. Their behavior, if it could be interpreted as a 'function', is entirely a consequence of self-organization. In a complex dissipative structure, one may associate 'functions' to various subsystems, but those functions are entirely self-generated. If one could associate an 'algorithm' for its behavior, that too originates from within (44)." The structures and accompanying behavior of societies and the System is self-organized and originates from within.
- *'Repair' versus self-healing*. "Thermodynamic stability of dissipative structure means dissipative processes restore the structure if it is perturbed or 'damaged', within bounds, of course. This bestows them with the property of 'self-healing'. This is clearly not the case with machines or computers". KA during RSP's can also be considered (instrumental in) self-healing: The purpose of KA is to 'correct' (entropic) perturbations of the stationary state. As I explain in detail in paragraph 41/5, the 2nd exceptional period (1945-1989, the Cold War) - when the (globalized) System was temporarily shut down and in an ossified state, and the former core was recovering - can also be considered as an example of self-healing.

42.3. Human-designed versus self-organized organizational structures

It is s also possible to make a (fundamental) distinction between human-designed and imposed *organizational* structures and self-organized (emergent) organizational structures like the FTS. In table 41.4, an overview of fundamental differences is shown:

TABLE 41.1: Fundamental differences between designed and self-organized organizational systems.

Aspect/property	Designed organizational systems	Self-organized organizational systems
Origin	External origin: The design originates from a process external to the system it is applied to.	Internal origin: The design originates from processes within (intrinsic to) the system; the organizational structures are manifestations of emergence (self-organization).
Entropy	Entropy-production is minimized in case of designed organizational systems; it is assumed that entropy has a negative impact; the designed organizational system has difficulty dealing with entropy.	Entropy (production) is essential to the functioning of the system; entropy is used to explore and exploit new possibilities; EMIS-flows are coordinated and effectively regulated from within. Entropy is a source of order.
Implementation	The organizational structure is top-down imposed.	The organizational structure has developed ('matured') gradually from within.
Response to perturbations	The organization responds to perturbations with 'designed' responses; these responses are 'mechanistic' and not fully coordinated with internal processes; 'outside healing'.	The organization responds to perturbations with responses intrinsic - embedded in - the system/structure; these responses are inseparably linked and coordinated with internal processes; self-healing.
Relationship with the environment	External influences and interactions with the environment are 'mechanistically 'controlled; uncertainty is avoided.	The self-organized organizational system and its environment constantly interact and constantly exchange EMIS; uncertainty (entropy) is exploited.
Adaptation to changes (in the environment)	The organizational design - the imposed 'blueprint' - serves as a reference to decide on necessary changes that are then implemented top down.	All parts of the structure - at all levels - adapt to changes based on an internal and 'local' logic, the local 'logics' of the parts are an integral part of the overall design of the systems and its operation.

41.4. Limitations to nation-building

The fundamental differences between human-designed and self-organized organizational structures also explain the limitations to nation-building, which are (mostly) top-down efforts to impose state structures (externally designed blueprints) and political systems on communities, societies and populations, while these state-structures do not - and often cannot - match with the societal processes and the EMIS-flows that societies generate. The limitations of nation-building are on full display in for example Afghanistan and Iraq, respectively since 2001 and 2003.

That nation-building through top-down imposed organizational structures is doomed to fail should also not come as a surprise when the typical properties of a nation are taken into consideration: A nation is defined as a stable community of people, that is formed on the basis of a common language, territory, economic life, ethnicity or psychological make-up manifested in a common culture (96). A nation requires - according to this definition - at least stability, a common language (that allows for communication), a territory and a common culture. This requires a long-term process of evolution and development.

Afghanistan and Iraq do at this stage still not qualify as nations. Afghanistan consists of a collection of tribes, while the state Iraq is an artificial construct that still lacks a shared cultural base.

41.5. Application (1): The 2nd exceptional period (1945-1989) was a period needed of self-healing

In the last phase of the phase transition (1480-1945), the European State-System destroyed itself, with the 'infinite' KA the (State-)System produced at that stage (1939-1945). The phase transition that was accomplished had two complimentary effects: Thermodynamic equilibrium in the core, and the globalization of the State-System.

Following the phase transition, the two most prominent Great Powers (the United States and the Soviet-Union), filled the vacuum the self-destructed European State System had left behind. The intense rivalries between the two competing Great Powers, resulted in a 2nd exceptional period (1945-1989), during which non-systemic KA was suppressed.

This period can be understood as a period of recovery - of self-healing - when the former core could recover from the destruction it had inflicted on itself during the last stage of the phase transition (the 4th systemic KA/war, the Second World War, 1939-1945), and the components of the 2nd FTS could be also be fully developed.

When the Soviet-union collapsed in 1989, the 2nd FTS became fully operational and chaotic non-systemic KA (now at a global scale) resumed. See figure 41.1.

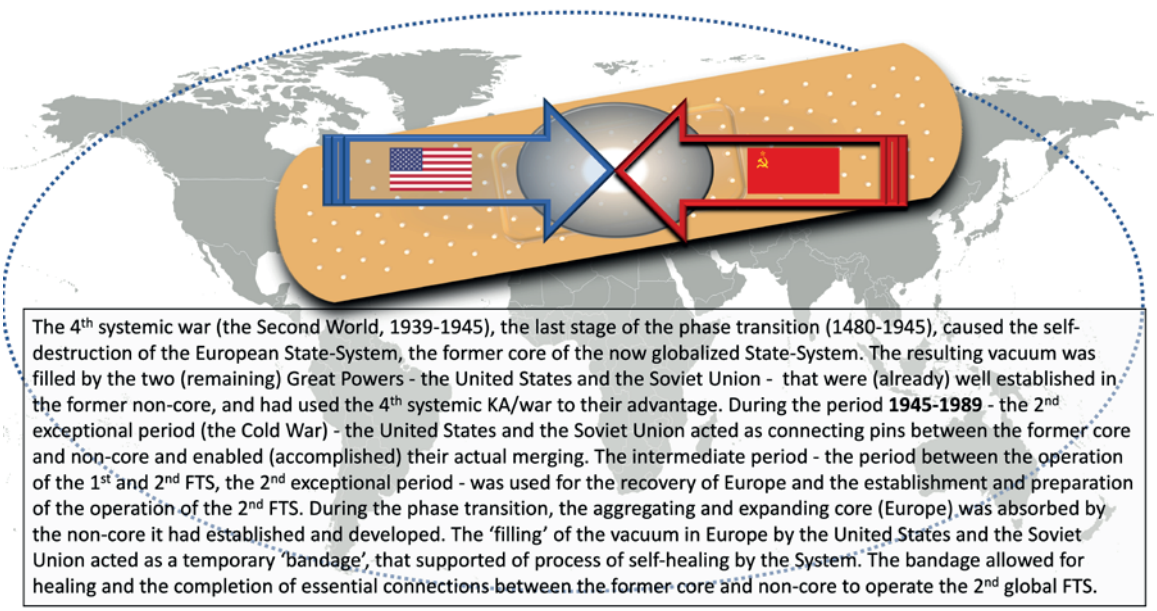


FIGURE 41.1: Self-healing of the (State-)System, during the 2nd exceptional period (1945-1989). This period can be understood as a period of recovery - of self-healing - when the former core could recover from the destruction it had inflicted on itself during the last stage of the phase transition (the 4th systemic KA/war, the Second World War, 1939-1945), and the components of the 2nd FTS could be also be fully developed.

41.6. Application (2): Design principles

Fialkowski et al. (31) have formulated heuristic design rules that apply to the engineering of DySa-systems. These efforts can be understood as efforts to mimic internal design processes - design "from within" - by ensuring alignment at the lowest levels of organization.

Fialkowski et al. "adopted a bottom-up approach to DySA (31) to try to deconstruct it into basic "engineering principles" and "use these principles to build model systems, make these systems more and more complex, study the limits of their controllability and of our understanding, and finally use the knowledge gained to fuel the theory".

These principles do not (without 'modification) apply to social systems, but a (methodologically) similar approach could possibly also be used to improve our ability to 'build' social systems with specific properties.

Fialkowski et al. formulated several heuristic design principles:

1. *Identifying suitable interactions*. According to Fialkowski et al. "The first necessary condition for DySA is that at least one type of interaction acting in the system must depend on and be regulated by externally delivered energy (if the changes in energy supply would have no effect on the system's components, it would be energetically isolated and not dissipative). The energy-dependence rule might apply to the interactions between the components of different types and/or to the global potential (e.g., an external field or boundaries of a container) acting on all of these components and keeping them together" (31).
2. *Choosing "competing" interactions/potentials*. "One interaction, or even one type of interaction, acting in the system is not enough to build a full-fledged DySA system. If the only forces acting between/on the components are repulsive, the system will simply fall apart; if they are all attractive, the system might dynamically aggregate (cf. previous section), but the aggregate will not develop order beyond, at best, simple closest packing. If we were to build dynamic assemblies of ordered and more complex internal structures, we must use both attractive and repulsive interactions. Only by having them "compete" with one another is it possible to introduce selectivity into the system" (31). This dynamic can also be observed in the FTS and (State-)System, where competing thermodynamic potentials and their extremization, drive the process of growth and evolution/development of structures.
3. *Choosing a proper length scale*. "To build a steady state dynamic structure, a proper environment and a length scale must be chosen such that the opposing (attractive-repulsive) forces are similar in magnitude and can therefore balance one another" (31).
4. *Synthesis*. "This very general rule embodies the natural, "bottom-up" direction for developing DySA systems, from very simple systems based on a minimal number of components and types of interactions, to complex ensembles of large numbers of particles interacting in specific ways. Conceptually, this approach is akin to synthetic methods of chemistry, where one progresses from simple reactants to complex products. We advocate this methodology over the recent trend in systems' science to analyze inherently complex assemblies/structures in a "top-down" manner. The synthetic approach offers better fundamental understanding of and ability to rationally design various levels and aspects of dynamic self-assembly" (31).

41.7. Application (3): Social planning at a societal scale

Although Simon did not make an explicit distinction between the fundamental differences between structures created by dissipative processes and human-designed machine-like structures, he has discussed the subject of social planning at a societal scale and taken some design principles closely related to the functioning of dissipative structures, into consideration. Quotes are from: *The Sciences of the Artificial* (78).

According to Simon, the "success of planning on such a scale may call for modesty and restraint in setting the design objectives and drastic simplification of the real-world situation in representing it for purposes of the design process. Even with restraint and simplification difficult obstacles must usually be surmounted to reach the design objectives".

Simon discusses "the obstacles and some of the techniques for overcoming them". Simon discusses the following topics: (1) Problem representation, (2) ways of accommodating to the inadequacies that can be expected in data, (3) how the nature of the client affects planning, (4) limits on the planner's time and attention, and (5) the ambiguity and conflict of goals in societal planning.

Some of these topics - because of their relevance to the subjects discussed in this study - I elaborate on:

- *Problem representation*. Simon observes (in reference to the Marshall Plan) that conceptualizing a problem in a particular way implies "organizing the agency in a manner consistent with that conceptualization. And different organizations would lead inevitably to the implementation of quite different programs, emphasizing certain goals and subordinating others, even if all the alternative policies were in some general sense consistent (78)". Simon argues, that "what was needed was not so much a "correct" conceptualization as one that could be understood by all the participants and that would facilitate action rather than paralyze it.

  Furthermore, Simon points to the importance "of identifying correctly the limiting resource or resources". "What paths are open to us when we must plan in the face of extremely poor data? One minimal strategy (...) is to associate with every estimated quantity a measure of its precision. Labeling estimates in this way does not make them more reliable, but it does remind us how hard or soft they are and hence how much trust to place in them".
- *Accommodating inadequacies that can be expected in data*. (...) given a good problem representation, (...) "The quality of design is likely to depend heavily on the quality of the data available. The task is not to design without data but to incorporate assessments of the quality of the data, or its lack of quality, in the design process itself."

  According to Simon, in regard to prediction: "Data about the future predictions are commonly the weakest points in our armor of fact. Good predictions have two requisites that are often hard to come by. First, they require either a theoretical understanding of the phenomena to be predicted, as a basis for the prediction model, or phenomena that are sufficiently regular that they can simply be extrapolated. Since the latter condition is seldom satisfied by data about human affairs (or even about the weather), our predictions will generally be only as good as our theories".

  "The second requisite for prediction is having reliable data about the initial conditions the starting point from which the extrapolation is to be made. Systems vary in the extent to which their paths are

sensitive to small changes in initial conditions. Weather prediction is difficult in good part because the course of meteorological events is highly sensitive to the details of initial conditions. We have every reason to think that social phenomena are similarly sensitive".

In case of the (State-)System, we now have - I assume - a better theoretical understanding of the dynamics of the (State-)System, and - as I showed - some very regular dynamics can be identified (and explained). As far as Simon's second requisite for prediction is concerned, some valuable observations can be made regarding the (State-)System: Non-systemic KA/war R1-dynamics - contrary to the cyclic R2-dynamics (systemic KA/wars) - are indeed very sensitive to small changes in initial conditions, because of their chaotic properties.

The fact that chaotic non-systemic KA/war is intrinsically unpredictable, is also valuable information. However, this study also shows that the European State-System (1480-1945) was, and the global State-System (1945-....) is pushed to pushed to thermodynamic equilibrium, by respectively the 1st and a 2nd FTS; a process that also involves highly predictable cyclic (R2-)dynamics and a phase transition; if the process proceeds 'unchecked, the global State-System will also self-destruct.

Furthermore, Simon observes: "The heart of the data problem for design is not forecasting but constructing alternative scenarios for the future and analyzing their sensitivity to errors in the theory and data". And: "Design for distant futures would be wholly impossible if remote events had to be envisioned in detail. What makes such design even conceivable is that we need to know or guess about the future only enough to guide the commitments we must make today. Future contingencies that have no implications for present commitment have no relevance to design".

Simon argues that: "Few of the adaptive systems that have been forged by evolution or shaped by man depend on prediction as their main means for coping with the future. Two complementary mechanisms for dealing with changes in the external environment are often far more effective than prediction: Homeostatic mechanisms that make the system relatively insensitive to the environment and retrospective feedback adjustment to the environment's variation". "Thus, a stock of inventories permits a factory to operate without concern for very short-run fluctuations in product orders. Energy storage in the tissues of a predator enables it to cope with uncertainties in the availability of prey. A modest excess of capacity in electric generating plants avoids the need for precise estimation of peak loads. Homeostatic mechanisms are especially useful for handling short-range fluctuations in the environment, hence for making shortrange prediction unnecessary".

"Feedback mechanisms, on the other hand, by continually responding to discrepancies between a system's actual and desired states, adapt it to long-range fluctuations in the environment without forecasting. In whatever directions the environment changes, the feedback adjustment tracks it, with of course some delay".

"In domains where some reasonable degree of prediction is possible, a system's adaptation to its environment can usually be improved by combining predictive control with homeostatic and feedback methods. It is well known in control theory, however, that active, feed forward control, using predictions, can throw a system into undamped oscillation unless the control responses are carefully designed to maintain stability. Because of the possible destabilizing effects of taking inaccurate predictive data too seriously, it is sometimes advantageous to omit prediction entirely, relying wholly on feedback, unless the quality of the predictions is high".

- *Who is the client?* "It may seem peculiar to ask, "Who is the client?" when speaking of the design of large social systems" ("The question need not be raised about smaller-scale design tasks, since the answer

is built into the definitions of the professional roles of designers"). Simon explains that "all ambiguities should be resolved by identifying the client with the whole society. That would be a clear-cut solution in a world without conflict of interest or uncertainty in professional judgment. But when conflict and uncertainty are present, it is a solution that abdicates organized social control over professionals and leaves it to them to define social goals and priorities. If some measure of control is to be maintained, the institutions of the society must share with the professional the redefinition of the goals of design".
"The client seeks to control professionals not only by defining their goals of design but also by reacting to the plans they propose. (...) In any planning whose implementation involves a pattern of human behavior, that behavior must be motivated. Knowledge that "it is for your own good" seldom provides adequate motivation".
"The members of an organization or a society for whom plans are made are not passive instruments but are themselves designers who are seeking to use the system to further their own goals. Organization theory deals with this motivational question by examining organizations in terms of the balance between the inducements that are provided to members to perform their organizational roles and the contributions that the members thereby provide to the achievement of organizational goals".

Simon also makes some useful observations about social planning and evolution: "Social planning without fixed goals has much in common with the processes of biological evolution. Social planning, no less than evolution, is myopic. Looking a short distance ahead, it tries to generate a future that is a little better (read "fitter") than the present. In so doing, it creates a new situation in which the process is then repeated. In the theory of evolution there are no theorems that extract a long-run direction of development from this myopic hill climbing. In fact, evolutionary biologists are extremely wary of postulating such a direction or of introducing any notion of "progress." By definition the fit are those who survive and multiply".
"Whether there is a long-run direction in evolution, and whether that direction is to be considered progress are of course two different questions. We might answer the former affirmatively but the latter negatively. Let me venture a speculation about the direction of social and biological evolution (78). My speculation is emphatically not a claim about progress. From a reading of evolutionary history whether biological or social one might conjecture that there has been a long-run trend toward variety and complexity. There are more than a hundred kinds of atoms, thousands of kinds of inorganic molecules, hundreds of thousands of organic molecules, and millions of species of living organisms. Mankind has elaborated several thousand distinct languages, and modern industrial societies count their specialized occupations in the tens of thousands (...) forms can proliferate in this way
because the more complex arise out of a combinatoric play upon the simpler. The larger and richer the collection of building blocks that is available for construction, the more elaborate are the structures that can be generated".
"If there is such a trend toward variety, then evolution is not to be understood as a series of tournaments for the occupation of a fixed set of environmental niches, each tournament won by the organism that is fittest for that niche. Instead evolution brings about a proliferation of niches. The environments to which most biological organisms adapt are formed mainly of other organisms, and the environments to which human beings adapt, mainly of other human beings. Each new bird or mammal provides a niche for one

or more new kind of flea. (...) Vannevar Bush wrote of science as an "endless frontier." It can be endless, as can be the process of design and the evolution of human society, because there is no limit on diversity in the world. By combinatorics on a few primitive elements, unbounded variety can be created."
According to Simon, designing without final goals, means designing for future flexibility, design activity as goal, designing an evolving system.

42. The interplay between individual and collective behaviour

42.1. Introduction

In the previous chapters, I explained that the laws of thermodynamics and related principles that apply to the (State-)System - and the dynamics and structures that were consequently produced - acted (and still act) as a - template - a straitjacket - for social dynamics in the contingent domain. I discussed the interplay between the H- and S-imperatives in chapter 38.
This explanation of the interplay between the two imperatives, still leaves some important questions unaddressed: i.e. the question how coordination - synchronization - is accomplished between individual and collective behavior in the (State-)System: Why and how do individual humans and social systems obey the demands of the S-imperative? How did the 1st FTS accomplish that individual humans and social systems at exactly the right time started and stopped systemic KA/wars? And why is it so difficult to recognize this obedient behavior?
In this chapter, I explain that several mechanisms contribute to the coordination and synchronization of individual and collective behavior, including the mechanisms of sensemaking and conditioning, and feedback-structures that ensure that self-fulfilling prophecies - mutual expectations - of interacting actors become synchronized.

42.2. Subjugation to a collective dimension: A system perspective

FTS-regulation affects - penetrates - the whole (State-)System; from the level of the individual human to the (State-)System itself: EMIS-flows connect the various levels of organization. Humans cooperate and form collective structures to be able to (better) fulfill their basic requirements, in accord with the H-imperative.
The H-imperative is instrumental in processing and regulating entropy - uncertainty, possibilities, etc. - for individual humans and social systems in the contingent domain; the H-imperative works as a filter and is instrumental in a process of (social) selection. Processing of information by the brain and psychological processes conducted by the mind (like sensation, perception, attention, learning and

memory) contribute to entropy-regulation. Efficient entropy-regulation helps an individual to create situational awareness and to make assessments and choices: (The need for) entropy-regulation impacts on an individual's thoughts, feelings and behaviors.
The H-imperative also serves as a reference and provides guidance and feedback. Thoughts, feelings and behaviors are cognitively constructed - processes that involve information processing, psychological processes and interactions with others - and they in turn, impact on a human's (inter)actions.
Our self-image (self-concept), our assessment of others and of the environment, are continuously (re) constructed through our (inter)actions. Our assessments - and our (inter)actions - are continuously adjusted to ensure compliance with the H-imperative, and with certain demands from our (social) environment.
The H-imperative also provides us with a certain flexibility, to enable us to make use of opportunities that (suddenly) present themselves through the available contingent latitude and through probabilistic factors.
Flexibility is also required to ensure timely adaptation to a constantly changing internal and external environment.
Cooperation with other humans improves our ability to fulfill our basic requirements and to satisfy the H-imperative. However, the social systems (e.g. communities) humans interactively build, also constitute constraints that subsequently restrain - and shape - their behavior. Social systems also generate their own autonomous behavior.
The collective upscaling and the autonomous needs and behavior these social structures generate, are also shaped in accord with the demands of the S-imperative (the Second Law and related principles). In chapter 6, I explained that these social systems organize in hierarchical structures, as defined by Simon, with their typical properties.
This dynamic - process - introduces "the possibility that individuals acting according to their own particular criteria may find that the resulting collective vector may sweep them in an entirely unexpected direction, perhaps involving qualitative changes in the state of the system" (64).

42.3. Sensemaking

Living systems must fulfill a set of basic requirements, to ensure their survival. Humans are the basic 'parts' of a network of hierarchically organized social systems. Humans participate in different hierarchical structures (social systems), at different levels of organization. Continuous interaction is required to generate the necessary EMIS-flows to maintain these structures and the network.
Humans and social systems must continuously make sense of their (inter)actions, and of their environments(s). According to Weick (94), the process of sensemaking is an interactive process. Weick argues that "sensemaking is about such things as placement of items into frameworks, comprehending, redressing surprise, constructing meaning, interacting in pursuit of mutual understanding, and patterning".
Sensemaking is also described as "the reciprocal interaction of information seeking, meaning ascription, and action, which means that environmental scanning, interpretation, and 'associated responses' all are included" (94). Various mechanisms are at work in case of sensemaking: "That organizational members

(*IP: and I assume members of social systems, in general*) use to attribute meaning to events, mechanisms that include the standards and rules for perceiving, interpreting, believing, and acting that are typically used in a given cultural setting" (94).

Weick observes that "a critical property of sensemaking is that human situations are progressively clarified, but this clarification often works in reverse. It is less often the case that an outcome fulfills some prior definition of the situation, and more often the case that an outcome develops that prior definition" (94). "To talk about sensemaking is to talk about reality as an ongoing accomplishment that takes form when people make retrospective sense of the situations in which they find themselves and their creations." A similar emphasis on the idea that outcomes develop prior definitions of the situation is found in cognitive dissonance theory: "Dissonance theory focuses on post-decisional efforts to revise the meaning of decisions that have negative consequences" (94): "people start with an outcome in hand - a verdict, a choice - and then render that outcome sensible by constructing a plausible story that produced it" (94). According to Weick, sensemaking is "grounded in identity construction".

I argue that these mechanisms also impact on KA/war decisions and (inter)actions. The process of sensemaking is 'flexible', in the sense that different explanations and justifications - meaning - can be 'constructed' for the same event: "Individuals are not seen as living in, and acting out their lives in relation to, a wider reality, so much as creating and sustaining images of a wider reality, in part to rationalize what they are doing" (94).

The process of sensemaking contributes to our ability to collectively decide and justify going to war. Actions - and history - can be shaped to our own needs.

42.4. Restrictions to free will through conditioning and socialization

In this study, I have introduced the term contingent latitude and defined as "a certain latitude to determine - without causing conflicts with constraints - to make 'choices'". The question is, given the constraints that are imposed, how much choice we (humans and decisionmakers of social systems) actually have, and how 'free' this choice is. This study shows that our freedom of choice/action is much more limited, than we (want to) belief. The regularity of KA/war dynamics during the transient period (1480-1945) shows that it did not occur to the Great Powers involved and their respective societies/state-structures, to simply ignore (for example) the 3rd systemic war (the First World War, 1914-1918); this systemic KA/war - as well as the others - started and ended at the 'prescribed' time: Participation in this war was not a matter of choice it seems: Individual humans and societies/states were (and still are) fully conditioned to the requirements of the FTS and of the (State-)System, we are intrinsic parts of. Our responses are generated by the H-imperative, which is subjugated to the S-imperative (thermodynamic laws and related principles).

The processes of sensemaking (discussed in above paragraph), conditioning and socialization (help) shape (collective) responses and ensure coordination.

Conditioning in psychology is a theory that states that the response or reaction by a person to an event (stimulus) can be modified by learning (that is conditioning). A distinction is made between classical and operant conditioning, when respectively an involuntary response and voluntary behavior are associated with a stimulus; in case of operant conditioning the agent is active.

Socialization in sociology is "the process of internalizing the norms and ideologies of society. Socialization encompasses both learning and teaching and is thus "the means by which social and cultural continuity are attained". Socialization is strongly connected to developmental psychology. Humans need social experiences to learn their culture and to survive. Socialization essentially represents the whole process of learning throughout the life course and is a central influence on the behavior, beliefs, and actions of adults as well as of children" (96).
Through the process of socialization, values, norms - but also convictions and myths - are internalized; values, norms, convictions and myths are also institutionalized. Socialization
contributes to our ability to cooperate and to the continuity and stability of societies. Harmony and conformity have evolutionary advantages; institutionalization refers to the process of embedding some conception (for example a belief, norm, social role, particular value or mode of behavior) within an organization, social system, or society as a whole (96).
However, the mechanisms of conditioning, socialization and institutionalization also contribute to our (collective) capacity for (self-)deception: We can create our own 'realities' that can impact negatively on the accuracy of our assessments, including of our interpretations of historical events.
Too often, we assume we make choices out of free will, while in fact, we are deceived by our ability for collective deception and our conditioning - subjugation - to the H-imperative, which always must comply with the S-imperative (thermodynamic laws and related principles). Our urge to cooperate and socialize (to satisfy the H-imperative) is often stronger than our ability to make objective assessments and to act accordingly. Through the connection between the S- and H-imperatives, the subjugation of the H-imperative by the S-imperative, and the mechanisms of conditioning and socialization, is our behavior always aligned with the demands of the Second Law and related principles.
We failed to observe the subtle - but very effective - interplay between our (inter)actions and the emergent behavior of the (State-System): During the transient period (1480-1945), we became increasingly encapsulated in an accelerating war-trap - the 1st FTS - that eventually (1939) led to the self-destruction of the European State-System; with the help of collectively created justifications, we could (and still can) explain and justify this destructive behavior.
Societal harmony and conformity have a downside, despite their functionality: These same urges can cause humanities collective self-destruction, if the 2nd global FTS - which we together sustain through our (inter)actions - is not stopped in its path.

42.5. Interacting self-fulfilling prophecies (ISFP's) and the role of the security dilemma

Self-fulfilling prophecies also play a decisive role in the generation of collective behavior in the (State-) System. A self-fulfilling prophecy is a prediction that directly or indirectly causes itself to become true, by the very terms of the prophecy itself, due to positive feedback between belief and behavior. In case of a self-fulfilling prophecy, the behavior produced by a 'prediction' or expectation causes the prediction or expectation to become true.
In case of the (State-)System, self-fulfilling prophecies of various 'actors' (e.g. societies and decisionmakers of states) - their mutual expectations - interact and shape each other; it is a process in which the actors are actively involved, playing their part.

The process of sensemaking and the security-dilemma play important roles in the - what I refer to as - process of interacting self-fulfilling prophecies (ISFP's).

The process of ISFP's is concerned with the interplay between individual and collective behavior, and with the interplay between the deterministic and contingent domains (respectively the S- and H-imperatives). Through the process of ISFP are states and societies 'prepared' to engage in KA/war "at the right time"; the process of ISFP's ensures that (members of) societies are aligned and states/societies find meaning and justification to engage in war (KA). The process of ISFP is powered by entropy(-production) and shaped by the security dilemma in the contingent domain.

During the HCR of RSP's the ISFP-mechanism runs at full speed, so to speak, and powers the autocatalytic process that drives the (State-)System to a critical state.

The security dilemma and interacting self-fulfilling prophecies constitute the interface between the deterministic and contingent domains of the System (59).

As I mentioned, the security dilemma and ISFP's interact and reinforce each other:

- *The security dilemma*. The security dilemma is an intrinsic property of anarchistic systems. In anarchistic systems states are responsible for their own security. The dilemma is that one state's security is another state's insecurity.

  The security dilemma constitutes a self-reinforcing (positive feedback mechanism): if state A (preventively) deploys destructive energy because of a perceived threat by state B, state B will probably take certain precautions in response; the response of state B will be interpreted by state A as a confirmation of state B's aggressive behavior towards state, etc. See figure 42.1.

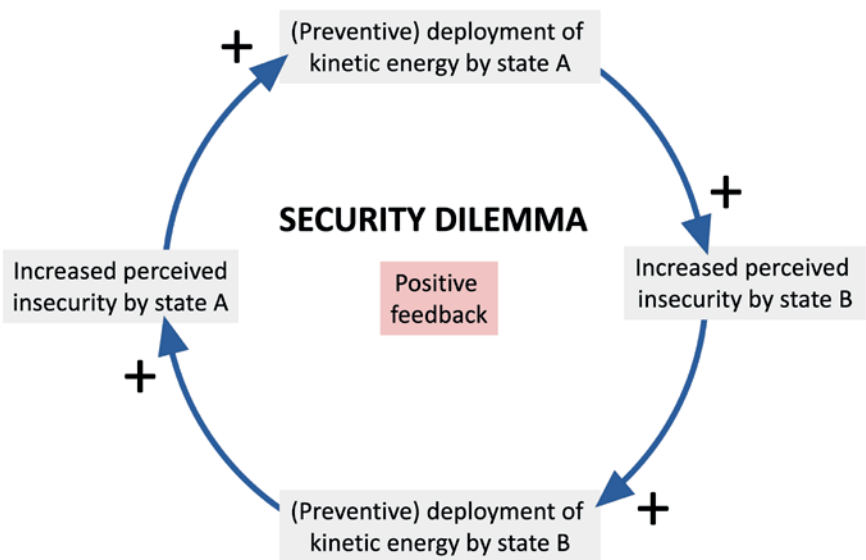


FIGURE 42.1: The workings of the security dilemma. The security dilemma qualifies as a self-reinforcing positive feedback mechanism and is an integral component/aspect of anarchistic systems. In anarchistic systems, states are ultimately responsible for their own security. One state's security, typically achieved through a combination of kinetic capabilities and alliances, constitutes another state's insecurity. The state that feels insecure will enhance its security by producing, preventively mobilizing, and deploying destructive energy, and by participating in alliances. These responses then affect the sense of security of other states, setting in motion a self-reinforcing mechanism that creates more tensions and new issues. Through the security dilemma issues and tensions create more issues and tensions, etc.

- *Interacting self-fulfilling prophecies (ISFP's)*. Interacting self-fulfilling prophecies constitute a powerful mechanism that produced and shaped (and still produces and shapes) tensions (entropy), issues and the nucleation of VC's in the (State-)System, during the transient period (1480-1945). This positive feedback mechanism is closely related to the security dilemma. In an anarchistic system, there is a certain level of distrust regarding the intensions of other societies/states, especially rivals, and to what extent they could pose a threat to the fulfillment of basic requirements.
  In an anarchistic system, perceived threats by state A sometimes provoke precautionary actions by state B, for example the preventive deployment of destructive energy. Countermeasures by state A confirm state B's distrust of state A and start a self-reinforcing loop. This is a self-fulfilling prophecy. Interacting self-fulfilling prophecies produce and shape issues and tensions in the contingent domain of the (State-)System.
  Through interacting self-fulfilling prophecies states can justify their interactions. Because of this powerful mechanism, it is not difficult in anarchistic systems to prove oneself right. A perceived threat, even if it is just imagined, has a high chance of becoming a reality. Through interacting self-fulfilling prophecies, every state can produce and justify its actions and create its own reality and justifications. See figure 42.2.

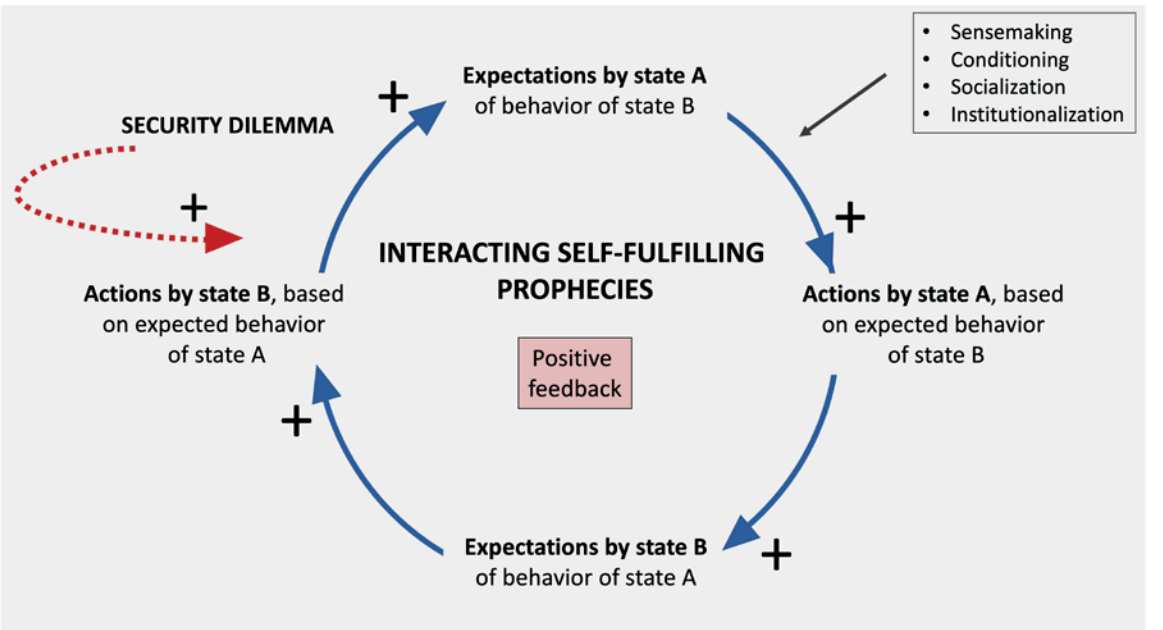


FIGURE 42.2: The workings of the ISFP-mechanism. Interacting self-fulfilling prophecies produce and shape issues in the contingent domain of the (State-)System that act as attractors around which tensions (entropy) 'crystallize'. The ISFP-mechanisms interacts with the security-dilemma; and the processes of sensemaking, conditioning, socialization and institutionalization also play their part.

42.6. Application (1): The purpose of ideologies and doctrines

Ideologies provide identity, purpose and direction to humans and societies, and are used to mobilize and focus societies/states. Ideologies provide also justification for the use of kinetic energy, and for the suffering and destruction that is consequently caused.
Ideologies, in combination with political and military doctrines, were indispensable for the sustainment and acceleration of the 1st FTS, during the transient period (1480-1945); the 1st FTS and supporting ideologies coevolved.

42.7. Application (2): Clausewitz's theory 'On War'

Clausewitz's theory 'On War' (22) is an example of the timely - and highly instrumental - introduction of a military doctrine, consistent with the increasing demands of the accelerating 1st FTS, (1480-1945). It shows how the contingent domain is shaped in accordance with the demands of the Second Law and related principles (the S-imperative).
Clausewitz's war theory is based on his observations and study of (especially) the Napoleonic wars (the 2nd systemic war, 1792-1815). Clausewitz emphasized the political nature of war - the subordination of war (KA) to political control - and by doing so contributed to the increasing totality of KA/war.
According to Clausewitz, "war is merely the continuation of politics (policy) by other means" (22). Clausewitz also stressed the necessity to destroy the enemy to ensure submission of the enemy (enemy states) to one's 'will' (political objectives).
Clausewitz's theory and related doctrines provided politicians and military strategists with the 'logic' to deploy the increasing levels of kinetic energy that were necessary to maintain the momentum of the 1st FTS. The requirements of the 1st FTS (1480-1945), the necessary mobilization of societies, and the ideologies and military doctrines that justified these efforts, coevolved and reinforced each other. Interactions between these 'variables' constitute a positive feedback mechanism.

42.8. Application (3): The School of Political Realism is a component of the ISFP-mechanism

The school of Political Realism is a component of the ISFP-mechanism that was - and still is - instrumental in shaping VC's and in justifying the use of kinetic energy, consistent with the demands of the FTS.
The school of Political Realism is at the heart of the security dilemma and interacting self-fulfilling prophecies. It provided (and still provides) societies and states, in combination with ideologies they developed, with the justification to prepare for KA/war and deploy kinetic energy. Representatives of the school of Political Realism do not leave much doubt about what international politics is about: International politics is about power, and its application.
Political Realism is a normative doctrine for decision-makers of states that provides clear instructions to ensure survival in an anarchistic system; at least that is their assumption. Morgenthau (54) and Kissinger (43) are representatives of the school of Political Realism. There is however nothing scientific about their ideas and dogmas.

These ideas shaped (and still shape) interactions between states and contributed to the build-up of tensions (entropy-production) in the (State-)System. Realist logic was also responsible for shaping interacting self-fulfilling prophecies between states. These interacting self-fulfilling prophecies ensured that states could always justify and make sense of their actions and reactions regarding other states.
Because of the rules that govern anarchistic systems and the mechanisms these rules produce, including the security dilemma and interacting self-fulfilling prophecies, Realist's logic never disappoints. If, for example, a state preventively deployed destructive power in response to a security issue with another state, its threat perception would be confirmed by the reaction of the other state. The target state, obeying the security dilemma and supported by 'its own' interacting self-fulfilling prophecies, would take adequate counter measures by also deploying preventive destructive energy. In an anarchistic System, preventive deployments of destructive power provoke reactions by other states that confirm the initial deployment.
During the unfolding of the 1st FTS (1495-1945), decision makers saw their worst assumptions always confirmed and considered their self-fulfilling experiences wise lessons for similar situations in the future, which further reinforced the Realist war-trap logic.
The Realist School, as well as Clausewitz (22), were products of the 1st FTS, and vice versa; they were (necessary) enablers for the accelerating 1st FTS. It was through these doctrines and dogmas that the dynamics of (State-)System connected with the decision makers who had to decide on KA/war. These theories did what they were supposed to do. The result shows humanity's unbounded flexibility and creativity for creating ideas and 'realities' that make sense justify behavior and policy (KA/war) decisions: The urge to survive is not only strong, but also creative.

42.9. Application (4): 'Great Men' in history

So, called 'Great Men in history', are in fact highly contingent individuals that share an ability to utilize entropy to their own advantage of to the advantage of the society/state they control/represent.
These 'great men in history' were (and are) not the cause of KA/wars they played (play) a prominent role in: KA/wars were/are produced and regulated by the FTS. The 'great men of history' put the ISFP-mechanism to their own - or their society's/state - use.
Morgenthau's (54) explanation for the Second World War (the 4th systemic war, 1939-1945), illustrates the simplistic, unscientific and sometimes reprehensible explanations the School of Political Realism is able to produce. Morgenthau argues, that "Chamberlain's politics of appeasement were, as far as we can judge, inspired by good motives; he was probably less motivated by considerations of personal power than were many other British prime ministers, and he sought to preserve peace and to assure the happiness of all concerned. Yet his policies helped to make the Second World War inevitable and to bring untold miseries to millions of people." As I show and explain in this study, KA was produced and regulated by the 1st FTS: The timing, duration etc. of the 4th systemic KA/war lie in the laws of thermodynamics and related principles that apply to the (State-)System.
Like its predecessors, a 4th systemic war was unavoidable and cannot be attributed to Chamberlain's politics, as Morgenthau suggests.
However, in the version that was produced of the (unavoidable) 4th systemic KA/war - the Second World War and its outcome, as we now know it - "great men" and probabilistic factors played a role.

42.10. Application (4): Mission creep: Collective deception in action

A military mission describes the objective for a military unit in a military operation; the mission specifies what objective(s) must be accomplished, in support of what purpose (goal) of a higher order. Mission creep refers to changes in the (initial) mission beyond its original goals.
I argue that 'mission creep' is a phenomenon that is closely related to our inability to predict war(dynamics), and are efforts to realign goals, missions and resources, etc. once predictions turn out to be inaccurate (as is in fact always the case). Missions must also be redefined to ensure the illusion of control and protect the credibility (and eventual the legitimacy) of decision-makers.
Various factors contribute to the unpredictability of (KA/war) dynamics:

- The interplay between deterministic and probabilistic factors, which can for example be observed at the bifurcation point in 1480, when the System selected a stable branch.
- The intrinsic unpredictability of chaotic non-systemic KA/war dynamics, because of the sensitivity to initial conditions of these dynamics during RSP's.
- The contingent latitude of the (System); i.e. the fact that different solutions (in the contingent domain) can satisfy demands of the Second Law and related principles; Georgescu-Roegen also refers to as 'entropic indeterminateness' (34).
- Our lack of understanding of the workings of the (State-)System, and our inability to identify underlying laws/principles and/or regularities that provide clues to identify these laws/principles.

Despite the unpredictability, decision-makers mostly act on the assumption that a war and its properties are highly predictable and can be managed.
Mission creep utilizes our ability for collective deception; the ability to (re-)adjust the interpretation of events to accommodate the actual state of affairs in a 'coherent story', that serves the H-imperative. The mechanism of interacting self-fulfilling prophecies is helpful in the adjustments process.
However, mission creep - the (re-)adjustment of the interpretation of events - has its limitations: The H-imperative has a certain latitude, the S-imperative has not.
Mission creep was for example 'applied' during the Vietnam War (1965-1975), the Iraq War (2003-2011) and War of Afghanistan (2003-2014).

43. Social and political volatility and radicalization

43.1. Introduction

In this study, I explain that entropy is the source of order in the (State-)System FFE; entropy is required to create and to maintain order. Entropy provides (new) possibilities that can be realized through the use of energy; this process involves selection.
In case of the (State-)System entropy - EMIS-flows - is regulated by dissipative structures, respectively the 1st (1480-1945) and 2nd FTS (1945-....) and through the H-imperative, in the contingent domain.
To function, social systems require an intermediate level of entropy: Too large amounts/levels of entropy result in too much disorder, while a lack of entropy - a shortage - results in over-structuring and a lack of adaptability.
In this chapter, I discuss the interplay between entropy/EMIS-regulation and social and political volatility in the contingent domain, and between entropy/EMIS-regulation and radicalization. Radicalization, points to 'over-regulation', the dysfunctional - unbalanced - application of the MEP-Principle, causing rigidity, extreme focus and the risk of (self-)destruction through the application of accumulated free (kinetic) energy.
The collapse of the European State-System in 1939, German society/state in the 1930's of the 20th century and the Islamic State, are examples of "radicalized" structures that became too low on entropy and consequently contained too high amounts/levels of free energy.

43.2. Social and political volatility

Social processes - exchanges and interactions between human individuals, but also between societies/states - are irreversible processes that generate entropy. Entropy is more than a 'byproduct', it is also a valuable (essential) source of order for e.g. societies and the (State-)System FFE.
During the transient period (1480-1945), entropy(-production) in the (State-)System was regulated by the 1st FTS, which involved four mutually supporting processes: The processes of KA, aggregation in the core (Europe), expansion of the core to the non-core and of empowerment.
As explained in this study, the behavior of the (State-)System - including of societies and states - was determined and shaped by competing thermodynamic potentials and their extremization; a process that was regulated by the 1st FTS.

The 1st FTS was accompanied by four accelerating cycles; each cycle consisted of a RSP, followed by a critical period; these cycles had identical life-cycles. The frequency and amplitude of these cycles (systemic KA/wars) increased, during the transient period, until - in 1939 - the European State-System collapsed. The 1st FTS (1480-1945), was instrumental in a phase transition with two closely related (complementary) effects: Full aggregation of the core (Europe, stage 3A) and the globalization of the State-System (the merging of core and non-core, and the simultaneous termination of the submission of the non-core by the core).

Not only became the European State-System increasingly unstable - volatile - over time (1480-1945), also during HCR's of cycles, the social and political volatility typically increased in the contingent domain, because of the accumulation of issues and tensions (entropy). During HCR's, entropy could no longer be effectively redistributed and neutralized through non-systemic KA/wars. The accumulation of entropy (tensions and issues) and an autocatalytic process during HCR's, 'powered' a process of nucleation of VC's and their percolation. Once the percolation was accomplished, the (State-)System was in a critical state, and the accumulated entropy was released - put to work - through systemic KA/war. The entropy and KA were used to upgrade the order of the (State-)System, to allow for a new RSP, and a new phase of growth and development. See figure 43.1.

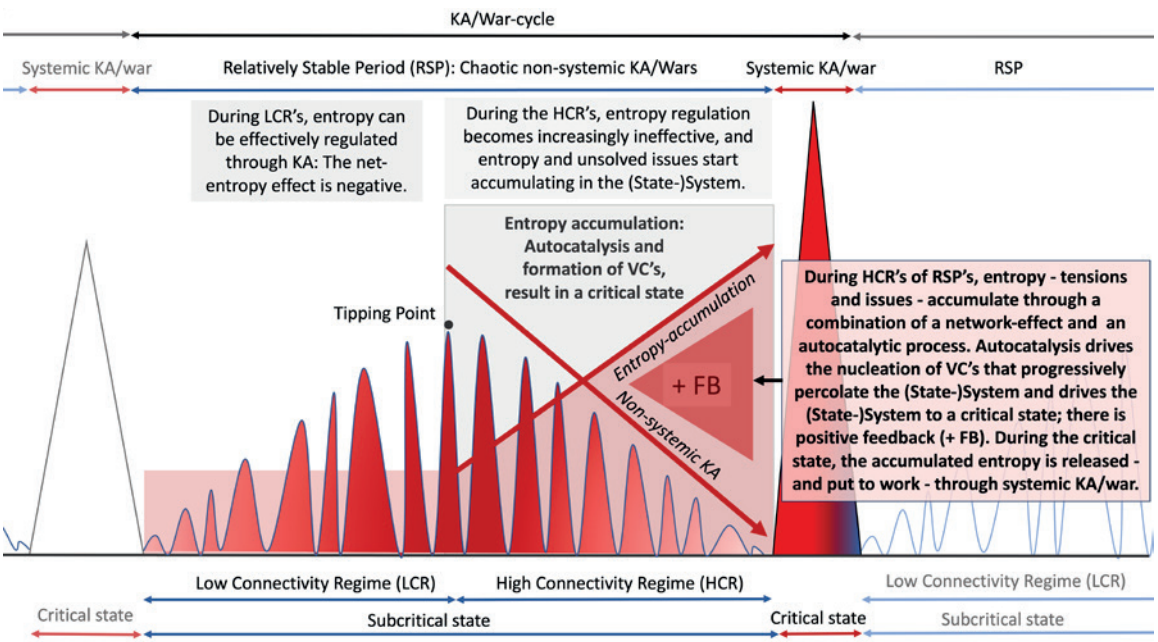


FIGURE 43.1: Accumulation of entropy during HCR's, due to reduced effectiveness of KA-regulation. The accumulation of entropy during HCR's also caused an entropy-influx in societies/states, which fueled social and political volatility in the contingent domain.

The reduced effectiveness of KA-regulation during HCR's - the regulation of entropy through non-systemic KA, during HCR's of RSP's - causes an influx of entropy - of tensions and issues - in societies/

states: The accumulating entropy searches for "a way out", so to speak. The influx of entropy (issues and tensions) contributes to societal anxieties and uncertainty, and consequently to social and political volatility. The influx of entropy poses challenges for societies/states. See figure 43.2.

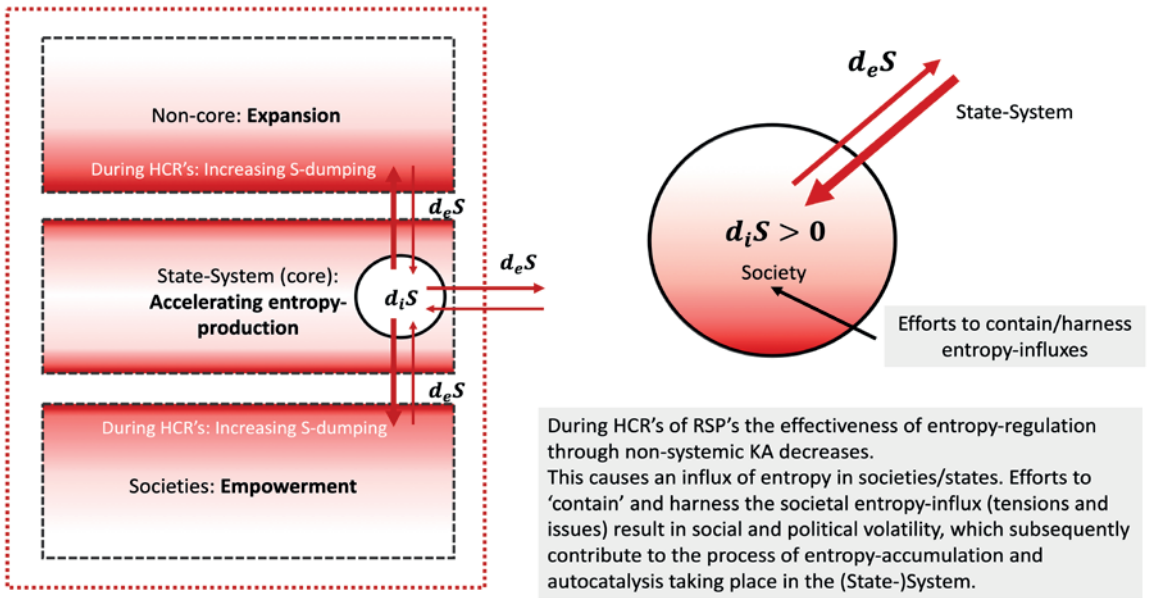


FIGURE 43.2: Increased entropy-input in societies. During HCR's there is "entropy-dumping" (S-dumping) from the State-System to societies/states and to the non-core.

The increased levels of entropy - tensions and uncertainty - in societies, trigger efforts by/in societies and states to contain and harness entropy(-production), and put the entropy to use, e.g. through political ideas and initiatives.

This state of affairs - high levels of entropy - make individuals and societies vulnerable for extreme ideas and radicalization. Not surprisingly, given the insights in the workings of the System discussed in this study, extremization of entropy(-production) in the (State-)System, goes hand in hand with increasingly extreme measures of humans and societies/states - e.g. contained in ideas, ideologies, etc. - to regulate these increasingly high levels of entropy they are confronted with. Efforts are made to ensure intermediate levels of entropy are maintained.

The current social and political volatility of/in the (State-)System and its components - including Brexit (an initiative to reverse an irreversible process, with the predictable effect of increased entropy(-production) at the expense of stability), increased populism, preference for authoritarian leadership, and trade-wars, etc. - are manifestations of increased entropy(-production), and of efforts to contain uncertainty; however, these measures are (predictably) counterproductive: There are no solutions, and (increasingly extreme) initiatives/actions only contribute to further accumulation of entropy and reinforcement of the autocatalytic process taking place in the (State-)System. Criticality is a matter of time.

43.3. Radicalization

Humans, societies and states must regulate entropy to ensure their viability/survival: The H-imperative is also instrumental in the regulation of entropy, as discussed in this and preceding chapters.

In the preceding paragraph, I explained the relationship between entropy(-production) - tensions, uncertainty, new possibilities, etc. - in social systems, and a tendency for radicalization - extremization - resulting from societal/state efforts to contain and harness high levels of entropy.

Application of the MEP-Principle to the State-System, the requirement for social systems to maintain an intermediate level of entropy, in combination with the accumulation and autocatalysis of entropy during HCR's of cycles, and the entropy-influx this causes in societies/states, results in a tendency for extremization of political ideas and solutions in the contingent domain.

The (State-)System is especially vulnerable for radicalization during HCR's of RSP's; HCR's provide fertile conditions for radicalization: Uncertainty (entropy) is countered with increasingly extreme solutions, because moderate solutions are no longer effective; but the effects are counterproductive, as mentioned. Entropy becomes a source of extreme order.

It is no coincidence I argue, that terrorist activity increased dramatically around 2011, when the current RSP (of the 1st global cycle) reached (according to calculations based on war-data) its tipping point, and the effectiveness of entropy-regulation through non-systemic KA started decreasing, as the development of the average size of non-systemic KA shows. See figure 43.3.

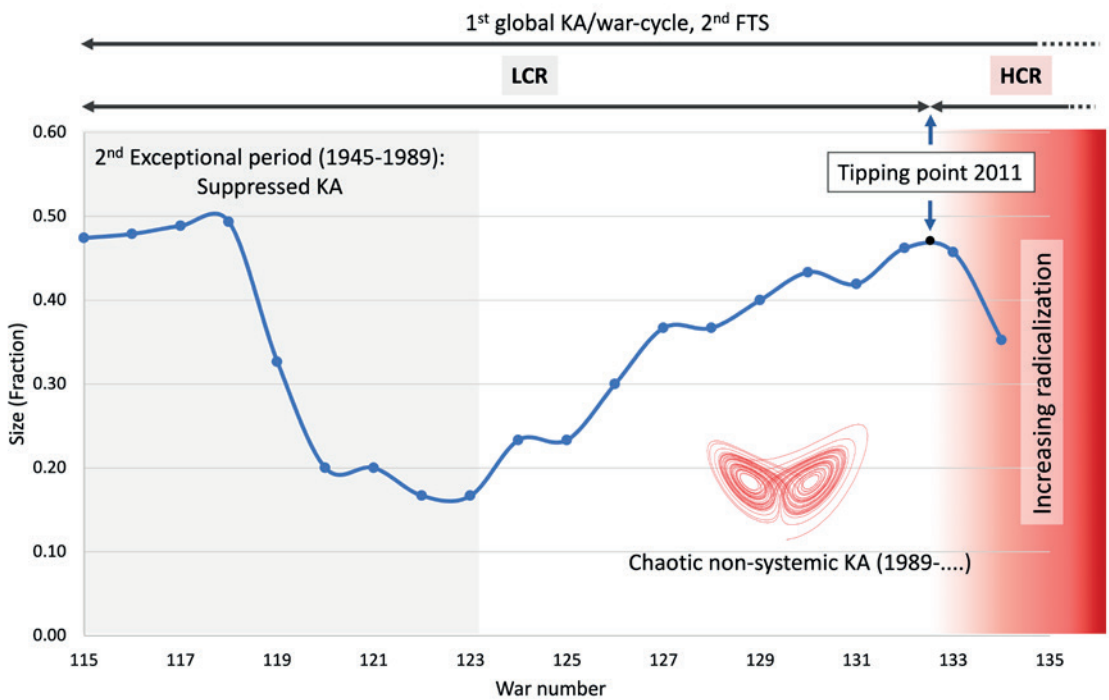


FIGURE 43.3: Decrease in the effectiveness of non-systemic KA/war regulation during the HCR (2011-....), of the 1st global KA/war-cycle of the 2nd FTS (1945-...).

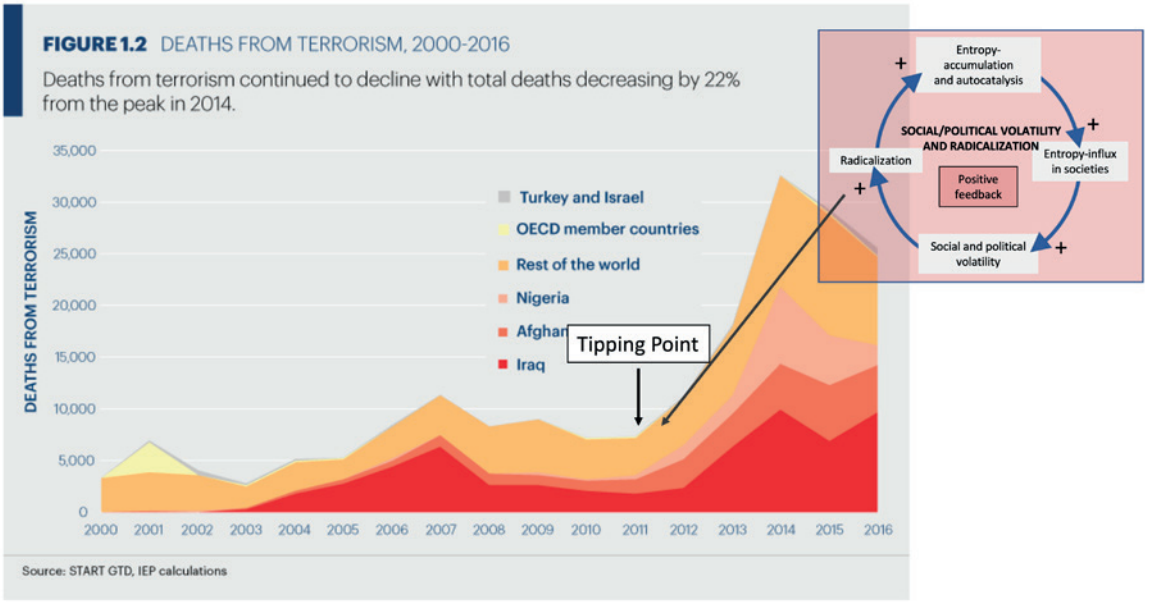


FIGURE 43.4: Increase in deaths from terrorism in 2011 (...). The increase coincides with the decrease in the average size of non-systemic KA/war in 2011. Further research is required (36, 85)

Terrorist activity can also be understood as explorative behavior of 'parts' in the contingent domain of the System that search for new solutions to exploit gradients, to ensure the fulfilment of their basic requirements (to be discussed later). See figure 43.4.

Radicalization - extremization of ideas and (inter)actions - results in a lowering of entropy for the social system (human, community or society) it concerns, and in a simultaneous increase in its free energy ($\boldsymbol{E} = \boldsymbol{F} + \boldsymbol{S}$).

Radicalization is equivalent with the 'squeezing out' of entropy, and 'symptoms' of radicalization include: Enhanced efforts for (information) control, decreased variety and diversity, standardization, isolation, intolerance (diversity is seen as a threat), utilization of 'attractors' to divert entropy and focus energy, simplified responses in efforts to reduce uncertainty, enforced subjugation, etc.

It is possible to measure the degree of radicalization, based on the criteria just mentioned, and to define a 'radicalization index' (R-index).

The process of radicalization has a tendency to reinforce itself, especially if it is continuously fed by the increasing production of entropy to which the radicalized ideas and related (inter)actions also contribute. The PDLI-mechanism also plays a role in this process. See table 43.1 and figure 43.5.

Radicalization - the reduction of entropy - goes hand in hand with an increase in free energy in the system, which can be utilized for particular purposes. Ideologies define/determine how the increasing amounts of free energy (potential) should be utilized.

TABLE 43.1: Symptoms of radicalization and related effects.

Symptom	Effects
Control	Regulatory capabilities of (for example) states are enhanced through more control (e.g. laws) and restrictions that are imposed.
Information control	Entropy is regulated, and ideas are shaped through information control (e.g. censorship). Information contains new possibilities that must be controlled in zero entropy - radicalizing - systems.
Variety, diversity, standardization	Reduction in variety/diversity, implies a reduction in entropy.
Isolation	Entropy-input (e.g. uncertainty and diversity) is reduced through isolation, e.g. through building walls.
Intolerance	Intolerance is a reaction to diversity and variety, which is seen/experienced as a threat.
Extremization of ideas/ solutions	More extreme/radical ideas are symptoms of efforts to reduce tensions/entropy; moderate ideas are no longer considered effective.
Ideologies	Ideologies are used to provide direction, define socially desirable behavior, and to provide justification. Ideologies also contribute to standardization.
Creation of attractors	'Attractors' - e.g. enemies or issues - are created to mobilize and focus attention and increasing amounts of free energy on. These enemies and issues are chosen and exploited to proof and support ideologies. The free energy that is created needs an "application".

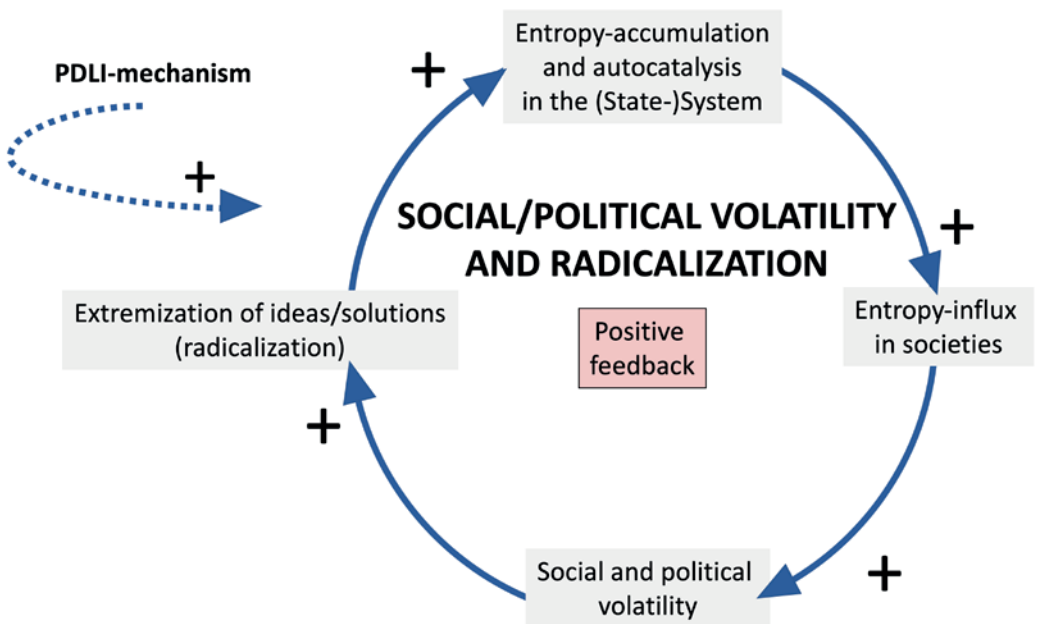


FIGURE 43.5: The self-reinforcing process of radicalization.

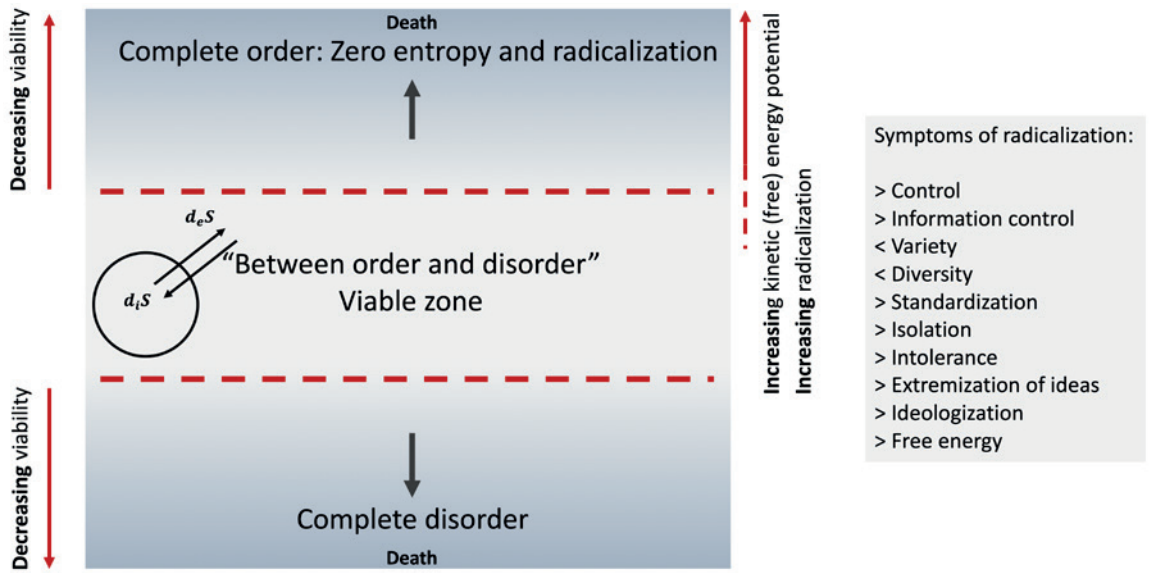


FIGURE 43.6: Radicalization: Symptoms and reduced viability

43.4. Application (1): Two types of death

Two types of 'death' can be distinguished, associated with dysfunctional levels of entropy: (1) Death - or malfunction and collapse - as a consequence of a shortage of entropy (and consequently of a shortage of new possibilities) and an overload of free energy, and (2) death as a consequence of an 'overdoses' of entropy, resulting in a shortage of order and structure. See figure 43.6.

Unrestrained radicalization causes the first type of death: Structure and order - and an overload of free energy - 'choke' the social system, and it can no longer adequately respond. Radicalization (of political and religious ideas), means that variety (entropy) is pushed out of the system; radicalization is equivalent with standardization and a reduction in entropy. Extreme radicalization - intentionally or unintentionally - reduces the ability to adapt, while at the same time the free energy is maximized, but this energy can only be put to use for a singular objective (more control, to reduce entropy).

The social system in question runs out of options and is no longer able to respond effectively to new possibilities and changes; consequently, the homeostatic imperative can no longer be satisfied, and regulatory structures are undermined. Collapse is unavoidable, and when collapse takes place, the accumulated (and maximized) free energy is released.

43.5. Application (2): Death of the European State-System

During the transient period (1480-1945), successive orders that ensured stability during RSP's collapsed, respectively in 1618, 1792, 1924 and in 1939, and triggered systemic kinetic responses (KA), which were used to upgrade the order of the (State-)System. The (final) collapse in 1939, triggered the (final stage) of the phase transition (1480-1945).
In all four cases, entropy had accumulated in the (State-)System, but could at a certain point, not be effectively regulated through non-systemic KA.
The collapse of the European State-System can be considered a 'death' - a collapse - caused by the squeezing-out of viable options, caused by the State-System's radicalization; a combination of zero entropy and maximum free energy.

43.6. Application (3): Some examples

The development - radicalization - of German society/state, during the 4th RSP (1918-1939), a process that became orchestrated/controlled by the German state, is an illustration of the squeezing out of societal entropy - to near zero - and the simultaneous increase in free energy; in kinetic (military) capabilities.
During the 1930's, the German state increasingly tightened its control - including information-control - over German society, and variety and diversity - including racial variety and diversity - were minimized, there was a program of "social standardization", and 'enemies' - attractors - were introduced to generate (more) entropy and focus free energy.
These processes were shaped and justified by a fascist ideology. The decrease in entropy in German society went hand in hand with an increase in kinetic potential, military capabilities, and the reinforcement of borders (barriers) to reduce entropy-input. The German society became subject to absolute control.
Presently, in the United States, tendencies toward radicalization can also be observed: Ideas to build walls, the decoupling from international institutions, disqualification of the media and disqualification of certain populations, can be considered efforts to minimize entropy in American society. This results in increasing political and social volatility, and the question is if the political system - which is in some respects (already) dysfunctional - can maintain viable levels of entropy. Also, in the United States, efforts to decrease entropy go hand in hand with the increase in kinetic (military) capabilities.
This is typical 'HCR-behavior', social systems are more prone to radicalization once the tipping point of the RSP is reached: While president Trump did not make any change as a presidential candidate in 2012, in 2016, entropy levels - uncertainty and tensions - in American society and the (State-)System were much higher and provided a fertile soil for Trump's more extreme ideas and 'solutions'. The American electorate expected that these more extreme ideas could contain uncertainty.
North-Korea and the Islamic State (IS) are examples of respectively a zero-entropy state and a zero-entropy community with a global reach. IS successfully exploited increasing instability in the (State-) System and higher levels of societal entropy, and used social media, etc. to promote its radical ideas and solutions.

Zero-entropy systems - including zero entropy/radicalized human individuals - are doomed to fail, if they cannot reverse the self-reinforcing dynamics, they produce. At a certain point, their entropy-level becomes too low, and their free energy-level simultaneously too high; this results in self-destruction, mostly also at the expense of their respective environments.

In their efforts to survive, these systems are forced to isolate themselves from there environment to stop/reduce entropy-input (e.g. North Korea), and/or to undertake radical initiatives to reshape their environments, in accordance with their radical requirements. Germany's aggressive expansion during the late 1930's and 4th systemic war (the Second World War, 1939-1945), and IS's aggressive expansion (through a combination of terrorist activity, 'promotion' of their ideology and by territorial control) can be understood as necessary initiatives to acquire control over their respective environments, and to find "outlets" for their increased levels of free energy. See figure 43.6.

In case of Germany and IS, the accumulating free energy (kinetic/military capabilities) - which accumulated hand in hand with the decrease in entropy - was used to maximize internal control and to reshape and control their respective environments.

What North Korea's response eventually will be, is at this stage not yet clear, but application of the accumulated free energy (kinetic capabilities) is a possible scenario, if the drive to zero-entropy cannot be reversed.

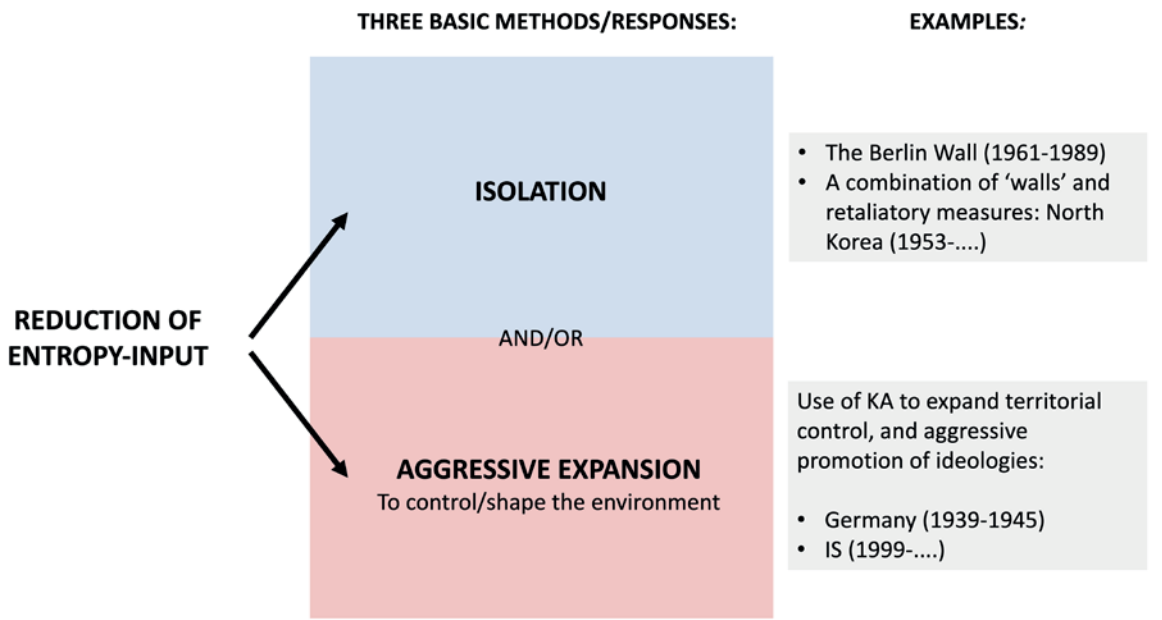


FIGURE 43.7: Three basic methods to respond to entropy-input that reinforce radicalization tendencies.

43.7. Application (4): Radicalization of individual humans

The process of radicalization of individual humans, is not fundamentally different from the process of radicalization of communities and societies. Individual humans must also regulate entropy(-input) - new possibilities, uncertainty, anxiety, etc. - and assess if new possibilities pose threats or opportunities.
Identical mechanisms are involved in the process of radicalization of individuals e.g.: The use of ideologies, selective input and interpretation of information, isolation, reduced tolerance, etc.

43.8. Application (5): Democracy and entropy-regulation

Various systems of governing exist: Democracy, oligarchy and autocracy (96). It is not the aim of this paragraph to discuss these forms of government in detail, but to point to the fact that each form of government has a certain capacity for EMIS-regulation; to assess and select new possibilities that present themselves to/in societies and e.g. to effectively deal with (the potential for) disorder and uncertainty. Different forms of government are more or less vulnerable for radicalization.
In case of democratic governance, citizens exercise power by voting. "According to American political scientist Larry Diamond, democracy consists of four key elements: A political system for choosing and replacing the government through free and fair elections; the active participation of the people, as citizens, in politics and civic life; protection of the human rights of all citizens; a rule of law, in which the laws and procedures apply equally to all citizens" (96).
"Oligarchy, meaning "rule of the few", is a form of power structure in which power rests with a small number of people. These people might be distinguished by nobility, wealth, family ties, education or corporate, religious or military control. Such states are often controlled by families who typically pass their influence from one generation to the next, but inheritance is not a necessary condition for the application of this term" (96).
"Autocracy is a system of government in which supreme power (social and political) is concentrated in the hands of one person or polity, whose decisions are subject to neither external legal restraints nor regularized mechanisms of popular control (...)" (96).
In case of democracy, the state and society are 'fully' integrated, and society is actively involved in the EMIS-regulation by the state: Continuity and change are 'balanced'. Through elections citizens have a vote in choices that are made. e.g. concerning the direction of development of their society and state. Democracy requires active involvement of citizens.
But - as Germany showed in the 1930's of the previous century - democracy is not a guarantee.

44. Social development and evolution

44.1. Introduction

In this chapter, I elaborate on social evolution and development, by building on some ideas discussed in the previous chapters; as discussed, nonlinear dynamics, nonequilibrium, fluctuations, bifurcations and symmetry breaking are closely related to diversification and evolution and are a prerequisite for complex behavior.
Symmetry-breaking also is a prerequisite for information (a, 74).
The aim now is to identify the main characteristics of the (process of) social evolution and development of the (State-)System.
To identify these characteristics, I make use of patterns (regularities) that can be perceived in the (development) of the structure of the System and its components (16), as discussed in this study, and of concepts from evolutionary biology. As I explained, the System shows some remarkable similarities with simple biological organisms.

44.2. Different laws of evolution in case of far from equilibrium (FFE) systems

Prigogine et al. have demonstrated "that there exists a class of thermodynamic systems which exhibit two completely different types of behavior: In some circumstances the expected tendency toward maximum disorder, but in others the spontaneous appearance of qualitatively new states of matter which exhibit a high degree of organization in space, time, or function. The coherent behavior of such macroscopic states is precisely that which characterizes living systems (...) (72)". Contrary to equilibrium and near-equilibrium systems, under far-from-equilibrium conditions; nonequilibrium constraints and irreversible processes can become a source of order. This constructive role of irreversible processes manifests itself in the form of dissipative structures, of coherent behavior arising beyond an instability point of a less-ordered state, FFE (72). Several prerequisites must be met by a system to produce dissipative structures: "They are open to exchange of energy and matter with their surroundings, the interactions among the various "units" are nonlinear (e.g., catalytic), and they operate under far-from-equilibrium conditions" (72). In this study, I have explained that the System produced a first dissipative structure in 1480, - the 1st FTS - that was instrumental in a phase transition during the period 1480-1945 and resulted in a 2nd FTS (1945-...) at a global scale.

The laws of evolution that apply to far from equilibrium (FFE) are different from that of equilibrium systems, e.g. they are both deterministic and stochastic (4). The nature of these different laws is closely related to the social evolution and development of the (State-)System and their constituencies. The symmetry-breaking property of the 1st FTS - the patterns in space and time it produced - can be considered the first link of the System to an 'organized' process of social evolution and development that involved multiple societies/communities.

44.3. The essence of evolution

"Evolution is governed by the laws of physics and in particular the laws of thermodynamics" (20). Arguably, utilization of opportunities far from equilibrium conditions (can) offer to biological and social systems, is the essence of evolution, from a thermodynamic perspective; as discussed in this study: "When the second law of thermodynamics operates in non-equilibrium dynamical settings construction of order is possible" (20). As discussed, the FTS initiated the same developments that can be observed in growing and developing biosystems: An increase of the total dissipation, the development of more complex structures with more energy flow, an increase in cyclic activity, and the development of greater diversity and more hierarchical levels (A2).

Through dissipative structures, biological and social systems "are able to circumvent locally and temporarily the normal entropy process by absorbing available (free) energy from their surroundings" (20) and can utilize two contradicting tendencies of thermodynamic conditions FFE: A tendency for homogenization and a simultaneous tendency for differentiation.

Social evolution consists mainly in the filling of empty niches by mutation and complexification, these contradicting tendencies produce.

Chaisson argues (20), that complexity itself "is insufficient to demonstrate the direction of evolution, at least not biological evolution" (20), and that the direction of (cosmic) evolution seems to obey the 'basic maxim' that "the collective efforts of living organisms tend to utilize optimally (per unit volume or mass) both their energy intake and their use of free energy by dissipative (dispersive) processes occurring within them. It is in this sense that biological evolutionary events have some temporal direction" (20).

According to Chaisson, "Organized systems of a physical, biological, or cultural kind everywhere apparently optimize (per unit volume or mass) the flux of energy passing through them. By "optimum" is meant an intermediate range in energy flow, below which the energy flow is too small to affect order, and above which is so large as to destroy order"

By utilizing niches, social (and biological) systems can secure adequate EMIS-regulation. In case of social systems, the tendency for homogenization is subject to the S-imperative, whereas the tendency for differentiation is subject to the H-imperative; each tendency comes with its own "rule-set", so to speak. In case of the (State-)System, the FTS reconciles both tendencies.

Through the reconciliation of the two tendencies by the FTS, at the level of the (State-)System, and the opportunities for niche-utilization that are created as a result for societies/states, societies/states have some latitude for their "own" evolution and development (within constraints) and can (also within certain constraints) sustain their own EMIS-regulation.

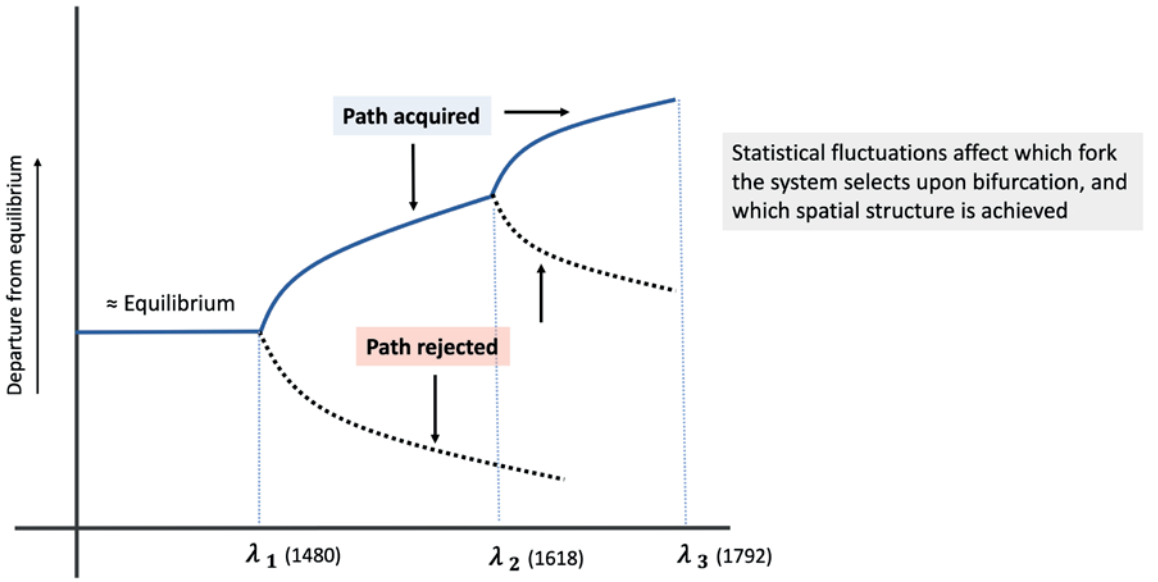


FIGURE 44.1: Selection of a path in phase space. In 1480, the System produced a bifurcation and a dissipative structure - the 1st FTS - emerged. The 1st FTS can be considered a vehicle of social evolution and development: "The fact that only one among many possibilities occurred gives the system a historical dimension, some sort of "memory" of a past event that took place at a critical moment and which will affect its further evolution" (65). Given the selection of a particular branch, the chosen trajectory is then stabilized through the selection of kinetic events (KA/wars) and social interactions (65), a process that is "orchestrated" by the FTS.

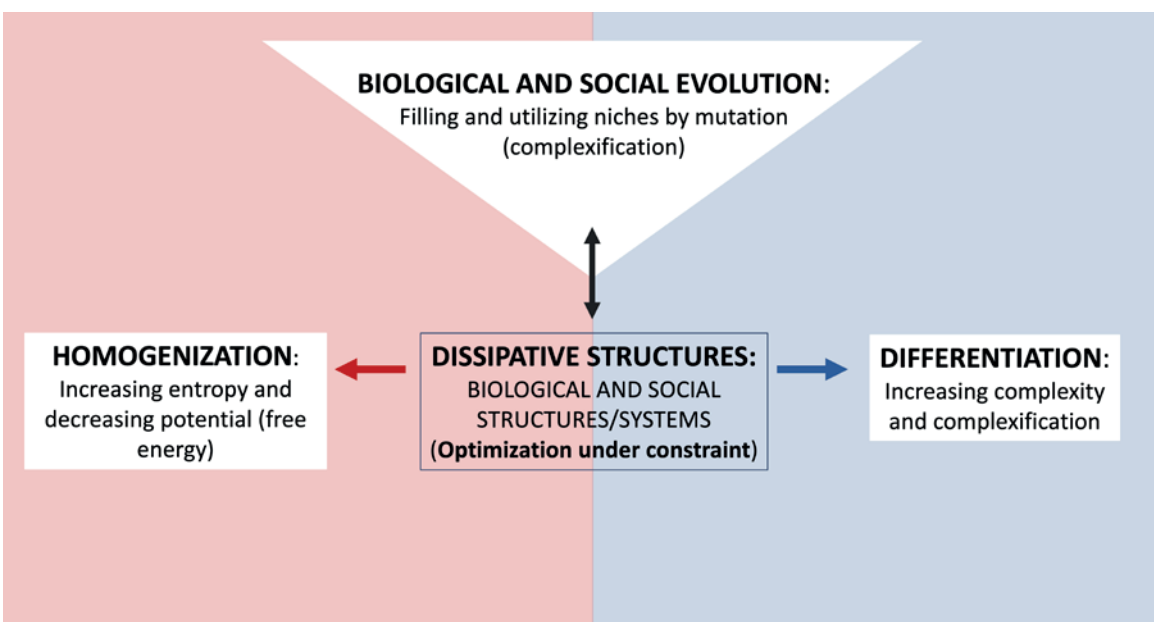


FIGURE 44.2: Schematic representation of the process of biological and social evolution.

The (processes of) sustainment and evolution/development of the FTS and State-System (the structural component of the FTS), and of its components (societies/states), are complementary; there is mutual dependence.
During the transient period (1480-1945), the process of evolution and development - the process of innovation - of/in the (State-)System and its components, accelerated continuously. Through accelerating entropy-production in the (State-)System, the availability of enough opportunities was ensured.
Although, there is a fundamental resemblance between biological and social evolution (see also figure 44.2 and 44.3) - in both cases evolution consists mainly in the creation and utilization of niches by mutation (complexification) - there are also some (fundamental) differences: In case of social evolution, niche expansion is accomplished through the invention and production of artifacts (16). Artifacts include material artefacts, organizational structures and social artefacts (like cultures as defined by Damasio (25)) (16). Contrary to prehumen biological systems, humans can cooperate and utilize (decoupled) information. These typical human traits (properties) allow for the creation and utilization of (new) niches that can also be collectively explored and exploited. In the process, the mechanism of "novelty by combination" works as a multiplier.

44.4. Niche construction

The creation and utilization of niches - the process of innovation - is also essential for social evolution. "Niche construction occurs when an organism modifies the functional relationship between itself and its environment by actively changing one or more of the factors in its environment either by physically perturbing these factors or by relocating to expose itself to different factors" (57).
Because of their ability to utilize decoupled information, to communicate, and to cooperate, have humans an exceptional ability for niche construction. Social selection and the ability for niche construction - to create and exploit variety, the ability to innovate - are arguably closely related; the ability for niche creation determines the ability to fulfill basic requirements, to ensure a certain well-being and to survive. Social fitness can be defined as the ability social systems to sustain niche construction, which requires an ability to command energy sources (20) and select opportunities (contained in entropy).

44.5. Increasing energy expenditure of the (State-)System

Chaisson (20) shows that the exponentially increase of the free energy rate density (Φ_m) is a property of a variety of inanimate and animate objects and systems in the Universe (20); it seems, that the (State-) System is no exception. According to Chaisson, "rising energy expenditure per capita has been the hallmark of cultural evolution"; culture must be understood in this context as defined by Damasio (25).
Chaisson observes: "... the increasing expenditure of energy has been an important factor in the emergence and development of humankind (20); cultural evolution occurs when societies alter their organizational posture in response to changes in the flow of energy through them, for it is increased organization that helps dynamically stabilize a far-from-equilibrium society" (20). According to Chaisson: "These increases in Φ_m values have been evolutionary, competitive processes in which selection has once again played a role (20) people elected to concentrate their energy for greater efficiency", (...) and

luxuries eventually became necessities (20). "Rising energy expenditure per capita has been the hallmark of cultural evolution (20)" and this fact "conforms to the widely observed principle of natural selection and the second law of thermodynamics (...)" (20).

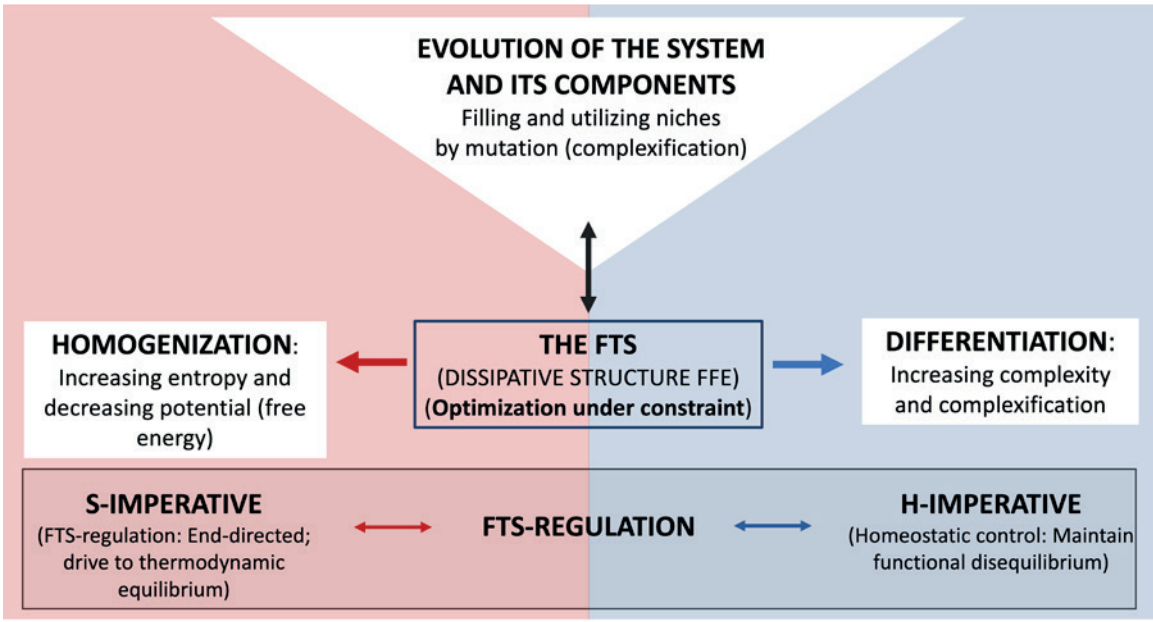


FIGURE 44.3: Schematic representation of the process of social evolution and development of the System and its components.

Societies are voracious users of energy (20), and energy-flows were (and still) are regulated and sustained by the FTS. If the Φ_m cannot be maintained the pace of evolution and development in the contingent domain of the System - also necessary to sustain the population and ensure a certain well-being - (generated by the FTS) cannot be sustained.

According to Chaisson: "(...) all organized entities exist uneasily "on the edge" (...) it is "their dynamic steady-states that act as sources of innovativeness, creativity, and the very way that systems take advantage of chances to advance steadfastly along the scale of complexity" (20). The (State-)System needs disequilibrium and entropy- and energy-flows to maintain order, and to evolve and develop.

44.6. Aspects of social evolution of the (State-)System

This study shows that various aspects - factors and conditions - determine and shape the process of social evolution of the (State-)System. See table 44.1; factors and conditions are arranged in random order.

TABLE 44.1: Aspects of social evolution. In this table the most important aspects - factors and conditions - that determine and impact on the social evolution and development of the (State-)System are summed up. Some of these aspects will be discussed in more detail in paragraph 44/10.

Aspect	Explanation
Basic sources	The availability of Energy (***E***), Matter (***M***), Information (***I***) and entropy (***S***).
Basic laws	• Thermodynamic laws; • Related principles that apply; Which are included in the S-imperative.
Shapers/ determinants	• Dissipative structures; • Initial conditions; • Distance from equilibrium; which e.g. determines what thermodynamic principles apply, the (potential) gradient-richness of the (State-)System, and the strengths of forces and flows in the (State-) system; • Gradient, forces and flows, S/T-field • Irreversibility and the arrow of time; • Hysteresis; • History; • Bifurcation and critical points; • Barriers and activation energy; • Symmetry-breaking; • The free energy rate density (***Φm***) of the (State-)System and complexification; • Thermodynamic principles that apply to thermodynamic states of (parts) of the (State-)System; • End-directed evolution to thermodynamic equilibrium of the State-System, via the most efficient path, in the deterministic domain; • Open-ended evolution in the contingent domain; • Energetic (un)favorability of processes/interactions; • The interplay between probabilistic and deterministic factors; • The number of degrees of freedom of the State-System, which determines e.g. (balance) mode-coupling and (consequently) the performance of the FTS to balance continuity and change in the (State-)System; • Optimization under constraint; • The net-entropy effect (positive or negative), which determines the effectiveness of KA-regulation, during RSP's; • Availability of contingent latitude; • The H-imperative (homeostasis); • The rate of entropy-production; • The degree/amount of entropy in the (State-)System; • Acceleration, pace of life (PoL).
Processes	• Dissipation (to sustain the FTS/dissipative structure); • (FTS-)regulation; • Mixing; • Autocatalysis; • Criticality; • Phase transition; • The regulatory processes of: KA, aggregation (of the core), expansion (to the non-core), and empowerment of subsystems.
Mechanisms	• Mode-coupling; • A network-effect, resulting in increasing local stability, during HCR's of RSP's; • Dominant feedback-structures; e.g. the self-reinforcement of innovation(s); • PDLI-mechanism; • PBMP-mechanism; • Novelty by combination; • The release-ratios of cycles.

44.7. Minimum conditions to sustain evolution and development of the (State-)System

For social evolution and development of the (State-)System to proceed at the current pace, a number of preconditions and requirements must be met; if these requirements are not met, the process of social evolution and development (1) will be delayed, and/or (2) comes to a halt, and/or (3) human artefacts that depend on a functioning dissipative structure (the FTS) will (partially) collapse.
I consider the sustainment of the 2nd FTS (1945-....) critical for the sustainment of the coherence of the current global (State-)System, and for the (pace of the) process of social evolution and development of the (State-)System and its components.
If it is desirable to sustain the 2nd FTS (1945-....) - given the increasing KA it produces and the unavoidable destruction of the new (global) core, it will eventually cause - is another matter, I discuss in the next chapter.
The question what preconditions and requirements must be met to sustain the evolution and development of the (current) (State-)System, boils down to the question what is required to sustain the 2nd FTS.
This study shows, that in order to sustain the 2nd FTS, two main requirements are critical: (1) *Sustained EMIS-flows* and (2) *sustained EMIS-regulation*; these requirements are closely related.
The requirement "*sustained EMIS-flows*" means that entropy-production in the (State-)System must continue to accelerate, and that enough free energy is made available and utilized. If EMIS-flows are sustained, the FFE-state of the (State-)System is ensured (and vice versa) and that a certain set of thermodynamic principles applies (e.g. the MEP-Principle that ensures that the State-System is pushed to zero entropy). Sustainment of EMIS-flows requires continuous EMIS-exchanges with (suitable) environments.
The requirement "*sustained EMIS-regulation*" means that the regulatory performance of the FTS is sustained, which requires it can periodically upgrade its order, in accordance with the demands of the Second Law and related principles that apply; this can only be accomplished if non-systemic KA/wars during RSP's of cycles is chaotic in nature.
As this study shows, for non-systemic KA/wars to be chaotic, the number of degrees of freedom ($\boldsymbol{n}$) must be greater than two ($\boldsymbol{n} > \mathbf{2}$). If this is not the case, (1) phase space cannot be adequately explored, (2) the network-effect will not be activated, (3) entropy-accumulation and autocatalysis cannot take place, (4) fractal VC's cannot form (implying that divergence of the correlation length of VC's cannot be achieved) and (5) not percolate the (State-)System, and (6) the (State-)System cannot become critical to ensure its order can be upgraded. In case non-systemic KA is non-chaotic ($\boldsymbol{n} \leq \mathbf{2}$) in nature - as was the case during the exceptional periods - the development of the FTS and (State-)System is interrupted.

44.8. Institutionalization of thermodynamic potentials and stability conditions

Thermodynamic potentials and stability conditions can be considered evolutionary conditions that are conducive to social evolutionary processes. See figure 44.4.
For example, during RSP's, when the minimization of entropy(-production) applies, our (inter)actions in the State-System are focused on maintaining stability and the status quo; policies (arms control measures), meeting structures, etc. are initiated by the minimization of entropy-production principle.

However, the moment the System becomes critical and produces a systemic war, the maximization of free energy principle applies, and we immediately, adjust our (collective behavior): All our efforts are now directed at maximizing the available military capabilities (free energy) and at deploying these capabilities as efficient as possible. The deployment - distribution of these capabilities takes place through highly optimized fractal military organizations.

We (collectively) obey these principles, without much thought, so to speak. The H-imperative keeps us focused on well-being and survival. The thermodynamic potentials and stability conditions are embedded in our culture (culture as defined by Damasio) and institutionalized (in social structures and policies) by the H-imperative. Through these mechanisms we can very flexibly - 'immediately' - switch from non-kinetic behavior when the minimization of entropy-production principle applies, to the collective use of KA, the moment the maximization of free energy principle takes control. The FTS not only put energy and entropy (EMIS) to use, but also our (human) flexibility. The societies, the System and FTS are a product of human behavior, but also vice versa.

PHASE II	Thermodynamic potential
System (core and non-core)	Maximization of entropy-production
European State-System (core)	Minimization of entropy(-production)
Critical periods	Maximization of free energy

PHASE III	Thermodynamic potential
System (global)	Maximization of entropy-production
Global State-System	Minimization of entropy(-production)
Europe (former core)	Minimization of free energy, maximization of entropy

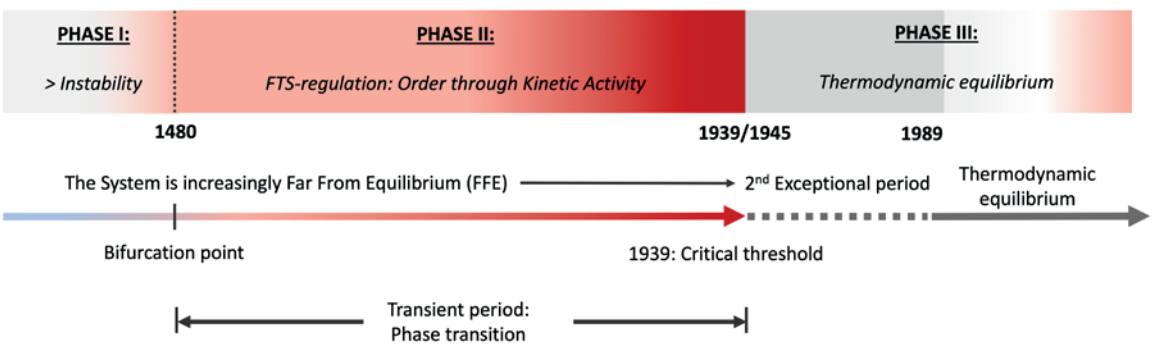


FIGURE 44.4: A change in thermodynamic potentials. The 1st FTS was instrumental in a phase transition of the (State-)System (1480-1945). The transition required for a change in the institutionalized thermodynamic potentials and stability conditions. During the transient period (1480-1945), through a process of social evolution and development regulated by the 1st FTS, were thermodynamic potentials and stability conditions (related to FTS- and kinetic-regulation) institutionalized in the (State-)System and in societies/states. Certain norms and (social) roles of/in societies, related to FTS-regulation were embedded within societies as a whole and in organizational structures: "Armies" and related regulatory structures (under control by states) can be considered embedded thermodynamic potentials, that are activated under specific conditions, regulated by the FTS. The United Nations order (1945-....) - an example of the embedding of thermodynamic potentials concerning entropy-regulation during RSP's - can be considered the manifestation of the MEP-principle in the (State-)System, during RSP's. The phase transition of the European State-System to thermodynamic equilibrium required the destruction of the "institutions" (including of embedded norms in societies/states) that were associated with FTS-/KA-regulation of/in the core, during the transient period (1480-1945), and the replacement of these "FTS-institutions", with norms and specific institutions associated with homeostatic control.

44.9. Application (1): "Evolution under strict constraints"

The process of social evolution and development of the (State-)System and its components (including of societies/states) is constrained by demands of the Second Law and related principles; i.e. the "template" - the straitjacket - that is imposed by the FTS and the State-System (which is the structural component of the FTS) on the System, and on societies and states: The FTS ensures - in accordance with the Second Law and related principles - that the State-System accomplishes thermodynamic equilibrium, via the most efficient path. Within this template - these constraints - there is a certain contingent latitude; a certain latitude the H-imperative can exploit e.g. by the creation and utilization of artifacts.
Besides the Second Law and related principles, other mechanisms - like the PDLI- and PBMP-mechanisms - also shape the process of artifact creation and exploitation.
The constraints on the (State-)System are very powerful, as the effects of for example the MEP-Principle during the transient period (1480-1945) show: Through the MEP-Principle, the European State-System was driven to zero-entropy, which subsequently caused the European State-System's collapse. That humans and social systems are then able to utilize the systemic KA/war that is triggered, shows the ingenuity of the human species and the Second Law and related principles.

44.10. Application (2): Some factors and conditions explained.

See table 44.2: Some of the aspects and conditions named in table 44.1 are discussed in more detail in this paragraph.

44.11. Application (3): 1480: A fundamental change in the purpose of KA (war)

The moment a dissipative structure - the 1st FTS, an organized state FFE - emerged in 1480, - the nature of KA/war (dynamics) changed fundamentally: KA/war dynamics were no longer without structure and without a clear 'overarching' purpose, but became instrumental in sustaining the 1st FTS, to ensure thermodynamic equilibrium of the European State-System was accomplished via the most efficient path. In 1480, KA had become system-behavior, to which societies and states were subjugated.
The (superimposed) FTS had its own purpose (logic): To find the most efficient path to thermodynamic equilibrium in the core (European State-System) and the 1st FTS consequently imposed a template for social development and evolution on societies. The 'template' shaped the processes of KA (war), aggregation, expansion and empowerment.
The FTS - the template - also 'shaped', which entropic perturbations (issues in the contingent domain), would be amplified (involving interaction between the perturbation/issue and the S/T-field), involving a combination of probabilistic and deterministic factors. The 1st FTS was - and the 2nd FTS now is - the ultimate arbiter in the System.

TABLE 44.2: Thermodynamic "mechanisms" and their impacts.

No.	Basic thermodynamic mechanisms	Effects/impacts
1	The Second law of thermodynamics	Entropy always increases. **Entropy is a source of innovation, order, but also disorder**. To maintain a certain level of order in a social system FFE, entropy must be exchanged with the environment. Energy must be put to use to accomplish work (create and maintain order). Expansion from the core (Europe) to the non-core is an effect of entropy-production in the core. The core (Europe) could not evolve/develop without a suitable environment. More entropy(-production) requires more regulation.
2	Irreversibility of processes and the arrow of time	Because of the irreversibility of social processes, is the structure/organization of the System different at each moment of time and is the evolution/development of the System 'time oriented': **Time has a forward direction** ('to the future'), this is also referred to as the arrow of time. "Reversible processes do not know any privileged direction of time" (65).
3	Regulation	To create and maintain organization FFE, **entropy (EMIS-flows) must be regulated**. From 1480 onwards, this resulted in organized KA, and processes of aggregation, expansion and empowerment in the System.
4	Acceleration	Accelerating entropy-production, **accelerates the FTS**, to ensure a certain level of order is maintained.
5	Increasing complexity (complexification)	Accelerating entropy production, the utilization of entropy to maintain a certain order and the need to ensure the fulfilment of basic requirements of societies/states and their constituents, drives **innovation and novelty by combination**.
6	Initial conditions	Different initial conditions will place the System in different basins of attraction. The (initial) conditions when the System bifurcated to an organized state (1480), also determined to solution - branch - that was chosen. **The initial conditions impact on the 'choice' involved in a bifurcation, the trajectories for further evolution and development that were consequently available, and to a certain extent how history could and would be shaped**. The initial conditions co-determined the properties of the dissipative structure (the 1st FTS), e.g. the fact that the FTS was accomplished by four accelerating cycles, the rate of acceleration, and when the critical point, would be reached, assuming the FTS would not be disturbed. Initial conditions also impact on the chaotic dynamics: By definition are chaotic dynamics very sensitive for the initial conditions of the System (during RSP's), and this sensitivity explains the intrinsic unpredictability of chaotic non-systemic KA during RSP's.
9	Mixing	Mixing, e.g. accomplished through aggregation results in **an increase in entropy and entropy-production** in the System.
10	Volume increase	A volume increase, accomplished through expansion from the core (Europe) to the non-core, during the transient period (1480-1945), resulted in an **increase in entropy and entropy-production** in the System.
11	Thermodynamic potentials	During the cycles that accompanied the 1st FTS during transient period (1480-1945), different thermodynamic potentials were extremized during RSP's and critical periods of these cycles. This mechanism - **the close relationships and interplay between thermodynamic potentials and 'behavior'** (e.g. amount of KA) - explains the fundamental differences of behavior, between: (1) The periods before 1480, during the transient period (1480-1945), and the period when thermodynamic equilibrium was achieved in the former core (Europe, > 1945), (2) RSP's and critical periods of cycles during the transient period (1480-1945), and (3) homeostatic regulation and FTS-regulation that highly depends on the use of kinetic energy (KA) for to produce/create order out of entropy, and to ensure its regulation.
12	Lowest energy state	The System tries to lower its energy state. e.g. through establishing **upgraded orders**.

TABLE 44.2: Continued.

No.	Basic thermodynamic mechanisms	Effects/impacts
13	Autocatalysis	At a certain point during RSP's - the tipping point of the RSP - the net-entropy-effect of non-systemic KA/wars becomes positive: More entropy is added through KA (it is an irreversible process), than is effectively neutralized/redistributed. Entropy starts accumulating and there is autocatalysis (**tensions and issues create more tensions and issues**, that feed on each other). The (State-)System becomes critical.
14	Nucleation	The process of autocatalysis during RSP's is accompanied by **a process of nucleation of issues and tensions** (entropy) in VC's that increasingly become connected and eventually percolate the (State-)System.
15	Critical point of RSP's	When eventually during a RSP VC's percolate the (State-)System, the (State-)System becomes critical and the accumulated entropy triggers **a massive (system-wide) kinetic response (systemic KA/war)**. The critical condition - the divergence of the correlation length - allows for an upgrade of the order of the System.
16	Critical point of the State-System (1939); critical connectivity threshold	The FTS - the State-System - also has a critical point; the point when the FTS reaches the singularity in finite time, which actually happened in 1939, in case of the European State-System. At that point entropy-production of the State-System (core, Europe) became infinite, as well as the frequency and magnitude of the cycles that accompanied the FTS. Regulation was no longer possible, and **the core (Europe) collapsed**.
17	Bifurcations	In case of a bifurcation, a system has to perform a critical choice (66), as was the case with the System in 1480 (as well as in 1618, 1792, 1914 and 1939, which can be considered secondary bifurcations, albeit with a decreasing latitude for choice): Nonlinearity combined with nonequilibrium constraints allows for multiple solutions, and hence for the diversification of behaviors. The possibility of having multiple solutions in a nonlinear system raises the question of choice between the different outcomes that are available (66). In case of a bifurcation, a "system will in effect scan the territory and will make a few attempts, perhaps unsuccessful at first, to stabilize (66)". It is not possible to determine beforehand the path the system will choose: Chance will decide, through the dynamics of fluctuations. In case of the System, there is also "a remarkable interplay between chance and constraint, between fluctuations and irreversibility" (66). By offering multiple solutions to reestablish stability, fluctuations involved in the bifurcation-process create diversities: The search for 'new' stability creates diversity. In 1480, the System bifurcated from an increasingly unstable state (< 1480) to **an organized state FFE**, a dissipative structure (the 1st FTS). Entropy regulation was now optimized, and the FTS ensured that the State-System made a transition to thermodynamic equilibrium via the most efficient path. **This organized state imposed four accelerating cycles on the System**.
18	Symmetry-breaking	In case of symmetry-breaking in the System, small fluctuations acting on the System at the bifurcation point decide what branch was taken (what solution was chosen), which determined the (nature of the) organized state of the System. The choice is not arbitrary, because the 'demands' of the laws of thermodynamics must be obeyed. The process is called symmetry-breaking because the System changed from a more symmetric and disorderly state (< 1480), to a more asymmetric and organized state (> 1480). **Symmetry-breaking involves selection and a choice**.

TABLE 44.2: Continued.

No.	Basic thermodynamic mechanisms	Effects/impacts
19	Interplay between probabilistic and deterministic facors	Despite their deterministic nature, are (nonlinear) dynamics in nonequilibrium systems a source of stochastic processes. Determinism and randomness are in case of nonequilibrium systems complimentary (65). Nonequilibrium - through the amplification of 'incidents' etc. - reveals the potentialities hidden in the nonlinearities, potentialities that remain dormant at or near equilibrium (66). Bifurcations and chaotic dynamics are sources of stochasticity (66): Randomness and stochastic behavior can arise naturally within a completely deterministic description (66). Prigogine (66) describes this phenomenon as follows: "Far from equilibrium, that is, when a constraint is sufficiently strong, the system can adjust to its environment in several different ways. **Stated more formally, several solutions are possible for the same parameter values. Chance alone will decide which of these solutions will be realized**. The fact that only one among many possibilities occurred gives the system a historical dimension, some sort of "memory' of a past event that took place at a critical moment and which will affect its further evolution". **Given the selection of a particular branch, the chosen trajectory is then stabilized through the selection of social interactions that can accomplish this (to which chaotic non-systemic KA during RSP's contribute by exploring phase space)** (65). Social processes (in the System) are deterministic and probabilistic. Chance plays for example a role in the 'selection' of branches in case of bifurcations: What fluctuation is magnified, is (at least) to a degree probabilistic. The critical points of RSP's (1618, 1792, 1914) and critical periods that follow, can also be considered bifurcations. The selection process of upgraded orders during critical periods also are deterministic and probabilistic. KA is generated in accordance with the laws of thermodynamics and related principles, while the kinetic fluctuation that is magnified is (also) open to chance. For example: The Soviet offenses against Germany in eastern Europe and/or the Allied Normandy landings in June 1944, during the 4th systemic war (the Second World War, 1939-1945) could have failed, and the alternative order that was established would also have met the requirements of the laws of thermodynamics. In case of chaotic non-systemic KA, the properties of the KA that is generated (like size and duration) are intrinsically unpredictable. Chance plays also a role in the selection of the trajectories in phase space, in case of chaotic non-systemic KA/war. The unpredictability impacts on the structuring of military capabilities of states (the need for readiness, contingency planning, etc.).
20	Activation energy, barriers	In case of the System certain structures - including orders of RSP's - constitute barriers that require activation energy to overcome. The combination of an arrow of time (irreversibility), social order at various levels, and memory constitute important 'ingredients for continuity and history.
21	Mode-coupling	The organized state - the 1st FTS, a dissipative structure - established by a bifurcation in 1480 **emerged out of the interplay between short-range interactions and long-range correlations involving the nonequilibrium constraint, as well as through interplay between deterministic and probabilistic properties of the System FFE**.

44.12. Application (4): Homeostasis as a selection force

According to Damasio (25), "Homeostasis has guided, non-consciously and non-deliberatively, without prior design, the selection of biological structures and mechanisms capable of not only maintaining life but also advancing the evolution of species to be found in varied branches of the evolutionary tree. This conception of homeostasis, which conforms most closely to the physical, chemical, and biological evidence, is remarkably different from the conventional and impoverished conception of homeostasis that confines itself to the "balanced" regulation of life's operations. It is my view that the unshakable imperative of homeostasis has been the pervasive governor of life in all its guises. Homeostasis has been the basis for the value behind natural selection, which in turn favors the genes—and consequently the kinds of organisms—that exhibit the most innovative and efficient homeostasis. The development of the genetic apparatus, which helps regulate life optimally and transmit it to descendants, is not conceivable without homeostasis."

Damasio also explains that culture can be considered as innovations that serve the homeostatic imperative. Damasio's theory explains how the H-imperative drives cultural innovation and other collective interactions: The H-imperative is a factor in the selective pressures (25). Humans are equipped with a 'cultural mind', which is itself a product of natural selection: "It is apparent that natural selection and genetic transmission have been hard at work in shaping and sculpting such modes of reacting in social environments to construct the scaffolding of the human cultural mind. Together, subjective feelings and creative intelligence have operated in that setting and created cultural instruments that serve the needs of our lives". See figure 44.5.

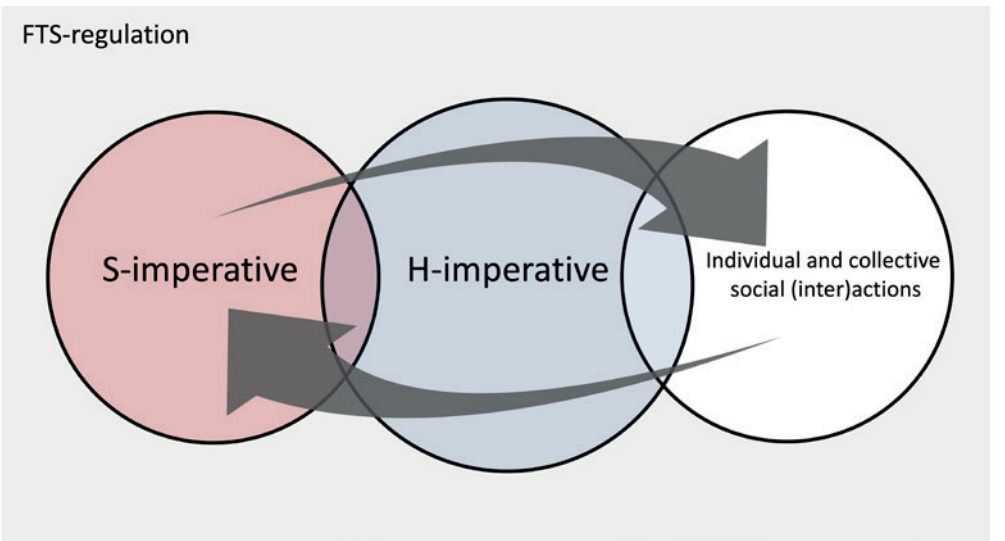


FIGURE 44.5: The H-imperative - homeostasis - also serves as a social selection force.

44.13. Application (5): History cannot be ignored

Because of the interplay between determinism and chance, various trajectories - solutions - are available to the (State-)System. The (basic) requirement is that the solution fits the parameters. Once a trajectory (solution) is chosen, certain constraints are introduced that (further) shape the System's trajectory; these constraints also provide new opportunities (e.g. new opportunities for novelty by combination): Since chance is involved together with deterministic constraints, evolution is partly decided by historical accidents (4).

Contrary to conservative (reversible) systems, is the evolution of dissipative (irreversible) systems not entirely dictated by the initial conditions. "The fact that only one among many possibilities occurred gives the system a historical dimension, some sort of "memory' of a past event that took place at a critical moment and which will affect its further evolution (a, 14)". Following the choice for a trajectory, social interactions are explored and selected - e.g. through chaotic non-systemic KA - to stabilize the particular trajectory (65). "By stabilizing the trajectory, the system becomes a historical object in the sense that its subsequent evolution depends on this critical choice (66)".

The history we now 'have' is in fact only one solution, out of a multitude of solutions and trajectories that were available.

During the "unfolding" of the 1st FTS (1480-1945), the State-System was pushed to zero entropy, and consequently the available options - viable trajectories, in other words 'potential histories' - decreased.

44.14. Application (6): Under- and over-charging

To sustain the FTS, several requirements must be met, as discussed in this chapter. Entropy is the main source of opportunity and energy - the main driver - of the FTS. To sustain the FTS, entropy-production must accelerate.

Three situations can be distinguished: (1) A situation when adequate FTS-regulation can be accomplished, (2) a situation when entropy-production falls short; a situation I refer to as "under-charged", and (3) a situation when too much entropy is produced (e.g. because a third degree of freedom is not available), I refer to as "over-charged". See figure 44.6.

Before the bifurcation in 1480, due to a combination of factors - including a lack of connectedness and entropy-production - the System could not yet produce a bifurcation; the minimum requirements for a bifurcation and the emergence of a dissipative structure (FTS) were not yet met. The state of the System can be defined as "under-charged".

As discussed, during both exceptional periods, the (State-)System was overcharged - so to speak - because the (State-)System lacked a third (a balancing) degree of freedom.

A relevant question that needs urgent answering is, what the (potential) effects of climate change (instability of the Earth system) are on the functioning and performance of the 2nd FTS and global State-System. Arguably, climate change will cause increasing rivalries between (and in) societies/states, and cause (abrupt?) increases in entropy-production in the (State-)System. These developments can then impact on the available degrees of freedom in the (State-)System (this is at least a probable scenario) and cause a "over-charged" situation.

This potential state of affairs raises another question: Given the mode of functioning of the 2nd FTS and the coherence in the global State-System this results in, is there a route to collapse and fragmentation of the (State-)System, when the entropy-production at a certain point exceeds the regulatory capabilities of the FTS? What happens if the entropy-production exceeds the ability of the FTS (State-System) to sustain period non-systemic KA, and the FTS cannot recover, and resume chaotic non-systemic KA (as was the case in 1763)?

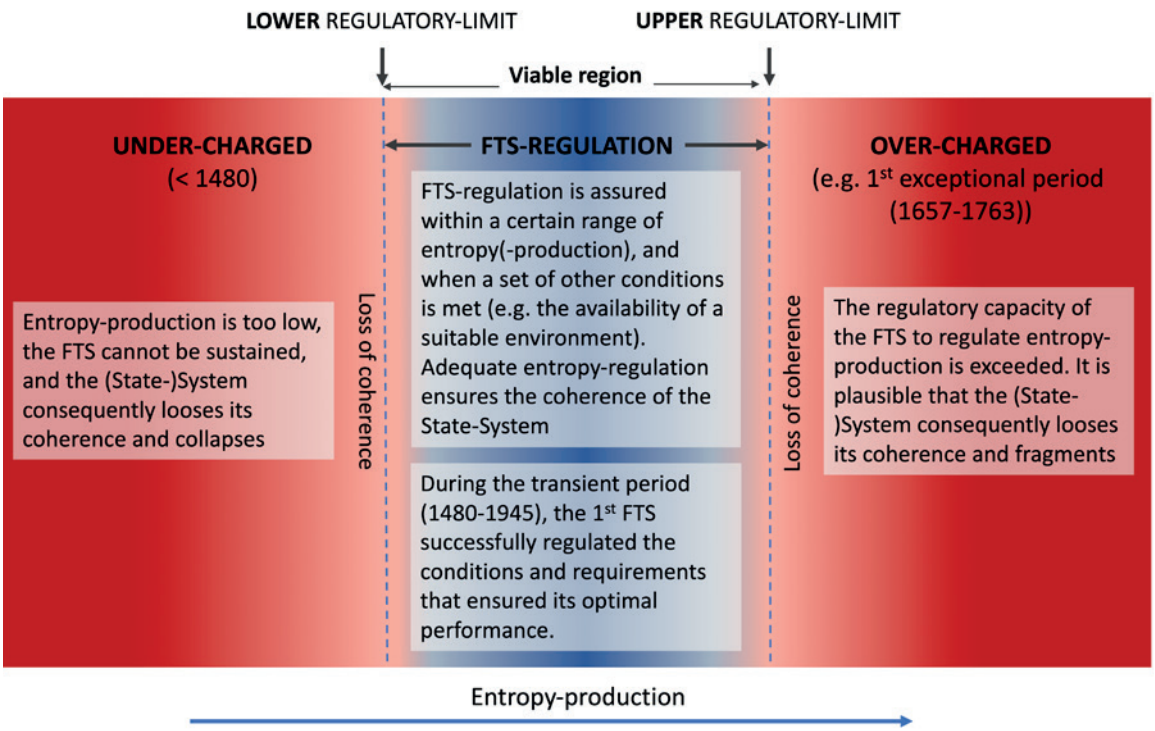


FIGURE 44.6: FTS-regulation can only be accomplished within certain ranges of parameters.

44.15. Application (7): The double nature of destruction

Chaotic KA is integral to FTS regulation and critical for the sustainment of the coherence of the State-System. KA results in "selective" and carefully "metered' use of entropy and kinetic energy, a process that it regulated by the FTS, in accordance with the Second Law and related principles that apply.
In the contingent domain, KA results in destruction and suffering, which is however of no concern to the FTS. From the perspective of the deterministic domain, KA is functional.

From the contingent perspective, the destruction of artifacts - e.g. of dysfunctional organizational structures, which block(ed) (further) development and evolution - can also be functional, when it allows for (new) niche construction.
KA, evolution and development, and destruction are complementary processes.

44.16. Application (8): Why convergence and not diversification?

During the period preceding the 1480-bifurcation and the emergence of the 1st FTS, and during the early stages of the European State-System (1480-1945), there was still diversity in state-structures.
However, the diversity decreased, and state-structures increasingly adopted identical organizations: The ability of societies and state-structures to develop, produce, organize and utilize kinetic energy (KA), increasingly became the defining property of these organizational structures, that could ensure their survival. The process of state-formation and of the formation of the State-System was a coevolutionary process, and "kinetic performance" and "war-fighting" became the most powerful selection forces for states. Other organizational structures could not survive and were destroyed. These powerful selection forces did not allow for diversification as a viable survival strategy for societies/states: Societies and states were forced - through the FTS, supported by the PDLI-mechanism - onto an increasingly "kinetic path".
One of the questions this state of affairs raises is, at what point - and under what conditions - diversification strategies are no longer viable to ensure survival in a (social) system, and evolutionary trajectories start to converge.

44.17. Application (9): Φm serve as indicators for complexity

Chaisson argues that values of $\boldsymbol{\Phi m}$ serve as indicators for complexity. However, "this is not to say that indefinitely high values of $\boldsymbol{\Phi m}$ would in every case lead to even more complexity. Examples abound in Nature where too much energy flow triggers just the opposite; namely, an open system that suffers breakdown, robbing the system of complexity and often returning it to equilibrium" (20). During the transient period (1480-1945), $\boldsymbol{\Phi m}$ of the core - as well as the complexity of societies/states making up the European State-System - continuously increased. In 1939 a (by then)" infinite" energy (KA) flow caused the State-System to collapse and "robbed the system of complexity and returned it to equilibrium".

44.18. Application (10): The critical availability of a suitable environment for evolution and development

With respect to biosystems Toussaint observes that "As biosystems grow and develop, they should increase their total dissipation, and develop more complex structures with more energy flow, increase their cycling activity, develop greater diversity and generate more hierarchical levels. As a corollary to this general statement, biosystems which do not increase their total dissipation, are organisms dedicated to death, like observed during the aging of any biosystem. Species which survive in ecosystems are those that funnel energy into their own production and reproduction and contribute to autocatalytic

processes which increase the total dissipation of the ecosystem while at same time surviving within the constraints of their changing environment. In a broad class of biosystems, stress and aging have similar thermodynamic properties and suggests common underlying principles" (92). I argue that these requirements also apply the (State-)System and to its growth and development; the European (State-)System - through the 1st FTS - continuously (and necessarily) increased its total EMIS-dissipation, developed more complex structures (in the contingent domain), increased its entropy- and energy-production, and increased its cyclic activity, etc.

There are limited options available to humanity, including: (1) decrease of entropy-production, and alignment of entropy-production with the ability of the available environment(s) to absorb the excess entropy production, (2) create 'alternative' environments (can the abstract domain serve as an alternative?), (3) change entropy- (EMIS-)regulation (now there is emergent EMIS-regulation by the 2nd FTS, with a high dependence on KA).

This basic principle - the need for a suitable environment, to ensure: $\boldsymbol{dS} = \boldsymbol{d_iS} + \boldsymbol{d_eS} \geq \mathbf{0}$ - also provides a practical framework to better understand the impacts of climate change: Climate change and its effects are also related to the basic law*:* $\boldsymbol{dS} = \boldsymbol{d_iS} + \boldsymbol{d_eS} \geq \mathbf{0}$, that cannot be violated: The entropy - waste - produced by humanity exceeds the entropy-absorption capacity of the physical environment (the biosphere, atmosphere, etc.) and impacts on (control) parameters of the climate- and Earth-systems that determine their stability: The climate- and Earth-system are forced into other stability-domains.

44.19. Application (11): Increasing adaptation of societies through evolution

Jantsch (40) observes, that early life forms were best adapted; life forms developed from "adjuster" (e.g. adaptation of the temperature of the life form to the environment), to "regulator" (e.g. the ability to have a constant temperature), to "extra-regulator" (the ability to create an artificial environment (e.g. shelter)). The evolution/development of societies can also be understood in these terms: Through the coevolutionary process of states and the State-System during the transient period, societies evolved from adaptor to an increasingly hostile environment, to regulator of the environment through (e.g.) KA, to extra-regulator by creating interactively (with other societies and states) a suitable - and shared - environment.

45. Developments and scenarios

45.1. Introduction

In this study, regularities in the dynamics and development of the (State-)System are studied. I show that in 1480, the System produced a dissipative structure – the 1st FTS – in response to increasing instability. During the transient period, the 1st FTS accomplished a phase transition, with two complementary effects: Thermodynamic equilibrium in/of the European State-System (core), and the simultaneous merging of the core (Europe) and non-core, resulting in a global State-System. Thermodynamic equilibrium of the European State-System was accomplished through self-destruction, during the last stage of the phase transition; the 4th systemic war (the Second World War, 1939-1945).
Based on the insights this study provides, I have made an initial attempt to identify the main characteristics of the (process of) social evolution and development of the (State-)System.
In this chapter, I discuss some scenarios for the development of the (State-)System by making use of the results of this study. This is only a very limited effort (at this stage).
It is important to take several factors into consideration for the development of scenarios:

- *Intrinsic unpredictability of chaotic dynamics*. Although - as this study shows - physical laws apply to the dynamics of the System, there is also intrinsic unpredictability in the dynamics of the (State-) System, caused by several (in some cases related) factors, including: (1) The statistic nature of the laws of physics, (2) the interplay between deterministic and probabilistic factors, in case of conditions FFE, (3) the sensitivity of chaotic dynamics for the initial conditions, (4) the indeterminateness of the Second Law in combination with the multitude of options through novelty by combination, and (5) the fact that there is a certain contingent latitude in case of the (State-)System, which means that different (contingent) solutions can satisfy the Second Law and related principles. The fact that the intrinsic unpredictability of certain aspects of the dynamics and development of the (State-)System have now come to light, is also very valuable and useful information; it e.g. explains why non-systemic KA/wars are intrinsically unpredictable and why all sorts of forecasts and predictions concerning the timing, duration and severity of these KA/wars were/are always wrong. As is the case for weather - which also involves chaotic dynamics – forecasting is problematic.
- *Predictability of (aspects) of R2-dynamics*. However, despite the intrinsic unpredictability of certain aspects of (especially) chaotic non-systemic KA/wars during RSP's, this study also shows that systemic KA/wars and certain properties of the dynamics and development of the (State-)System are highly predictable, including the unavoidable self-destruction of the State-System if the FTS is sustained.

- *A distinction between domains.* A distinction must be made between predictions related to the deterministic and the contingent domain of the (State-)System: Whereas systemic KA can be accurately predicted in the deterministic domain, the prediction of the appearance of these wars in the contingent domain, is another matter.
- *The accuracy of the model used*. The model that is used to make predictions must be (sufficiently) accurate. The model that is used for the scenarios discussed in this chapter, is based on the 1st FTS (1480-1945) (59). Study of the 1st FTS shows that the behavior of the (State-)System, depends on the stage of development of the current (2nd) FTS: The (State-)System behaves differently during RSP's and critical periods, and during the LCR's and HCR's, for example.
- *The time-span of predictions*. A distinction must be made between short-, medium- and long-term predictions.
- *The data that is used must be accurate*.
- *A force is now applied at a global scale*. The emergence of a 2nd FTS with a global reach (albeit with a delay), means that now a force is applied to the global State-System, and not a directed force at Europe, the former core. The (now) global force, in combination with the chaotic non-systemic KA, tears the still vulnerable structures in Europe apart. The fact that we are presently in the HCR of the 1st cycle of the 2nd FTS, also contributes the challenges in and of Europe and the European Union. Further fragmentation - disaggregation - of Europe seems unavoidable, and the process that took place during the transient period, suggests that a next critical period is probably required to reinforce the process of aggregation, not only at a global scale, but also in Europe.
- *The (State-)System needs a suitable environment, that supports EMIS-exchanges and regulation*. The amount and rate of entropy a system can exchange to its environment - the entropy-absorption capacity of the system's environment - determines the system's rate of evolution/development/aggregation. If the entropy-absorption capacity of the environment is exceeded - and the law $\boldsymbol{dS = diS + d_eS \geq 0}$ is consequently violated - the evolution/development of the system - its order - will be affected. A system's environment requires active regulation/management, because the entropy exchanged to the environment affects the environment's entropy-absorption capacity. Exceedance of the entropy-absorption capacity of a system's environment is not without consequences and can cause a system's collapse. The entropy that cannot be exchanged to the environment damages the order (organization) of the system generating the entropy.
- *New conditions and factors*. New events and factors could have a significant impact. Historical continuities - also the continuities identified in this study - do not guarantee that the future will be a continuance of the past; certain control parameters that concern the 2nd FTS and global State-System, (can) change fundamentally (e.g. through climate change). As I discussed, it is possible that the FTS is pushed out of its stability domain through under- or overcharging (respectively a too low or too high entropy-production), and that consequently, the (State-)System makes FFE sudden changes (e.g. through bifurcations) in which probabilistic factors also play a significant role.

  (At least) two factors/developments - which also interact - have a significant impact on the behavior of the 2nd FTS (1945-....) and the (further) development of the global (State-)System: (1) The quite recent possibility of individual humans and social systems to connect to other individuals/communities through the Internet and social media, with (almost) no limitations (at least at this stage), and (2) the effects of climate change, that will also have a significant impact on the carrying capacity of the (State-)System; physical limitations (e.g. caused by pollution and increasingly extreme weather

events) will affect entropy-production in the (State-)System and consequently the processes of KA, aggregation, expansion and empowerment. We now enter a new phase, in which the Earth system will - directly and indirectly - impose increasing constraints on the (State-)System and will increasingly impact on the performance of the 2nd FTS.

The scenarios I discuss in this chapter, are not only based on these considerations, but also on the following assumptions:

- A 2nd FTS is now operational and gathering pace; KA/war-cycles that accompany the 2nd FTS will accelerate.
- Presently, the global (State-)System is since 2011 in the HCR of the 1st (global) KA/war-cycle (1945-....).
- The purpose of the 2nd FTS is - assuming the FTS is sustained - to accomplish thermodynamic equilibrium at a global scale.

In this chapter I discuss several subjects, including: (1) fragile states, and the future of the state in general, (2) terrorism, (3) climate change, (4) sustainability of the 2nd FTS (apart from the fact that this is undesirable), (5) the interplay between the current state of development of the State-System, fragile states, terrorism and climate change, (6) scenarios and (7) the feasibility to engineer the dynamics of the (State-)System/2nd FTS to control its dynamics at a macroscale.
This chapter is limited to the (first) exploration of the possibilities the insights discussed in this study can offer to get a better understanding of the future of the (State-)System. E.g. model building would of course make a very significant contribution to our ability to make certain forecasts and define (more accurate) scenarios.

45.2. Sustainability of the 2nd FTS (1945-....)

Before elaborating on possible developments and scenarios, I discuss several preconditions that must be met to sustain the current (2nd) FTS. This study shows that for the operation and sustainment several conditions/requirements must be met, including the presence of more than two degrees of freedom (required to produce chaotic non-systemic KA/war dynamics during RSP's) and balanced mode-coupling. In this paragraph, I discuss several other requirements that also apply; the fulfilment of these conditions is (also) not a matter of course.

- *Population growth*. The primary driver of the entropy-production that sustains the FTS, is population growth. Based on projected population growth rates, it can be expected that the 2nd FTs can be sustained, at least until the 22nd century. See table 45.1.
- *The availability of suitable environments*. Dissipative structures need suitable environments to support entropy- and energy-exchanges. In case of the 1st FTS and European State-System, the "rest of the world" (the non-core) and European societies served as environments. For the sustainment of the 2nd FTS (1945-....), suitable environments are also required. Societies and fragile states (could) serve as suitable environments; it is no coincidence, that space exploration and exploitation started when the

2nd FTS emerged. The question is if the available environments can fulfil the requirements of the 2nd FTS. Climate change also impacts on the availability of suitable environments. If EMIS-transfer with the environment of the State-System is/becomes insufficient or stops, the FTS falls apart.

TABLE 45.1: Comparison of growth rates Europe and world. This table shows the growth rate during successive periods of 50 years in Europe (1500-1950) and at a global scale (1900-2150) (Data from United Nations Population Division and related sources).

Period	Europe (10^6)	Growth rate Europe	World (10^6)	Growth rate world
1500	84		458	
1550	96	14.3%	500	
1600	111	15.6%	580	
1650	118	6.3%	630	
1700	125	5.9%	682	
1750	163	30.4%	791	
1800	203	24.5%	978	
1850	276	36.0%	1.262	
1900	408	47.8%	1.650	30.7%
1950	547	34.1%	2.521	52.8%
2000	729		5.978	137.1%
2050	734		9.725	62.7%
2100	639		10.854	11.6%
2150	517		9.746	-10.2%

- *The presence of state-like structures*. For the 2nd FTS to function, state-structures - or state-like structures - are required. State-structures as we now know them are a product of the core (Europe) of the 1st FTS (1480-1945). The state is optimized to function as an optimized part of/in the 1st FTS, the dissipative structure that ensured that the European State-System was driven to thermodynamic equilibrium via the most efficient path, during the transient period, 1480-1945.
  Following the collapse of the core, and the merging of the core and non-core, state-structures were implemented as the (only) legitimate organizational structure that could
  Two developments can now (since 1989) be observed in the global (State-)System: Continued - but failing - efforts in the former core to accomplish full aggregation (stage 3B), and processes of fragmentation: The Soviet Union collapsed in 1989-1991, Yugoslavia broke up in 1991-1992, state structures that were established in the Middle East and Africa increasingly fail(ed) and/or collapse(d), the United kingdom has decided to leave the European Union (despite continued efforts to achieve full aggregation 3B in Europe), and regions in established states have expressed their desire to acquire autonomy (I refer to e.g. Scotland in the United Kingdom and Catalonia in Spain). More recent developments that promote fragmentation include the ignorance and disbandment of various

treaties and agreements by the United States. The processes of fragmentation impacts on EMIS-flows and their regulation. Because of the United States centrality, its impact will reverberate through the global (State-)System.

These developments - especially the process of fragmentation - raise the question if states - with their specific properties - are (still) the most optimal organizational structures to drive the global State-System to thermodynamic equilibrium via the most efficient path, as demanded by the laws of thermodynamics and related principles? Or could thermodynamic equilibrium be achieved more efficiently by empowered individuals and communities that can ignore constraints (barriers) imposed by states?

45.3 Current state of the (State-)System

Presently (2018), the State-System is in the HCR of the 1st global KA/war-cycle, produced by the 2nd FTS (1945-....). Entropy is now accumulating, and an autocatalytic process contributes to the formation and percolation of VC's. In the contingent domain there is increasing social and political volatility, and tendencies for radicalization - in efforts to harness and utilize entropy - can be observed. See figure 45.1.

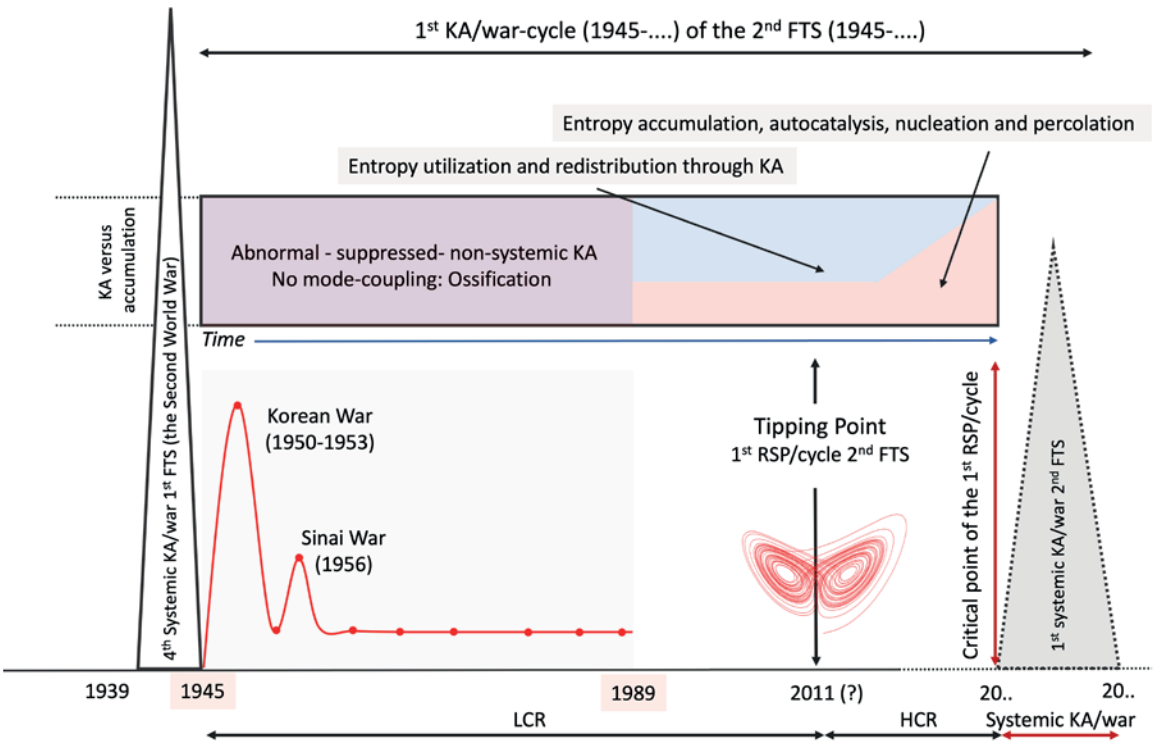


FIGURE 45.1: Current state of the State-System.

45.4. Fragile states

Fragile states are states with a weak state capacity or weak state legitimacy leaving citizens vulnerable to a range of shocks.

It is important to understand the phenomenon of fragile states from a thermodynamic perspective, as well: Fragile states are 'systems' that lack structure to ensure adequate EMIS-regulation of a society they 'represent'. The lack of regulation affects societal homeostasis, and the ability of the society concerned to interact constructively with its environment, i.e. the (State-)System. Fragile structures lack organization, and an ability to maintain an intermediate level of internal entropy.

A fragile state not only impacts on the ability of the society to fulfill its basic requirements, to achieve a certain well-being and ensure its survival, but also impacts on the EMIS-regulation of the (overall) (State-) System.

According to the FSI report 2017 (33), six states (South Sudan, Somalia, Central African Republic, Yemen, Syria and Sudan) fall in the category 'very high alert', nine states (Congo Democratic Republic, Chad, Afghanistan, Iraq, Haiti, Guinea, Zimbabwe, Nigeria and Ethiopia) fall in the category 'high alert' and twenty states in the category 'alert' (including Pakistan and North-Korea; both states are in the possession of nuclear weapons). See figure 45.2.

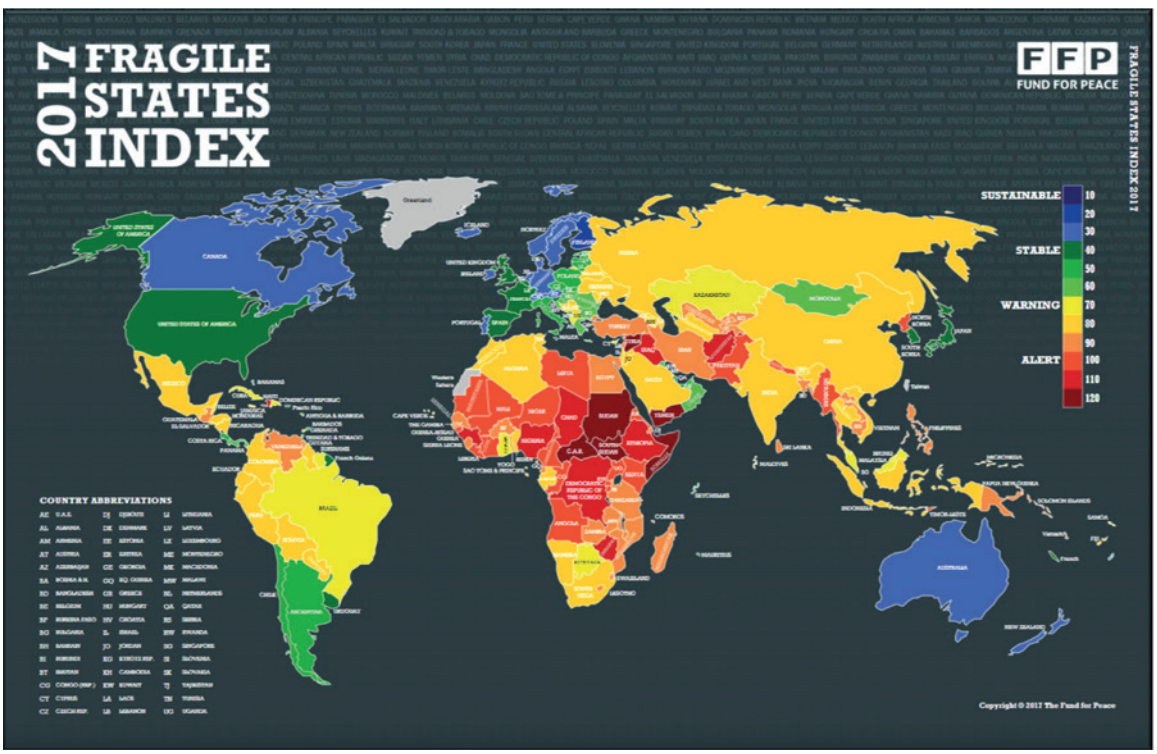


FIGURE 45.2: Fragile State Index 2017 (33).

The 'top twenty' fragile states - the states in the categories 'very high alert' and 'high alert', plus Guinea Bissau, Burundi, Pakistan, Niger and Cote d'Ivoire) - have a total population of 880.618.000 which represented 11.7% of the world population (7.550.000.000) in 2017.
Assuming that these twenty states are not able to improve their state capacity, and the population growth as projected by the United Nations (medium variant) for these states is indeed realized (*source: United Nations DESA/Population Division, World Population Prospects: The 2017 Revision, total population/ both sexes*), the total population of above mentioned top twenty fragile states as a fraction of the world population, increases dramatically during the period 2017-2100: From 11.7% in 2017, to 13.9% in 2030 (1.191.340.000), to 17.8% in 2050 (1.735.432.000) and to 25.8% (2.884.238.000) in the year 2100. See figure 45.3.

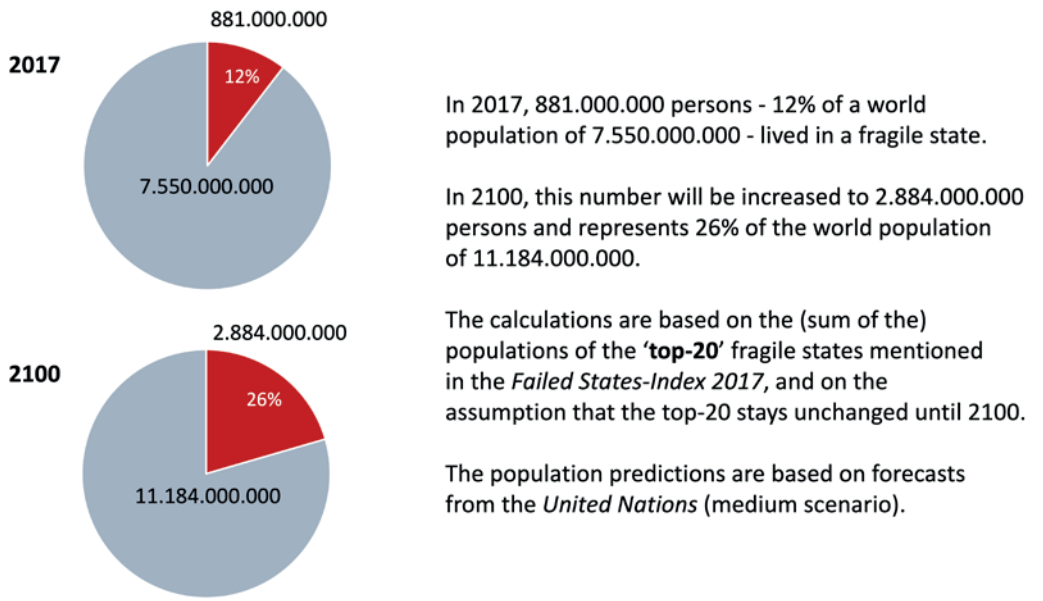


FIGURE 45.3: A dramatic increase in populations living in fragile states.

45.5. The future of the state: From a System based on state-structures to a community-based global System (?)

The state is an organizational structure that controls a well-defined territory and society/population(s), with centralized governmental structures, and with a monopoly on the use of violence. The state is - so to speak - a European invention, shaped by the 1st FTS, during the transient period (1480-1945).
This state is selected - has evolved as it is - because of its ability to develop, mobilize and deploy kinetic energy; a property that best guarantees the well-being and the survival of the society it regulates.

With the selection of the state - with its typical properties - as the only legitimate structure in the (now) global State-System - a decision that is embedded in the 1st global order (the United Nations Charter) - the global State-System, also has adopted the same properties as its European predecessor (1480-1945). KA has the same function in the global State-System, as during the existence of the European State-System (1480-1945), but now at a global scale. In the global State-System, KA is regulated by the 2nd FTS, and contributes to the coherence of functioning of both the 2nd FTS and global State-System. Although KA is often not functional in the contingent domain - through war, social and political (predetermined) objectives are seldom achieved - in the deterministic domain KA fulfills a constructive role, as discussed in this study.

During the transient period (1480-1945), besides a process of KA, aggregation and expansion, a process of empowerment was also an intrinsic component of the 1st FTS; these processes reinforced each other.

I have explained that through the now global force that is applied by the 2nd FTS and the resumption of chaotic non-systemic KA (since 1989) at a global scale, the fragmentation of the not yet fully completed European 'super-state' is unavoidable: The force the 2nd FTS now applies and the chaotic non-systemic KA (at a global scale), have the effects of a centrifugal force that tears the European Union apart.

It should also not come as a surprise that states - (especially) in the Middle-East and Africa - struggle to establish and sustain themselves, after these territories have been governed and exploited by their colonizers, during the transient period.

In these regions, states were "simply" imposed on populations and territories, following their independence. State-structures in these regions, are not the outcome of a long-term process of evolution, development and fine-tuning of societal EMIS-flows, as was the case in Europe. In Europe, states are dissipative structures that have evolved from an internal logic, through a gradual process of natural growth, during a period of centuries; while outside Europe, states were often imposed as externally designed and engineered structures that originate from processes external to the societies they are supposed to regulate; the fit has consequently certain limitations.

Developments show that these states did not and cannot become effective regulatory structures, and consequently collapse(d). It should also not come as a surprise that the populations of these failed states, necessarily fall back on alternative social structures and arrangements, which are often based on religious concepts; survival and well-being require organization and a perspective; religions can provide both.

These developments - states being too small in Europe to allow for the full exploitation of available economies of scale and scope, and state-structures being ineffective in other regions of the world to accomplish effective regulation - raise the question what the future of the state is (or can be).

The state is an invention shaped by requirements of the Second Law and related principles (during the period 1480-1945), the same laws and principles will not hesitate to impose corrections, if these corrections ensure more efficiency of the overall system. As was the case in the past, the contingent domain will obey the demands of the Second Law and related principles.

To acquire a better understanding of current developments concerning the state, the dominance of feedback structures in the (State-)System can provide useful clues. During the transient period (1480-1945), the processes of aggregation in the core (the European State-System) and expansion to the non-core were the dominant processes, the 1st FTS generated; these processes were supported by KA. Strong and increasingly established positive feedback structures - reinforcing aggregation - dominated the dynamics in the core (Europe), during the transient period. See figure 45.4.

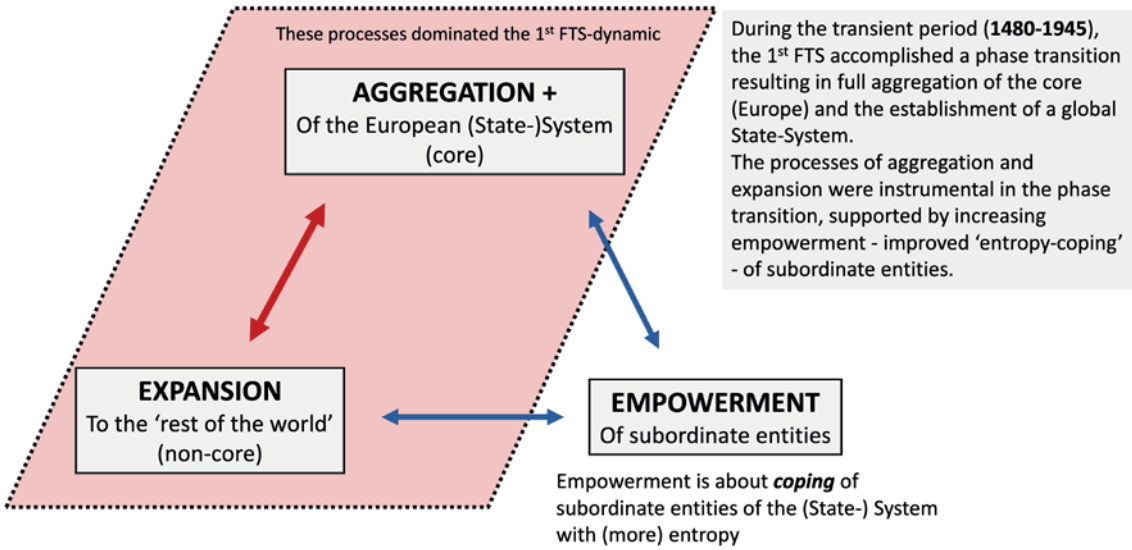


FIGURE 45.4: Relationship between the processes of aggregation, expansion and empowerment during the transient period (1480-1945). The processes of aggregation and expansion - regulated by KA - were dominant.

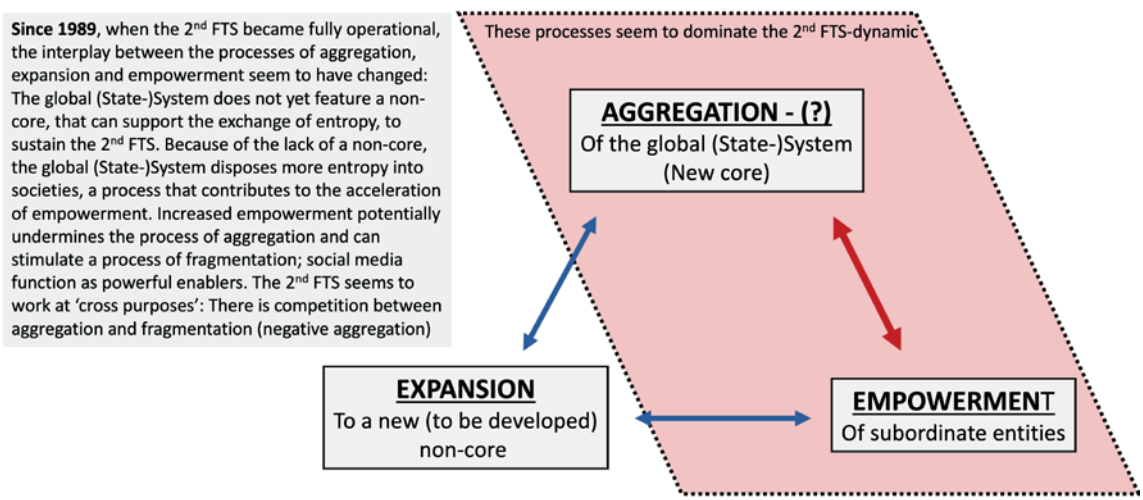


FIGURE 45.5: Relationship between the processes of aggregation, expansion and empowerment from 1989 onwards. It seems that there is now negative aggregation - fragmentation - instead of positive fragmentation; the processes of aggregation and empowerment now seem to be dominant.

It seems that currently - since 1989 - social structures are fragmenting (fragmentation can be considered as 'negative aggregation', aggregation in reverse); not only state-structures (in the Middle East and Africa), but also the European Union, and European States. See figure 45.5.

The process of empowerment - enabled by the Internet and social media - is instrumental in this process of fragmentation.

These developments raise the question, if the (State-)System is in a transition process from a global System regulated by states, to a global System that is more efficiently regulated through a network of world-wide communities, that can better ensure the fulfillment of the basic requirements of its members (citizens). Regarding the next critical period (systemic KA/war), the question is: Will the state – during a next critical period – be reaffirmed -be resurrect - or will the process of fragmentation be (further) reinforced?

45.6. Terrorism

In this paragraph, I discuss two perspectives on terrorism: (1) A thermodynamic and (2) a contingent perspective on terrorism.

- *Terrorism: A contingent perspective*. Terrorism is "in the broadest sense, the use of intentionally indiscriminate violence as a means to create terror among masses of people; or fear to achieve a religious or political aim" (96).

  From a thermodynamic perspective, terrorism can be considered efforts to eradicate gradients, and as explorative behavior of the (State-)System to find new solutions for these instabilities. As is the case with KA, terrorist activity can become amplified through the interplay with the S/T-field of the System.

  Terrorist attacks can be considered KA by non-state actors and are by definition considered illegitimate: Only states are recognized as legitimate representatives of societies and are allowed - under certain conditions - to legally apply kinetic energy (military capabilities).

  Entropy (new possibilities, uncertainty, etc.) - and entropic instabilities - is the source of terrorist activity, like KA/war generated by the State-System.

  If the issues - and the underlying ideologies - which are 'promoted' through terrorist activity get 'traction', (terrorist) communities can be formed, that can compete with state-structures.

  A distinction can be made between terrorist attacks in support of war activity - e.g. suicide attacks on American and NATO-forces in Afghanistan - with a (predominantly) military and more limited/local aim, and terrorist attacks on/in (other) states/societies to create political awareness for certain issues and ideologies, and to provoke (state-)responses; e.g. IS-attacks in European cities, with a political/religious aim. These two types are 'extremes', there are numerous variants.

  In case of the last variant, the aim is (also) to achieve publicity - news agencies are always eager to provide - which will not only contribute to the awareness terrorist organizations want to achieve for their case, but at the same time contributes to an increased sense of fear in the society/state that is targeted.

  Terrorist attacks often reveal weaknesses of governments and can - if these attacks are not prevented and contained - undermine a societies social fabric and eventually a government's legitimacy; the security of its citizens is the first responsibility of a state/government and the primary justification for a state's monopoly on violence.

  Not only undermine terrorist attacks (the functioning of) states, and contribute to their fragility, fragile states - because of their ineffectiveness - also tend to generate terrorist activity.

There are two main reasons why fragile states tend to generate terrorist activity: (1) Because citizens take their life (security) 'in their own hands' (the state is not able to fulfill its primary responsibility), and (2) in fragile states, citizens form/organize their own social structures to ensure the fulfillment of their basic requirements, as alternatives for state-structures.

Religions provide powerful alternatives to state-structures: Organization, regulation, direction and justification. Because of the high entropy-levels in fragile states - high levels of uncertainty - there is a tendency for radicalization.

The phenomena of fragile states, terrorism and (political and religious) radicalization are related.

Terrorist activity is measured with the Global Terrorism Index (GTI); the GTI "provides a comprehensive summary of the key global trends and patterns in terrorism over the last 17 years in covering the period from the beginning of 2000 to the end of 2016" (36, 85). "The GTI is produced by the Institute for Economics & Peace (IEP) and is based on data from the Global Terrorism Database (GTD). Data for the GTD is collected and collated by the National Consortium for the Study of Terrorism and Responses to Terrorism (START); a Department of Homeland Security Centre of Excellence led by the University of Maryland.

The GTD is considered to be the most comprehensive global dataset on terrorist activity and has now codified over 170.000 terrorist incidents" (36, 85).

According to the report, "In 2016, deaths resulting from terrorism decreased by 13 per cent to 25.673. Deaths have now fallen by 22 per cent from the peak in 2014. There has also been an increase in the number of countries that improved their GTI score: 79 countries improved while 58 countries deteriorated. Some countries, including Nigeria and Pakistan saw large improvements. However, overall the index deteriorated because the countries that deteriorated did so by a much larger degree than those that improved. The decline in deaths is encouraging but 2016 was still the third deadliest year for terrorism since 2000 with a nearly eight-fold increase in the number of deaths over this time period. While the intensity of terrorism in many countries has decreased, terrorism continues to spread to more countries. The average country score for the GTI, which measures the impact of terrorism, deteriorated by four per cent and reflects this spread of terrorism. There were 77 countries that experienced deaths from terrorism, which is an increase from 65 the previous year. Two thirds of all countries experienced a terrorist attack in 2016" (36, 85). See figures 45.6, 45.7 and 45.8.

The top twenty states in the ranking of the Global Terrorism Index 2017 are: Iraq, Afghanistan, Nigeria, Syria, Pakistan, Yemen, Somalia, India, Turkey, Libya, Egypt, Philippines, Democratic Republic of the Congo, South Sudan, Cameroon, Thailand, Ukraine, Sudan, Central African Republic and Niger. The top five (Iraq, Afghanistan, Nigeria, Syria and Pakistan) account for three quarters of all deaths from terrorism.

A (statistical) relationship exists between state fragility and terrorism: Twelve states are represented in both top twenties, including the terrorism top five (Iraq, Afghanistan, Nigeria, Syria and Pakistan). Given the projected growth of populations living in fragile states – from 11.7% in 2017 to 25.8% in 2100 – an increase in terrorist activity can be expected.

The impacts of climate change, to which fragile states are extra vulnerable because of their fragile governments, are not taken into consideration.

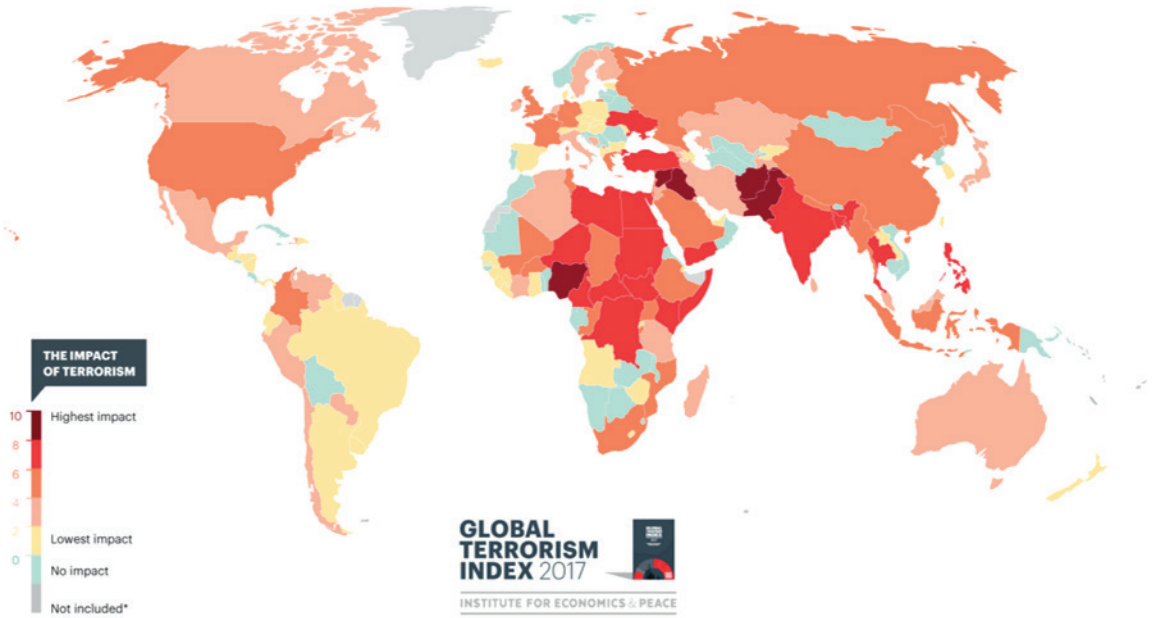


FIGURE 45.6: Global terrorism Index 2017 (36, 85). Comparison of this figure with figure 45.2 reveals the overlap between fragile states and terrorist activity.

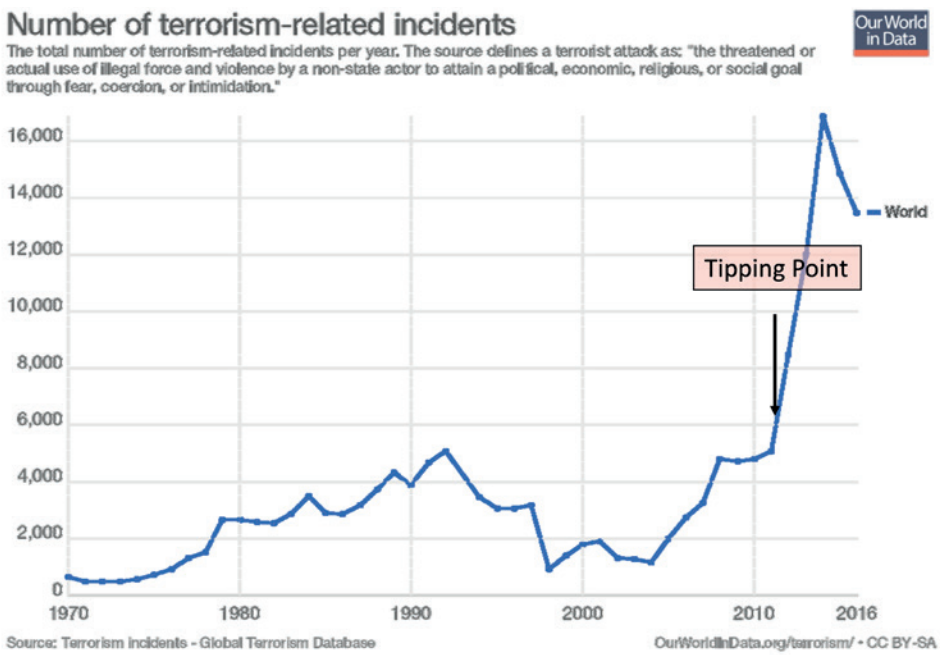


FIGURE 45.7: Number of terrorism-related incidents (1970- 2016), (36, 85). A sudden increase can be observed in 2011. The question is if the (sudden) increase in terrorism-related incidents is related to the tipping point of the RSP that was also reached in 2011, and if the increase is indicative for a decreased capacity of the (State-)System to effectively regulate entropy through non-systemic KA. Further research is required.

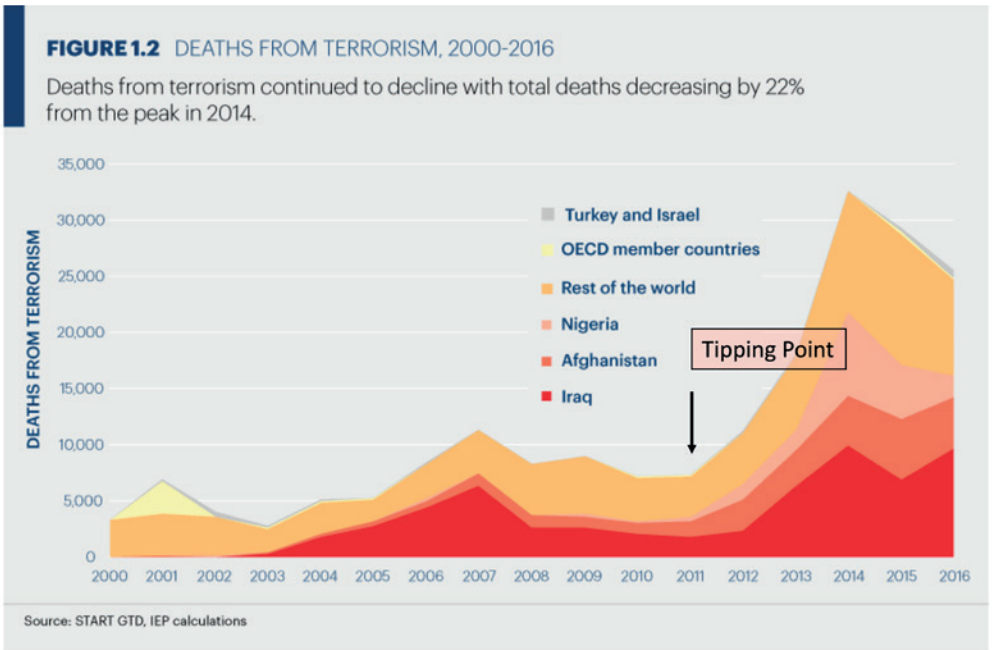


FIGURE 45.8: Number of deaths from terrorism (2000- 2016), (36, 85). A sudden increase can be observed in 2011. The question is if the (sudden) increase in the number of deaths from terrorism is related to the tipping point of the RSP that was also reached in 2011, and if the increase is indicative for a decreased capacity of the (State-)System to effectively regulate entropy through non-systemic KA. Further research is required.

- *Terrorism: A thermodynamic perspective.* As discussed in previous chapters, order can be considered a compromise between two coupled 'antagonists' (modes): (1) local nonlinear entropic perturbations which are part of - connected to - the network of VC's and S/T-field, and (2) the EMIS-transport process that is enabled by the S/T-field, a system-level. The interactions between 'local' and 'field' (System) - also referred to as mode-coupling: the transport of entropy contained in the S/T-field and the local issue, and the kinetic energy (Gibbs Free Energy) that is put to use - is regulated by the FTS.
  The transport process – between local issues and the S/T-field – includes information (content), and (local) issues in fact send continuous and more or less coherent "innovation signals" to the System, especially to the S/T-field, and the network of VC's. Prigogine et al. explain that the transport process "captures, relays, and stabilizes the signals" (66).
  As I mentioned, from a (thermodynamic) perspective, terrorist attacks (like chaotic non-systemic wars/ KA during RSP's) can be considered explorative behavior and "innovation signals", local perturbations that are provided with a context through the "transport processes" between these perturbations and the S/T-field of the System: The S/T-field captures, relays, and stabilizes these signals (terrorist attacks), and can chose to amplify them, causing (further) escalation in the contingent domain. The signals and responses impact on the configuration of VC's, in which they are embedded, and "memorized". This process also combines deterministic and probabilistic elements.

45.7. Climate change

"Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather within the context of longer-term average conditions, defined by the World Meteorological Organization as a 30 years or longer term. Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Certain human activities have been identified as primary causes of ongoing climate change, often referred to as global warming" (96).
A relevant question is how climate change - and its (indirect effects) - can impact on the 2nd FTS and global State-System: How do the climate system and 2nd FTS/global State-System interact? This is of course a question that needs (much) more research.
In this paragraph, I restrict myself to some observations:

- *Entropy-production*. As discussed in this study, entropy-production and regulation by the FTS determine the KA/war dynamics of the (State-)System.
  During the transient period (1480-1945), the 1st FTS was remarkably resilient in its ability to "absorb" perturbations. Only during the 1st exceptional period (1657-1763), the otherwise highly efficient dynamics of the 1st FTS were temporarily distorted. The 1st FTS and European State-System were obviously able to stay within the stability domain: Enough EMIS-flows could be generated and adequately regulated, to ensure the phase transition was eventually accomplished (1945).
  The deterioration and depletion of the "carrying capacity" of the (Earth) system will cause an increase in entropy-production in the (State-)System caused by increased scarcity of resources, increased rivalries between societies/states, displacement of citizens of states and disruption of supply, etc. The question is how the increased entropy-production and disruptions will impact on (the functioning of) the 2nd FTS and global (State-)System.
  I assume that the effects of increased entropy-production could have several possible effects, that (also) depend on the stage of development of the RSP of the KA/war-cycle (LCR or HCR): During LCR's, intensifying rivalries in the (State-)System could result in a decrease in the number of degrees of freedom and cause a 3rd exceptional period; consequently the development of the State-System will be interrupted; during HCR's the impact will not be noticeable, entropy (tensions and issues) will accumulate, and the (State-)System will eventually become critical.
- *Switch to another stability domain*. Another more drastic impact would be if the entropy-production in the (State-)System - through effects induced by climate change - forces the 2nd FTS and global State-System out of the stability domain; the global State-System becomes overcharged (also because external noise is increasingly introduced by the environment), and internal (KA) fluctuations are no longer independent of the (physical) environment. The entropy-production (issues and tensions) will impact - "overpower" and destroy - the mechanism of mode-coupling, and the global State-System and 2nd FTS will lose coherence. The force the 2nd FTS applies on the global State-System, will cause it to fragment.
  I assume that in case of such a scenario, the global State-System will fragment into "regions", that are controlled by regional Great Powers, and that - through unbalanced mode-coupling - states in the (State-)System cannot act in concert. See figure 45.9.

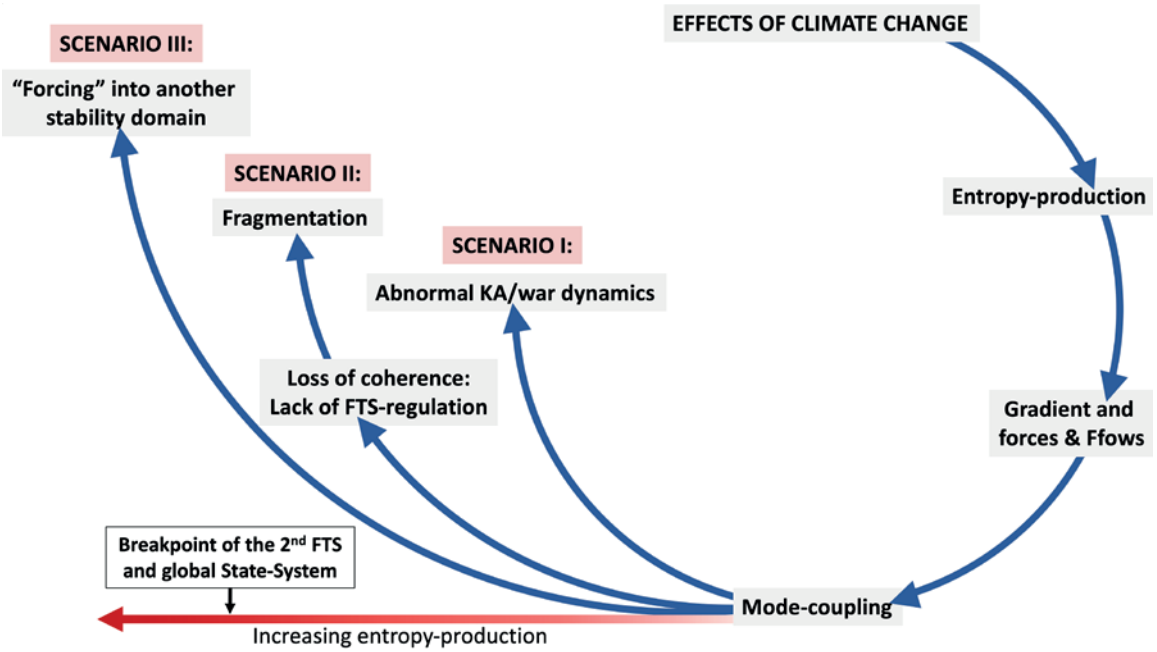


FIGURE 45.9: Three different paths and scenarios for the development of the 2nd FTS and global state-System. This figure shows three paths - and accompanying scenarios - for the further development of the 2nd FTS and global State-System; the entropy-production induced by (effects of) climate change is the control parameter.

45.8. Interactions between the 2nd FTS/(State-)System, fragile states, terrorism and climate change

The 2nd FTS/global State-System, fragile states, terrorist activity and the effects of climate change are related phenomena. How the relationships between these variables manifest themselves in the (State-) System, depends on the regulatory ability of the 2nd FTS and on the dominance of feedback structures that can emerge through the interplay between these variables/phenomena.
In table 45.2, some aspects of the relationships are discussed.

TABLE 45.2: Relationships between the 2nd FTS/global State-System (GSS), fragile states, terrorism and (the effects of) climate change. Eco-terrorism is discussed in paragraph 45/13.

	2nd FTS/GSS	Fragile states	Terrorism	Climate change
2nd FTS/ GSS		The 2nd FTS applies a force to (fragile) states that can further undermine their already limited capacity. On the other hand, the 2nd FTS also forces societies to adopt state-structures to (better) ensure their well-being and survival in the State-System: The question is if fragile states can overcome their weaknesses.	The 2nd FTS - and its limits to entropy-regulation, in combination with the fragmentation of social structures reinforces terrorist activity. Through terrorist activity, the (State-) System explores new solutions.	The 2nd FTS dominates and regulates EMIS-flows, which (in) directly impact on the functioning of the State-System: The 2nd FTS undermines cooperation, especially during HCR's of KA/ war-cycles.
Fragile states	Fragile states contribute to entropy-production and rivalries. Fragile states can serve as environments to the 2nd FTS, to "dump" entropy.		Fragile states reinforce terrorist activity, because of their limited capacity to ensure security and other basic requirements for their citizens.	Fragile states lack effective mechanisms to mitigate the effects of climate change.
Terrorism	Terrorist activity contributes to entropy-production and the search for innovative solutions.	Terrorism (further) undermines the capacity and legitimacy of fragile states.		Terrorism undermines the ability to mitigate the effects of climate change by undermining state capacity, but also contributes to the exploration of innovative solutions. The state of affairs could trigger "eco-terrorism".
Climate change	Climate change results in (more) entropy-production and can destroy mode-coupling and the 2nd FTS.	Climate change contributes to the fragility of states, e.g. through the non-availability of resources, damage to/degradation of the environment and displacement of citizens.	Climate change contributes to tensions and issues that can reinforce terrorist activity and initiate "eco-terrorism".	

45.9. Scenarios for the further development of the 2nd FTS

In this paragraph, I discuss - only superficially - three scenarios that can be distinguished for the development of the 2nd FTS.

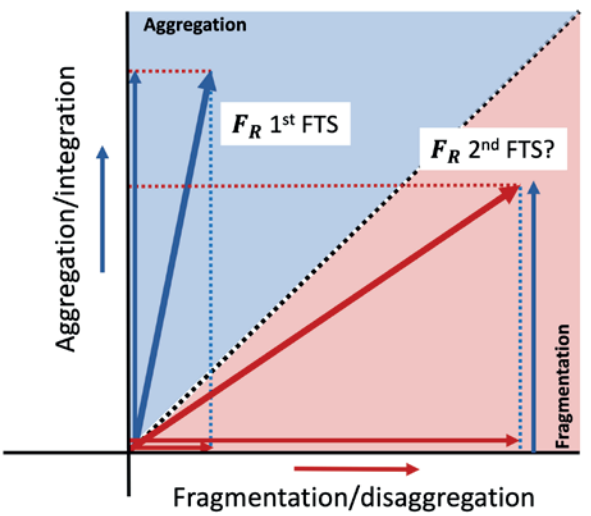
1. *The 2nd FTS is identical to the 1st FTS*. It is possible that the 2nd FTS unfolds as its Europe-centric predecessor the 1st FTS. In that case, the 2nd FTS is also accompanied by accelerating cycles and

will eventually reach the critical point of the phase transition. During this process, the global State-System is pushed to zero-entropy. The 2nd FTS will accomplish thermodynamic equilibrium, meaning full aggregation (stage 3A) at a global scale.

Based on the insights the 1st FTS provides, assuming the 2nd FTS follows the same path of development, that the same ratios apply (e.g. the acceleration of successive cycles, the development of the release-ratios of successive cycles, etc.) and the 2nd FTS is also accompanied by four accelerating cycles, a model of the 2nd FTS can be constructed (59). According to this model, the global State-System reaches the critical connectivity/population threshold in 2185 (59).

There are however various reasons that suggest that the 2nd FTS will not develop (exactly) according to this model. For example, the level of development of the (State-)System at the start-up of the 2nd FTS (1945/1989), was much more advanced than the level of development of the System at the start-up of the 1st FTS in 1480: State-structures of the Great Powers were at the inception of the 2nd FTS already fully developed. The 2nd FTS has probably a shorter life-span and will not accompanied by four (accelerating) cycles.

Forces contributing to AGGREGATION/INTEGRATION:	Forces contributing to FRAGMENTATION/DISAGGREGATION:
Process of aggregation generated by the FTS	Process of empowerment generated by the FTS
Process of expansion generated by the FTS	Political interests
Economic interests (contingent domain)	Economic interests
A collective dimension (e.g. the need to cooperate to mitigate the effects of climate change)	Rival social models, etc.



The (State-)System is subject to various competing forces that either contribute to aggregation/integration or fragmentation/disintegration of the (State-)System: The resulting force (F_R) determines the development path of the (State-)System. The 1st FTS generated a powerful force that assured full aggregation of the Europe-centric System (stage 3A). In this figure the resulting force is shown for a scenario concerning the global State-System, in which the forces that contribute to fragmentation/disintegration dominate.

FIGURE 45.10: A competition between forces.

2. *Loss of coherence*. For the emergence and sustainment of a FTS - a dissipative structure - a set of conditions/requirements must be met, I discussed in previous chapters.
   Climate change can have a significant impact on these conditions and negatively impair the sustainment of the 2nd FTS: the 2nd FTS and global (State-)System will lose coherence (as discussed).
   The structural stability, the sensitivity and behavior of the System and FTS can be tested with computer models. Climate-models can serve as a source of inspiration; I expect models of the System/FTS to be simpler than climate models, that have to take into account many more not yet fully understood feedbacks.
3. *Premature collapse and a shift to a community-based system*. State-structures can be considered components of the FTS. State-structures - as was the case during the transient period 1480-1945 - are temporary structures that are subject to contradicting forces that simultaneously promote aggregation and fragmentation.
   During the transient period (1480-1945), forces (and the momentum that was generated by the 1st FTS) were sufficiently strong to support a highly efficient process of aggregation in the core (Europe).

As discussed, the question now is if the resulting force $\boldsymbol{F_R}$ in case of the 2nd FTS, reinforces a process of (global) aggregation - the achievement of thermodynamic equilibrium at a global scale - or causes the global State-System and its building blocks to fragment. Such a "switch" could be the start of a transition of the global System to a "network of networks", based on (globally) connected communities. See figure 45.10.

45.10. A second infinity war

In 1939, the moment the 1st FTS reached the critical connectivity/population threshold - the critical point of the European State-System - the singularity in finite time of the 1st FTS was reached and the European State-System (core) consequently produced infinite amounts of entropy and generated infinite KA, which was instrumental in the final stage (the 4th systemic KA/war, 1939-1945, the Second World War) of the phase transition (1480-1945).
At that point, the core of the System had reached full aggregation (stage 3A). The infinite KA, resulted in the self-destruction of the European State-System, and the resulting vacuum was 'filled' by the United States and the Soviet Union, the two remaining Great Powers that were (also) well established in the non-core. The core was in fact absorbed - enveloped - by the non-core of the System, and the core and non-core could subsequently merge, under "direction" of non-core Great Powers.
The destructed of the (former) core required mending; a process in which the United States and the Soviet Union were instrumental. The temporary "shut-down" - ossification - of the (now) global (State-)System was also used to reconfigure the global (State-)System and to "organize" the start-up the 2nd global FTS.
As discussed in previous chapters, the phase transition (1480-1945), can also be considered a process of kinetic - destructive - growth: Aggregation of the core (Europe) was supported by a simultaneous process of expansion of the core to a subordinated non-core - a delineated part of the environment - that eventually - when the non-core was fully matured (1939-1945) - enclosed and absorbed the core; At the same time, the organization of the globalized System was reconfigured, based on blueprint of the former core.

If the global (State-)System follows the same path of development as the 1st FTS and the European State-System, a similar dynamic can be expected, including an 'infinity war' when the 2nd FTS reaches the critical point of the (second) phase transition: At that point the global State-System produces infinite amounts of entropy and generates infinite KA in response. The global State-System self-destructs. See figure 45.11. During the 2nd transient period (1945-....), the 2nd FTS requires a suitable non-core to sustain its operation: Excess entropy must be exchanged with/to a suitable environment. The question is, if the "next" non-core, which will be developed by the 2nd FTS, will (also) be able to enclose and absorb the global vacuum that is created by the 2nd infinity war, to ensure continuity of the System (and probably humanity).
A non-core that is established "outside" planet Earth - through the colonization of the Moon or other planets, or the utilization of man-made (space) structures - could (theoretically, at least), serve as a viable non-core. The extraterrestrial colonies that are established in the non-core can serve as advanced "stepping stones" for further exploration and exploitation of space, also if the self-destructed global system (core of the 2nd FTS) is beyond repair.

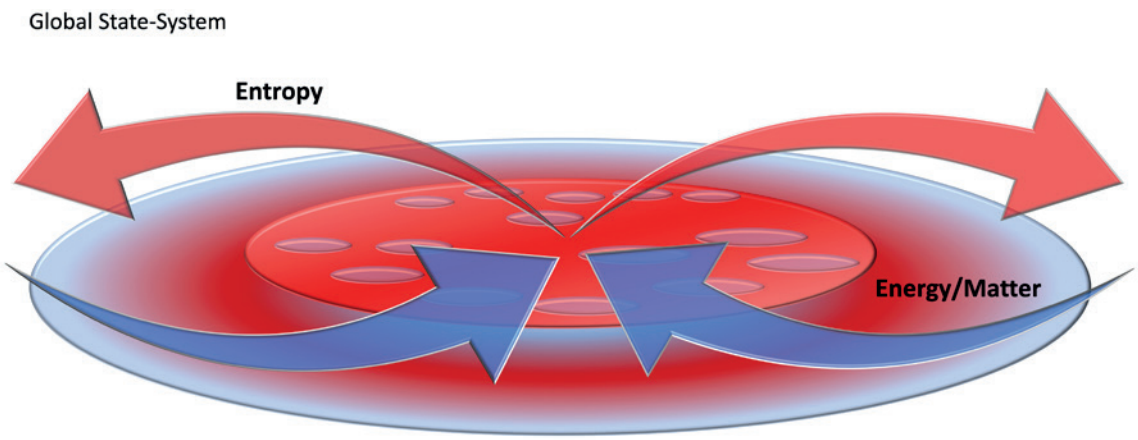


FIGURE 45.11: A 2nd infinity war. Assuming the 2nd FTS follows the same path of development as the 1st FTS, the global State-System (self-) destructs through the 2nd infinity war and is subsequently absorbed by the ("next") non-core that will be developed during the 2nd transient period (1945-....).

45.11. Carrying capacity

The carrying capacity of the human species in an environment is the maximum population size the environment can sustain indefinitely, given the food, habitat, water, and other necessities available in the environment. The (State-)System and societies/states also contribute - determine - the carrying capacity of the environment for the human species, e.g. by providing certain resources and services, but also through the depletion of and damage to the environment these structures cause.

"In population biology, carrying capacity is defined as the environment's maximal load" (45). Through the damage that is caused to the atmosphere and climate system, the human species has (almost) reached the environment's maximum load.

Arguably, an (increasingly) close relationship exists between the 1st and 2nd FTS, the environment and the environment's carrying capacity. In this paragraph I discuss the relationships between population size, the FTS and carrying capacity.

During the transient period, the population in Europe increased from 83 million in 1480, to 544 million in 1945. Population growth accomplished in other regions (e.g. Asia and Africa) shows that the presence of a FTS is not required to accomplish such a population growth/size.

During the transient period (1480-1945), the 1st FTS served above all as a supercharger of - an accelerator for - scientific and cultural discovery (culture as defined by Damasio (..)) and innovation and was instrumental in the diffusion of these innovations in the core and to the non-core of the (sate-)System. The 1st FTS served as a supercharger for processes of complexification and was instrumental in a dramatic increase in the free energy rate density Φ_m of the European (State-)System.

The 1st FTS had (and has) its own carrying capacity (as explained, the FTS/(State-)System can also be considered a primitive organism). The carrying capacity of a FTS/state-System in an environment is the maximum size and acceleration of the FTS/State-System, the environment can sustain. Societies/states, the non-core and the physical environment (the Earth system) constitute the environment of the FTS/State-System.

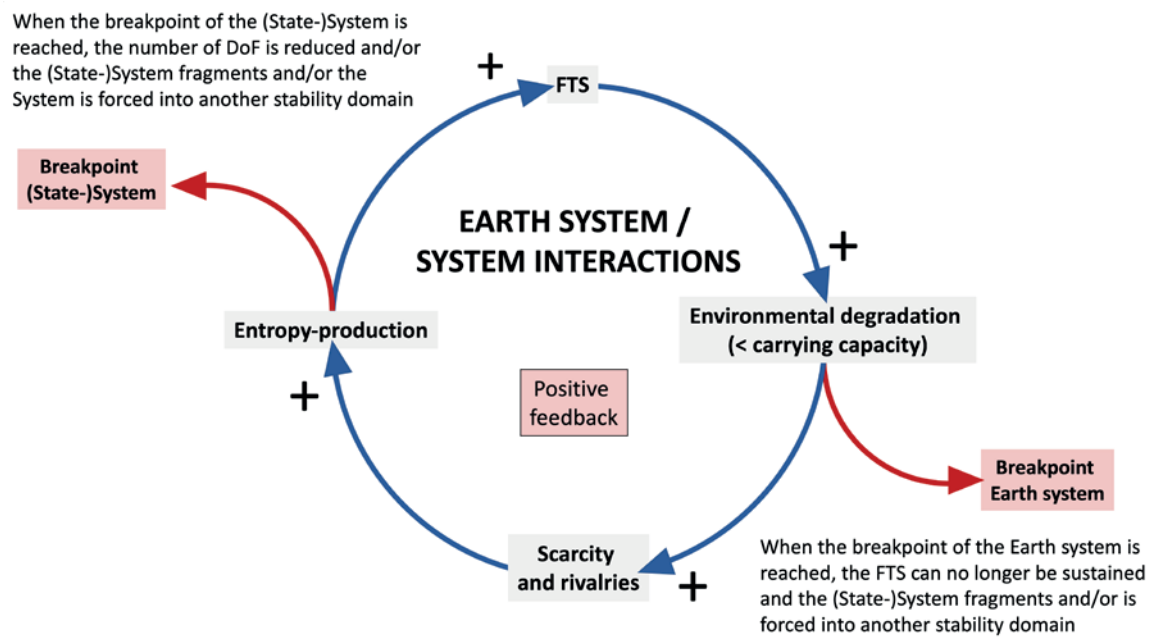


FIGURE 45.12: Interplay between the Earth system and System. The Earth system and FTS/(State-)System have become increasingly tightly coupled due to a decrease in the carrying capacity of the System.

The energy that was required to sustain the 1st FTS and the processes it produced during the period 1480-1945, was extracted from societies/states, the non-core and the Earth system; from the environment of the FTS. Also because of the damage these processes cause(d), the carrying capacity of the FTS/State-System System was/is increasingly depleted.
Only demands which are within the carrying capacity are sustainable. The problem for the human species and for the 2nd FTS (and global State-System) is that their demands exceed their respective (but overlapping) carrying capacities. Furthermore, the regenerative powers of these environments are also negatively affected. Over time, the carrying capacities of the physical environment and the human species and FTS, have become increasingly tightly coupled; there is not much slack left.
Arguably, the Earth system crisis can be attributed to innovations that were produced by the 1st FTS and 2nd FTS, and the acceleration of (related) processes the FTS's caused.
The destructive effects of the FTS are in fact twofold, not only pushes the 2nd FTS the (State-)System toward a 2nd infinity KA/war, but the 2nd FTS is also instrumental in the sustainment of processes and dynamics that further deplete the Earth system and the System's carrying capacity, at an accelerating rate. See figure 45.12.

45.12. The FTS cannot be (easily) stopped

The 2nd FTS contributes to the (potential) destruction of the global State-System: The 2nd FTS forces accelerating KA/war-dynamics on the (State-)System, which eventually result in an "infinity war", that will cause the (self) destruction of the global State-System. The 2nd FTS also demands an increasing free energy rate density Φ_m to sustain its operation, which causes further - accelerated - depletion of the Earth system. The 1st FTS was, and the 2nd FTS is, a forceful booster of climate change, and cause for the accelerated - and accelerating - depletion of the carrying capacity.
Furthermore, it can also be expected that the 2nd FTS causes even more damage to the Earth system in case nuclear and/or biological weapons are used in future KA/wars.
These damaging effects - which endanger humanity - raise the question if the FTS can be stopped or escaped from.
As the (development of the) 1st FTS shows, the FTS has its own "autonomous" momentum, in which individual humans and societies play a subordinate role: Furthermore, societies/states - and their citizens - have become (increasingly) dependent on a functioning (2nd) FTS for the fulfilment of their basic requirements, well-being (including security) and survival. The S-imperative "governs" the FTS and State-System; to which the H-imperative is subordinated.
Stopping the FTS is not a realistic and feasible option: It requires a coordinated response of societies/states in the (State-)System. It is also not a realistic option for societies/states to decide not to "participate" in the FTS; it is not a matter of choice: The FTS can be considered an accelerating treadmill that at the same time serves as a life support system; which "commands" - through societies/states - increasing amounts of resources that sustain its operation, but at the same time deplete the Earth system.
In chapter 41, I discussed to limitations of designed structures (versus dissipative structures): It is very doubtful if human engineered corrections to the (State-)System can produce the desired effects.
The most likely path of the (State-)System is that it will continue toward thermodynamic equilibrium via the most efficient path, and in case EMIS flows are distorted - e.g. through overcharging (with entropy)

of the 2nd FTS, or depletion of the Earth system - the Second Law and related principles will "decide" the response - the adjustments that must be made - to which - as was always the case until now - humans and societies/states will adjust.
Our ability for collective deception and the ISFP-mechanism, will ensure that we can justify the decisions that are required in the contingent domain. Until now, the FTS "decides": It constitutes a KA/war-trap we cannot escape.
Although humanity has achieved (some) control over biological evolution through gene engineering, we have not (yet?) achieved adequate control over human behavior and the (emergent) responses it generates.

45.13. Application (1): Eco-terrorism is a matter of time

There is always a tendency in systems - including in social systems - to "eradicate" - neutralize - gradients, including entropy-gradients. As discussed in this study, entropy can be redistributed and neutralized through KA. During RSP's of KA/war-cycles chaotic non-systemic KA/wars is used to "correct" entropic perturbations (issues and tensions). Solutions that are found to issues in the (State-)System are embedded in VC's. During systemic KA/wars this information can be used to contribute to the design of an upgraded order. During RSP's, the (State-)System - so to speak - explores phase space and produces innovations, through chaotic non-systemic KA/wars.
Terrorist activity can also be understood as responses of humans and social systems (communities) to gradients in the (State-)System, e.g. perceived inequalities, and differences in value-systems (information content). Through terrorist activity, the (State-)System is exploring and trying to find viable solutions to gradients in the (State-)System, also by trying to introduce new gradients to manipulate (inter)actions and developments.
It can be expected that the (State-)System will at a certain point - it seems only a matter of time - generate terrorist activity in response to the System's inability to adequately address the effects of climate change on societies and humanity: States are not able to adequately respond to the challenges of climate change, while the survival of humanity is at stake.
Through a combination of empowerment and "eco-terrorism" - e.g. by targeting certain infra-structures/ facilities that contribute to global warming - contributions can be made to the search for solutions to prevent and mitigate the effects of climate change.
Eco-terrorism also creates awareness and can force societies and the (State-)System to adapt; through eco-terrorism, mitigation of the effects of climate change can become a theme in the "interactive design" of the next order, during the next systemic KA/war.

For an overview of the main observations and conclusions, I refer to chapter 1.

Appendices

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Appendix A. Terms and definitions

Abnormal (non-chaotic non-systemic) KA/war dynamics

During two periods - respectively from 1657 until 1763 (denoted as the 1st exceptional period), and from 1953-1989 (denoted as the 2nd exceptional period) - the System produced series of 'abnormal' - non-chaotic non-systemic - KA/wars.
In both cases, these abnormal war dynamics can be attributed to a temporary reduction in the numbers of degree of freedom of the System to two. During the 1st exceptional period this was a consequence of intense rivalries between Britain and France and their respective allies; during the 2nd exceptional period because of intense rivalries between the United States and the Soviet Union and their respective allies.
The abnormal KA/war dynamics during the 1st exceptional periods caused inefficiencies in the (development of the) 1st FTS. The impact(s) of the abnormal KA/war dynamics during the 2nd exceptional period cannot yet be determined.

Abstract domain

The abstract domain of the System is the information domain, in which (cybernetic) information can be freely (re)combined. A distinction is made between the deterministic, contingent and abstract domains.

Accelerating cycle(s)

The 1st FTS (1480-1945) was accompanied by four accelerating cycles (oscillations), that developed very regularly and consistently. Each cycle consisted of a relatively stable period (RSP) followed by a critical period (systemic KA/war. The cyclic dynamics of the European (State-)System are also referred to as the R2-dynamics.

Accelerating growth

See: *Exponential growth*.

Activation energy

In chemistry and physics, activation energy is the energy which must be provided to a chemical or nuclear system with potential reactants to result in: a chemical reaction, nuclear reaction, or various other physical phenomena (96). Activation energy can be thought of as the magnitude of the potential barrier (sometimes called the energy barrier) separating minima of the potential energy surface pertaining to

the initial and final thermodynamic state. For a chemical reaction, or division to proceed at a reasonable rate, the temperature of the system should be high enough such that there exists an appreciable number of molecules with translational energy equal to or greater than the activation energy (96).
The concept of activation energy can also be applied to the State-System, where during the transient period (1480-1945), the State-System had to produce, accumulate, and put to use enough kinetic energy to overcome barriers that were contained in the order of the (State-)System. The activation energy that was required is a function of e.g. the connectedness and thresholds in the (State-)System, including barriers that were raised through the network-effect, during successive RSP's of cycles.

Actual FTS

See: *FTS*.

Affinity

See: *Social affinity*.

Aggregation (Process of)

Aggregation is the merging of (mostly) geographically contagious societies/states into a single structure/system. The process of aggregation started with the cooperation between families and tribes. Aggregation can be explained from a thermodynamic and social perspective: EMIS-regulation is optimized, and aggregation (cooperation) allows for the collective exploration and exploitation of economies of scale and scope (synergetic- of combination effects) in/between social systems. The process of aggregation also contributed to the ability of aggregated societies/states to improve their ability to develop, produce, mobilize and deploy kinetic energy (military capabilities).
A certain complementarity is a precondition for aggregation.
During the transient period (1480-1945), the 1st FTS was instrumental in a phase transition of the System, including in the accomplishment of full aggregation (thermodynamic equilibrium) in the core (Europe) of the System.
See also: See: *Nucleation (process)* and *Stages of aggregation*.

Amplification

The term amplification points to the non-linear reinforcement of entropic perturbations and/or kinetic responses - fluctuations - of/in the (State-)System. In case of entropic- and/or KA-amplification in the State-System, the S/T-field is involved, and through mode-coupling - a transportation process - the 'local' entropic perturbation is reinforced by the S/T-field; consequently the (initially local) perturbation is no longer local and has become subject to FTS (State-System) regulation. What perturbations are amplified, is determined by a combination of probabilistic and deterministic factors.

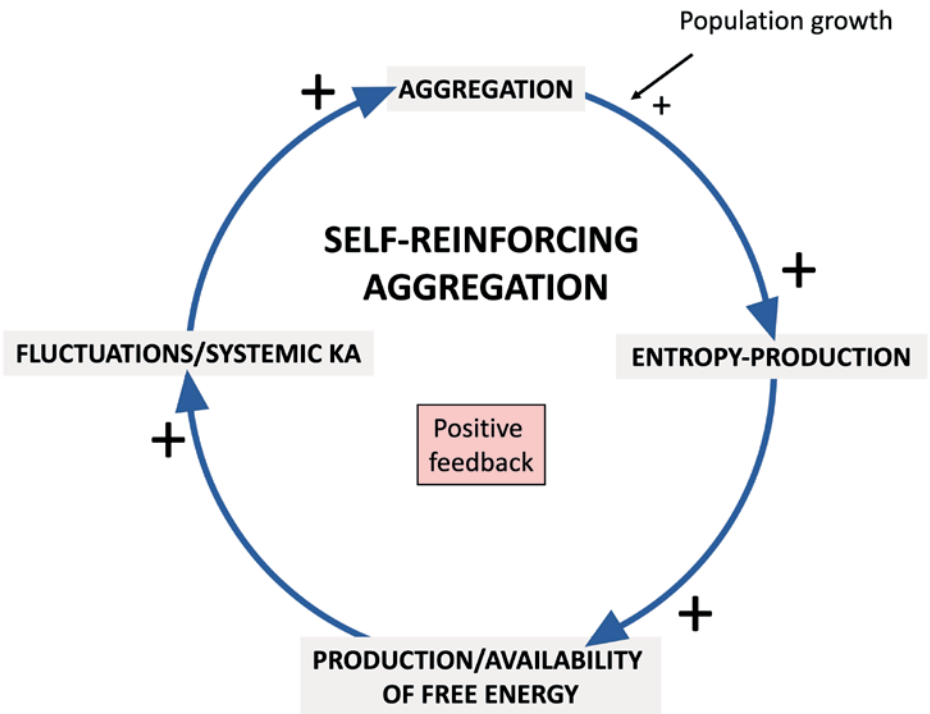


FIGURE A-1: CLD of the process of aggregation, during the transient period (1480-1945).

Anagenesis

Jantsch defines anagenesis as "the step-wise evolution of the dynamics of self-organization itself (*IP: "the evolution of evolutionary processes"*), bringing into play new levels of systems with their appropriate self-organization dynamics. It may be interpreted as self-transcendence in space-time (40).

Anarchistic systems

The State-System lacks a 'legitimate' integrative structure that is accepted by states in the System. States in an anarchistic system are considered sovereign and can govern themselves without 'outside' interference. States in an anarchistic system are responsible for their own security (the fulfillment of their basic requirements). The security dilemma is intrinsic to the dynamics of anarchistic systems: "a state's security is another state's insecurity". As Spruyt puts it: "Given the anarchical nature of the international system, force is viewed as the final arbiter regarding the viability of any institution" (84).

Arrow of time

See also: *Irreversible process(s)*.

Artifacts

In case of social evolution, niche expansion is accomplished through the invention and production of artifacts. Artifacts include material artefacts, organizational structures and social artefacts (like cultures as defined by Damasio (25)) (16).

Asymptotic stability

When a system is in a state such that the perturbations acting on it die out more or less quickly, the state of that system is asymptotically stable (66). Asymptotic stability is directly related to irreversibility (66), a property that is essentially responsible for the reproducibility of (deterministic) events. The resumption of chaotic kinetic interactions (non-systemic wars) after a temporary perturbation (a decrease in the number of degrees of freedom of the System from $n > 2$ to $n = 2$), is an example of asymptotic stability: The System resumed its default dynamics.

Contrary to dissipative systems like the System, a *conservative* system will keep the memory of a disturbance forever by permanently changing the patterns of oscillation (like a frictionless pendulum), and its dynamics are invariant with time reversal.

Asymptotic stability results in reproducible behavior, which can only be accomplished in dissipative systems. The four similar-cycles the System produced (Regime I dynamics), as well as the fact that the System resumes chaotic non-systemic dynamics during RSP's (Regime II) are manifestations of asymptotic stability, at the two levels of the system.

It can be argued that the reproduction of the first FTS (1480 - 1945), but now at a global scale also is a manifestation of asymptotic stability, characteristic for dissipative systems.

Attractor

"The general definition of an attractor is a set of points or states in state space to which trajectories within some volume of state space converge asymptotically over time. Thus, in addition to simple steady states, continuous dynamical systems may admit of more complex attractors. The simplest of these is a limit cycle, or hoop of states. If released on the hoop, the system flows around the hoop repeatedly. Over time, the variables exhibit a repetitive oscillation. The hoop is called a limit cycle because points not on it lie on trajectories which spiral either in or out and ultimately converge on it in the limit of infinite time. Thus, a stable limit cycle drains some basin of attraction. Just as a steady state is a zero-dimensional attractor in an N-dimensional state space, a limit cycle is a closed one-dimensional attractor in higher-dimensional state space".

In addition to these classes of attractors, strange, or "chaotic" attractors exist.

The interesting property of such attractors is that, if the system is released from two points on the attractor that are arbitrarily close to each other, the subsequent trajectories remain on the attractor surface but diverge away from each other. After a sufficient time flowing on the attractor, the two trajectories can be arbitrarily far apart on it. The first critical novel feature found in strange attractors but not in steady states, limit cycles, and so forth is due to this divergence of trajectories on the attractor. It is a sensitivity to initial conditions. Tiny differences in initial conditions make vast differences in the subsequent behavior of the system. In contrast, a system with a stable limit cycle squeezes all flows onto the same hoop of states; hence nearby initial points are still nearby later on.

The second feature to notice about strange attractors is that they may be of very low dimensionality even in a high-dimensional state space. Thus, a system may have 100 variables, but flow may be restricted to a strange attractor of two dimensions, a folded surface closing back on itself in that 100-dimensional space. From the point of view of the entire state space, the attractor is a very small object indeed. The system is boxed into a tiny volume of state space even though its behavior within that small volume is chaotic in the precise sense of high sensitivity to initial conditions. This point is very important to stress, for the behavior of such a system which exhibits low-dimensional chaos is much more orderly than the behavior of a system which wanders through vast tracts of state space on high-dimensional attractors." This definition is based on Kauffman (42).

Autocatalysis

In case of autocatalytic reactions, the product of a chemical reaction is involved in its own synthesis. Autocatalytic reactions are those in which at least one of the products is a reactant. Perhaps the simplest autocatalytic reaction can be written: $A + B \rightleftharpoons 2B$ (40). In case of the (State-)System there was/is "social autocatalysis".

During the period preceding the bifurcation in 1480 (which resulted in the emergence of the 1st FTS), and during HCR's, there was autocatalysis: Entropy and issues produced more entropy and issues. Autocatalysis during HCR's of RSP's/cycles can be attributed to the network-effect, which at a certain point (the tipping point) inhibits chaotic non-systemic KA/war; consequently, entropy is not adequately regulated or redistributed, but instead accumulates in the (State-)System. Autocatalysis is "a convenient way to introduce non-linearity" (65). The autocatalytic processes are essential for the development of the (State-)System.

Auto-correlation

Autocorrelation is the cross-correlation of a signal with itself. Informally, it is the similarity between observations as a function of the time lag between them. It is a mathematical tool for finding repeating patterns, such as the presence of a periodic signal obscured by noise or identifying the missing fundamental frequency in a signal implied by its harmonic frequencies. It is often used in signal processing for analyzing functions or series of values, such as time domain signals (96)

Basic requirements

Survival and a certain level of well-being of living systems, require the fulfilment of a set of basic requirements. Human/social basic requirements include: Energy-input and waste (entropy) disposal, identity and sense-making, security, and integration/balancing of these requirements (through governance in case of societies) (59).

Battle casualty deaths (BCD)

The measure 'BCD' stands for battle casualty deaths, the number of battle-connected deaths of military personnel of Great Powers that are involved in KA (wars) (48). BCD is a measure for the degree/amount of entropy and KA in the (State-)System. In the (State-)System FFE, BCD is a measure for the energy that is put to use and the entropy in the (State-)System.

Betweenness of a node

It is also possible to determine the shortest path - the distance - between nodes; the number of degrees that separates two nodes. The betweenness of a node is the total number of shortest paths between all possible pairs of nodes in the network that pass through this node. This measure characterizes the role - relevance - of a node in the network. Nodes with a larger betweenness are more influential, but also more influenced. This 'quantity' is also called the load or the betweenness centrality of a node; it indicates whether or not a node is important in traffic on a network. Great Powers typically have a high betweenness (centrality).

Bifurcation

Kondepudi et al. explain that "far-from-equilibrium states can lose their stability and evolve to one of the many states available to the system. Irreversible processes and the boundary conditions do not uniquely specify the nonequilibrium state to which the system will evolve; driven by internal fluctuations or other small external influences, the system leaves the unstable state and evolves to one of the many possible new states. These new states can be highly organized and are called dissipative structures" (44).
The 'switch' to the *organized* state FFE is also referred to as a bifurcation. The System experienced a bifurcation in 1480, which resulted in the emergence of the 1st FTS, and secondary bifurcations in: 1618, 1792, 1914 and 1939.

Binary decision(s) (with externalities and thresholds)

War decisions can be considered binary decisions: States decide to 'go to war' or 'not go to war' their "KA-state" (condition) is either 'active' ('on'), or 'inactive' ('off'). I assume that war decisions by states to a high degree depend on the condition ('war' or 'no war') of other states they are connected to. The number of other states that must switch to 'war' for a particular state to make a similar decision determines the state's threshold. War decisions of states qualify as binary decisions with externalities and thresholds: Other states ("externalities") determine a state's decision (war, or no war)), while thresholds apply to these decisions.

Binary network, dynamics of binary networks

A binary network consists of nodes that have two possible states of activity: On (active, war) or off (not active, no war). I consider the State-System a network of binary nodes, in which states constitute binary switches (nodes).

Bounded energy or degraded energy

Bounded or degraded energy is energy which is not available to accomplish work and is also referred to as entropy.

Carrying capacity

The carrying capacity "of a biological species in an environment is the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water, and other

necessities available in the environment. In population biology, carrying capacity is defined as the environment's maximal load". A metapopulation is "an assemblage of local populations living in a network of habitat patches. More generally, spatially structured populations at landscape scales are often called metapopulations" (96). Metapopulation capacity "is a measure of the size of the habitat patch that takes into account the total amount of habitat as well as the influence of fragmentation on metapopulation viability" (96).
The constraint also has a certain capacity (and certain limitations) to fulfill the 'demands' of the System and the FTS, of which the constraint is an integral part. By balancing continuity and change, the FTS enabled population growth, and a process of aggregation etc.
The 'carrying capacity' of the FTS can be defined as the maximum 'size' of the System - in terms of population size, but also as a collection of interacting societies - it can effectively regulate FFE, without the System losing its coherence and macroscopic/collective behavior.
I assume that the 'performance' of the 1st FTS during the transient period (1480-1945), is equivalent with its maximal load.

Causal loop diagram (CLD)

Causal loop diagrams are maps that show causal links among variables with arrows from a cause to an effect. A plus (+) denotes a positive relationship, while a minus (-) denotes a negative relationship between variables (87).

Chaos and **chaotic dynamics**

"Chaos is a phenomenon encountered in science and mathematics wherein a deterministic rule-based system behaves unpredictably. That is, a system, which is governed by fixed, precise rules, nevertheless behaves in a way that is, for all practical purposes, unpredictable in the long run" (30). Chaotic systems are deterministic systems that appear to be random. However, they actually follow precise (mathematical) rules (61). Thus, "behind the veil of apparent randomness, though, many processes are highly ordered, following simple rules" (23). "Mathematically chaotic systems are, in a sense perfectly ordered, despite their apparent randomness." "The study of chaos shows that simple systems can exhibit complex and unpredictable behavior. This realization both suggests limits on our ability to predict certain phenomena and that complex behavior may have a simple explanation" (30).
A dynamical system is chaotic if it possesses each of the following properties (30):

- The dynamical rule is deterministic.
- The orbits are aperiodic, i.e., they never repeat.
- The orbits are bounded and thus remain between an upper and lower limit.
- The dynamical system has sensitive dependence for initial conditions. A system that has sensitive dependence for initial conditions has the property that a very small change in its initial conditions will lead to a very large change in orbit in the phase state.

Chaos requires a system with only a few - but at least three - so-called degrees of freedom or variables, but not too many. Chaotic dynamics rely on the assumption that only a few major variables interact nonlinearly and create complicated trajectories (83). From a mathematical perspective, the fact that

chaotic dynamics are deterministic implies that the output of a deterministic function that describes the behavior of the chaotic dynamics is used as the input for the next step, which can be thought of as a feedback process in which output is used as input.

Sterman (87) defines chaotic dynamics from a system dynamics perspective as follows: "Chaos, like damped fluctuations and limit cycles, is a form of oscillation. However, unlike limit cycles, a chaotic system fluctuates irregularly, never exactly repeating, even though its motion is completely deterministic." "The irregularity arises endogenously and is not created by external, random shocks. Like a limit cycle, the path of a chaotic system is bounded to a certain region in state space. Because chaotic systems are bounded, chaos, like limit cycles, can only arise in nonlinear systems. However, unlike linear systems or limit cycles, chaotic dynamics do not have a well-defined period. The motion of a chaotic system never repeats; instead, the orbits of the system approach what is known as strange attractor, a set of closely related but slightly different orbits rather than a single closed curve. Furthermore, chaotic systems have the property known as sensitive dependence on initial conditions. Two nearby trajectories, no matter how close, will diverge exponentially until the state of one provides no more information about the state of the other than any randomly chosen trajectory. Sensitive dependence means that the prediction horizon for chaotic systems, the length of time over which forecasts of future behavior are accurate, is likely to be short even if our model of the system structure and parameter estimates are perfect."

This study shows that two types of non-systemic KA/war dynamics can be distinguished: chaotic- and non-chaotic non-systemic KA/war dynamics. 'Normally' - I argue - non-systemic KA/war dynamics are chaotic in nature; however, it is not possible to scientifically prove that war dynamics are chaotic in this mathematical sense, since (for one reason) insufficient data is available.

This study shows that the nature of non-systemic KA/war dynamics - chaotic or non-chaotic - is determined by the number of degrees of freedom (n) of the (State-)System: In case $n > 2$, KA/war dynamics are chaotic in nature; if $n = 2$ non-systemic KA/war dynamics are periodic (as was the case during the 1st exceptional period, 1657-1763), or subdued (as was the case during the 2nd exceptional period (1945-1989). The intensities of rivalries between Great Powers determine the number of degrees of freedom of the (State-)System. In case of the 1st and 2nd exceptional period, the number of degrees of freedom of the (State-)System was temporarily decreased as a consequence of the intense rivalry between respectively Britain and France, and between the United States and the Soviet Union.

During the 1st exceptional period (1657-1763), non-systemic KA/war dynamics were periodic (two subcycles can be distinguished), often extreme (in size and severity), and 'hyper-excited'. I attribute the extreme and hyper-excited nature of non-systemic war dynamics to a lack of 'inhibition' of the (State-) System's non-chaotic KA/war dynamics; as a consequence of a lack of a third - balancing - degree of freedom. During the 1st exceptional period, not only produced the (State-)System extreme tensions, but they were also 'immediately' released.

Chaotic KA/war dynamics are a precondition for the (State-)System to reach the tipping point of the cycle/RSP and the become critical.

Chaotic (non-systemic) KA/war dynamics

See: *Non-systemic KA/war*.

Chirality

A structure whose geometrical structure is not identical to its mirror image is said to possess chirality or 'handedness'.

CINC-index

CINC-index stands for the 'Composite Index of National Capability' and is based on six variables: (1) total population, (2) urban population, (3) iron and steel production, (4) energy consumption, (5) military personnel, and (6) military expenditure. CINC is s statistical measure of national power; its components represent demographic, economic and military strength. Each component (out of six) is a percentage of the word's total: Component ratio = state / global; the CINC (by state) = the sum of the six ratios / 6 (79).

Closed system

Closed systems exchange energy with their environment. Isolated systems do not exchange energy and matter with their environment; open systems exchange energy and matter with their environment.

Coexistence region

See: Phase transition.

Cold War

See: *Exceptional periods*.

Collective deception

See: *Deception*.

Collective dimension

The so-called collective dimension - which is related to the carrying capacity of the System - is closely related to the constraint of the (State-)System.
Increasing interdependence (and connectivity) implies a strengthening of the collective dimension. The correlation length of VC's can be considered a measure for the 'collective dimension' of the (State-)System.

Complexity and complex behavior

Complexity is defined in different ways, also depending on the particular perspective. One of the essential features of complex behavior is the ability to perform transitions between different states. Stated differentially, complexity is concerned with systems in which evolution, and hence history, plays or has played an important role in the observed behavior. (66). Nonequilibrium, feedback, transition phenomena, evolution are ingredients of complex behavior (66).
Properties of complexity (10), include:

- Complex systems contain many constituents interacting nonlinearly.
- The constituents of a complex system are interdependent.
- A complex system possesses a structure spanning several scales.
- A complex system is capable of emerging behavior.
- Complexity involves an interplay between chaos and non-chaos.
- Complexity involves an interplay between cooperation and competition.

Chaisson defines complexity as "a state of intricacy, complication, variety, or involvement, as in the interconnected parts of a structure; a quality of having many interacting, different components" (20). Chaisson uses the term "complexity" to describe "the state and degree of order" (organization) of a system or structure. Chaisson uses the free energy rate density as a measure - a diagnostic tool - for complexity of a system; Chaisson also argues that "a more thorough analysis of open systems' emergent properties must account for not just quantity of energy flow, but also the quality and efficiency of that flow" (20).

Complex region

Because of the generation of complexity in the region between order and disorder, this region is also referred to as the complex state or complex region.

Complex system

Various definitions of complex systems exist. Simon describes a complex system as a system that is "made up of a large number of parts that interact in a non-simple way. In such systems, the whole is more than the sum of the parts, not in an ultimate, metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole".

Conditioning

Conditioning in psychology is a theory that states that the response or reaction by a person to an event (stimulus) can be modified by learning (that is conditioning). A distinction is made between classical and operant conditioning, when respectively an involuntary response and voluntary behavior are associated with a stimulus; in case of operant conditioning the agent is active.

Connectivity of the (State-)System

With the connectivity of the (State-)System, I refer to two different (but related) systems/networks, to: (1) The connectivity of the 'overall' network/System, related to its population size and to population growth, and (2) the connectivity of the network of VC's, and accompanying tensions.
Population size (concerning the overall network/System) determines the (State-)System's pace of life; the degree of connectivity of the issue network determines if relatively stable periods (international orders) are in a low-or high-connectivity regime.

Connectivity or population threshold

The connectivity or population threshold of the State-System is the point when the connectivity and population of the State-System have reached such levels that the State-System consequently produces infinite amounts of entropy and KA; connectivity and population-size are closely related.
The European State-System reached the threshold in 1939 and consequently collapsed. The critical population threshold of the European State-System - the population-size in 1939 - was 544 million.

Conservative system

A dissipative system displays irreversibility, contrary to conservative systems, in which dynamics are invariant with time reversal (66).

Constraint

The term 'constraint' is related to certain limitations of a system, that define boundaries to its dynamics. A constraint has an important function in generating and in maintaining nonequilibrium states and nonlinearities, and in producing dissipative structures (66). A constraint drives the EMIS-flows required to generate and sustain dissipative structures. The constraint has a certain 'strength' and generates a certain force and flows. The S/T-field is a manifestation of the constraint of the (State-)System.

Contingent domain

Analytically, it is possible to make a distinction between a contingent and a 'underlying' deterministic domain in the System; there also exists an abstract domain. The deterministic domain can be considered a 'platform' that imposes a number of (deterministic) constraints on the contingent domain; laws of physics that apply to the (State-)System and its dynamics reside in the deterministic domain. The deterministic domain determines the contingent latitude of the contingent domain. Both domains are inseparably linked and interact continuously. Although the deterministic domain is governed by certain physical and thermodynamically laws there also is a combination of probabilistic and deterministic factors at play in this domain.
The world we experience and act upon plays out in the contingent domain; the contingent domain is our living 'space' and playing field.

Contingent latitude

Although the deterministic domain determines the dynamics and development of the (State-)System, some 'latitude' is left for contingent dynamics (the contingent domain); in principle 'all' contingent dynamics are possible ('allowed') as long as they do not conflict with - infringe on - deterministic laws. When the entropy of a social system decreases, the contingent latitude also decreases. Entropy - new possibilities - is the "source" of contingent latitude. The 'amount' of contingent latitude - entropy we can effectively put to use - determines the degrees of freedom of humans and social systems.

Control parameter

A control parameter determines the dynamics - behavior - of a system. See also: *Order parameter*.

Core

During the transient period (1480-1945), the System consisted of a core - Europe - and a non-core; "the rest of the world".

Corrected FTS

See: *FTS*.

Correlation length

The correlation length of a system measures the characteristic distance with which the behavior of one element of the system is correlated with or influenced by the behavior of another element. The correlation length in the State-System is the size of largest VC. At the critical point of the (State-)System, there is a divergence of the correlation length of the System and the largest VC spans the (State-)System. Consequently, at the critical point, the (State-)System is highly susceptible for perturbations, that can propagate through the whole system. Criticality enables system-wide communication, coordination and planning; properties that are 'used' by the (State-)System during systemic wars to interactively "design" and implement (system-wide) upgraded orders.
Jensen (41) explains the term correlation length as follows: "The nature of the critical state is described by the response of a system to external perturbation. For systems exhibiting noncritical behavior, the reaction of the system is described by a characteristic response time and characteristic length scale over which the perturbation is felt spatially. Although the response of a noncritical system may differ in detail as the system is perturbed at different positions and at different times, the distributions of responses is narrow and well described by the average response. For a critical system, the same perturbation applied at different positions or at the same position at different times can lead to a response of any size. The average may not be a useful measure of the response; in fact, the average might not even exist."

Cosmic evolution

See: *Universal change*.

Criticality and the functionality of critical states

"The word criticality has a very precise meaning in equilibrium thermodynamics: It is used in connection with phase transitions". At a specific transition value of the control parameter, a local distortion of the system not only influences the local neighborhood, but also propagates throughout the entire system. "The system becomes critical in the sense that all members of the system influence each other" (41).
Systemic KA/war is equivalent with a critical state of the (State-)System: There is a divergence of the correlation length of VCs and the largest VC spans the (State-)System. These properties allow for system-wide communication and coordination to design and implement an upgraded order.
Other systems, like the brain, as Beggs et al. (12) argue also seem to 'use' criticality to perform certain functions.
Beggs et al. argue that "Relatively recent work has reported that networks of neurons can produce avalanches of activity whose sizes follow a power law distribution. This suggests that these

networks may be operating near a critical point, poised between a phase where activity rapidly dies out and a phase where activity is amplified over time. The hypothesis that the electrical activity of neural networks in the brain is critical is potentially important, as many simulations suggest that information processing functions would be optimized at the critical point."
"Criticality is a phenomenon that has been observed in physical systems like magnets, water, and piles of sand. Many systems that are composed of large numbers of interacting, similar units can reach the critical point. At that point, they behave in some very unusual ways. A similar dynamic seems at work in the brain. Some people, including myself, suspect that cortical networks within the brain may be operating near the critical point."
Beggs et al. explain that, at the critical point, the disordering force is counterbalanced by an ordering force and vice versa. At that point, the system lacks global order and consists of ordered and disordered clusters of all sizes. This is best described by a power-law distribution. At the critical point between the ordered and disordered phases, "you have the phase transition region, which is very narrow and occurs at the critical temperature." "Only at the critical temperature (*IP: at the critical point*) can you have communication that spans large distances. So, if I (*IP: Beggs et al.*) were to make an analogy with a neural network, it would be that at the critical point, the neurons can communicate most strongly and over the largest number of synapses."
Beggs et al. further explain, "At the critical point two qualities of the system – coupling and variability – are balanced to produce long distance communication. And it turns out that it is not just communication that would be optimized at the critical point." Referring to other research, Beggs et al. explained that a number of brain functions seem to be optimized at the critical point, including information storage, computational power, dynamic range, and phase synchrony." The point now is not to discuss criticality of the brain as such, but rather the phenomenon that the brain's information processing functions are optimized at the critical point according to Beggs et al.

Critical connectivity threshold

See: *Critical population threshold*.

Critical fraction

During the transient period (1480-1945), the (State-)System produced four accelerating KA/war-cycles; each cycle with an identical life-cycle, consisting of a RSP followed by a critical period. A RSP consisted of a LCR and HCR. During HCR's the average size of non-systemic KA/war decreased because of the network-effect. Analysis shows that a systemic KA/war was triggered when the average size of five successive non-systemic KA/wars had decreased to a range of 0,17 - 0,30. The average size of non-systemic KA/wars, the moment a systemic KA/war is triggered is referred to as the critical fraction (59).

Critical period

The term critical period refers to the (critical) period which typically followed a RSP, after it had reached the critical point. During RSP's, the (State-)System is in a subcritical state.

Critical point

According to Solé (81) "the term critical point is used to describe the presence of a very narrow transition domain separating two well-define phases, which are characterized by distinct macroscopic properties that are ultimately linked to changes in the nature of microscopic interactions among the basic units". At the critical point, there is a divergence of the correlation length of vulnerable clusters, and this configuration of VC's enables system-wide 'communication' and coordination: An incident will cascade - reverberate - through the (State-)System; an incident and the kinetic response that follows cannot stay localized. The system-wide communication and coordination enabled by the divergence of the correlation length, during criticality - during systemic KA/war - also allows for the collective design and implementation of an upgraded order of the State-System.

According to Sornette (83) "in physics, critical points are widely considered to be one of the most interesting properties of complex systems. A system goes critical when local influences propagate over long distances and the average state of the system becomes exquisitely sensitive to a small perturbation; that is, different parts of the system become highly correlated. Another characteristic is that critical systems are self-similar across scales."

"A critical point is used to describe the presence of a very narrow transition domain separating two well-defined phases, which are characterized by distinct macroscopic properties that are ultimately linked to changes in the nature of microscopic interactions among the basic units. The lack of a boundary beyond the critical point makes possible a continuous movement from one phase to the other, provided that we follow the appropriate path; the critical curve (boundary) does not have to be crossed."

The critical point describes a condition where there is in fact no longer a distinction between two phases. Such a condition is reached when the control parameters of the system (in the case of water, temperature and pressure) have specific values. "The presence of this point has a crucial relevance in understanding the nature and dynamics of many natural and social phenomena" (81).

During the transient period (1480-1945), two types of critical points can be distinguished: Critical points during cycles/RSP's that were reached in 1618, 1792 and in 1914, triggered systemic KA/war, which resulted in upgrades of the order of the European State-System, and the critical point - also referred to as the critical population or connectivity threshold - of the European State-System that was reached in 1939, which caused the European State-System's collapsed and triggered the last stage in the phase transition; the 4th systemic KA/war (the Second World War, 1939-1945).

See also: *Phase transitions*.

Critical point of RSP's

See: *Critical point*.

Critical point of the State-System

The State-System has a critical point, when regulation by the FTS and the State-System (which is the structural component of the FTS) is no longer possible and the State-System (and FTS) collapses. At the critical point of the State-System, the State-System produces "infinite" amounts of entropy and KA. The critical point of the State-System is equivalent with a critical population size (being the basic driver

of the (State-)System). The European State-System reached the critical point in 1939, collapsed and consequently experienced the last stage of the phase transition to thermodynamic equilibrium of the European State-System. See also: *Critical point*.

Critical population threshold or critical connectivity threshold

In 1939, the European State-System reached the critical population or connectivity threshold and produced infinite amounts of entropy and consequently KA, the 1st FTS could no longer regulate. The European State-System collapsed in 1939 and the last stage of the phase transition (1480-1945) - the 4th systemic KA/war (the Second World War, 1939-1945) - was triggered.
The critical population threshold of the European State-System was about 544 million (the population size at the time (1939) of collapse).

Critical slowing down

Critical slowing down is defined as a sharply marked increase in the relaxation time of a system close to a phase transition and is by some scientists considered a dynamical signature of criticality, that can be used as a warning signal of a critical transition, and an indicator of future changes (15, 24, 46, 69, 70, 71). Relaxation time refers to the rate at which a system recovers from small perturbations.
This study shows that critical slowing down cannot be observed in the (State-)System, during the transient period (1480-1945): To the contrary: there was a speeding up of the phase transition taking place, a phenomenon that can be attributed to the accelerating entropy=production by the 1st FTS/ European State-System.

Critical speeding up

See: *Critical slowing down*.

Critical transition

I consider critical transitions and phase transitions identical phenomena.

Cyber domain (or cyber space)

The cyber domain is part of the abstract domain. The word 'cyber' has become closely related to information, information and computer technology and their applications, and communication (the exchange of information). In the cyber domain, communication (information exchange) occurs over computer networks. In case of cyber warfare, the cyber domain is put to use to influence users and to exploit computer and information networks to perform acts sabotage and cause physical destruction in support of political and military objectives.

Cybernetic information

Cybernetic information is a specific 'category' of information, for example used by biological and social systems to control and communicate. "In cybernetics, stress is placed on the quantitative flow of an intangible attribute (that is information), from transmitter to receiver".

Cybernetics

Cybernetics is a transdisciplinary approach for exploring regulatory systems; their structures, constraints, and possibilities. Norbert Wiener defined cybernetics in 1948 as "the scientific study of control and communication in the animal and the machine." In the 21st century, the term is often used in a rather loose way to imply "control of any system using technology." In other words, it is the scientific study of how humans, animals and machines control and communicate with each other.

Cyclic (KA/war) dynamics, R2-dynamics

During the transient period (1480-1945), the (State-)System produced R1 dynamics - chaotic non-systemic KA/wars, during RSP's of cycles that are subject to a thermodynamic state FFE - and cyclic R2-dynamics (four accelerating cycles), which are subject to near equilibrium thermodynamics. Whereas R1-dynamics are intrinsically unpredictable, are R2-dynamics highly predictable. See also: *Non-systemic and systemic KA/wars*.

Damped oscillator

According to Sterman: "In an oscillatory system, the state of the system constantly overshoots its goal or equilibrium state, reverses, then undershoots, and so on. The overshooting arises from the presence of time delays in the negative loop. The time delays cause corrective actions to continue even after the state of the system reaches its goal, forcing the system to adjust too much, and triggering a new correction in the opposite direction" (87). Different types of oscillations can be distinguished, including "damped" oscillations. The equilibrium of a damped oscillator is said to be locally stable (*IP: a RSP is locally stable*). "Perturbations will cause the system to oscillate, but it will eventually return to the same equilibrium" (87) (*IP: The initial order that was established in 1480, in this case*). While many oscillatory systems are damped, the equilibriums of other systems are locally unstable, meaning that small disturbances tend to move the system farther away from the equilibrium point".
During the period 1495-1618, of the 1st RSP (1480-1618), of the 1st KA/war-cycle (1480-1648) of the 1st FTS (1480-1945), produced the chaotic non-systemic KA/wars (n = 45), nine orbits which constituted a damped oscillator.

Deception

Deception refers to the ability of humans to individually or collectively deny or rationalize away the relevance, significance, or importance of opposing evidence and logical argument. The ability for collective deception is a powerful variable in the interacting self-fulfilling prophecy mechanism that ensures that the contingent domain is synchronized with the deterministic domain.

Decision threshold

KA/war decisions in the (State-)System qualify as binary decisions with thresholds and externalities. States apply, mostly implicitly, thresholds that define when they switch to positive war decisions. The number and properties of incoming signals that trigger a positive war decision by states define their respective thresholds. Thresholds are properties of states. The thresholds that states apply, explicitly or implicitly, are a function of their basic requirements, perceived threats and tensions, and issues the state is connected with. Different states apply different thresholds, and the thresholds of particular states are dynamic. With respect to thresholds of states, the System qualifies as a heterogeneous network.
Thresholds of states are not expressed in terms of the absolute number of a state's 'neighbors' that choose a given alternative ('war' or 'no war'), but the corresponding fraction of connected states. "This is a natural condition to impose for decision-making problems, because the more signals a decision maker receives, the less significant any one signal becomes (93)."

Degraded energy

Degraded or bounded energy is energy which is not available to accomplish work and is also referred to as entropy. See: *Entropy*.

Degree of a network (k)

The number of connections of a node (for example a state-structure as part of the network of VC's) is referred to as its degree $\boldsymbol{k}$.

Degrees of freedom

The number of degrees of freedom ($\boldsymbol{n}$) are the number of independent positions or momenta of the problem (66); "the independent modes of motion are often called degrees of freedom" (44). In case of the (State-)System, the degrees of freedom ($\boldsymbol{n}$) refer to the number of states that impact on KA/war-decisions of states. Normally, during RSP's of cycles, $\boldsymbol{n} > \mathbf{2}$, and the non-systemic KA/war dynamics are chaotic in nature. During the 1st and 2nd exceptional period (respectively, 1657-1763, and 1945-1989), $\boldsymbol{n} = \mathbf{2}$, and the non-systemic KA/wars were respectively periodic and highly suppressed.

Destructive growth

See: *Kinetic growth*.

Detailed balance

In case of equilibrium there is detailed balance; it only holds at equilibrium: "detailed balance precludes nonrandom behavior: "motions" are cancelled out; in case the poissonian behavior is temporarily/locally disturbed, it will be recovered" (35).

Deterministic domain

The deterministic domain consists of the collection of laws of physics and nature, that apply to the (dynamics of the) State-System.

Developmental biology

Developmental biology is the study of the process by which animals and plants grow and develop, and is concerned with e.g. the questions of differentiation, the organization in functional structures and growth and reproduction (35).

Diffusion

Diffusion is the net movement of molecules or atoms from a region of high concentration (or high chemical potential) to a region of low concentration (or low chemical potential) as a result of random motion of the molecules or atoms. Diffusion is driven by a gradient in chemical potential of the diffusing species (96).

Dissipation

"Dissipation is the result of an irreversible process that takes place in homogeneous thermodynamic systems. A dissipative process is a process in which energy (internal, bulk flow kinetic, or system potential) is transformed from some initial form to some final form; the capacity of the final form to do mechanical work is less than that of the initial form. For example, heat transfer is dissipative because it is a transfer of internal energy from a hotter body to a colder one. Following the second law of thermodynamics, the entropy varies with temperature (reduces the capacity of the combination of the two bodies to do mechanical work), but never decreases in an isolated system" (96).

Dissipative structure or dissipative system

Contrary to conservative systems, dissipative systems give rise to irreversible processes. AA dissipative structure (or system) system is an open system which is operating out of, and often far from, thermodynamic equilibrium in an environment with which it exchanges energy and matter. "Dissipative structures are generated and maintained through irreversible processes that continuously generate entropy" (44). "A characteristic feature of dissipative structures is that consumption of energy is required to maintain the organized state" FFE (4).

The formation of a dissipative structure "requires a thermodynamic threshold corresponding to a minimum level of dissipation" and is a far more phenomenon than originally thought (62). A dissipative structure can be considered a "a giant fluctuation" that is stabilized by the flow of energy and matter from the outside world (the system's environment) (u). This has "a lower entropy compared to the uniform steady-state entropy" and the "entropy decrease is translated by the emergence of space order".

Initially - in the nineteenth century - dissipation was associated with degradation, the exhaustion of available energy (66). In physics, irreversibility and dissipation were interpreted as degradation, while

among natural scientists biological evolution, which is obviously an irreversible process, was associated with increasing complexity (66). Today scientists realize that dissipative systems constitute a very large and important class of natural systems (66).
The FTS - of which the State-System is the structural component - qualifies as a dissipative system and is highly dependent on flows of energy (***E***), information (***I***), matter (***M***) and entropy (***S***).

TABLE A-1: Properties of conservative and dissipative systems (a, 194-198).

	Conservative dynamical systems	Dissipative dynamical systems
Phase space	Volume is conserved and has a deformed shape as a consequence of instability.	Volume is not conserved in phase space.
(In)stability	Intrinsically unstable - orbital randomness - because of the absence of asymptotic stability.	Asymptotic stability, allowing for balancing processes and regulation, as is accomplished in the (State-)System through the FTS. But randomness also exists.
Attractor	Maximum stability through orbital stability.	If nonequilibrium constraints are imposed, the evolution will be to a point attractor, a limit cycle or a strange attractor.
Sensitivity to initial conditions	Extreme sensitivity to initial conditions.	Sensitivity to initial conditions exists in case of a strange attractor.
Arrow of time	No arrow of time.	Arrow of time. In our world, a universal time symmetry breaking is present.
Time (ir)reversibility		Not invariant to time reversal.
Privileged situation		A privileged situation will be reached asymptotically, as $t \rightarrow \alpha$. If constraints are not imposed, this will be the equilibrium situation: A dissipative system will be driven to equilibrium, or to some nonequilibrium state characterized by suitable attractors when constraints are introduced.
Chaos	Chaotic behavior can be observed.	Chaotic behavior can be observed, however, the Lyapounov exponents that characterize the instability of motion, are characterized by macroscopic quantities (such as the transport of tensions and energy, in case of the System), and not by microscopic dynamics.
Entropy	Positive entropy production.	Positive entropy production. Dissipative dynamical systems, order in general, is a manifestation of the Second Law of thermodynamics, and related principles that apply.
Evolution	No place for probabilistic evolution.	Probabilistic evolution is possible.

Driving force

The primary driving force of the (State-)System is entropy(production), caused by population growth

Dual behavior

Depending on the state of a system - in equilibrium, near equilibrium or far from equilibrium (FFE) - the effect - impact - of the Second Law is different: "Although the destruction of order always prevails in a system in or near thermodynamic equilibrium, the construction of order may occur in a system far from equilibrium. Whereas classical thermodynamics deals with the first type of physical behavior, novel aspects of non-equilibrium thermodynamics are only now being developed and are needed to decipher the second type of behavior" (20). The System displayed dual behavior, a combination of destruction and construction.

Dynamic self-assembly (DySA)

See: *Self-assembly*.

Dynamic steady state

See: *Steady State*.

Dynamical systems

In physics, a dynamical system is described as a "particle or ensemble of particles whose state varies over time and thus obeys differential equations involving time derivatives" (96). The (State-)System and its components (including societies and states) qualify as dynamical systems, of which e.g. the thermodynamic states vary over time.
Sterman (87) describes three common modes of behavior of dynamical systems: Goal seeking, exponential growth and oscillations. See: *Modes of behavior dynamical systems*.

Dynamics of and on the network (System)

A distinction must be made, between the dynamics of the "underlying" networks of VC's that form in the (State-)System, and the resulting KA/war dynamics *on* these evolving networks. The network-effect - which is activated once the tipping point of a cycle/RSP is reached - can be considered a dynamic *of* the "underlying" networks of VC's, while the resulting decrease in the average size of non-Systemic KA/wars is a dynamic (effect) that concerns a dynamic *on* these networks.

Early Warning Signal(s) (EWS)

With the term 'early warning signals' I refer to signals in the dynamics and (development of) properties of the (State-)System that are related to particular dynamics of/in the (State-)System. For example, increasing political and social volatility in the contingent domain, signals the accumulation of entropy (tensions and issues) in the (State-)System.

Ecology

Ecology is the scientific study of the interactions that determine the distribution and abundance of organisms (interactions among organisms and their environment) (45).

Eco-terrorism

Eco-terrorism is a form of terrorism, when non-state actors engage in terrorist activity to generate publicity and to enforce social and political change, to prevent further damage to the climate system. See also: *Terrorism*.

Edge of chaos

The 'edge of chaos' concerns a concept introduced by Kauffman (87). The edge of chaos correspondents with a system's critical point. Kauffman argues that the edge of chaos (a critical point) is the attractor of certain complex systems, because their performance and evolvability are than optimized. The concept of the edge of chaos is to a high degree identical with 'self-organized criticality' (8).
"Many people have suggested that complexity occurs "at the edge of chaos", but no one has been able to make this totally clear. Presumably it means something like the following. Imagine that the equations of motion contain some "control" parameter which can be changed, depending on the environment (examples: temperature, concentration, intensity of some external effect like sunlight). We know that most nonlinear systems are not 100% chaotic: they are chaotic for some values of the control parameter and not chaotic for others. Then there is the edge of chaos, i.e. the precise value of the control for which the nature of the dynamics switches. It is like a critical point in phase transitions. It is the point where the long-range correlations are most important. Perhaps complex systems, such as biological systems, manage to modify their environment so as to operate as much as possible at this edge-of-chaos place, which would also be the place where self-organization is most likely to occur. It makes sense to expect self-organization to happen when there are strong long-range correlations' (10).

Emergence

"In philosophy, systems theory, science, and art, emergence is the condition of an entity having properties its parts do not have, due to interactions among the parts. Emergence plays a central role in theories of integrative levels and of complex systems. For instance, the phenomenon of life as studied in biology is an emergent property of chemistry, and psychological phenomena emerge from the neurobiological phenomena of living things" (96).

EMIS, EMIS-flows

The term "EMIS-flows" refer to (closely) related flows of energy ($\boldsymbol{E}$), Matter ($\boldsymbol{M}$), Information ($\boldsymbol{I}$) and entropy ($\boldsymbol{S}$) in the (State-)System.

Empowerment (Process of)

The process of empowerment refers to the "transfer" of "degrees of freedom" to lower-level entities - e.g. individuals and communities - in societies/states. Through empowerment the ability to cope with entropy(-production) is enhanced. The process of empowerment - like the processes of KA, aggregation and expansion - is regulated by the FTS.

End-directed evolution

From a thermodynamic point of view, the emergence of dissipative structures may be interpreted as end-directed evolution by which is meant "that the system may take several different paths but reach the same final state" (44). "End-directed evolution is a familiar concept in thermodynamics; after all, according to the Second Law, systems evolve to states of maximum entropy or minimum Gibbs or Helmholtz energy. We might not know the mechanism or the path a system will take to its final extremum state, but we can be sure that it will reach that state. In this case, the final state is an equilibrium state in which there is no entropy production. It is possible that end-directed evolution may also be a property of far-from-equilibrium systems" (44).

Energetically (un)favorable

According to the Second Law, a process can proceed only spontaneously, if it results in a net increase in disorder (entropy, $\Delta \boldsymbol{S} > \boldsymbol{0}$) of the 'overall' system.

The criterion for an increase in disorder ($\boldsymbol{S}$) of the overall system "can be expressed most conveniently in terms of the quantity free energy", $\boldsymbol{F}$, of a system (Cell). As explained in chapter 3, $\Delta \boldsymbol{F}$ is a measure for the disorder $\boldsymbol{S}$ that is created ($\boldsymbol{E}$ (the total energy) = $\boldsymbol{F}$ (free energy) + $\boldsymbol{S}$ (entropy), at least if the system is not open). The value of F is of interest only when a system undergoes a change - as is the case for KA/war (a correction is made, or the order is upgraded) - and the change in $\boldsymbol{F}$ ($\Delta \boldsymbol{F}$), is critical (2).

A reaction or process $\boldsymbol{Y} \rightarrow \boldsymbol{X}$ is said to be energetically favorable - the process can take place spontaneously - if the free energy of $\boldsymbol{Y}$ is greater than the free energy of $\boldsymbol{X}$. Then, $\Delta \boldsymbol{F} < \boldsymbol{0}$ and the disorder of the overall system (environment) can increase during the process ($\Delta \boldsymbol{S} > \boldsymbol{0}$), in accord with requirements of the Second Law.

However, if the reverse process $\boldsymbol{X} \rightarrow \boldsymbol{Y}$ would occur, $\Delta \boldsymbol{F} > \boldsymbol{0}$, and the environment would become more ordered ($\Delta \boldsymbol{S} < \boldsymbol{0}$), this process can only occur, if it is coupled to a second, energetically favorable reaction/process, which supplies the free energy, and ensures the Second Law is not violated (2).

Energy

Energy ($\boldsymbol{E}$) is defined in physics as the ability to do work.

Energy state

The energy state of the (State-)System concerns the amount of energy in the (State-)System, which is a function of the entropy in the (State)System FFE. During successive cycles of the 1st FTS, during the transient period (1480-1945), the energy-state of the State-System increased, whereas its entropy decreased. Systemic KA/war only resulted in a temporary decrease in the energy-state.

Energy transformation

During the transient period various (energy) transformation processes occurred; e.g. "societal energies" were transformed into kinetic energy (military capabilities), a process that was regulated by states, and

in which entropy (issues and tensions) served as a catalyst. During KA/war, the kinetic energy was put to work (to use), to neutralize/correct entropic perturbations (during RSP's of cycles) and to upgrade the order of the State-System (during critical periods).

Ensemble

In physics, the set of all microstates that yield the same macrostate is called an ensemble of microstates (88).

Enthalpy

"Enthalpy comprises a system's internal energy, which is the energy required to create the system, plus the amount of work required to make room for it by displacing its environment and establishing its volume and pressure.
More technically, enthalpy includes the internal energy, which is the energy required to create a system, and the amount of energy required to make room for it by displacing its environment and establishing its volume and pressure" (96).

Entropic imperative or S-imperative

The term S-imperative refers to laws of thermodynamics - in particular the Second Law and related principles - that apply to the (State-)System and its components.

Entropic indeterminateness

Although, entropy always increases according to the Second Law; how the increase in entropy - and the order that is produced FFE - manifests itself is not (pre)determined; the Second Law provides a certain latitude for solutions. Entropic indeterminateness limits our ability to make (accurate) predictions.

Entropic perturbation(s)

The term entropic perturbation refers to the entropy that is produced as a consequence of issues in the contingent domain of the System. Entropic perturbations (in the deterministic domain) are equivalent with issues and tensions in the contingent domain.

Entropy

The Second Law of thermodynamics introduces "a physical quantity, entropy, which endows time with a privileged direction: the 'arrow of time'" (66), also implying the irreversibility of time. Entropy is closely related to probability (66). The second law and entropy have somewhat remained outside the mainstream of physics (66). A "flagrant contradiction" exists between the laws of conservative dynamical systems and the second law of thermodynamics. Entropy has become the fundamental measure for disorder and information (76).

Irreversibility plays a fundamental role in nature: the development of the (State-)System - the FTS, including the regulation of energy transformation - cannot be understood without appealing to dissipative systems (implying irreversibility), explored by Prigogine (66).

Entropy-accumulation

During HCR's of RSP's of cycles, entropy-regulation becomes problematic due to the network-effect that is "activated", once the tipping point of the RSP/cycle is reached. Instead of being regulated (neutralized and redistributed), entropy accumulates in the (State-)System and triggers an autocatalytic process, that drives the (State-)System to a critical point.

Entropy-balance

The term entropy balance refers for the need of living systems - including e.g. societies and the (State-) System - to maintain an intermediate level/amount of entropy; "between order and disorder": Not too much entropy - resulting in too much disorder, and a lack of structure - but also not too little entropy, resulting in ossification; a lack of opportunities and adaptability.

Entropy law

See: *Second Law of thermodynamics*.

Entropy-regulation

The term "entropy-regulation" concerns the regulation of entropy by (social) systems, to maintain an intermediate level of entropy, to ensure a certain order (structure) and viability; "between order and disorder". Homeostatic control is (also) instrumental in entropy-regulation of social systems that have achieved homeostasis.

During the transient period (1480-1945), the 1st FTS regulated the entropy of the (State-) System and ensured that the European State-System accomplished thermodynamic equilibrium, via the most efficient path.

Because of the close and intrinsic relationships between energy (***E***), Matter (***M***), Information (***I***) and entropy (***S***) in the (State-)System, does entropy-regulation always involve the regulation of energy (***E***), Matter (***M***) and Information (***I***), as well.

Entropy- (EMIS-)regulation by the FTS involved four complementary processes; the processes of KA, aggregation (core), expansion (to the non-core), and empowerment.

Environment (of a system)

The environment is the remainder of the universe that lies outside the boundaries of a system. For example, societies and the State-System constitute environments of states (respectively internal and external environments). The physical environment (like the climate system) is also part of the environment of states. Interactions and exchanges of systems differ with different "parts" of the environment.

European State-System

The European State-System is the system of states on the European continent, during the period 1480-1945. The European State-System constituted the core of the System; while the "rest of the world" constituted the non-core.

Evolution

The term "evolution is often used to describe the process by which ideas, designs or plans, and animate and inanimate objects change over time into different forms. Things that emerge, unwind, develop, spread out, or appear in succession or series are all said to evolve". Applied to biology, evolution describes genetic changes that occur in organisms over time. It is distinct from maturational changes that occur during development or in organisms that have metamorphosis" (57).
In evolutionary biology, the term evolution - and related terms as adaptation - have a very precise meaning. In evolutionary biology, evolution is defined as "change in the heritable characteristics of biological populations over successive generations. These changes are driven by evolutionary processes such as natural selection and genetic drift acting on variations produced by mutations, genetic recombination and gene flow, resulting in biodiversity at every level of biological organization, including the levels of species, individual organisms, and molecules" (96).

Evolutionary biology

Evolutionary biology is the subfield of biology that studies evolutionary processes.

Evolutionary criterion

An evolutionary criterion is a criterion (factor, specific condition, etc.) that impacts on the evolution - change - of the system concerned.
The principle of minimum entropy production, resulting in a push to zero entropy of the State-System has a significant impact on the evolution of the system, and qualifies as an 'evolutionary criterion' of the (State-)System. Another evolutionary criterion of the (State-)System is the network-effect, which is responsible for the accumulation of entropy during RSP's. The accumulation of entropy causes the (State-)System to become critical and enables the design and implementation of upgraded orders (which happened four times during the transient period).

Evolutionary potential

From a thermodynamic perspective, the evolutionary potential of a social system depends on four factors/conditions:

- The difference - the gap - between the actual entropy of/in the State-System ($S_{Actual\ State\text{-}System'}$ lower than maximum, because of the order established in the core) and the maximum possible entropy of the System ($S_{Maximum\ System}$) that would have been achieved had equilibrium been restored (the FTS ensured from did not happen) continuously increased;
- The gradient richness of the social system;

- The availability and entropy-absorption capacity of a suitable environment to maintain the dissipative structure;
- The effectiveness and efficiency of the dissipative structure to regulate EMIS-flows.

Equilibrium

In case of equilibrium of the (State-)System are all competing influences balanced.
In mechanics, equilibrium can be considered a 'state of rest': The net balance of forces acting on each point is zero at each moment. If this balance is disturbed, equilibrium will be broken (66). The notion of thermodynamic equilibrium is sharply different. Contrary to mechanical equilibrium, the molecules constituting the system are subjected to forces that are not balanced and move continuously in all possible directions unless the temperature becomes very low. 'Equilibrium' refers here to some collective properties characterizing the system as a whole, such as temperature, pressure, or the concentration of a chemical constituent (66).
(Thermodynamic) Equilibrium of the State-System also refers to some collective properties that characterize the State-System as a whole; e.g. forces and flows between state-structures involving the exchange of kinetic energy, and entropy-production by state-structures. In case of thermodynamic equilibrium of the State-System "parts" constituting the State-System (like individual humans and communities) are (still) subjected to forces and flows that are not balanced.

Exceptional period

Two exceptional periods can be identified during the period 1480-present: The 1st exceptional period from 1657 until 1763, during the 2nd cycle (1648-1815) of the 1st FTS (1480-1945), and the 2nd exceptional period - better known as the Cold War - from 1945 until 1989, during the 1st cycle (1945-....) of the 2nd FTS (1945-....).
During exceptional periods, non-systemic KA/war dynamics during RSP's of cycles are abnormal; non-chaotic in nature. During the 1st exceptional period, non-systemic KA/war dynamics were periodic, and during the 2nd exceptional period highly suppressed. In both cases the abnormal KA/war dynamics can be attributed to a decrease in the number of degrees of freedom of the (State-)System to only two, caused by intense rivalries between two powerful Great Powers.
Expansion; *Process of expansion*.

Expansion (Process of)

During the transient period (1480-1945), the core of the System (Europe) expanded to the non-core (The rest of the world). The non-core constituted the environment of the core. For the 1st FTS to emerge and to be sustained during the transient period (1480-1945), expansion to the non-core was required: An FTS requires continuous EMIS-exchanges with a (suitable) environment to sustain its "operation". The process of aggregation in the core and of expansion to the non-core, were complementary and reinforced each other. European unification and colonization during the transient period, were two sides of the same coin.

Expansion wars

During the transient period (1495-1945), the (State-)System produced four KA/war-cycles. During the RSP's of these cycles, the (State-)System produced respectively 45, 34, 21 and 6 (total: 106) non-systemic KA/wars. A closer look reveals that nine of these wars, concern - or are related to - the expansion of the European State-System to non-core territories; see below table.

These 'expansion wars', as I name them, are in a number of cases excluded from analysis of the dynamics of the (State-)System.

Although the 'War of the American Revolution' (war number 81 (1778-1784) in Levy's dataset (48)) took place outside the core of the System (outside Europe), I do not consider this war an 'expansion war', but foremost a European War that was fought outside the core of the System. Contrary to the nine expansion wars (mentioned in above table), three Great Powers were involved in the 'War of the American Revolution': France, England and Spain.

TABLE A-2: Expansion wars during the period 1495-1945. Based on data from Levy (48).

	Number Levy	Name	Period	Great Power involvement
1	88	War of 1812	1812-1814	UK
2	97	Anglo-Persian War	1856-1857	UK
3	99	Franco-Mexican War	1862-1867	France
4	104	Sino-French War	1884-1885	France
5	105	Russo-Japanese War	1904-1905	Russia
6	109	Manchurian War	1931-1933	Japan
7	110	Italo-Ethiopian War	1935-1936	Italy
8	111	Sino-Japanese War	1937-1941	Japan
9	112	Russo-Japanese War	1939-1939	Russia, Japan

Exploration of phase space

During RSP's of KA/war-cycles, the (State-)System explores phase space through chaotic non-systemic KA/war dynamics. Through chaotic non-systemic KA/wars, (new) solutions - innovations - are produced and selected, in response to entropic perturbations (issues and tensions in the contingent domain). The solutions are embedded in VC's, which shape the next systemic KA/war, when an upgraded order is interactively designed and implemented.

Exponential growth

In case of exponential growth, the rate of change—the change per instant or unit of time—of the value of a mathematical function is proportional to the function's current value, resulting in its value at any time being an exponential function of time, i.e., a function in which the time value is the exponent.

In case of accelerated growth, the rate of change is not proportional to the function's current value increases but increases.
Sterman (87) describes three common modes of behavior of dynamical systems: Exponential growth, goal seeking, and oscillations. See: *Modes of behavior dynamical systems*.

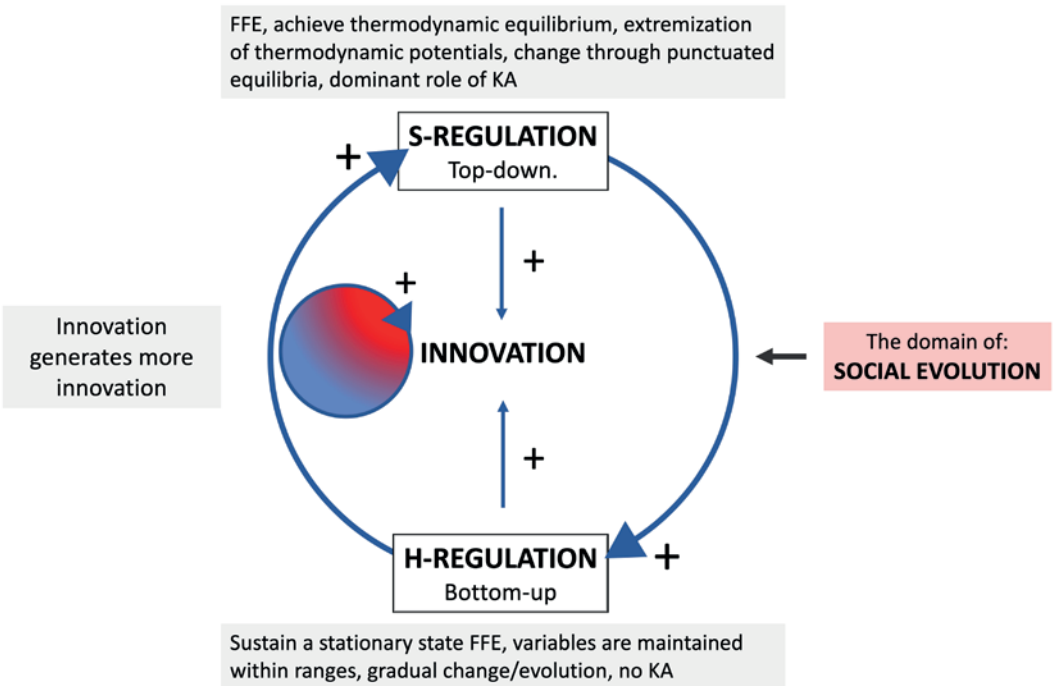


FIGURE A-2: CLD of the process of innovation through exploration of phase space by chaotic non-systemic KA/war, during RSP's of cycles.

Extremization

The term extremization is used for the minimization or maximization of a thermodynamic potential.

Far from equilibrium (FFE)

The term far from equilibrium concerns the "distance" of a system from equilibrium. The further the distance from equilibrium, the stronger the gradient and the forces and flows in/on the system concerned. FFE a system is allowed to fully manifest its nonlinearity: The system is much more sensitive for the amplification of perturbations (66), and entropy can serve as a source of order.

Feedback, feedback control

Feedback occurs when outputs of a system are routed back as inputs as part of a chain of cause-and-effect that forms a circuit or loop (96). There are two types of feedback: positive feedback and negative feedback.

Because "the feedback structure of a system generates its behavior", "much of the art of systems modeling is discovering and representing the feedback processes, which, along with stock and flow structures, and with time-delays, and nonlinearities, determine the dynamics of a system", Sterman (87) argues. Real systems, like the System, are nonlinear, meaning that the feedback loops and parameters governing the dynamics vary depending on the state of the system.

Most complex behaviors arise from the interactions (feedback) between components of the system, not from the complexity of the components themselves. Dynamics arise from the interaction of just two types of feedback loops, positive (or self-reinforcing) and negative (or self-correcting). Loops can be illustrated using 'causal loop diagrams' (CLDs), which are maps that show causal links among variables with arrows from a cause to an effect. Correlations are not included in these diagrams: "Correlations among variables reflect the past behavior of a system. Correlations do not represent the structure of the system." Correlations among variables will emerge from the behavior and dynamics of the system.

Positive loops tend to reinforce or amplify whatever is happening in the system. This is also the case in the System as population and connectivity growth, for example, produce tensions that then result in the buildup of destructive energy and alliance dynamics. A security dilemma is inseparably linked to anarchistic systems and constitutes a self-reinforcing (positive feedback) loop. As a consequence of the security dilemma, the buildup of destructive energy and alliance dynamics, which were initiated in response to rising tensions, create more tensions and stimulate further buildup of destructive energy and alliance dynamics. "Most dynamics observed in the real world are examples of a small set of basic patterns or modes of behavior. Three of these modes are fundamental: exponential growth, goal seeking, and oscillation. Each of these modes is generated by a particular underlying feedback structure. Positive feedback processes generate exponential growth. However, goal seeking is generated by negative feedback, and oscillations are generated by negative feedback with delays. More complex patterns of behavior, such as S-shaped growth, growth with overshoot, and overshoot and collapse, result from the nonlinear interaction of these basic feedback structures."

Negative loops counteract and oppose change. While tensions and destructive energy produce disorder in the System, other forces will counteract this change and try to re-establish certain order.

All systems, no matter how complex, consist of networks of positive and negative feedback loops, and, as already mentioned, all dynamics arise from the interaction of these loops with one another. When multiple loops interact, it can be difficult to determine what the dynamics will be. System dynamics emphasizes the multi-loop, multistate, nonlinear character of the feedback systems, as well as the multiple connections in which we live. The System meets all these system dynamics conditions.

Sterman observes, "adding time delays to negative feedback loops increases the tendency for the system to oscillate." Delays create instability in dynamic systems.

The cycles that accompanied the finite-time singularity dynamic of the System that unfolded during the period between 1495–1945 are a consequence of a delayed response of the System to counter increasing disorder. This study shows that, when the System eventually reaches a critical point, a systemic war will

be triggered to counter the 'disorder' (the unresolved tensions and issues) that has accumulated in the system. A systemic war is an ordering force, and, through systemic wars, new increasingly upgraded orders were introduced in the System.

Finite-time singularity dynamic (FTS)

The dissipative structures/systems the System produced during respectively the period 1480-1945, and 1945-present, are referred to as respectively the 1st and 2nd finite-time singularity dynamic (1st and 2nd FTS).
The term finite-time singularity, points to the singularity these dissipative structures at a certain point reach(ed) in finite-time - in case of the 1st FTS in 1939 - because of the unsustainability of the (accelerating) entropy-production (the FTS generates).
The 1st FTS was accompanied by four accelerating KA/war-cycles and was instrumental in the accomplishment of thermodynamic equilibrium of the European State-System.

First Law of thermodynamics (conservation law)

The First Law of thermodynamics is a version of the law of conservation of energy, adapted for thermodynamic systems. This law means that energy can neither be created nor destroyed; it can only be transformed from one form to another.
The law of conservation of energy states that the total energy of an isolated system is constant; energy can be transformed from one form to another but can be neither created nor destroyed. The first law can be formulated as: $\Delta \boldsymbol{U} = \boldsymbol{Q} - \boldsymbol{W}$ (96).
"The law of conservation of energy can be stated and utilized entirely in terms of macroscopic variables. A transformation of state may occur due to an exchange of heat, performance of work and change in chemical composition and other such macroscopic processes. Each of these processes is associated with a change in energy, and the First Law of thermodynamics could be stated as: When a system undergoes a transformation of state, the algebraic sum of the different energy changes, heat exchanged, work done, etc., is independent of the manner of the transformation. It therefore depends only on the initial and final states of the transformation (….) given a certain transformation (…) the total change in energy is independent of the path" (…) (44).
In the System various forms of energy are available and put to use, including kinetic energy during KA/war.
I assume that the number of 'Battle Casualty Deaths' (BCD) of KA/war is indicative for the energy that is put to use by states in the (State-)System, for the forces that are exerted on the System, and for the work performed on the (State-)System.

First order phase transition

See: *Phase transition*.

Fitness

Fitness (in biology) is reproductive success. Evolution is directed towards higher fitness.

Flickering

When a system falls (temporarily) back into a previous stability domain because of an unstable control parameter, is also referred to as "flickering" (24, 69). The question is if "Europe" can/will fall back into State-System.

Fluctuations

The System is composed of a large number of interacting entities. Certain state variables of the System must be understood in a statistical sense: they represent either averages of the instantaneous states over a long-time interval, or the most probable among the values that the state variables can reach. Actual measurement of the state will show continuous deviations from these reference values of the macroscopic state variables (66).
Fluctuations are upward or downward swings - variations - in properties of the (State-)System, e.g. kinetic activity or entropy-production. Fluctuations may differ in the degree of deviation from mean values, but also in size: e.g. localized versus system-wide fluctuations. Systemic KA/wars can be considered system-wide kinetic fluctuations, which are generated by internal dynamics independent of the environment (66). Fluctuations typically originate in the form of localized and random small-scale events (66).
FFE fluctuations have a function. Prigogine describes the function of fluctuations in physico-chemical systems (at a microscopic level) as follows: "Because of fluctuations, physico-chemical systems are capable of exploring the phase space continuously and of performing excursions around the state predicted by the solution of the phenomenological deterministic equations that describe systems." (66). Non-systemic KA/wars - non-systemic fluctuations - also serve such a purpose: By means of non-systemic KA/wars during RSP's, the (State-)System explores phase space and solutions that are (still) available to entropic perturbations.

Force (F)

In physics, a force is any interaction that, when unopposed, will change the motion of an object. A force can cause an object with mass to change its velocity (which includes to begin moving from a state of rest), i.e., to accelerate. Force can also be described intuitively as a push or a pull. A force has both magnitude and direction, making it a vector quantity.
In case of the (State-)System, a (social) force causes (social) change. Forces and flows are related: When there is a force. there is a flow and vice versa.

Fractals or fractal structures

Fractals are objects whose dimensionality is between that of a point (R = 0) and a line (R = 1), or a line and a surface (R = 2), or a surface and a volume (R = 3); such objects are topological manifolds referred to as fractals (66). Also, attractors exist in three-dimensional phase space, other than fixed points, or closed curves of bounded two-dimensional surfaces, but with fractal dimensions (66). "The corresponding object in three-dimensional space consists of an infinity of sheets such that a section taken transverse to the sheets is a Cantor set" (66). Self-similarity - similarity at different scales, scale invariance - is a property of fractal structures. These fractal objects are often referred to as strange attractors, that constitute the models describing the onset of chaotic, turbulent-like behavior (66).

Fractals are ubiquitous in nature and in social processes and structures. It is not exactly clear why and how fractals are formed. I assume (see also Jensen (41)) that the principle of least free energy selects for these typical structures and that fractal structures point to optimality: Fractal structures and processes ensure the simultaneous maximization of the scaling of exchange surface areas, and minimization of the scaling of transport distances and times. Fractal structures are optimal structures.
As is (often) the case in other systems, I argue that fractal structures are best able to reconcile conflicting requirements and optimize certain properties in a system (network) of nodes that regularly interact. Bettencourt et al. (13) observe in relation to fractal structures: "Highly complex, self-sustaining structures, whether cells, organisms, cities require close integration of enormous numbers of constituent units that need efficient servicing".
"To accomplish this integration", Bettencourt et al. continue, "life at all scales is sustained by optimized, in some cases space filling, hierarchical branching networks which grow with the size of the organism as uniquely specified approximately self-similar structures…. Because these networks, e.g. the vascular systems of animals and plants, determine the rates at which energy is delivered to functional units (cells), they set the pace of physiological processes as scaling functions of the size of the organism." It is the "self-similar nature of resource distribution networks, common to all organisms, that provides the basis for a quantitative, predictive theory of biological structure and dynamics, despite much external variation in appearance and form."
Bettencourt et al. relate these observations not only to biological, but also to social systems: "From this perspective, it is natural to ask whether social organizations also display universal power law scaling for variables reflecting key structural and dynamical characteristics." This line of thought is at the basis of Bettencourt's et al. study of "*Growth, innovation, scaling, and the pace of life in cities*" (13).
West et al. (95) point to the relationship between selection and optimization: "Natural selection has tended to maximize both metabolic capacity, by maximizing the scaling of exchange surface areas, and internal efficiency, by minimizing the scaling of transport distances and times."

Fraction

I have introduced fraction as a measure for the size of KA/wars: The fraction - size - of KA/wars is defined as the number of Great Powers participating in a KA/war divided by the total number of Great Powers present in the (State-)System, at the time of the KA/war.
Severity of KA/wars is also used as a measure for size. The idea to use fraction as a measure of size, relates KA-war-activity of the (State-)System to percolation theory and criticality.

Fragility

Fragility of a RSP or of the State-System refers to the ability of the System to sustain (itself) in a particular stability domain. The life span of RSP's is a measure for the fragility of the order that is in place, and the life span of the European State-System is its measure for its fragility. The fact that the life-spans of successive RSP's decreased during the transient period (1480-1945), points to the increasing fragility - and increasing instability - of the European State-System. See also: *Robust yet fragile*.

Fragile states

Fragile states are states with a weak state capacity or weak state legitimacy leaving citizens vulnerable to a range of shocks. It is important to understand the phenomenon of fragile states from a thermodynamic perspective, as well: Fragile states are 'systems' that lack structure to ensure adequate EMIS-regulation of a society they 'represent'. The lack of regulation affects societal homeostasis, and the ability of the society concerned to interact constructively with its environment, i.e. the (State-)System. Fragile structures lack organization, and an ability to maintain an intermediate level of internal entropy. A fragile state not only impacts on the ability of the society to fulfill its basic requirements, to achieve a certain well-being and ensure its survival, but also impacts on the EMIS-regulation of the (overall) (State-)System.

Fragile state index (FSI)

The Fund for Peace (FFP) (33) has developed an index - the Fragile States Index (FSI) - to measure state-capacity. "Since 2005, the Fragile States Index has measured the social, economic and political pressures facing 178 countries around the world. Comprised of 12 primary indicators and hundreds of sub-indicators, the index uses a unique triangulated methodology that integrates content analysis of millions of documents pulled from more than 10.000 sources around the world, with quantitative data-sets and qualitative review. The index and its indicators are based on a social-science framework that has been used by practitioners in the field of conflict early warning for over two decades" (33).

Free energy, Gibbs free energy

Free energy is the energy in a system that can be converted to do work. The Second Law determines that all processes occur in order to minimize the overall free energy (i.e. to maximize entropy); systems strive to decrease free energy.

In thermodynamics, the Gibbs free energy (also known as free enthalpy to distinguish it from Helmholtz free energy) is a thermodynamic potential that can be used to calculate the maximum of reversible work that may be performed by a thermodynamic system at a constant temperature and pressure (isothermal, isobaric). The Gibbs free energy is the maximum amount of non-expansion work that can be extracted from a thermodynamically closed system (one that can exchange heat and work with its surroundings, but not matter); this maximum can be attained only in a completely reversible process. When a system transforms reversibly from an initial state to a final state, the decrease in Gibbs free energy equals the work done by the system to its surroundings, minus the work of the pressure forces (96).

When the term free energy is used in this study, it (mostly) refers to military capabilities and their utilization: Military capabilities can be considered the "free energy of/in the State-System", from the perspective of the contingent domain. Military capabilities can be considered as the social potential of states in the State-System, but the effectiveness of their application depends on numerous factors/conditions.

Free energy rate density

According to Chaisson "it is the organized energy density that best characterizes the degree of order or complexity in any system, just as it was radiation energy density and matter energy density that were significant earlier in the Universe" (20).

Chaisson considers the free energy rate density a useful quantity to specify the order and organization of any system: The free energy rate density mimics the rise of complexity in systems (20); according to Chaisson: "The greater the perceived complexity of the system, the greater the flow of free energy density through that system, either to build it, or to maintain it, or both." (20). Accordingly, all systems can be compared on a fair and level spectrum. To biologists, this term is known as the metabolic rate (20). The free energy rate density is expressed in units of energy per time per mass and denoted by the symbol $\boldsymbol{\Phi m}$" (the units are erg $\boldsymbol{s^{-1}}$ $\boldsymbol{g^{-1}}$, $\boldsymbol{\Phi m}$ is an energy rate (i.e. per unit time) density (i.e. per unit mass)) (20). $\boldsymbol{\Phi m}$ is considered by Chaisson a reasonable measure of the energy that is available to organize - create order in - a given amount of matter (20) Chaisson points to the relationship between the free energy rate density and its vital role in evolution: Evolution proceeds in such a direction, that the total energy flux through a system is optimized within the constraints that apply (20).

Free will

With the term "free will" I refer to the ability of individuals humans, and decision-makers (od states for example), to choose "freely" between different courses of action. This study shows that our "free will" is much more restricted than we assume(d), and that we are "encapsulated" in numerous constraints, which are (in)directly related to laws of physics and related principles that apply. System dynamics - i.e. the PDLI- and PBMP-mechanisms, and the network-effect - also constraint choices. The latitude that is available to choose "freely", is referred to as the contingent latitude of the System. The contingent latitude of the System, is a function of various factors/conditions, including of the stage of development of RSP's and of the FTS.

FTS-engine

During the transient period (1480-1945), the 1st FTs constituted an engine, that accomplished work: Thermodynamic equilibrium of the European State-System, via the most efficient path, in accordance with the Second Law and related principles that applied.

Fundamental postulate

"According to the fundamental postulate of statistical mechanics: the microstates of an isolated thermodynamic system are equally possible" (47). "The assumed equal probability of the microstates of an isolated system is the material out of which we compose the probability of a macrostate. According to the fundamental postulate, the probability of a macrostate is proportional to the number of microstates contained in the macrostate" (47). Boltzmann called the number of microstates that compose a macrostate its multiplicity which is denoted with the symbol omega ($\boldsymbol{\Omega}$).

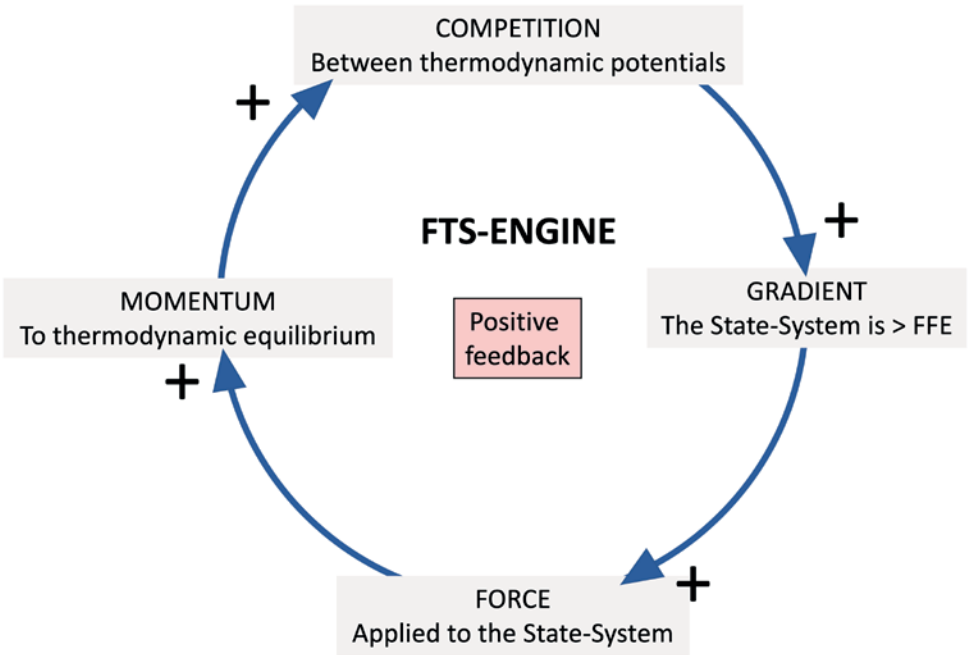


FIGURE A-3: CLD of the "FTS-engine".

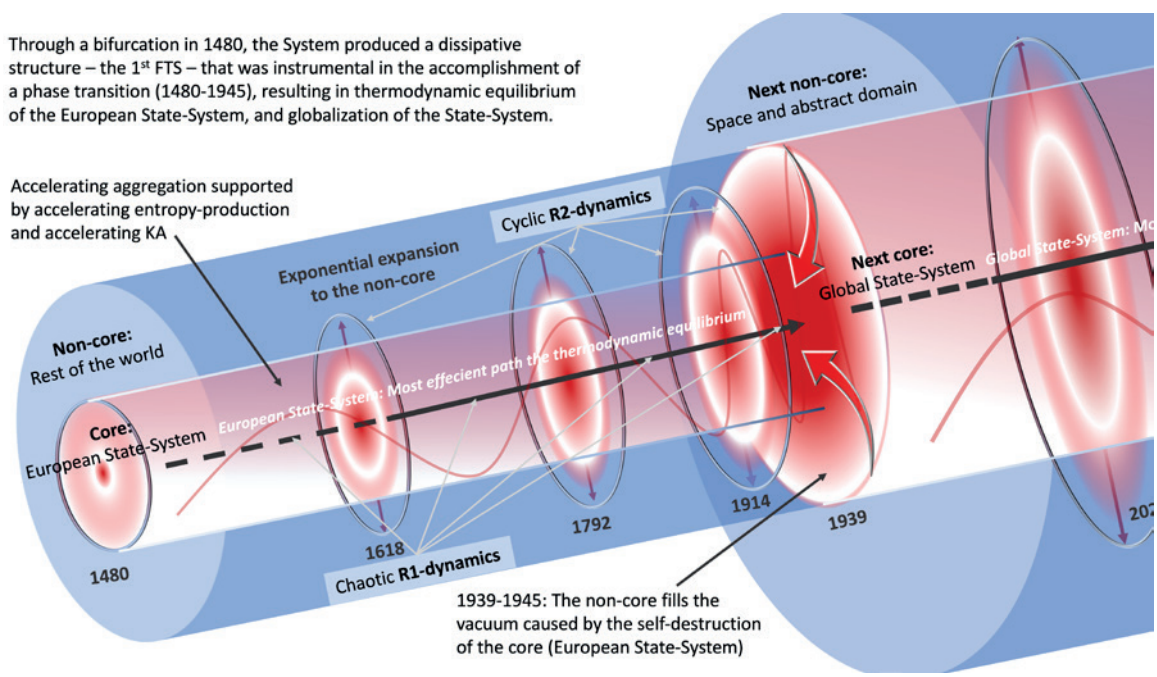


FIGURE A-4: The 1st FTS depicted as an engine (turbine).

Global awareness and responsiveness

The term global awareness and responsiveness refers to (1) the ability of states to perceive - to 'construct' - an image of the (State-)System and its dynamics, that more or less accurately depicts the threats and opportunities these states confront, or will confront in the future, and (2) to act in accordance with their interests (basic requirements) to neutralize threats and leverage opportunities. How states perceive the (State-)System - including opportunities and threats - is subjective, and closely related to their basic requirements and their value-systems.

Globalization (of the State-System)

In this study, the term globalization refers to the globalization of the State-System in December 1941, when Germany declared on 11 December 1941 war on the United States in response to Japan's attack on Pearl harbor (7 December 1941). At that moment, the European and Asian VC's and KA became linked, through active American involvement in the 4th systemic KA/war (1939-1945), and these clusters spanned the global(ized) State-System.

Global State-System

The global State-System (1945-....) is a subsystem of the System. The global State-System emerged in 1945, as a successor to the European State-System (1480-1945). The 1st FTS was instrumental in the accomplishment of the phase transition (1480-1945), that produced the global State-System. See also: *System*

Goal seeking

Sterman (69) describes three common modes of behavior of dynamical systems: Goal seeking, exponential growth and oscillations. See: *Modes of behavior dynamical systems*.

Gradient

The strength of a (local) gradient is determined by the inhomogeneity - the 'local' slope - of a field. A gradient is a function of multiple variables. The strength of a gradient determines the force that is (locally) applied. The gradient determines the force that is applied, and the flows and momentum that are (consequently) generated. During the transient period (1480-1945), the distance from equilibrium - the gradient - of the State-System increased, and consequently the EMIS-flows that were generated and the force that was applied on the core (Europe).

Great Power (System)

Great Power as defined by Levy (48), as follows: "A Great Power is defined here as a state that plays a major role in international politics with respect to security-related issues. The Great Powers can be differentiated from other states by their military power, their interests, their behavior in general and interactions with other powers' perception of them, and some formal criteria."

"Most important, a Great Power possesses a high level of military capabilities relative to other states. At a minimum, it has relative self-sufficiency with respect to military security. Great Powers are basically invulnerable to military threats by non-Powers and need only fear other Great Powers. In addition, Great Powers have the capability to project military power beyond their borders to conduct offensive as well as defensive military operations. They can actively come to the defense of allies, wage an aggressive war against other states (including most of the Powers), and generally use force or the threat of force to help shape their external environment."
"Second, the interests and objectives of Great Powers are different from those of other states. They think of their interests as continental or global rather than local or regional. Their conception of security goes beyond territorial defense or even extended defense to include maintenance of a continental or global balance of power. Great Powers generally define their national interests to include systemic interests and are therefore concerned with order maintenance in the international system. Symbolic interests of national honor and prestige are also given high priority by the Great Powers, for these are perceived as being essential components of national power and necessary for Great Power status."
"Third, the Great Powers are distinguished from other states by their general behavior. They defend their interests more aggressively and with a wider range of instrumentalities, including the frequent threat or use of military force. They also interact frequently with other Powers (…) Great Powers are further differentiated from other states by others' images and perceptions of them."
"Finally, Great Powers are differentiated from others by formal criteria, including identification as a Great Power by an international conference, congress, organization, or treaty, or the granting of such privileges as permanent membership or veto power by an international organization or treaty."

Great Power status dynamics

According to Levy (48) states can acquire or loose Great Power status. During the 1480-1945 period 20 (core plus non-core) Great Power status changes can be determined (17, in the core only). Great Power status dynamics decreased linearly over time, implying an increasing ability of states to maintain their centrality in the (State-)System. The decreasing Great Power status dynamics are indicative for the decreasing entropy of the European State-System, during the transient period (1480-1945). When the Great Power status dynamics neared zero, the entropy of the State-System had neared zero entropy: The European State-System had become ossified, and changes to its structure were no longer possible.

Great Power war(s)

Levy (48) defines war conceptually as "a substantial armed conflict between the organized military forces of independent political units". Great Power wars are wars in which Great Powers are involved. In the study "*War in the Modern Great Power System, 1495-1975*", Levy identified 119 Great Power wars during the period 1495-1975. This dataset - supplemented with Great Power wars during the period 1975-2018 - is used for the quantitative analysis of the KA/war dynamics of the (State-)System.

Growth (Types of growth)

It is possible, to distinguish three types of expansion/growth in the State-System: (1) Intrinsic (or organic) expansion/growth: Expansion (growth) of a system through the utilization of entropy - new possibilities

- the system itself 'exported' to its environment, and by applying (extending) its own intrinsic logic to the environment, (2) Non-organic expansion/growth: by expansion/growth of a system through imposing a 'new' logic on other 'autonomous' structures and systems that already developed - at least partially - an own intrinsic logic, and produced structures and processes that are consistent with this logic, and (3) A combination of organic and non-organic growth: Through the constraint - the collective dimension - autonomous social systems converge (their future is increasingly shared), while at the same time one social system absorbs another.

Heat

In thermodynamics, heat is energy in transfer to or from a thermodynamic system other than by macroscopic work or transfer of matter. "One could say that physical and chemical processes have a natural tendency to convert all other forms of energy to heat. In the classical picture of particle motion, it is the kinetic energy associated with chaotic motion" (44). Heat can also be in the form of radiation.

Hierarchical system

"A system that is composed of interrelated subsystems, each of the latter being, in turn, hierarchic in structure until we reach some lowest level of elementary subsystem" (77). Hierarchic systems have some common properties that are independent of their specific content.

Hierarchy and hierarchical structure

According the Simon, complex systems have hierarchical structures "independently of whether those systems are physical, chemical, biological, social, or artificial. The existence of these commonalities is a matter of empirical observation: their explanation is, in a broad sense, Darwinian; they concern properties that facilitate the evolution and survival of complexity" (58). Hierarchical structures are nearly decomposable.

High-connectivity KA/war-cluster(s)

During relatively stable periods, it is possible to distinguish low- and high-connectivity "regimes" separated by tipping points. Non-systemic wars that occur during low- and high-connectivity regimes, can be grouped in respectively low- and high-connectivity KA/war-clusters. The development of these KA/war-clusters show remarkable regularities, consistent with the theory that is proposed in this study.

High-connectivity regime (HCR) and Low-connectivity regime (LCR)

During RSP's of KA/war-cycles, two types of regimes can be distinguished: A low- and a high-connectivity regime, separated by a tipping point. During LCR's, the average size of chaotic non-systemic KA increases over time; while during HCR's there is a decrease, which can be attributed to the network-effect that is activated at the tipping point. During LCR's entropy-regulation through KA is still adequate, while during HCR's, entropy-regulation becomes problematic, and entropy starts accumulating, an autocatalytic process is triggered and VC's percolate the (State-)System and cause the (State-)System to become critical.

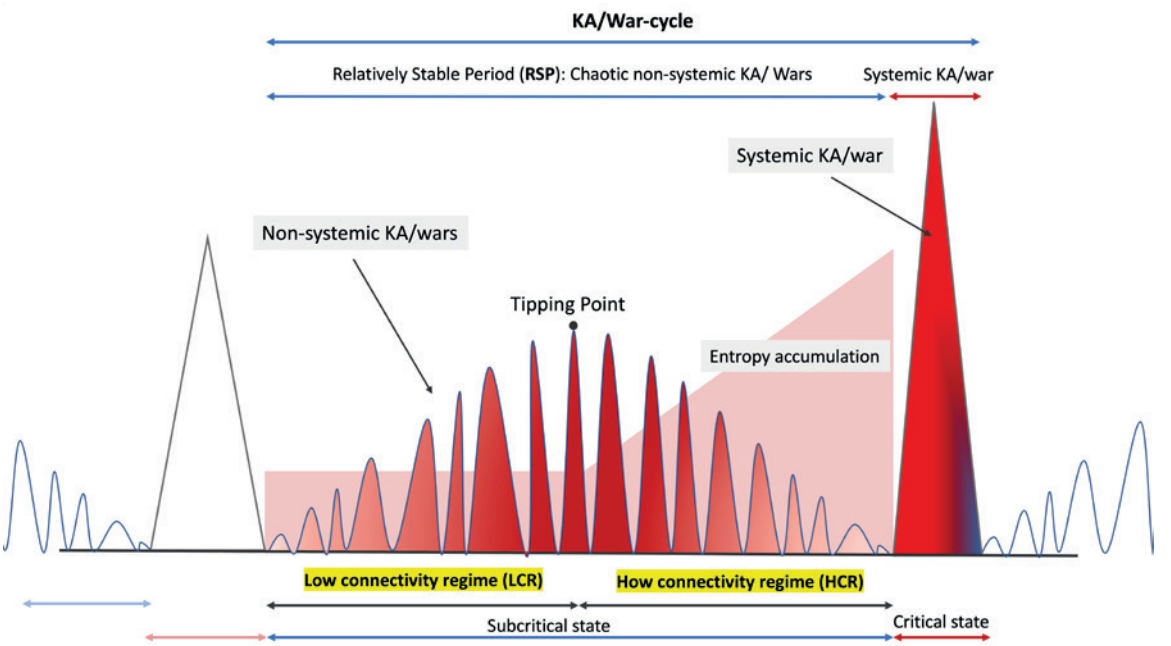


FIGURE A-5: Life-cycle of a KA/war-cycle.

Homeostasis

Homeostasis is the capacity of living systems for self-regulation or, more precisely, for self-equilibration (18). To the extent that human societies are homeostatic, they behave in the same way. They assess when some value of the social system has been pushed beyond acceptable limits and undertake some action to counteract this displacement until the system is restored to its previous condition (18).

Homeostatic imperative (H-imperative)

According to Damasio, "Homeostasis refers to the process by which the tendency of matter to drift into disorder is countered so as to maintain order but at a new level, the one allowed by the most efficient steady state. This countering takes advantage of the principle of least action - enunciated by the French mathematician Pierre Maupertuis - whereby free energy will be consumed most efficiently and as fast as possible" (25).

Homeostasis is about regulation of living systems. A living system is a nonequilibrium system; there are numerous flows and forces at play. This nonequilibrium state must be maintained and related processes must be regulated. To accomplish homeostasis a set of basic requirements must be fulfilled: The fulfilment of basic requirements requires the input of scarce resources, for which humans and social systems cooperate, but also compete.

Homeostasis is about resisting a 'natural' tendency of systems towards thermodynamic equilibrium. According to Damasio, comes life "equipped with a precise mandate: resist and project itself into the future, no matter what" and are living systems 'oriented' to survival' (25). "The homeostatic imperative

that pervaded the organization of early organisms led to the selection of programs of chemical pathways and specific actions that ensured the maintenance of organism integrity": The H-imperative must be obeyed, to ensure a certain well-being and viability (survival).
Damasio defines homeostasis as: "The natural process of life regulation orients living organisms so that they operate within the range of parameters compatible with life maintenance and flourishing. The heroic process of maintaining life requires a precise, herculean process of regulation, in individual cells as well as in whole organisms".
Through the mechanism of homeostasis are excessive deviations of the lower and/or upper limits of processes regulated. Perturbations are corrected; if the living system fails to take adequate corrective measures it can fail.
Damasio observes that two varieties of internal homeostatic control can be distinguished: (1) the 'automated' search for energy resources, and (2) H-control related to mental experiences - feelings - that express a certain value related to the condition of the living system. The second type of homeostatic control requires the existence of a mind, consciousness and related mental phenomena (25). Minds allow for the "deliberate interference with preset homeostatic mechanisms and even later allowed creative and intelligent invention to expand homeostasis into the sociocultural domain" (25).

Homoclinic orbit

In mathematics, a homoclinic orbit is a trajectory of a flow of a dynamical system which joins a saddle equilibrium point to itself. More precisely, a homoclinic orbit lies in the intersection of the stable manifold and the unstable manifold of an equilibrium.

Infinity war

The term infinity war refers to the kinetic response of the (State-)System when the critical connectivity/population threshold - the singularity in finite time of the FTS - is reached. At that point, the (State-) System produces infinite amounts of entropy and triggers infinite KA, which causes its (self-destruction). The European State-System reached the singularity in finite time in 1939, which then triggered the last stage in the phase transition (the 4th systemic KA/war the Second World War (1939-1945)).
If the 2nd FTS/global State-System develops according to the same "logic" as the 1st FTS, the global State-System reaches the singularity in finite time in 2185 (59).

Information

"Just as the amount of information in a system is a measure of its degree of organization, so the entropy of a system is a measure of its degree of disorganization; and the one is simply the negative of the other" (6). From an entropic perspective, "Information is that what removes uncertainty" and is measured by the uncertainty it removes (s): Information is the negative of uncertainty. "A lack of information about the internal structure of a system, and it is this lack of information that allows a great variety of possible structural arrangements among the system's microscopic states; the positions, motions, and orientations of the many varied parts of a high-entropic system cannot in practice be specified precisely. Since any one of many microscopic states might be realized at any given time, the lack of information (or ignorance) about a system corresponds to what we have earlier labeled disorder (or uncertainty)" (20).

A distinction between two types of information can be made between: Thermodynamic information and cybernetic information (q). Whereas thermodynamic-information is a physical property (and amounts to a certain amount of energy), cybernetic information can be recombined and manipulated in the *abstract domain* of the System. All energy and matter - especially human artefacts - contain information.
Inhomogeneities in the (State-)System are amplified through nonlinear behavior, and consequently variation and choice 'emerge'. Bifurcations imply symmetry-breaking; symmetry breaking implies choices between solutions that are open to the System come available, given the (State-)System's parameter-set and conditions. According to Prigogine, "it is selection that enables us to detect, interpret, and transmit the 'message' hidden in the nonlinear, nonequilibrium dynamics of the systems. Selection decodes information, and that allows the transfer of complexity from one level to another" (a, 143). The System experienced a bifurcation in 1480, and secondary bifurcations in 1618, 1792 and 1914 that allowed for the transfer of complexity from the (State-)System to societies/states.

Inhibition

Inhibition is the opposite of reinforcement.

Institutionalization

Institutionalization refers to the process of embedding some conception (for example a belief, norm, social role, particular value or mode of behavior) within an organization, social system, or society as a whole (96).

Intensity (of KA/war)

The intensity dimension of KA/wars is designed to reflect the relative human costs of war compared to the population as a whole (Levy). The intensity of a KA/war is the ratio of battle deaths (BCD) to European population size (48), unless otherwise stated. Intensity (as well as severity) of KA/wars, is a measure for the 'amount' of kinetic energy (military capabilities) that is put to use during KA.

Interacting self-fulfilling prophesies (ISFP's)

In case of the (State-)System, self-fulfilling prophecies of various 'actors' (e.g. societies and decisionmakers of states) - their mutual expectations - interact and shape each other; it is a process in which the actors are actively involved, playing their part. The process of sensemaking and the security-dilemma play important roles in the process of interacting self-fulfilling prophecies (ISFP's).
The process of ISFP's is concerned with the interplay between individual and collective behavior, and with the interplay between the deterministic and contingent domains (respectively the S- and H-imperatives). Through the process of ISFP are states and societies 'prepared' to engage in KA/war "at the right time"; the process of ISFP's ensures that (members of) societies are aligned and states/societies find meaning and justification to engage in war (KA). The process of ISFP is powered by entropy(-production) and shaped by the security dilemma in the contingent domain.
During the HCR of RSP's the ISFP-mechanism runs at full speed, so to speak, and powers the autocatalytic process that drives the (State-)System to a critical state.

Internal energy

In thermodynamics, the internal energy of a system is the energy contained within the system, excluding the kinetic energy of motion of the system as a whole and the potential energy of the system as a whole due to external force fields. It keeps account of the gains and losses of energy of the system that are due to changes in its internal state. The internal energy of a system can be changed by transfers of matter or heat or by doing work.

International order

The term international order refers to the organizational arrangements between societies/states in the State-System concerning (especially) security, and security related issues. During systemic KA/wars, the (international) order is upgraded.

International relations theory

International relations theory is the study of international relations from a theoretical perspective. It attempts to provide a conceptual framework upon which international relations can be analyzed. International relations theory is concerned with the contingent domain and lacks a scientific foundation and scientific methods.

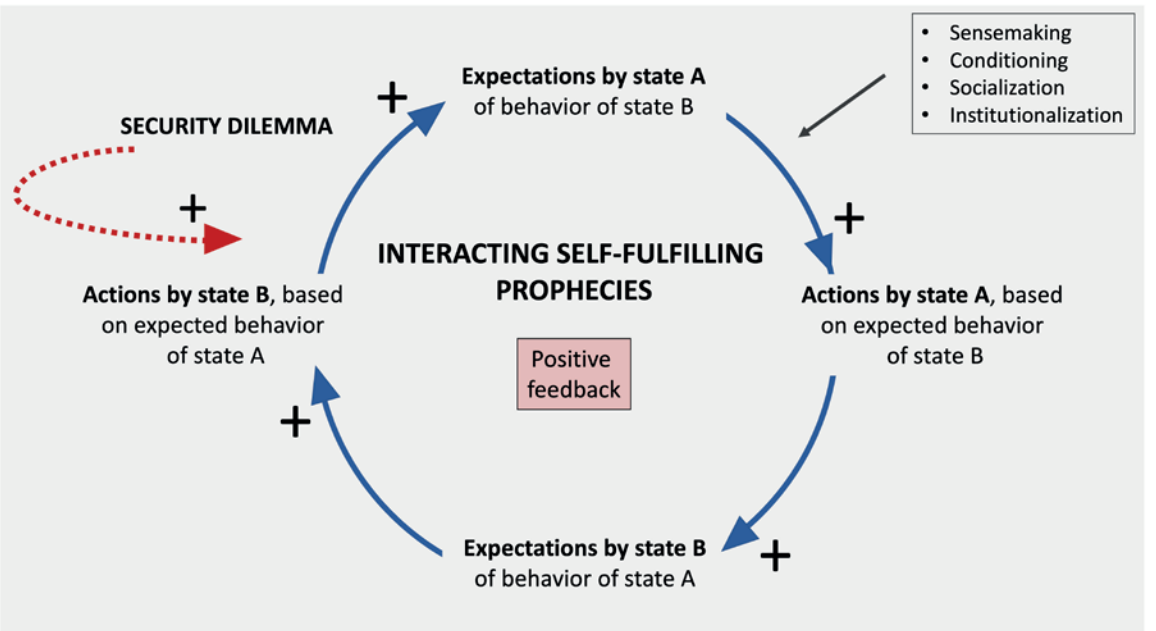


FIGURE A-6: CLD of interacting self-fulfilling prophecies.

Interplay between competing thermodynamic potentials (and their extremization)

The interplay between competing thermodynamic potentials (and their extremization) refers to the competing (conflicting) thermodynamic potentials (sub)systems of the System pursue. The interplay is orchestrated - and utilized - by the FTS to ensure thermodynamic equilibrium of the State-System is achieved via the most efficient path, in accordance with the Second Law and related principles that apply FFE.

Interplay between probabilistic and deterministic factors

Through various factors/conditions there is interplay between probabilistic and deterministic factors in case of the (State-)System. These factors include: The statistic nature of the Second Law (laws of physics in general), random factors that impact on the selection process of entropic perturbations and fluctuations, the sensitivity for initial conditions of chaotic dynamics, and the availability of a certain contingent latitude under certain conditions.

Irreversible process

Irreversible processes produce entropy. "There is no real system in nature that can go through a cycle of operations and return to its initial state without increasing the entropy of the exterior, or more generally the 'universe'. Because of the irreversibility of actual processes, "every process in Nature increases the entropy, thus establishing a distinction between the past and future. The Second Law establishes an arrow of time: the increase of entropy distinguishes the future from the past" (44). Because entropy-production - the degrading of energy - is unavoidable in irreversible processes, irreversible processes produce less work than the reversible process (55); the change of entropy due to irreversible processes within a system ($\boldsymbol{d_iS}$), is for that reason also referred to as entropy change due to 'uncompensated transformation' or 'uncompensated heat' (in case of heat engines). "(...) irreversible processes can create structure and organization in a system" (44).

Ising model

The Ising model is a simple model of critical behavior, and it is a useful framework for understanding different phase transitions using a few fundamental features.

Isolated system

Isolated systems do not exchange energy, matter and information with their environment. Whatever the initial condition of an isolated system, the equilibrium state will be attained in time, implying a monotonic increase of entropy in time. The equilibrium is asymptotically stable and constitute a global attractor. (66). Closed systems exchange energy with their environment; open systems exchange energy and matter with their environment.

Issues and tensions

The term "issues and tensions" refers to events and interactions in the contingent domain of the System that cause tensions. Entropic perturbations (in the deterministic domain) are equivalent with issues and tensions in the contingent domain.

KA/war-cycle

During the transient period (1480-1945), the life-span of the 1st FTS, the 1st FTS was accompanied by four accelerating KA/war-cycles, with identical life-cycles. The KA/war-cycles developed/evolved very regularly, until collapse of the FTS and of the European State-System became unavoidable in 1939. Each cycle consists of a RSP, followed by a critical period.

KA/war-frequency

The KA/war-frequency is calculated by dividing the number of non-systemic KA/wars by the duration of the period when these events were taking place.

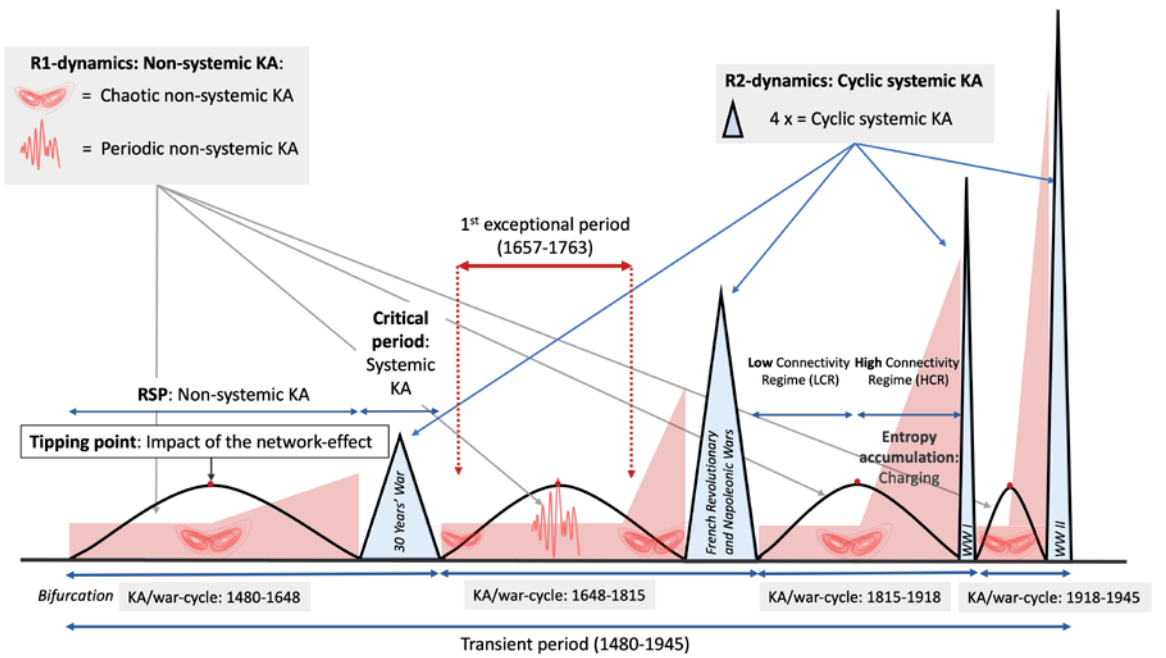


FIGURE A-7: The 1st FTS (1480-1945) was accompanied by four accelerating KA/war-cycles.

KA/war-window

Based on the research of Watts, it is possible to define a KA/war-window, a window a bounded area in phase space - defined by the connectivity and decision thresholds of states in (State-)System - in which the (State-)System can produce KA. Outside of this window, KA is not fully suppressed.

Kinetic activity (KA, process of)

The term kinetic activity refers to the use (application) of kinetic energy in the (State-)System. KA (in the deterministic domain) is equivalent with war in the contingent domain of the System. KA is subject to the First and Second Law, and related principles that apply. The purpose of non-systemic KA/war during RSP's of cycles is to "naturalize" entropic perturbations, to ensure continuity (a dynamic steady state, the status quo is maintained); and the purpose of systemic KA/war, during critical periods of cycles is to upgrade the order of the (State-)System and to ensure necessary change, in accordance with "demands" of the Second Law and related principles.

Kinetic energy

During KA/war, kinetic energy is put to use in response to entropic perturbations (issues and tensions), and entropy-accumulation (in case of systemic KA/war). The kinetic energy is instrumental in the redistribution and neutralization of entropy. Military capabilities are the manifestation of kinetic energy in the contingent domain.

Kinetic engine (or War engine)

See: *FTS-engine*.

Kinetic growth

The (nature of the) growth process of the (State-)System that ensured its continuity - a combination of processes of KA, aggregation, expansion and empowerment, regulated by a FTS, resulting in its own destruction, and upscaling - I refer to as kinetic growth. During the transient period (1480-1945), the European State-System experienced a phase transition to thermodynamic equilibrium directed by the 1st FTS: It caused the European State-System's (self-)destruction, but the 1st FTS had also ensured that a non-core was developed, that could absorb the self-destructed core.

In case of kinetic growth is destruction functional - required - to ensure continuity of a (social) system. In case of the (State-)System, six stages and accompanying processes can be distinguished in the process of kinetic growth: (1) Growth and aggregation of a core; (2) growth and development of a non-core enabled by EMIS-exchanges between core and non-core; (3) destruction of the core on completion of the growth (aggregation) process; (4) absorption of the core by the non-core and (5) a process of 'healing' when the destructed core is repaired and processes and structures are formed and allowed to mature, to ensure the proper functioning of a globalized - scaled-up - System. Further growth, based on this model, requires (6) that the 'upscaled' System, "finds"/selects and develops its own non-core to ensure it can grow and develop, and to ensure the next non-core can eventually take control of the vacuum it will produce through its self-destruction.

Limit cycle

In mathematics, in the study of dynamical systems with two-dimensional phase space, a limit cycle is a closed trajectory in phase space having the property that at least one other trajectory spirals into it either as time approaches infinity or as time approaches negative infinity (96).

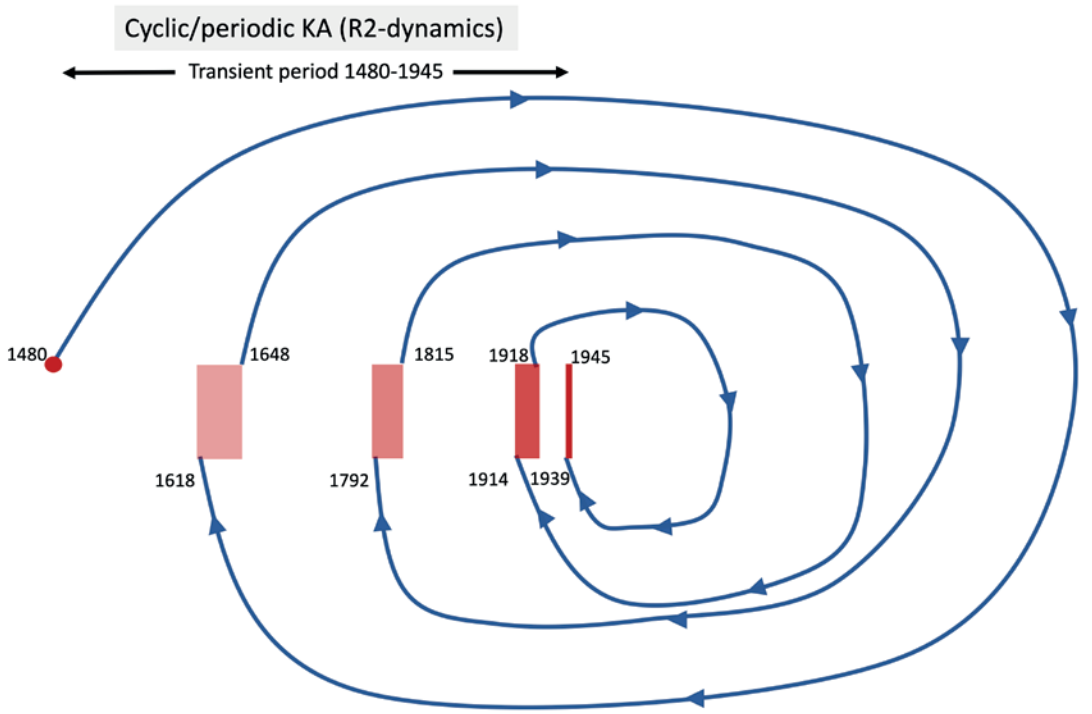


FIGURE A-8: During the transient period (1480-1945), a limit cycle was the attractor of the State-System.

Linear regime

In modern thermodynamics, a relationship is observed between stationary states near equilibrium, the extremization of entropy-production and a so-called linear regime. The term linear-regime refers to the linear evolution of certain properties (rates) of a system under certain conditions: The very regular - linear-evolution of certain properties of the (State-)System during successive RSP's, is a typical phenomenon of open systems near equilibrium (66).

Living system

According to Miller (53), complex structures which carry out living processes can be identified at seven hierarchical levels: the (1) cell, (2) organ, (3) organism, (4) group, (5) organization, (6) society, (7) supranational system.

Miller's central thesis is that systems at all these levels are open systems composed of subsystems which process inputs, throughputs, and outputs of various forms of matter, energy, and information. Miller "identifies 19 critical subsystems (see table) whose processes are essential for life, some of which process matter or energy, some of which process information, and some of which process all three. Together they make up a living system."
According to Miller (53), living systems have several characteristics, including:

- Living systems are a special subset of the set of all possible concrete systems.
- Living systems are open systems, with significant inputs, throughputs, and outputs of various sorts of matter-energy and information.
- Living systems maintain a steady state of negentropy (low entropy).
- Living systems either contain genetic material composed of deoxyribonucleic acid (DNA), presumably descended from some primordial DNA common to all life or have a charter. One of these is the template - the original "blueprint" or "program" - of their structure and process from the moment of their origin.
- Complex structures which carry out living processes can be identified at seven hierarchical levels: the (1) cell, (2) organ, (3) organism, (4) group, (5) organization, (6) society, (7) supranational system.

Local stability

With the term "local stability", I refer to the stability-effect produced by the network-effect, during RSP's of KA/war-cycles. During HCR's, VC's become increasingly connected, and states - parts of VC's - become less susceptible to new issues and tensions, assuming that their decision-thresholds (to decide for KA/war) stay unchanged. Because of the network- and local stability effects, the average size of non-systemic KA/war during HCR's decreases.

Lock-in

Lock-in is a feature of path dependence. Initially, the trajectory, or direction of development, of the system is relatively flexible and can still change direction. However, it is a matter of time and the system becomes progressively locked in. The measure of lock-in of system determines the costs (e.g., energy) that are required to change its path (87). See: *Path dependence*.

Low-connectivity KA/war-cluster(s)

See: *High-connectivity KA/war-cluster(s)*.

Low-connectivity-regime (LCR)

See*: High-connectivity regime*.

Lyapounov exponent

Lyapounov exponents provide a measure for the instability of motion (in phase space) and the sensitivity of systems for initial conditions. Lyapounov exponents describe the mean rate of exponential divergence of two initially close trajectories (66).

A typical characteristic of chaotic dynamics is their sensitive dependence for initial conditions, which indicates that two almost similar initial conditions will develop differently and produce two completely different trajectories (orbits) in phase state. Sensitive dependence for initial conditions makes accurate predictions impossible.

The Lyapunov exponent is a measure of the rate of spread of two trajectories that originate from nearby initial conditions. "The Lyapunov exponent is defined as the average rate of trajectory divergence caused by the endogenous component (and not by stochasticity), using for its calculation two trajectories that start near one another and that are – this is an important assumption – affected by an identical sequence of random shocks" (37). A positive exponent is supposedly an indicator of chaos.

Matter

Matter is anything that occupies space and has mass (20).

Maximization

See: *Extremization*.

Maxwell's demon

"Maxwell's demon is a thought experiment created by the physicist James Clerk Maxwell in 1867 in which he suggested how the second law of thermodynamics might hypothetically be violated. In the thought experiment, a demon controls a small door between two chambers of gas. As individual gas molecules approach the door, the demon quickly opens and shuts the door so that only fast molecules are passed into one of the chambers, while only slow molecules are passed into the other. Because faster molecules are hotter, the demon's behaviour causes one chamber to warm up and the other to cool down, thereby decreasing entropy and violating the second law of thermodynamics. This thought experiment has provoked debate and theoretical work on the relation between thermodynamics and information theory extending to the present day, with a number of scientists arguing that theoretical considerations rule out any practical device violating the second law in this way" (96).

With a thought experiment (referred to as 'Maxwell's demon'), Maxwell "demonstrated that the Second Law of Thermodynamics is statistical in nature and that there is a relationship between entropy and information (6).

"An extremely interesting aspect of Maxwell's thought experiment is that his 'demon' uses information to perform sorting. The demon needs information about whether an approaching particle is fast or slow in order to know whether or not to open the door" (6).

The experiment

Metastable state

"In physics, metastability is a stable state of a dynamical system other than the system's state of least energy. A ball resting in a hollow on a slope is a simple example of metastability" (96). During the transient period (1480-1945), the (State-)System was in a metastable state, at two levels of organization: (1) At the level of cycles (R1-dynamics), during RSP's of KA/war-cycles, and (2) at the level of the (State-)System (R2-dynamics), during the transient period (1480-1945).

Microstate(s)

The internal possible arrangements or configurations of a system. The microscopic properties of any system with great randomness (high entropy) are arranged in many different ways and "a system of low entropy has only a few possible arrangements of its inherent properties" (20). High entropy (randomness and disorder) can be associated with a large number of possibilities (e.g. system configurations).

Minimum Entropy Production Principle (MEP-Principle, MEPP)

"In the linear regime, where the Onsager reciprocal relations are valid, all stationary states in which unconstrained thermodynamic flows vanish are characterized by the following general extremum principle:

In the linear regime, the total entropy production in a system subject to flow of energy and matter, $\boldsymbol{d_i S / dt = \int \sigma \, dV}$*, reaches a minimum value at the nonequilibrium stationary state.*

Such a general criterion was sought by Lord Rayleigh, who suggested a 'principle of least dissipation of energy'. Lars Onsager (1903-1976), in his well-known article on the reciprocal relations, comments on this principle and suggests that 'the rate of increase of entropy plays the role of a potential'. The general formulation and the demonstration of the validity of this principle is due to Prigogine" (44)
The R2-dynamics of the (State-)System manifest the MEP-P.

Military organization

Military organizations of states are tasked to apply kinetic energy in response to entropic perturbations (issues and tensions) in the external environment of societies/states. The purpose is to ensure a dynamic steady state during RSP's of KA/war-cycles, by contributing to non-systemic KA/war, and to contribute to the upgrade of RSP's (the order of the (State-)System) during critical periods, by participation in systemic KA/wars. BCD's are indicative for the kinetic energy that is put to use.
During the transient period (1480-1945), military organizations have developed self-similar - fractal - structures to ensure optimized distribution of kinetic energy (military capabilities). Because societies were subject to the same selection forces, state-structures - including military organizations - acquired identical organizational structures.

Minimization

See: *Extremization*.

Mission creep

Mission creep refers to changes in the (initial) mission of military units, beyond its original goals. Mission creep utilizes our ability for collective self-deception; the ability to (re-)adjust the interpretation of events to accommodate the actual state of affairs in a 'coherent story', that serves the H-imperative. The mechanism of interacting self-fulfilling prophecies is helpful in the adjustments process.

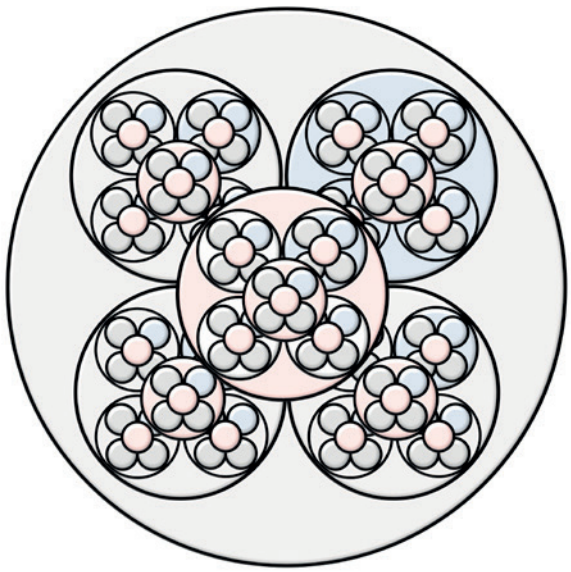


FIGURE A-9: During the transient period (1480-1945), military organizations and capabilities acquired fractal structures, which point to the optimized distribution of kinetic energy.

Mode-coupling

Mode-coupling can be considered the mechanism that is responsible for the establishment of long-range correlations between interactions (66); the coupling is nonlinear. The emergence of macroscopic behavior means that the system generates and maintains reproducible relationships among its distant parts: The system shows coherent - and very regular - behavior (66). Near bifurcation and critical points and during the operation of dissipative structures, the two modes become (increasingly) coupled: (1) A mode concerned with localized issues and interactions, and a (2) mode concerned with the transport of (entropy) tensions and energy in the system (66), between more distant parts. Both modes are needed - and need to be coupled - to ensure that a local fluctuation (inhomogeneity) can be 'communicated' - spread and cascade - through a system. Mode-coupling is a prerequisite for coherent macroscopic behavior, i.e. for the functioning of the FTS. The FTS provides mode-coupling to the (State-)System, by coupling local entropic perturbations (issues) to the S/T-field (collective dimension) and ensuring the transport of entropy and/or kinetic energy (causing amplification of the issue).

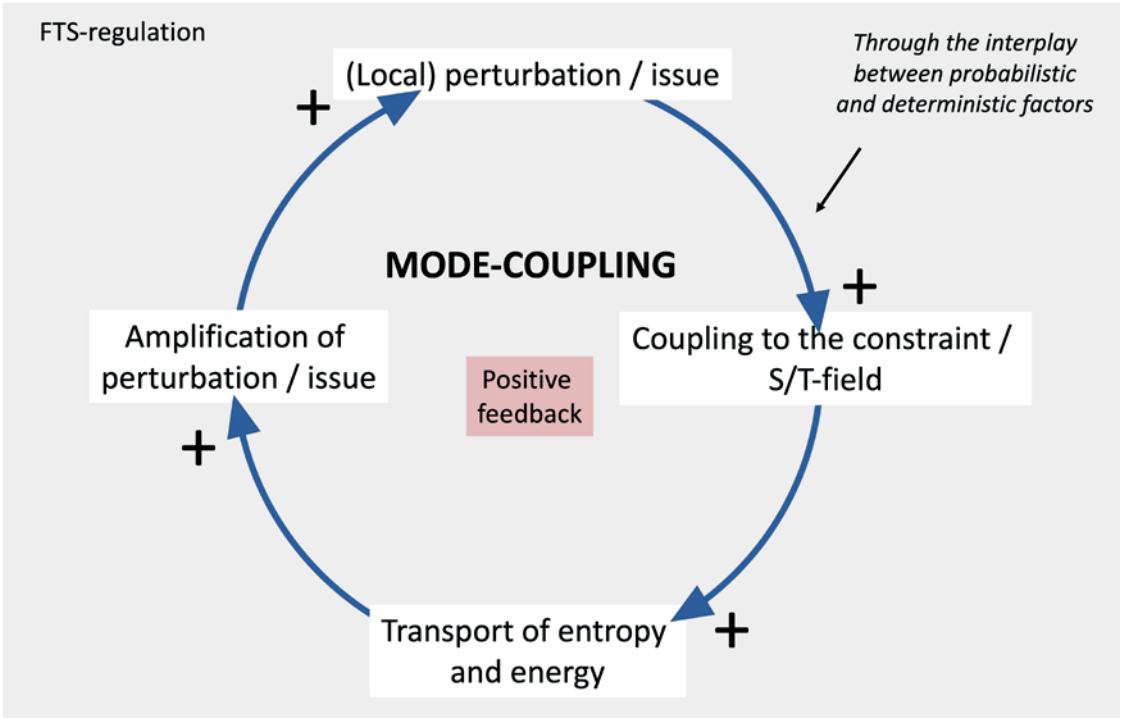


FIGURE A-10: CLD of Mode coupling.

Modern thermodynamics

Modern thermodynamics "is a theory of irreversible processes in contrast to nineteenth century thermodynamics, which is a theory of states. In the latter, thermodynamics is confined to initial and final states, the processes that transform a state are not central to the theory; they are treated as another subject, 'kinetics'.

In Modern Thermodynamics, however, entropy-increasing irreversible processes are central to the theory." According to Kondepudi et al. entropy and entropy-producing irreversible processes are generally thought of as agents of disorder, but under far-from-equilibrium conditions, irreversible processes are, in fact, the drivers of self-organization and order we see all around us in Nature. "These emergent structures, called dissipative structures, are distinct from machines and are a good thermodynamic basis on which we may begin to build a theory of biological organisms. It is an important direction for future developments in thermodynamics" (44).

Modes of behavior of dynamical systems

Sterman (87) describes three common modes of behavior: exponential growth, goal seeking, and oscillations.

- *Exponential growth*. "Exponential growth arises from positive, self-reinforcing feedbacks. The larger the quantity, the greater its net increase, thereby further augmenting the quantity and leading to ever-faster net growth. The growth rate, however, is constant. Exponential growth is characterized by a constant doubling time; the state of the system doubles in a fixed period of time regardless of its size. Positive feedback need not always generate growth; it can also create a self-reinforcing decline."
- *Goal seeking*. "Whereas positive feedback loops generate growth, amplify deviations, and reinforce change, negative loops seek balance, equilibrium, and stasis. Negative feedback loops act to bring the state of the system in line with a goal or a desired state.""Every negative loop includes a process to compare the desired and actual conditions and take corrective action. In most cases, the rate at which the state of the system approaches its goal diminishes as the discrepancy falls. The gradual approach arises because large gaps between desired and actual states tend to generate large responses, while small gaps tend to elicit small responses."
- *Oscillation*. Oscillation is the third fundamental mode of behavior observed in dynamic systems. Like goal-seeking behavior, oscillations are caused by negative feedback loops. "The state of the system is compared to its goal, and corrective actions are taken to eliminate any discrepancies. In an oscillatory system, the state of the system constantly overshoots its goal or equilibrium state, reverses, then undershoots, and so on. The overshooting arises from the presence of significant time delays in the negative loop. The time delays cause corrective actions to continue even after the state of the system reaches its goal, forcing the system to adjust too much, and triggering a new correction in the opposite direction."

There are many types of oscillation, including damped oscillations, limit cycles, and chaos. Each variant is caused by a particular feedback structure and set of parameters determining the strength of the loops and the length of the delays.

Sterman observes, that most real-world oscillations are not perfectly regular: "Biological, social, and economic systems involve huge numbers of interactions among tightly coupled elements. They are continuously bombarded by perturbations that cause their motion to be somewhat irregular, a (usually nonlinear) combination of their endogenous dynamics and these exogenous shocks."

As Sterman explains, "system dynamics arise from networks of positive and negative feedbacks, and how they interact with one another. The existence of various feedback loops in a system does not mean that all of them have the same impact on the dynamics of the system. The dominance of loops (positive and negative) can vary and shift." Sterman observes, "Identifying potential shifts in loop dominance arising from latent structures is a valuable function of modelling."

Multiplicity

Boltzmann called the number of microstates that compose a macrostate its multiplicity which is denoted with the symbol omega (Ω).

Near-decomposability

Based on the forces between parts of a system, Simon distinguishes between systems that are *decomposable* into subsystems comprised of the individual parts, and nearly-decomposable systems, "in which the interactions among the subsystems are weak, but not negligible." Simon argues: "At least

some kinds of hierarchic systems can be approximated successfully as nearly-decomposable systems. The main theoretical findings from the approach can be summed up in two propositions: (a) in a nearly-decomposable system, the short run behavior of each of the component subsystems is approximately *independent* of the short run behavior of the other components; (b) in the long run, the behavior of any one of the components depends in only *an aggregate way* on the behavior of the other components." (77)

Negative feedback

See: *Feedback*.

Net-entropy effect

The term net-entropy effect ($\Delta \boldsymbol{S}_{net}$) refers to the sum of the entropy generated by the issue (the entropic perturbation, "supplied" by the S/T-field) ($\boldsymbol{S}_{issue}$) and the entropy that is neutralized through the use of non-systemic KA ($\boldsymbol{S}_{neutralized}$).
During LCR's: $\Delta \boldsymbol{S}_{net} = \boldsymbol{S}_{issue} - \boldsymbol{S}_{neutralized} < \boldsymbol{0}$, and during HCR's: $\Delta \boldsymbol{S}_{net} = \boldsymbol{S}_{issue} - \boldsymbol{S}_{neutralized} > \boldsymbol{0}$
Contrary to what this schematic depiction of a war-cycle could suggest, the tipping point is not (necessarily) 'located' halfway through a RSP.

Network(s)

A network is a set of nodes (vertices) connected via edges (links). The total number of connections of a vertex is called its degree $\boldsymbol{k}$. *(26)*

Network-effect

Typically, during RSP's of KA/war-cycles, at a certain point - the tipping point - the average size of chaotic non-systemic KA/war starts to decrease. This effect - I refer to as the network-effect - can be attributed to the connectivity of VC's. The tipping point separates the low- and high-connectivity regimes of RSP's.
With the term "local stability" I refer to the stability-effect during HCR's, produced by the network-effect. The network-effect leads to instability of the (State-)System.

Niche

A niche refers to the fit of a living system (species, social systems, etc.) living under specific environmental conditions. By "occupying" a niche, the living system can exploit - utilize - the specific environmental conditions it is adapted to, and which are not available to other living systems.

Niche construction

"Niche construction occurs when an organism modifies the functional relationship between itself and its environment by actively changing one or more of the factors in its environment either by physically

perturbing these factors or by relocating to expose itself to different factors" (57). Because of their ability to utilize decoupled information, to communicate, and to cooperate, humans have an exceptional ability for niche construction.

Non-chaotic (abnormal) non-systemic KA/war dynamics

See: *Exceptional period*.

Non-core

During the transient period (1480-1945), the System consisted of a core - Europe - and a non-core; "the rest of the world".

Nonlinear resonance

In physics, nonlinear resonance is the occurrence of resonance in a nonlinear system. In case of nonlinear resonance, resonance frequencies depend on the amplitude of the oscillations. In case of the (State-) System, accelerating entropy-production (driven by population growth and reinforced by processes generated by the 1st FTS), resulted in an increase in the force that was applied to the State-System. Consequently, the frequency and amplitude of R2-dynamics, increased in conjunction.

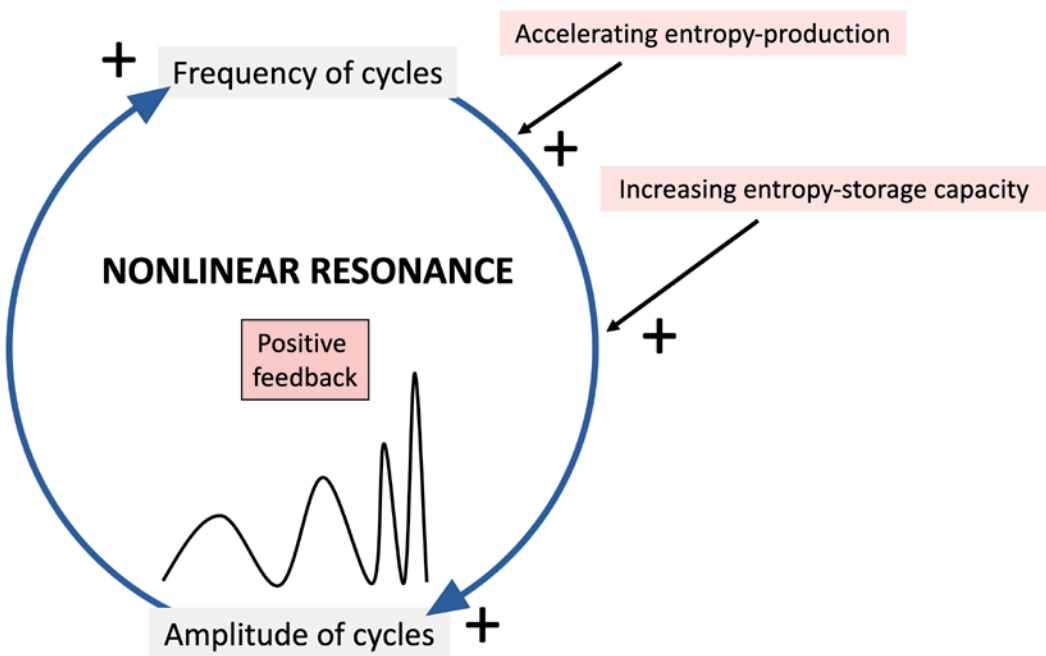


FIGURE A-11: CLD of nonlinear resonance during the transient period (1480-1945).

Nonlinear system

A nonlinear system is a system in which the change of the output is not proportional to the change of the input; the (State-)System is a nonlinear system.

Non-systemic KA/war

A distinction can be made between non-systemic KA/war and systemic KA/war. The purpose of non-systemic KA/wars is to correct entropic perturbations (issues and tensions) in the (State-)System, during RSP's of KA/war-cycles and to maintain the existing dynamic steady state (the status quo). The purpose of systemic KA/wars is to periodically upgrade the order of the (State-)System, during critical periods of KA/war-cycles. Non-systemic KA/war dynamics are normally chaotic in nature. Chaotic non-systemic KA/war dynamics are also referred to as R1-dynamics, and cyclic systemic KA/war dynamics as R2-dynamics.

Novelty by combination

Novelty by combination refers to new structures - and solutions - that can be produced by combining existing structures and solutions: "Novelty feeds on novelty". What novelty is produced depends on various factors and conditions, including: (1) the utility of new combinations in the deterministic, abstract and/or contingent domains, (2) the effects of the PDLI-mechanism, which (increasingly) limits the process of novelty by combination, and (3) the degree of hysteresis (hysteresis is the dependence of the state of a system on its history). More diversity means more opportunity for "novelty by combination" and more opportunity for niche construction.
Novelty by combination limits our ability to make (accurate) predictions.

Nucleation (process)

"Nucleation is the first step in the formation of either a new thermodynamic phase or a new structure via self-assembly or self-organization. Nucleation is typically defined to be the process that determines how long an observer has to wait before the new phase or self-organized structure appears" (96).
During the transient period (1480-1945), three "types" - distinct processes - of nucleation can be distinguished in the (State-)System: (1) *RSP-nucleation* (cycle level): The process of nucleation of VC's (especially) during HCR's of RSP's, which causes the (State-)System to become critical ("fluid"), (2) *Stability-nucleation* (cycle-level): The process of nucleation of an upgraded order during critical periods (during systemic KA/war), which can be considered as a process of resolidification, and (3) *Aggregation* (State-System-level, core): The merging of societies/states into a next level of organization, which is a key-feature of the phase transition of the European State-System to a state of thermodynamic equilibrium.

Onsager's reciprocity relations

In 1931, Lars Onsager discovered the first general relations in nonequilibrium thermodynamics for the linear, near-equilibrium region. These are the "reciprocal relations". Onsager assumed that the dynamics of all macroscopic coordinates were governed by a linear system of differential equations relating the force on one coordinate to the degree of displacement from equilibrium in all other coordinates.

In qualitative terms, they state that if a force, say 'one' (corresponding, for example, to a temperature gradient), may influence a flux 'two' (for example a diffusion process), then force 'two' (a concentration gradient) will also influence the flux 'one' (the heat flow) (44).

Open system

Open systems exchange energy and matter with their environment. Closed systems exchange energy with their environment; isolated systems do not exchange energy and matter with their environment.

Orbit

With the term "orbit" is referred to circular(-like) trajectories of certain variables of KA/war dynamics, in phase space. These orbits point to the chaotic nature of KA/war dynamics.

Order

The order of the (State-)System refers to the (State-)System's organization, but is not restricted to the organizational structure, but also includes values, arrangements (in the contingent domain), and certain mechanisms that underpin the organization.

Order parameter

An order parameter describes a specific aspect of the state - condition - of a system. The level of aggregation in/of the European State-System during the transient period (1480-1945), is an order parameter of the (State-)System.
See also: *Control parameter*.

Order through fluctuations

Order through fluctuations refers to the phenomenon that (increasingly) unstable nonequilibrium systems can bifurcate to organized states FFE; (amplified) fluctuations are instrumental in these bifurcations. "The new states thus attained are often 'ordered states' that possess spatiotemporal organization. Patterns in fluid flow, inhomogeneities in concentrations exhibiting geometrical patterns with great symmetry or periodic variations of concentrations are examples of such ordered states. Because of its fundamental character, we shall refer to the general phenomenon of a nonequilibrium system evolving to an ordered state as a result of fluctuations as order through fluctuations" (44).
The bifurcations are 'triggered' by fluctuations - by perturbations and/or inhomogeneities - in the system concerned, that are amplified because of the unstable conditions. The lack of extremum principles that (contrary to equilibrium systems) uniquely predict the states to which equilibrium systems evolve, make it impossible to predict the organized state FFE a nonequilibrium system will evolve to. The outcome is an interplay between change and constraint (deterministic laws).

Order through KA/war

With the term "order through KA", I refer to the phenomenon that during the transient period (1480-1945), order was maintained through chaotic non-systemic KA/war, during RSP's of cycles, and order was upgraded through systemic KA/war, during critical periods. Without KA, the FTS and the European State-System could not have maintained macroscopic coherence. Because KA (war) was (and still is) instrumental for maintaining order, KA/war is institutionalized in the contingent domain of the (State-) System.

Oscillation(s)

Sterman (87) describes three common modes of behavior of dynamical systems: Oscillation(s), goal seeking and exponential growth. See: *Modes of behavior dynamical systems*.

Pace of life of the (State-)System

Pace of life refers to the speed - and acceleration - of KA/war-cycles that accompanied the 1st FTS (1480-1945). The pace of life of the (State)System is a function of its connectivity, itself a function of population size. The pace of life of the System determines the spreading speed of information and tensions (59).

Path-dependence

"Path dependence is a pattern of behavior in which small, random events early in the history of a system determine the ultimate end state, even when all end states are equally likely at the beginning. Path dependence arises in systems whose dynamics are dominated by positive feedback."
"Path dependence is a pattern of behavior in which the ultimate equilibrium depends on the initial conditions and random shocks as the system evolves. In a path-dependent system, small, unpredictable events early in the history of the system can decisively determine its ultimate fate. The eventual end state of a path-dependent system depends on the starting point and on small, unpredictable perturbations early in its history. Even when all paths are initially equally attractive, the symmetry is broken by microscopic noise and external perturbations. Positive feedback processes then amplify these small initial differences until they reach macroscopic significance. Once a dominant design or standard has emerged, the costs of switching become prohibitive, so the equilibrium is self-enforcing: the system has locked in."
"Path dependence arises in systems with locally unstable equilibria," "also termed a repellor because nearby trajectories are forced away from it." Although the initial local equilibrium is unstable, the system as a whole must be stable.
"Microscopic differences in initial conditions lead to macroscopic differences in outcomes." Lock-in is another feature of path dependence. Initially, the trajectory, or direction of development, of the system is relatively flexible and can still change direction. However, it is a matter of time and the system becomes progressively locked in. The measure of lock-in of system determines the costs (e.g., energy) that are required to change its path. Based on: Sterman (87).

Path-dependence and lock-in (PDLI-) mechanism

The purpose of the 1st FTS (1480-1945), was to accomplish thermodynamic equilibrium of the European State-System, via the most efficient path, in accordance with the Second Law and related principles that applied. During the transient period (1480-1945), the 1st FTS and European State-System became increasingly locked-in, through a decrease in entropy of the European State-System.

Percolation theory

Percolation theory is concerned with cluster-formation in systems. Percolation theory is applied to the formation of VC's in the (State-)System (86).

Percolation threshold

At a certain point a system can reach a so-called percolation threshold, at that point, a percolation cluster can form; a cluster that percolates the whole system. The moment the System reaches the VC-percolation threshold, a VC percolates the whole State-System, and the State-System is in a critical state. In 1480, the (State-)System reached the percolation threshold; the minimal connectedness of the System that allowed for the forming of clusters that could percolate - "span" - the core of the System. In 1941, the percolation threshold of the global State-System was reached.

Periodic window

The term periodic window is associated with the transition (of systems) to chaos (chaotic dynamics). Systems/dynamics that make a transition to chaos show that chaos does not continue uninterrupted, but that various periodic windows can emerge (30). During 'periodic windows' dynamics are periodic in nature. The 1st exceptional period (1657-1763) is a periodic window.

Phase diagram

A phase diagram in physical chemistry is a diagram that shows the conditions (like for example pressure, volume, etc.) at which thermodynamically distinct phases occur and coexist. I applied this 'technique' to the State-System for the transient period (1480-1945).

Phase space

The evolution of a system can be visualized in an abstract space known as phase space (66). In phase space the coordinates are for example represented by the size (in terms of fraction) and severity of wars. During relatively stable periods, the kinetic activity - successive non-systemic KA/wars - can be represented by a series of successive points in phase space. By plotting certain properties of successive kinetic interactions in phase space, trajectories become visible and the contours of the stability domain of the relatively stable period.

In case of dissipative systems, there is a contraction of volume in phase space, as the system moves toward its attractor (66). This behavior can also be observed in case of the 1st FTS. On its path to thermodynamic equilibrium (full aggregation stage, 1945), the State-Systems 'possibilities' - and possible solutions - were constantly narrowing.

Phase space compression (or **shrinking of phase space)**

"Phase space compression is related to the loss of the system's dimensionality, and is facilitated by a continuous flow of entropy, which is transferred from the system to its surroundings. In other words, as the system organizes itself, the phase space available to its components becomes smaller, and the larger the change in the degree of system's ordering (per unit time), the more entropy is produced and transferred to the environment" (31). During the transient period (1480-1945) - during the four successive and accelerating cycles (and RSP's) - phase space of the State-System became increasingly compressed ('shrank', so to speak)

Phase transition

A distinction can be made between first and second order phase transitions. In case of first order - or discontinuous - phase transitions, there is an abrupt change in certain properties of the system concerned (44); in case of second order phase transitions the change is gradual. The phase transition of the European State-System qualifies as a first order phase transition.

Phase transitions occur because systems can lower their free energy by introducing a "new" order (81). In case of a phase transition symmetry-breaking occurs. The breaking of symmetry is accompanied by the appearance of new properties.

Typically, the basic properties of a system near a phase transition have nothing to do with the microscopic details of the system: "It doesn't matter whether we are dealing with a liquid- gas transition, a structural transition where a crystal deforms, or a magnetic transition where the little magnets or spins start pointing in the same direction" (8).

"A critical point is used to describe the presence of a very narrow transition domain separating two well-defined phases, which are characterized by distinct macroscopic properties that are ultimately linked to changes in the nature of microscopic interactions among the basic units. The lack of a boundary beyond the critical point makes possible a continuous movement from one phase to the other, provided that we follow the appropriate path; the critical curve (boundary) does not have to be crossed."

The critical point describes a condition where there is in fact no longer a distinction between two phases; there is phase coexistence. During the transient period (1480-1945), when the System neared the critical point of the European State-System (1939), the System was in a coexistence region, when order and disorder in the (State-)System coexisted. The thermodynamic properties during the transient period, are crucial in understanding social and political dynamics and developments in the contingent domain of the System. See also*: Critical point*.

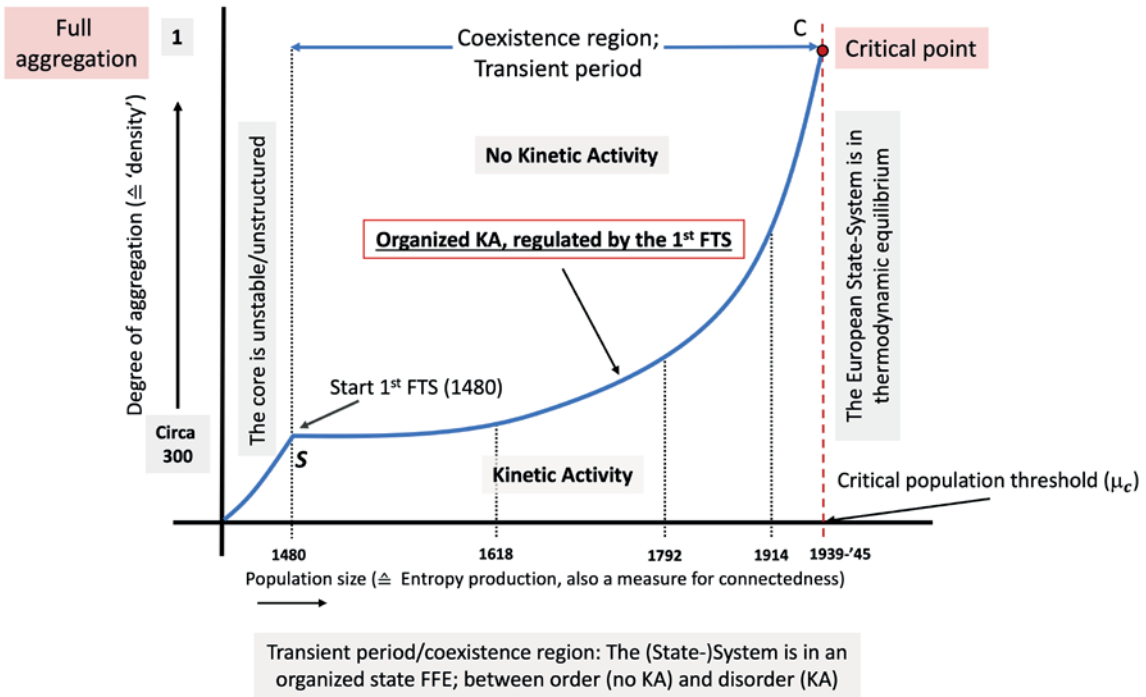


FIGURE A-12: Phase transition of the European State-System, during the transient period (1480-1945).

Phases in the development of the (State-)System

Based on analysis of war-data and the concepts discussed in this study, it is possible to distinguish three phases in the development of the System: (1) an unstable, unstructured phase (< 1480), (2) an organized phase FFE - the transient period 1480-1945- when a dissipative structure - the 1st FTS - regulated entropy-production (EMIS-flows), and (3) a phase (> 1945), when the core of the (State-)System (Europe) was (is) in thermodynamic equilibrium, and the System no longer consists of a core and non-core, but is globalized. From 1945 onwards, EMIS-flows are regulated by a 2nd (global) FTS.

The second and third phase - respectively from 1480-1945 and from 1945 onwards - were interrupted by abnormal war dynamics, respectively during the 1st exceptional period (1657-1763) and 2nd exceptional period (1945-1991, better known as the Cold War).

The characteristics of these phase will be discussed in this chapter.

Physical domain

The physical domain is the domain of energy and matter, and of their exchanges and transformations.

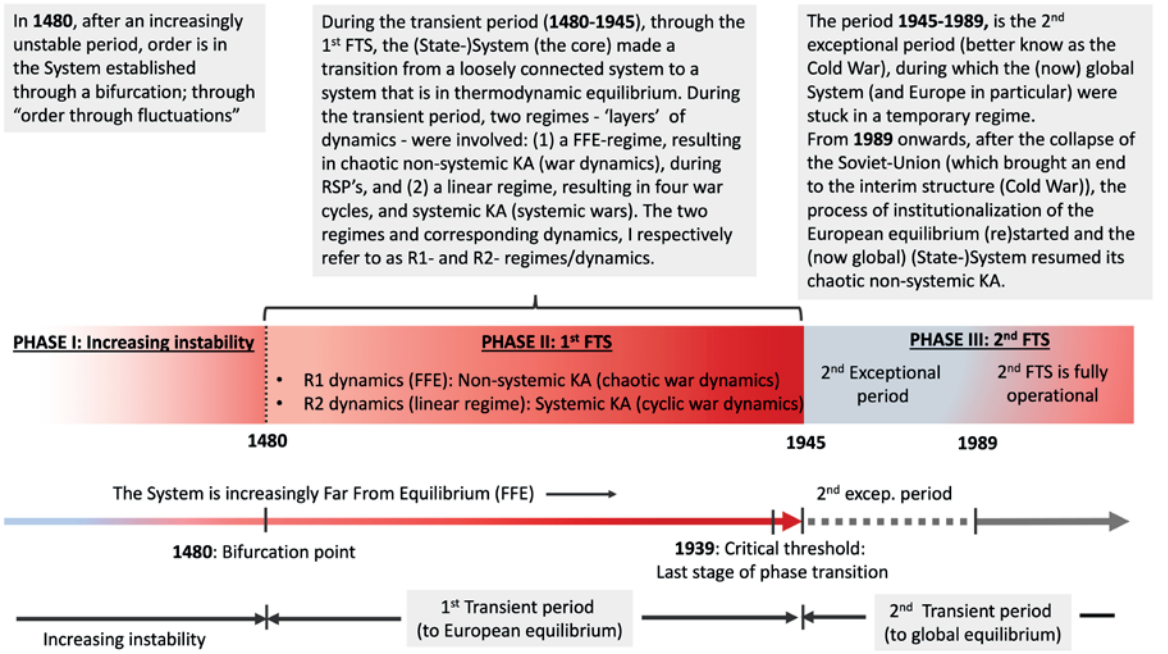


FIGURE A-13: Three phases in the development of the (State-)System.

Poissonian distribution

A poissonian (random) distribution of (for example) the sizes of fluctuations reflect the complete disorder in a system and its dynamics; this is the property of a system at thermodynamic equilibrium (66).

Population threshold

See: *Connectivity threshold*.

Positive feedback

See: *Feedback*.

Potential energy

In physics, potential energy is the energy possessed by an object because of its position relative to other objects, stresses within itself, its electric charge, or other factors.
Common types of potential energy include the gravitational potential energy of an object that depends on its mass and its distance from the center of mass of another object, the elastic potential energy of an extended spring, and the electric potential energy of an electric charge in an electric field (96).
Entropy in the (State-)System can also be considered a measure for the potential energy in the (State-) System. Entropy (issues and tensions) serves as a catalyst in the process of transformation of "societal energies and potentials" in military capabilities; kinetic energy that is put to use during KA/war.

Powerful-become-more-powerful (PBMP) mechanism

A 'powerful-become-more-powerful' mechanism was (and still is) instrumental in a co-evolutionary process involving states (units of the (State-)System) and successive orders. Through systemic KA/wars, dominant states could ensure that (upgraded) orders especially supported their interests and positions. Increased power was institutionalized through privileged arrangements, for these dominant states. These privileges further increased the power and influence of (already) dominant states, they could (again) put to use during the next systemic KA/war, etc.

Through the PBMP-mechanism is ensured that the most powerful states have the highest stake in maintaining the new status quo, which is crucial for the (State-)System's stability.

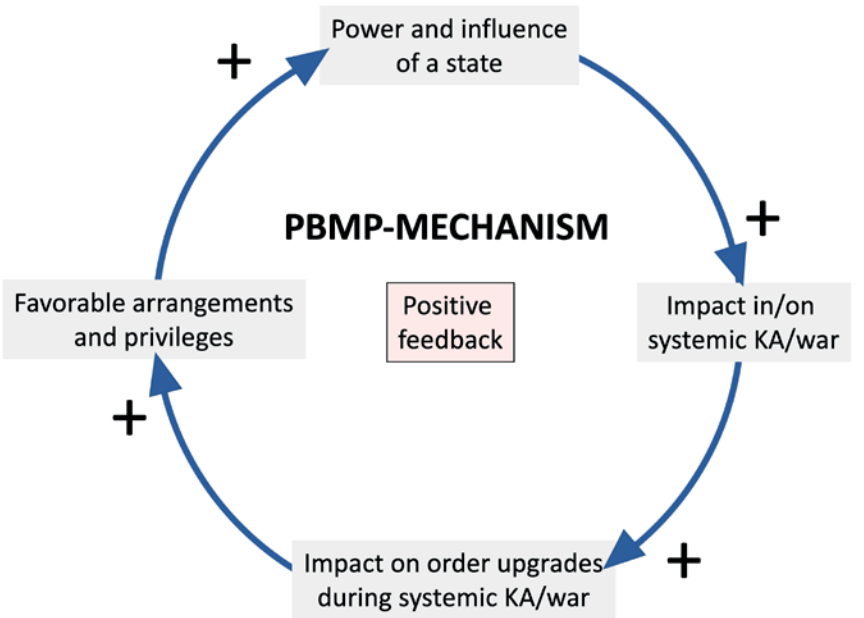


FIGURE A-14: CLD of the powerful-become-more-powerful-(PBMP-)mechanism.

Power law

So-called power laws (power functions) - which abound in nature - are functions concerned with self-similar - fractal - properties. A simple power function is: $f(x) = cx^{\alpha}$. "If x is rescaled (multiplied by a constant, then $f(x)$ is still proportional to x^{α}, albeit with a different constant of proportionality" (75). The exponent α reflects general dynamic rules that are at play across the system.

Near the critical point (during criticality) many variables of a system can be described by power law functions.

A feature of power laws is that they show no characteristic scale; a property also referred to as 'scale invariance'. When plotted in log-log coordinates, they produce a straight line; this implies that the data has a fractal structure, is 'self-similar. Self-similarity is a characteristic of fractals. Power law distributions are for that reason also referred to as 'scale-free'.
In scale-free networks, the degree distribution – the distribution of the number of connections each node possesses – follows a power law.
For a system to produce scale-free (self-similar) dynamics, that can be described by power-laws, it is *not* necessary that the 'underlying' network necessarily has a scale free structure (12).
Regarding scale invariance Sornette observes: "Right at the critical point, scale invariance holds exactly. It is only broken at either the smallest scale, if there is a minimum unit scale, and/or the largest scale corresponding to the finite system size. In between these two limiting scales, the system is fractal. When not exactly at the critical point, the same description holds true, but only up to a scale, called the correlation length, which now plays the same role as did the finite size of the system at the critical point (83)."

Primary bifurcation

The bifurcation of the System in 1480, which resulted in the emergence of the 1st FTS, is the primary bifurcation of the System.

Principle of least free energy

All systems, including the (State-)System, obey the Second law of thermodynamics, which states that all processes occur in order to minimize the overall free energy (and maximize entropy). I refer to this principle as the "principle of free energy".

Punctuated equilibrium dynamic

"Punctuated equilibrium theory makes two contentions: that evolutionary change (or at least very significant proportions thereof) occurs in rapid bursts over short intervals of time, and that there is relative stasis after the punctuational burst" (82). Arguably, the 1st FTS (1480-1945), qualifies as a punctuated equilibrium dynamic. However, this perspective is not in all respects exact: significant evolutionary change also takes place during relatively stable periods. Great Power status dynamics typically take place during relatively stable periods and are then during punctuations (systemic wars) embedded in the upgraded order of the System.
Relatively stable periods and periods of criticality (systemic wars) are inseparably linked: during high-connectivity regimes of relatively stable periods the System is 'charged' (with entropy) for a next systemic war.

Radicalization

Radicalization is a mechanism in the contingent domain to cope with entropy(-production), and (the process of) radicalization can be understood as an effort to harness entropy (uncertainty and tensions).

Radicalization itself is equivalent with a tendency toward zero entropy: zero diversity. Individual humans, communities and societies/states can radicalize. The drive to zero entropy of the European State-System can also be understood as a form of radicalization.

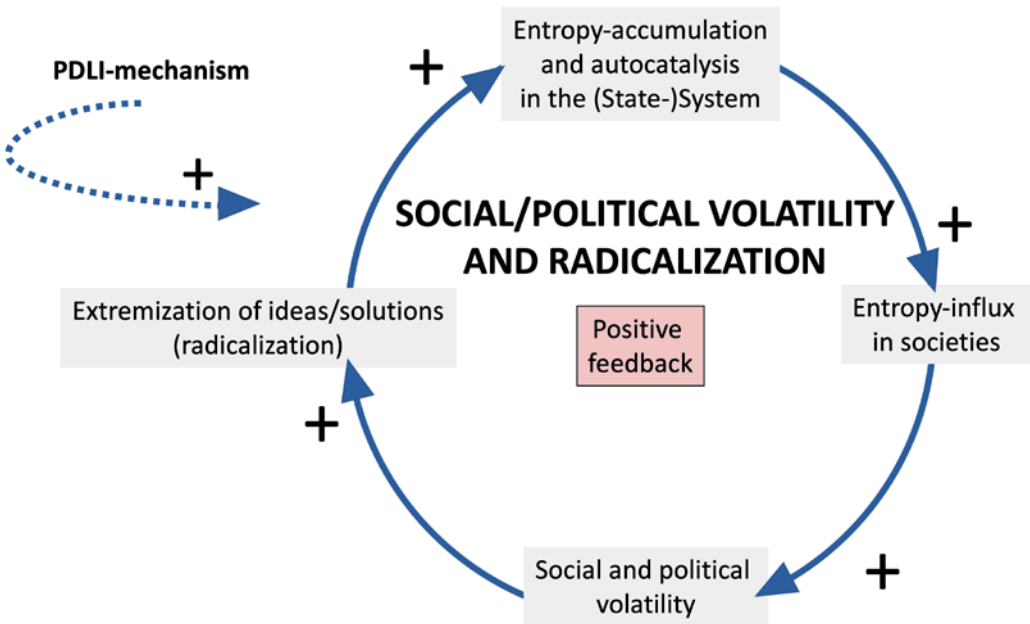


FIGURE A-15: CLD of the process of radicalization.

Reaction-rate

"The reaction rate is the speed at which reactants are converted into products" (96). KA is instrumental in the transition of the State-System to thermodynamic equilibrium; the transition of the European State-System took place during the period 1480-1945. Thermodynamic equilibrium implies (requires) the full aggregation/merging of societies and states. KA during successive RSP's - the number of non-systemic KA, non-systemic wars - and the Great Power status dynamics, can be considered measures for the reaction rate of the State-System. These reaction rates decreased linearly.

Relatively stable period (RSP)

See: *KA/war-cycle*.

Relaxation fluctuations

It is also possible, to consider the four cycles (R2-dynamics) as relaxation fluctuations: Through the systemic KA/war generated by the 1st FTS (1480-1945), the energy and entropy-states of the (State-) System were (temporarily) lowered.

Release-ratio

The severity of a systemic KA/war in terms of BCD, divided by the total severity of all KA/wars during the cycle concerned, I define as the release-ratio of a cycle

Resolidification (process)

See: *Nucleation (process)*.

Rest of the world

During the transient period (1480-1945), the System consisted of a core and a non-core. Europe was the core, and the "rest of the world" constituted the non-core.

Reversible processes

"A process is said to be reversible if and only if it can follow the same course phase by phase in the reverse order" (34). All natural processes are irreversible.

Robust, robustness

Robustness concerns a property of RSP's of KA/war-cycles: The ability of RSP's to 'absorb' perturbations without producing non-systemic KA/wars. The absolute number of non-systemic KA/wars during RSP's, and the KA/war-frequency of RSP's is a measure for the robustness of RSP's of cycles. I assume that the robustness of RSP's (of the (State-)System is a function of its connectivity. During the 4th RSP (1918-1939), robustness became 'absolute'; the (State-)System no longer produced (was able to produce) non-systemic KA/wars. See also: *Robust yet fragile*.

Robust yet fragile

In the (State-)System, goes an increase in the robustness of the (State-)System, hand in hand with an increase in the fragility of the (State-)System. The number of KA/wars during RSP's is a measure for robustness, while the decrease in the life-span of successive KA/war-cycles is a measure for the fragility of KA/war-cycles. Robustness and fragility are two sides of the same coin in case of the (State-)System.

RSP-nucleation

See: *Nucleation (process)*.

R1-dynamics (or 1st layer of dynamics, or **chaotic non-systemic KA/war dynamics)**

During the transient period (1480-1945), the (State-)System produced R-1 dynamics - chaotic non-systemic KA/wars, during RSP's of cycles that are subject to a thermodynamic state FFE - and cyclic R2-dynamics (four accelerating cycles), which are subject to near equilibrium thermodynamics. Whereas R1-dynamics are intrinsically unpredictable, are R2-dynamics highly predictable. See also: *Non-systemic and systemic KA/wars*.

R2-dynamics (or 2nd layer of dynamics, or **cyclic systemic KA/war dynamics).**

See: *R1-dynamics.*

Scientific method

In this study the scientific method is used, see figure A-16.

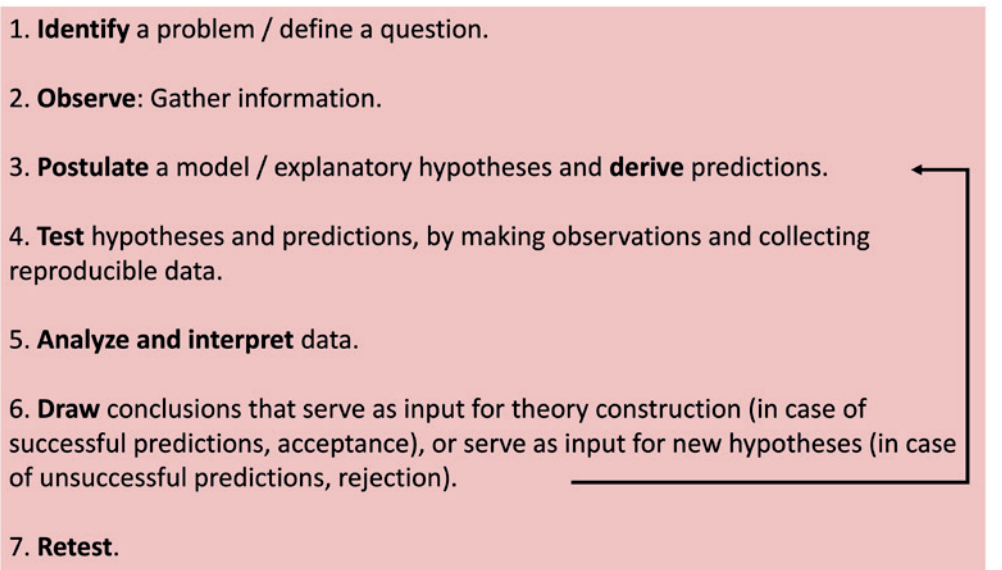


FIGURE A-16: The scientific method.

Scale-free network

A scale-free network is a network whose degree distribution (of its connections; that is interactions in this context) follows a power law, at least asymptotically. A scale-free network has fractal structures; there is self-similarity. A characteristic of scale-free networks is that it is possible to distinguish a relatively small number of "hubs" in these networks; this are the (relatively few) 'highest degrees' nodes.

S/E-budget of a KA/war-cycle

Each KA/war-cycle has a S/E-budget: Properties of KA/war-cycles of the 1st FTS during the transient period (1480-1945), reveal that exact amounts of energy (***E***) and entropy (***S***) are available per cycle (in terms of BCD). The FTS is responsible for regulation and (re)distribution.

Second Law of thermodynamics

"The Second Law says that even within the framework of conservation, there are certain 'limitations; "the Second Law invokes a quantity called entropy S (...)" (65). According to the Second Law, the entropy of the universe approaches a maximum (44). "The Second Law of thermodynamics requires that if there are any processes underway in the system, the quality of the energy in that system will degrade" (92).

Second order phase transition

See: *Phase transition.*

Secondary bifurcations

The critical points the (State-)System reached in 1618, 1792, 1914 in 1939 are secondary bifurcations. "1939" is also the critical point of the European State-System.

Security dilemma

The so-called security dilemma is intrinsic to the anarchistic State-System: In the anarchistic State-System states are (ultimately) responsible for their own security. Security is typically acquired through a combination of alliances and military capabilities. The problem is that in the (anarchistic) State-System, the security of one state (in terms of military capabilities and alliances) is (potentially) the insecurity of other states. If a state acquires military capabilities and builds alliances in response to a perceived threat by another state, these 'precautions' will be perceived as a threat by the other state and trigger a similar 'counter' response. The effect is an arms race. This dynamic constitutes a positive feedback - self-reinforcing mechanism.

Self-assembly (SA) or **auto-assembly**

According to Fialkowski et al. self-assembly is "the process by which isolated components organize autonomously and spontaneously into ordered and/or functional structures" and is "nature's preferred way of building its animate creations on various length scales" (31). Two major classes of self-assembly (SA exist: Static self-assembly (SSA) and dynamic self-assembly (DySA) (31). "The distinction between SSA and DySA refers to the thermodynamic description of the resulting assemblies, the former being equilibrium structures (in either global or local equilibrium) and the latter, stable nonequilibrium structures maintained in a steady state by a constant supply of energy, which is subsequently dissipated via the entropy producing (i.e., irreversible) processes associated with the interactions of the system's components" (31). "DySA structures represent a subset of a broader class of "dissipative" structures, in which the production of entropy directs the emergence of order" (31). The System, the State-System and states/societies also qualify as DySa-systems.

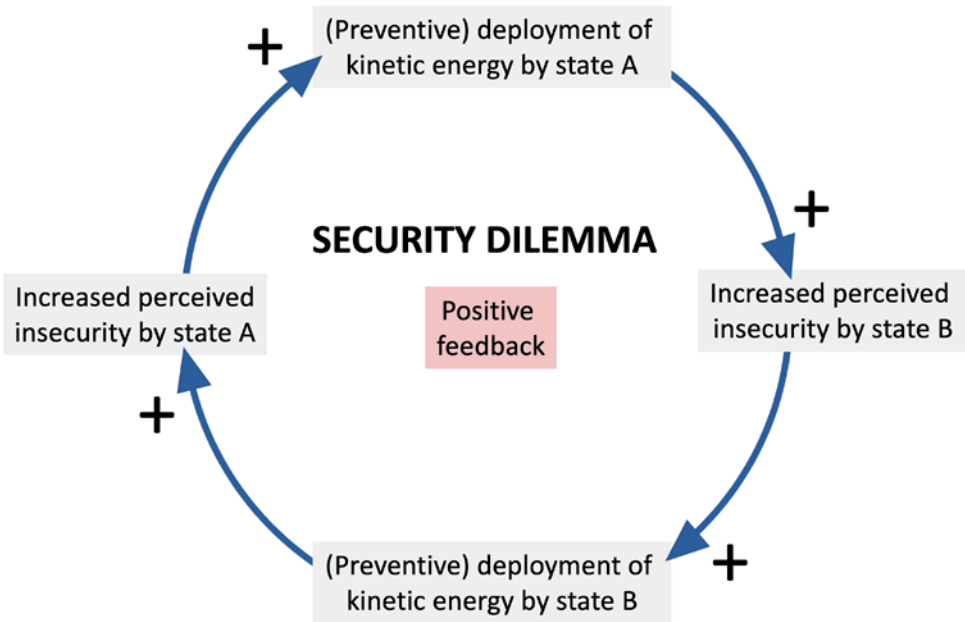


FIGURE A-17: The security dilemma.

In case of directed self-assembly, an external force is applied on a system "to change the potential landscape around elements in a system or change the elements itself to make it energetically favorable to self-assemble. This self-assembly might hold for as long as the force is applied in which case it is known as dissipative or reversible self-assembly. Another option is that the self-assembled system might find itself kinetically trapped in the new state. In either case the external force is the driving force of the self-assembly. This force can be a different force for different systems".

Self-deception

See: *Deception*.

Self-fulfilling prophecy

A self-fulfilling prophecy is a prediction that directly or indirectly causes itself to become true, by the very terms of the prophecy itself, due to positive feedback between belief and behavior. In case of a self-fulfilling prophecy, the behavior produced by a 'prediction' or expectation causes the prediction or expectation to become true.

Self-organization

Self-organization describes "the ability by certain non-equilibrium systems to develop structures and patterns in the absence of control or manipulation by an external agent" (41).

Self-organized criticality

Self-organized critical systems have a critical point as an attractor. Here I discuss SOC-systems in more detail, although the (State-)System does not qualify as a SOC-system, as is sometimes assumed (19).

To develop the theory of SOC-systems, Bak extensively researched sand piles, and avalanches that can be observed when sand is added to the pile. Avalanches are so-called 'release events,' defined as events by which a system releases energy that has built up in the system. 'Wars' can also be considered release events. Despite the fact that the System does not qualify as an SOC system (as I explain later), Bak's research is useful: It 'forces' us to address certain questions regarding the dynamics of the System, and by doing so provides us with valuable insights.

Bak et al. (7) suggests that "a general organizing principle governs a class of dissipative coupled systems" that "evolve naturally toward a critical state, with no intrinsic time or length scale." A critical point is assumed to be the attractor of this category of systems. By 'self-organized,' Bak means that the "system naturally evolves to a critical state without detailed specification of the initial conditions, i.e. the critical state is an attractor of the dynamics." According to Bak, the hallmark of SOC is its lack of any scale in time as well as in space (41). This is typical of any system at its critical point.

A number of systems - including the brain - seem to self-organize toward criticality (12). At the critical point these systems can optimize certain functions by 'using' its correlation length of one (at that point) that enables for system-wide communication, coordination and computation.

Although the System has certain SOC-characteristics, the System does not qualify as a SOC-system: the critical point of the System is not its attractor.

In the research article "*Self-organized criticality*", Bak et al. (7) describe the basic idea of SOC as follows: "To illustrate the basic idea of self-organized criticality in a transport system, consider a simple 'pile of sand.' Suppose we start from scratch and build the pile by randomly adding sand, a grain at a time. The pile will grow, and the slope will increase. Eventually, the slope will reach a critical value; if more sand is added it will slide off. Alternatively, if we start from a situation where the pile is too steep, the pile will collapse until it reaches the critical state, such that it is just barely stable with respect to further perturbations. The critical state is an attractor for the dynamics. The quantity which exhibits 1/f noise is simply the flow of sand falling off the pile." This and other models "evolve into a critical state: as the pile is built up, the characteristic size of the largest avalanches grows, until at the critical point there are avalanches of all sizes up to the size of the system, analogous to the domain distribution of a magnetic system at a phase transition.

The energy is dissipated at all length scales. Once the critical point is reached, the system stays there. The behavior of systems at the self-organized critical point is characterized by a number of critical exponents - which are connected by scaling relations - and the systems obey 'finite-size scaling' just as equilibrium systems at the critical point."

Bak argues that SOC is a general organizing principle that applies to a large category of systems: "I will argue that complex behavior in nature reflects the tendency of large systems with many components to evolve into a poised, 'critical' state, way out of balance, where minor disturbances may lead to events, called avalanches, of all sizes (8). Most of the changes take place through catastrophic events rather than by following a smooth gradual path. The evolution to this very delicate state occurs without design from any outside agent. The state is established solely because of the dynamical interactions among individual elements of the system: the critical state is self-organized."

Bak further argues (8) that SOC occurs and can only occur in non-equilibrium systems, producing a 'punctuated equilibrium dynamic' in which relatively long periods of stasis characterized by gradual development are punctuated by short intervals during which the system shows bursts of activity and volatility that result in more significant development/evolution: "In general, systems in balance do not exhibit any of the interesting behavior discussed above, such as large catastrophes, $\mathbf{1} / \boldsymbol{f}$ noise, and fractals. In the equilibrium state, small perturbations or shocks will cause only small disturbances, modifying the equilibrium state only slightly. The system's response is proportional to the size of the impact; equilibrium systems are said to be 'linear'. Contingency is irrelevant. Small freak events can never have dramatic consequences. Large fluctuations in equilibrium systems can occur only if many random events accidentally pull in the same direction, which is prohibitively unlikely. Therefore, equilibrium theory does not explain much of what is actually going on, such as why stock prices fluctuate the way they do. Systems in balance or equilibrium, by definition, do not go anywhere."

"As pointed out by Gould and Eldridge, the apparent equilibrium is only a period of tranquility, or stasis, between intermittent bursts of activity and volatility in which many species become extinct and new ones emerge. Also, the rate of evolution of individual species, as measured, for instance, by their change in size, takes place episodically in spurts. This phenomenon is called punctuated equilibrium. The concept of punctuated equilibrium turns out to be at the heart of the dynamics of complex systems. Large intermittent bursts have no place in equilibrium systems, but are ubiquitous in history, biology, and economics. None of the phenomena described above can be explained within an equilibrium picture. On the other hand, no general theory for large non-equilibrium systems exists."

According to Bak SOC-systems self-organize to a critical condition without outside tuning. Bak explains how a model system consisting of pendulums reaches a critical condition without tuning the control parameter of the system (8). At the critical point, "there were avalanches of all sizes just as there were clusters of all sizes at the critical point for equilibrium phase transitions. But no tuning was involved. (….) There is no temperature to regulate, no λ parameter to change. The simple behavior of the individual elements following their own simple local rules had conspired to create a unique, delicately balanced, poised, global situation in which the motion of any given element might affect any other element in the system. (….) The system had self-organized into the critical point without any external organizing force. Self-organized criticality (SOC) had been discovered. It was as if some 'invisible hand' had regulated the collection of pendulums precisely to the point where avalanches of all sizes could occur. The pendulums could communicate throughout the system. Once the poised state has been reached, the 'criticality' is similar to that of a nuclear chain reaction. Suppose you have a collection of radioactive atoms emitting neutrons. Other atoms, causing them to emit neutrons of their own, might absorb some of those neutrons. A single neutron leads to an avalanche. If the concentration of fissionable atoms is low, the chain reaction will die out very soon. If the concentration is high, there will be a nuclear explosion similar to that in an atomic bomb. At a unique critical concentration there will be avalanches of all sizes, all of which will eventually stop. Again, one has to 'tune' nuclear chain reaction by choosing precisely the correct amount of radioactive material to make it critical. In nuclear reactors this tuning is very important and is carried out by inserting neutron-absorbing graphite rods. In general, the reactor is not critical. There is absolutely no self-organization involved in a nuclear chain reaction, so in this all- important aspect the situation is entirely different."

I argue that during the period of 1480–1945, the System attained four times a critical point, also without outside tuning. The System was pushed into criticality by a combination of conditions, including

population and connectivity growth and rivalry between states. Although this behavior is in some respects similar to the behavior of self-organized criticality in Bak's sand pile, the System does not qualify as an SOC system. Although the System reached a critical point four times, a critical point is not the attractor of the System, but merely a 'step' in a process (the singularity dynamic) that ultimately results in a phase transition. Because systemic war represents criticality in the System, states and the System would self-destruct if the system reaches a 'stationary state,' a type of equilibrium, at a critical point: systemic war can for a number of reasons not be sustained for longer intervals

of time because of the 'energy' that is required and the destruction systemic wars cause. For the System, criticality is only an intermittent instrumental condition, not a viable and useful end condition that serves the purposes of the Systems and its constituents.

Bak also points to the importance of energy build ups and transfers in a system; such a perspective also is very useful to better understand the dynamics and the development of the System.

In his study, Bak described the process of energy transfer in the sand pile: "An open dissipative system had naturally organized itself into a critical scale-free state with avalanches of all sizes and all durations (8). The statistics of the avalanches follow the Gutenberg-Richter power law. There were small events and large events following the same laws. We had discovered a simple model for complexity in nature. The variability that we observe around us *(IP: Bak refers to avalanches of different sizes, and their distribution, produced by SOC)* might reflect parts of a universe operating at the self-organized critical state. While there had been indications for some time that complexity was associated with criticality, no robust mechanism for achieving the critical state had been proposed, nor had one been demonstrated by actual calculation on a real mathematical model."

"But before discussing the mathematical formulation of our model, let us recall the sandpile experiment."

"Consider a flat table, onto which sand is added slowly, one grain at a time. The grains might be added at random positions, or they may be added only at one point, for instance at the center of the table. The flat state represents the general equilibrium state; this state has the lowest energy, since obviously we would have to add energy to rearrange the sand to form heaps of any shape.

"Initially, the grains of sand will stay more or less where they land. As we continue to add more sand, the pile becomes steeper, and small sand slides or avalanches occur. The grain may land on top of other grains and topple to a lower level. This may in turn cause other grains to topple. The addition of a single grain of sand can cause a local disturbance, but nothing dramatic happens to the pile. In particular, events in one part of the pile do not affect sand grains in more distant parts of the pile. There is no global communication within the pile at this stage, just many individual grains of sand. As the slope increases *(IP: equivalent with the connectivity of the issue network of the System, that develops over time)*, a single grain is more likely to cause other grains to topple. Eventually the slope reaches a certain value and cannot increase any further, because the amount of sand added is balanced on average by the amount of sand leaving the pile by falling off the edges. This is called a stationary state, since the average amount of sand and the average slope are constant in time.

"It is clear that to have this average balance between the sand added to the pile, say, in the center, and the sand leaving along the edges, there must be communication throughout the entire system. There will occasionally be avalanches that span the whole pile. This is the self-organized critical (SOC) state. The addition of grains of sand has transformed the system from a state in which the individual grains follow their own local dynamics to a critical state where the emergent dynamics are global. In the stationary SOC state, there is one complex system, the sandpile, with its own emergent dynamics. The emergence

of the sandpile could not have been anticipated from the properties of the individual grains. The sandpile is an open dynamical system, since sand is added from outside. It has many degrees of freedom, or grains of sand. A grain of sand landing on the pile represents potential energy, measured as the height of the grain above the table."

"When the grain topples, this energy is transformed into kinetic energy. When the toppling grain comes to rest, the kinetic energy is dissipated, that is, transformed into heat in the pile. There is an energy flow through the system. The critical state can be maintained only because of energy in the form of new sand being supplied from the outside. The critical state must be robust with respect to modifications. This is of crucial importance for the concept of self-organized criticality to have any chance of describing the real world; in fact, this is the whole idea. Suppose that after the same system has reached its critical stationary state we suddenly start dropping wet sand instead of dry sand. Wet sand has greater friction than dry sand. Therefore, for a while the avalanches would be smaller and local. Less material will leave the system since the small avalanches cannot reach the edge of the table. The pile becomes steeper. This, in turn, will cause the avalanches to grow, on average. Eventually we will be back to the critical state with system-wide avalanches. The slope at this state will be higher than the original ones. Similarly, if we dry the sand, the pile will sink to a more shallow shape by temporarily shedding larger avalanches. If we try to prevent avalanches by putting local barriers, 'snow' screens, here and there, this would have a similar effect: for a while the avalanches will be smaller, but eventually the slope will become steep enough to overcome the barriers, by forcing more sand to flow somewhere else. The physical appearance of the pile changes, but the dynamics remain critical. The pile bounces back to a critical state when we try to force it away from the critical state."

Bak observed that initially the avalanche size increases until the critical point is reached and the sand pile at that stage produces avalanches of all sizes. The size distribution of avalanches at that critical point can best be described with a power law. Avalanches are like wars in that they can be considered release events of energy. The avalanche dynamics can be considered as energy 'transfers' in the sand pile.

In the case of sand piles, as Bak explained, every grain of sand adds energy to this dynamic system, making 'sand' the driver of the dynamics.

I argue that connectivity growth, along with the tensions and buildup of destructive energy it produces, is the driver of anarchistic systems. Destructive energy represents free energy in the System that will, by obeying the 'principle of least energy,' at a certain moment (during systemic wars) be put to work to create new order. In the System, two types of release events (e.g., wars) can be distinguished: systemic and non-systemic wars that have a fundamentally different function in the System. Systemic wars are a manifestation of criticality of the System, are system-wide events and instrumental in implementing new system-wide order. Non-systemic wars, on the other hand, are local events with only local effects that do not allow for system-wide communication, coordination, and planning (as is typically the case in case of criticality). Systemic wars are not scaled-up (i.e., exceptionally large) non-systemic wars; they are a class of their own.

Whereas systemic wars are closely associated with criticality—in fact, they are a manifestation of criticality—non-systemic wars are not directly related to criticality despite the fact that their remarkable size distribution can also best be described with a power law. Non-systemic wars are release events that precede criticality (systemic war). The fact the size distribution of non-systemic wars can be best described by a power law—as I will explain later— can be attributed to the chaotic and periodic properties of this category of wars.

Bak also states (8): "The toppling depends on how the individual grains lock together. Once a grain is falling, its motion is determined by the gravity field, which accelerates the grain, and the interaction with other grains, which tends to decelerate the motion. Stopping the motion depends on many factors, such as the shape of the grains it bumps into and its velocity at that point, and not just the height or slope of the pile at the neighbor points. As the process continues, it becomes more likely that at least one of the neighbors will reach its critical height, so the first toppling event induces a second event. One toppling event leads to the next, like falling dominos. As more sand is added, there will be bigger and bigger landslides, or avalanches, although there will still also be small ones. Eventually the entire sandpile enters into a stationary state where the average height of all sites does not increase further."

The 'toppling' of grains that Bak discussed can produce avalanches. In the case of the System, 'cascades' is a more suitable term. Wars can be considered cascades. In this study, I introduce a cascade-perspective (93) to further study the war dynamics of the System. Whereas with Bak's sand pile topplings (release events) depend on how individual grains are locked together, in the case of wars, the structure of the issue network determines how cascades (topplings) will and can evolve. Cascades are produced by so-called 'issue clusters': clusters of issues (and states that are an integral part of these issues) that 'collectively' switch to war as the preferred course of action; depending on the structure of the issue network the System produces a war (a cascade) of a certain size. Based on the model described by Watts, I argue that the size and frequency of non-systemic wars are determined by the connectivity and structure of the network of states and issues, as well as by 'thresholds' that states use to determine when they switch to positive war decisions.

Furthermore, "The pile has organized itself into a highly orchestrated, susceptible state through the process of repeatedly adding sand and having avalanches travel through the pile again and again."

"The power law indicates that the stationary state is critical. We conclude that the pile has self-organized into a critical state. One can show, by analyzing the geometry of the sandpile, that the profile of the sandpile is a fractal, like Norway's coast."

"The power law also indicates that the distribution of avalanches follows Zipf's law. Instead of plotting how many avalanches there are of each size, we could equally well plot how large the biggest avalanche was (the avalanche of "rank" one), how large the second biggest avalanche, of rank two was, how large the tenth biggest avalanche was, and so on, precisely the same way that Zipf plotted the ranking of cities. This is just another way of representing the information from the original power law. The straight line shows that the sandpile dynamics obey Zipf's law."

"We had to check that the criticality is robust with respect to modifications of the model. (…) One might speculate that the criticality is caused by the randomness of the way that the system is driven; we add new grains at random positions. In fact, this is not important at all. We can drive the system in a deterministic way with no randomness whatsoever, with all information about the system at all times encoded in the initial condition (….)."

"Since the whole history of the pile in this case was contained in the initial condition, the phenomenon of SOC is essentially a deterministic phenomenon, just like the chaos studied by Feigenbaum. The fact that the randomness of adding sand does not affect the power law indicates that the randomness is irrelevant for the complex behavior we are observing. This fact is important to realize when studying much more complicated systems. Economics deals with the more or less random behavior of many agents, whose minds were certainly not made up at the beginning of history. Nevertheless, this randomness does not preclude the system's evolving to the delicate critical state, with well-defined statistical properties. This

is a fascinating point that is difficult to grasp. How can a system evolve to an organized state despite all the obvious randomness in the real world? How can the particular configuration be contingent on minor details, but the criticality totally robust?"

Self-reinforcement

See: *Feedback*.

Self-similarity

See: *Fractals*.

Sensemaking

According to Weick (94), the process of sensemaking is an interactive process. Weick argues that "sensemaking is about such things as placement of items into frameworks, comprehending, redressing surprise, constructing meaning, interacting in pursuit of mutual understanding, and patterning".

Sensitivity to initial conditions

Sensitivity to initial conditions is a property of chaotic dynamics: small differences in initial conditions can lead to very different dynamics and outcomes. This property makes that chaotic (war) dynamics are intrinsically unpredictable.

Severity

Severity of a war is defined as the number of battle-connected deaths of military personnel (38) of Great Powers that participate in the war. I consider the severity of KA/wars a measure for the energy that is put to use. The unit of severity is 'BCD': the number of battle connected deaths of military personnel.

Singularity (in finite-time)

A singularity is a "point" when the properties of the (State-)System can no longer be defined, and the (State-)System exhibits extreme behavior.
The European (State-)System reached a singularity in finite-time in 1939, at the end of the 4th RSP, and is also referred to as the critical point of the European State-System or the critical connectivity or population threshold of the European State-System.

Size, size of KA/war

In this study I use two measures for the size of KA/war: (1) Size in terms of severity (BCD's), and size in terms of fraction. See: *Fraction*.

Social affinity

Social affinity can be defined as: "the force that corresponds with EMIS- flows - including KA (war), and the (related) processes of aggregation and expansion and empowerment"; social affinity drives social interactions.

Social entropy

Tensions - 'social entropy' - are generated by interactions - irreversible processes - between humans, between humans and communities, between communities, and between societies and states in the (State-)System, etc. Tensions can be compared with the heat produced by friction, e.g. in engines. Tensions can be considered "social entropy".

Social entropy (tensions) can be considered degraded energy, an unavoidable byproduct of (human/social) interactions. Tensions are also equivalent with (new) possibilities and (thus) uncertainty; tensions allow for - are the source of - new arrangements (microstates) in social systems. Tensions - new possibilities - can be considered threats or opportunities, depending on how these tensions are qualified in a social/human context. In fact, also threats constitute also opportunities; possibilities to adopt new - more favorable - arrangements.

Socialization

Socialization in sociology is "the process of internalizing the norms and ideologies of society. Socialization encompasses both learning and teaching and is thus "the means by which social and cultural continuity are attained". Socialization is strongly connected to developmental psychology. Humans need social experiences to learn their culture and to survive. Socialization essentially represents the whole process of learning throughout the life course and is a central influence on the behavior, beliefs, and actions of adults as well as of children" (96).

Socialization is an integral part of the process of aggregation. Aggregation requires complementarity of values and norms. Socialization also contributes to the predictability of (inter)actions; predictability contributes to stability. Socialization can be considered a form of learning; learning can be accomplished through various mechanisms, including: by providing rational arguments (a cost-/benefit approach), by enforcement and subjugation (by applying hard power, for example threats and kinetic interactions), and by applying social pressure, by applying soft power and manipulating the social context of the target.

Social reaction-rate

Social reaction rate can be defined as the speed at which societies and states aggregate/merge; the social reaction rate is about the speed of social transformation. Other factors than social affinities determine social reactions rates, including the presence of positive feedback loops (catalytic processes), and the (indirect) effects of the constraint that drives the FTS, and determines the Systems pace of life.

Society

"A society is a group of individuals involved in persistent social interaction, or a large social group sharing the same geographical or social territory, typically subject to the same political authority and dominant cultural expectations. Societies are characterized by patterns of relationships (social relations) between

individuals who share a distinctive culture and institutions; a given society may be described as the sum total of such relationships among its constituent of members. In the social sciences, a larger society often exhibits stratification or dominance patterns in subgroups" (96).

Span of a system

Simon speaks of a span of a system, by which he means "the number of subsystems into which it is partitioned" (77).

Stability

In below table, I clarify the meaning of the term stability, and of several closely related - and overlapping - terms.

TABLE A-3: In this table, I clarify some definitions I use in this study.

Closely related and overlapping terminology		
Term	**Definition**	**Application in this study**
Structural stability	Structural stability refers to changes in rule sets that determine (inter)actions (*physics*).	During critical periods (systemic KA, systemic wars) the System was temporarily structurally unstable. During these periods the rule sets of the System were adjusted.
Stability	Stability refers to the degree of change (and permanence) of structures and processes (*physics*).	During the transient period (1480-1945) the core of the System became increasingly unstable; the increasing frequency and magnitude of successive systemic KA (systemic wars) were indicative for the increasing instability of the System.
Local stability	Local stability refers to the kinetic responsiveness of states in the System (*network science*).	The local stability of states in the System increased during HCR's as a consequence of the network-effect during RSP's. Because this form of stability is produced locally by states (nodes) in the network, this type of stability is referred to as 'local stability'.
Asymptotic stability	When a system is in a state such that the perturbations acting on it die out in time more or less quickly, the state of the system is asymptotically stable (66).	
Robustness	Robustness refers to the sensitivity of a RSP to perturbations (*ecosystem science*).	The number (in a given period) and size of non-systemic KA (non-systemic wars) are indicative for the robustness of RSP's; the robustness of successive RSP's increased.
Fragility	Fragility refers to the permanence of structures; the ability of a structure to sustain in a stability domain (*ecosystem science*).	The fragility of successive RSP's (orders) decreased over time; the life-span of a RSP is indicative for its fragility.
Resilience	Resilience refers to the ability of a system to recover from perturbations and adjust to changes (*ecosystem science*).	The resilience of the System decreased during the transient period (1480-1945)

Stability diagram

A stability diagram shows the state of a system and its stability properties as a function of a (control) parameter.

Stability-nucleation

See: *Nucleation (process)*.

Stages of aggregation

Five stages of aggregation can be distinguished:

TABLE A-4: Five stages of Aggregation.

Stages of aggregation		Remarks
0	Fully decomposable	The 'System' consists of a collection of more or less closed structures.
1	Nearly-decomposable	The State-System consists of hierarchical structures that interact but are still highly 'autonomous'.
2	Tightly coupled	Connections and interactions between societies/states undermine their 'autonomous' regulation and overall efficiency. The tightly coupled societies/states are highly autonomous in certain respects, on the one hand, but also highly interdependent, on the other hand. During the transient period (1480-1939), societies/states became increasingly tightly coupled. The contractionary nature of societies/states in the European (State-)-System- their simultaneous attraction and repulsion - were regulated by the 1st FTS.
3A	Aggregated, not yet implemented	In accordance with thermodynamic requirements, the system accomplished a transition to another thermodynamic regime/state and thermodynamic potentials are adjusted accordingly. Aggregation is a fact, but the transition is not yet implemented - embedded - in (modified) structures of the aggregated structure. This stage is also referred to as 'aggregation enabled'. At present, Europe (the European Union) is in this stage: Full homeostatic control is not (yet?) achieved.
3B	Aggregated and fully implemented	At this (final) stage, EMIS-flows and their regulation and feedback/control structures are fully integrated and optimized. This stage is also referred to as 'fully aggregated'.

State or state structure

The state is an organizational structure that regulates a society and represents a society in the (State-) System; societies constitute the internal environment of states, while the State-System constitutes the external environment.

Typically, the state controls a specific (well-defined) territory and its population(s). Governments (mostly) have a centralized government and a monopoly on (the use of) violence. The state fulfils an important regulatory function for the society it represents, also in relation to other states (and societies). Internal and external security - to ensure its sovereignty - of the state/society are the primary responsibility. The state fulfils a central role in the control and regulation of EMIS production and flows.

The state is an emergent 'solution' that was contingent on the conditions that prevailed in the System at the bifurcation point (1480). The PBMP-mechanism contributed to the structuring of the state; over time state-structures became increasingly standardized.
Levy (38) defines a state as "a political organization commanding a predominance of political power within a given territory and characterized by independence from external hierarchical authority."

State of a system

See: *Thermodynamic state of a system*.

State-System

The State-System consists of a network of states. Interactions between states in the State-System are regulated by formal and informal rules. During the transient period (1480-1945), the core of the System (Europe) constitutes the European State-System. Although in 1898 and 1905 the United States and Japan acquired Great Power status (48), the non-core did not constitute a coherent (non-core) State-System (until after 1945) and was mainly controlled by European (core states). The State-System is the structural appearance of the FTS.

Static self-assembly (SSA)

See: *Self-assembly*.

Statistical mechanics

With the concept of statistical mechanics, the relationship between entropy (as a macroscopic concept) and molecular properties - the micro-level of a system - can be established. The basic idea that underlies statistical mechanics is that increasing order corresponds to decreasing entropy and vice versa (55).
Statistical mechanics explains the existence and properties of phases, by applying an ensemble-approach to these phenomena (44).
Statistical mechanics provides a set of powerful tools for understanding simple behavior that emerges from underlying complexity. Statistical mechanics is not based on the study of a single system, but on the study of a large collection or ensemble of systems. The deep principle underlying statistical mechanics is that it is often easier to understand the behavior of these ensembles of systems. Statistical mechanics applies methods that allow to find ensemble averages in systems, which are far too complicated to allow analytical evaluation (at for example particle or trajectory level). 'Temperature' is an ensemble property; as single particle does not have a temperature.

Steady state

A system which is not acted upon by the external world is said to approach *equilibrium* if and when it settles down at long times to a state which is independent of the initial conditions (except for conserved quantities like the total energy). If the system is driven (i.e. there are externally imposed forces or currents) we instead call this final condition the *steady state* (76).

"When the production of a substance X is exactly balanced by its consumption, it is said to be in a steady state" (44).

S/T-field

The S/T-field - the Entropy/tension-field - is a manifestation of the constraint (collective dimension) of the (State-)System, works/functions as a gradient, is instrumental in maintaining the carrying capacity of the System - by driving/powering the FTS - and contains networks of VC's. The S/T-field has a certain capacity to sustain the operation of the FTS. The S/T-field contains a certain amount of entropy (tensions) and has a certain configuration. The S/T-field is a dynamical non-homogeneous field.

Stochastic process. T

The dynamics of stochastic processes are nondeterministic, probabilistic, completely random and unpredictable (66).

Stocks and flows

Stocks and flows are besides feedbacks the two central concepts of dynamic systems theory. According to Sterman (87), "stocks are accumulations. They characterize the state of the system and generate the information upon which decisions and actions are based." Because stocks define the state of the system, they are also mostly referred to as state variables. "Flows are the rates at which these system states - stocks - change." "Stocks give systems inertia and provide them with memory. Stocks create delays by accumulating the difference between the inflow to a process and its outflow. By decoupling rates of flow, stocks are the source of disequilibrium dynamics in systems." "Stocks accumulate or integrate their flows; the net flow into the stock is the rate of change of the stock." Issues, tensions, and (potential) destructive energy are accumulations that are temporarily 'stocked' in the System. Population growth and the effects it causes are the sources of the inflow, while systemic wars are release events and constitute the outflow. Whereas the inflow is relatively gradual, taking place during the relatively stable periods, the outflow is always abrupt, producing a punctuated equilibrium dynamic.
According to Sterman, stocks are critical in generating the dynamics of systems for a number of reasons:

- *Stocks characterize the state of the system and provide the basis for actions*: Issues, tensions, and destructive energy characterize the System. Issues, tensions, and the build-up of destructive potential energy are closely monitored by states to determine potential threats and take appropriate actions. Besides continuous population and connectivity growth, and increasing rivalry between states, the security dilemma reinforces their dynamics and effects. Ultimately a global vulnerable cluster will percolate the system and, when triggered, will produce a systemic war.
- *Stocks provide systems with inertia and memory*: Sterman explains this particular property of stocks as follows: "Stocks accumulate past events. The content of a stock can only change through an inflow or outflow. Without changes in these flows, the past accumulation into the stock persists." This is also the case for the stock of issues, tensions, and destructive energy in the System. Issues, tensions and destructive energy are the outcome of past unresolved events. They increasingly impact on the security of states, cause blockades for further development, and cause the international order

to become increasingly dysfunctional (that increasingly undermines its already limited legitimacy). Issues, tensions, and destructive energy themselves do not provide inertia, but rather counter-forces that try to maintain the status quo and prevent the actual use of this destructive potential to create a new order. During relatively stable periods, the inflow and, as a consequence, the stock of issues, tensions, and potential destructive energy, increases, while there is no significant outflow. When a vulnerable cluster has ultimately percolated the System and is triggered, the System produces a systemic war to re-establish order (to implement an upgraded order). A systemic war is a massive release event, causing a fast outflow of the stock. This outflow can, from a more technical perspective, be described as a reset of initial conditions and the parameters of the System.

- *Stocks are the source of delays*: "All delays involve stocks. A delay is a process whose output lags behind its input." The delays discussed, can all be considered stocks, of which the respective outputs lag behind the respective inputs.
- *Stocks decouple rates of flow and create disequilibrium dynamics*: "Stocks absorb the differences between inflows and outflows, thus permitting the inflows and outflows to a process to differ. In equilibrium, the total inflow to a stock equals its total outflow so the level of the stock is unchanging." In the case of disequilibrium, that is not the case. Disequilibrium and disorder can be considered synonyms. During the life span of international orders, the System is increasingly in disequilibrium (i.e., the level of disorder increases continuously). At a certain stage when the disequilibrium becomes too large and the system reaches a critical point, a systemic war forces the system back into an (at least temporary) equilibrium. A higher level of disequilibrium means increased dysfunctionality of the System; the dysfunctionality - disequilibrium - of the System was 'complete' when the System 1in 1939 reached the critical connectivity threshold, the singularity in finite-time.

Strange attractor

An attractor is called strange if it has a fractal structure. A dynamic system with a chaotic attractor is locally unstable yet globally stable: once some sequences have entered the attractor, nearby points diverge from one another but never depart from the attractor.

Structural stability

A system is structurally stable when the trajectories in phase space are unaffected by small perturbations. Structural stability requires that the parameters of the system stay within certain ranges.

Stuck in the middle

With the term "stuck in the middle", I refer to the current state (condition) of "Europe"; of the European Union and of European states that are part of the European Union. Member-states (of the European Union) have transferred (certain) authority and responsibilities to the European Union, while the European Union is not yet fully developed. Consequently, European states and the European Union are vulnerable.

Subsystem

"In every system it is possible to identify one sort of unit, each of which carries out a distinct and separate process, and another sort of unit, each of which is a discrete, separate structure. The totality of all the structures in a system which carry out a particular process is a subsystem. A subsystem, thus, is identified by the process it carries out (...Miller).

Supra-system

According to Miller, "the supra-system of any living system is the next higher system in which it is a component or subsystem. For example, the supra-system of a cell or tissue is the organ it is in; the supra-system of an organism is the group it is in at the time (...). During the transient period 1480-1945, the State-System can be considered the supra-system of societies/states.

Symmetry-breaking

In physics, symmetry-breaking is a phenomenon in which small fluctuations acting on a system crossing a critical point decide the system's 'fate' - e.g. direction of development - by determining which branch of a bifurcation is taken.

System

The System (System with capital "S") consist of interacting communities and societies, and of their interactions with the respective environments on which they also depend. State-structures represent and regulate societies in the State-System and System. It is possible to distinguish different hierarchical levels in the System. Entities in the System exchange energy (***E***), matter (***M***), information (***I***) and entropy (***S***). Humans can be considered the 'elementary parts' of the System. The environment of the System is more than just physical and also contains a virtual 'component'. The System has a hierarchical structure as defined by Simon (77). The System is an open system.
Miller defines a system (in general) as "a set of interacting units with relationships among them. The word "set" implies that the units have some common properties. These common properties are essential if the units are to interact or have relationships. The state of each unit is constrained by, conditioned by, or dependent on the state of other units. The units are coupled. Moreover, there is at least one measure of the sum of its units which is larger than the sum of that measure of its units" (53).

System dynamics

System dynamics provides a powerful perspective and set of conceptual tools that enable us to understand the structure and dynamics of complex systems. System dynamics seeks endogenous explanations for phenomena.
This perspective helps us understand how the dynamics of the System are related to its structure and vice versa. A fundamental principle of system dynamics is that the structure of the system gives rise to its behavior. Sterman (87) distinguishes three central concepts in system dynamics: feedback process, stocks, and flows.

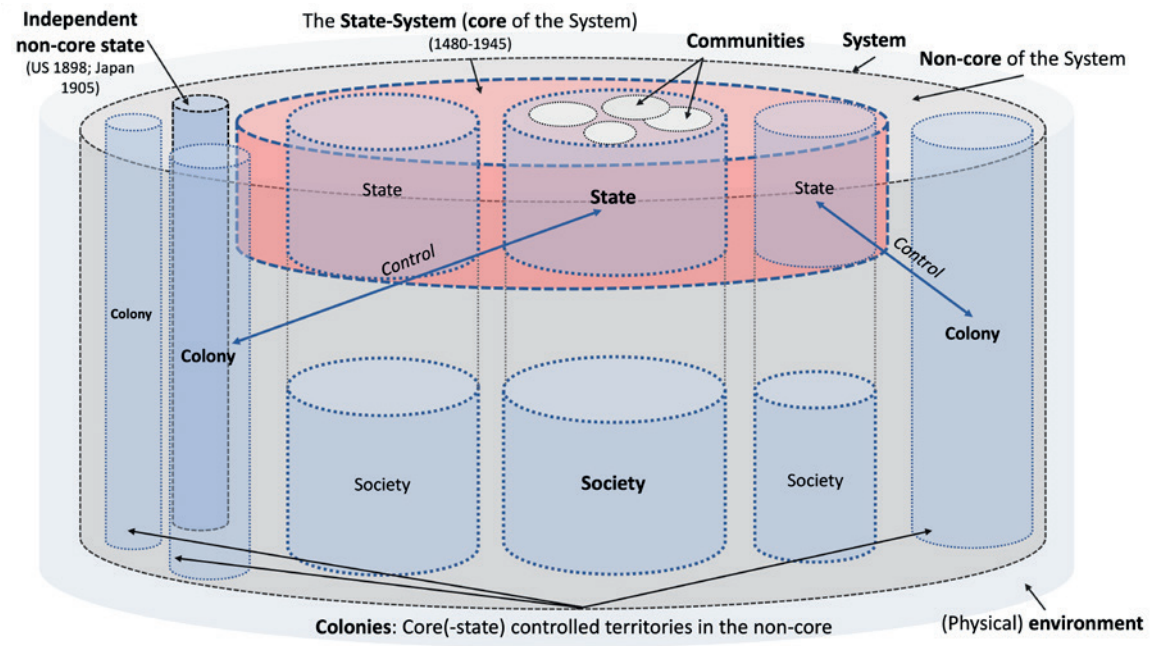


FIGURE A-18: Anatomy of the System (1).

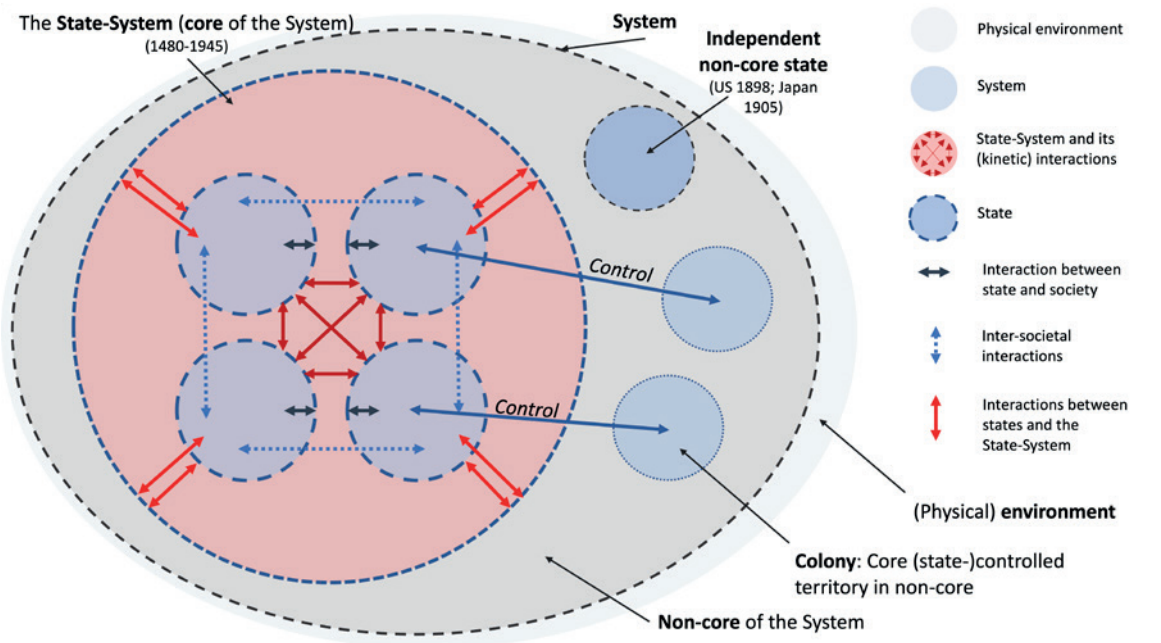


FIGURE A-19: Anatomy of the System (2).

Systemic KA/war

A distinction can be made between non-systemic KA/war and systemic KA/war. The purpose of non-systemic KA/wars is to correct entropic perturbations (issues and tensions) in the (State-)System, during RSP's of KA/war-cycles and to maintain the existing dynamic steady state (the status quo). The purpose of systemic KA/wars is to periodically upgrade the order of the (State-)System, during critical periods of KA/war-cycles. Non-systemic KA/war dynamics are normally chaotic in nature. Chaotic non-systemic KA/war dynamics are also referred to as R1-dynamics, and cyclic systemic KA/war dynamics as R2-dynamics. During the transient period (1480-1945), the (State-)System produced four systemic KA/wars: (1) the Thirty Years' War (1618-1648), (2) the French Revolutionary and Napoleonic Wars (1792-1815), (3) the First World War (1914-1918) and (4) the Second World War (1939-1945).

Tension

Tensions - 'social entropy' - are generated by interactions - irreversible processes - between humans, between humans and communities, between communities, and between societies and states in the (State-)System, etc. Tensions can be - so to speak - compared with the heat produced by friction, e.g. in engines. Tensions can be considered "social entropy".
Tensions (social entropy) can be considered degraded energy, an unavoidable by-product of (human/social) interactions. Tensions are also equivalent with (new) possibilities and (thus) uncertainty; tensions allow for - are the source of - new arrangements (microstates) in social systems. Tensions - new possibilities - can be considered threats or opportunities, depending on how these tensions are qualified in a social/human context. In fact, also threats constitute also opportunities; possibilities to adopt new - more favourable - arrangements.

Terrorism

Terrorism is "in the broadest sense, the use of intentionally indiscriminate violence as a means to create terror among masses of people; or fear to achieve a religious or political aim" (96). From a thermodynamic perspective, terrorism can be considered efforts to eradicate gradients, and as explorative behavior of the (State-)System to find new solutions for these instabilities. As is the case with KA, terrorist activity can become amplified through the interplay with the S/T-field of the System.

Thermodynamic branch

The thermodynamic branch represents a family of states of the System over time, in a stability diagram.

Thermodynamic equilibrium

"The state of thermodynamic equilibrium is static, devoid of processes; in this state there is no flow of energy or matter from one point to another and no chemical change takes place"; it is a homogeneous state (44). In case of thermodynamic equilibrium, the entropy is maximum, and the (Gibbs) free energy at a minimum level; there are no constraints (...) (5).

"In case of thermodynamic equilibrium, the characteristic space scales of the system are microscopic; there are no correlations of macroscopic range and consequently no transition phenomena arise FFE" (66).

Thermodynamic information

Thermodynamic information is a temperature-dependent and size-dependent physical quantity. Energy, entropy and information are closely related properties: energy contains information (thermodynamic information), and each unit of information (bit) is equivalent with a certain amount of energy.

Thermodynamic potential(s)

A thermodynamic potential is a quantity used to represent the thermodynamic state of a system. I assume that the amounts/levels and production-rates of free energy (***F***) and entropy (***S***) represent the thermodynamic potentials of social systems. Societies (through states), the State-System and the System pursue different thermodynamic potentials, and the interactions - competition in some respects - that consequently take place, in combination with the laws of thermodynamics and related principles that apply, shape these systems and their dynamics. I assume that societies (regulated by states) pursue minimum ***F*** (no military capabilities) and intermediate amounts/levels of entropy through homeostatic control; the State-System pursues minimum entropy, minimum ***F*** (KA), and minimum entropy-production (the MEP-Principle applies to the State-System) through FTS-regulation, whereas the System maximizes entropy and entropy-production.

Thermodynamics

Thermodynamics is the study of energy and its transformations.

"Thermodynamics is the science of macroscopic objects of many parts. The very size and complexity of thermodynamic systems allow us to describe them simply in terms of a mere handful of equilibrium or thermodynamic variables, for instance, pressure, volume temperature, mass or mole number, internal energy and, of course, Energy. Some of these variables are related to others via equations of state in ways that differently characterize different kinds of systems, whether gas, liquid, solid" (47).

Prigogine et al. showed that under nonequilibrium conditions entropy may produce, rather than degrade, order, organization, and therefore life. See also: *Modern thermodynamics*.

Thermodynamic state or state of a system

It is possible to distinguish three fundamentally different thermodynamic states: States of (1) equilibrium, of (2) near-equilibrium and of (3) far from equilibrium. Near-equilibrium and far from equilibrium states are also referred to as nonequilibrium states. During nonequilibrium states macroscopically distinct parts can become correlated and long-range coherence can appear.

"In thermodynamics, the state of a system is specified in terms of macroscopic state variables, such as volume, ***V***, pressure, ***p***, temperature, ***T***, and moles, ***Nk***, of chemical constituent ***k***, which are self-evident. These variables are adequate for the description of equilibrium systems. *When a system is not*

in thermodynamic equilibrium, more variables, such as the rate of convective flow or of metabolism, may be needed to describe it. The two laws of thermodynamics are founded on the concepts of energy, ***U***, and entropy, ***S***, which (...) are functions of state variables" (44).
In case of the (State-)System, the state of the system can be described by entropy(-production), the amount/level of KA, and the degree of aggregation (core) and expansion to the non-core.

Thermodynamic process

A system undergoes a thermodynamic process "when the variables that describe the system change from one set of values to another, that is change from one thermodynamic state to another" (47). Entropy (like energy) is also such a state variable.

Tipping point

The tipping point of RSP's / KA/war-cycles, is the point - not necessarily "halfway" the life-span of the RSP/ KA/war-cycle - when through the network-effect non-systemic KA-regulation is no longer effective. At that point entropy-accumulation, and an autocatalytic process start, which eventually result in a critical state of the (State-)System.

TABLE A-5: Tipping points of RSP's of the 1st FTS (59).

RSP	Period	Tipping point
1	1480-1618	1514
2	1648-1792	1774
3	1815-1914	1856
4	1918-1939	Cannot be determined

Transient period

The transient period from 1480-1945, is the period when the 1st FTS accomplished a phase transition in the (State-)System with two complementary effects: (1) Thermodynamic equilibrium in the European State-System, and (2) the globalization of the State-System.
The period 1945-.... can be considered a 2nd transient period when the global State-System achieves thermodynamic equilibrium (at a global scale), assuming the 2nd FTS is sustained.

Unified principle of thermodynamics

According to Toussaint: "To deal with this class of thermodynamics of nonequilibrium systems that are moved away from equilibrium and held at some distance from that equilibrium state, we propose the following corollary that follows from the proof by Kestin of the Unified Principle of Thermodynamics, that a system will tend toward its unique equilibrium state. Implicit in this observation is that a system will

resist being removed from the equilibrium state. The degree to which a system has been moved from equilibrium can be measured by the gradients imposed on the system. As systems are moved away from equilibrium, they will utilize all avenues available to counter the applied gradients. Attractors can emerge so that the system organizes in a way that reduces or degrades the gradient. As the applied gradients increase, so does the system's ability to oppose further movement from equilibrium. If dynamic and or kinetic conditions permit, self-organization processes are to be expected. The building of organizational structure and associated processes degrade the imposed gradient more effectively than if the dynamic and kinetic pathways for those structures were not available." (92)

Universal change

In the study with the title 'Cosmic Evolution', Chaisson describes an "underlying, ubiquitous pattern penetrating the fabric of all natural sciences (....) a sweepingly encompassing view of the order and structure of every known class of object in our richly endowed Universe", Chaisson refers to as "universal change" or "cosmic evolution" (20). Cosmic evolution, "is the study of change, the vast number of developmental and generative changes that have accumulated during all time and across all space, from the big bang to humankind (...) cosmic evolution comprises the sum total of all the many varied changes in the assembly and composition of radiation, matter and life throughout the history of the Universe" (20). "Cosmic evolution is a search for principles that subsume, and even transcend, Darwinian selection, a unifying law, an underlying pattern, or an ongoing process perhaps, that creates, orders, and maintains all structure in the Universe, in short a search for a principle of cosmic selection" (20).
According to Chaisson, "recent advances throughout the sciences suggest that all organized systems share generic phenomena characterizing their emergence, development, and evolution." Chaisson uses the "concept of energy flow as a measure of complexity among all organized systems, from elementary particles to cultured society" (20).

Volatility index of the System (VIXS)

The volatility of the System (VIXS) is defined as the product of the average size of non-systemic KA/wars constituting war-clusters, and their respective war-frequencies: VIXS = average size × frequency.

Vulnerable clusters (VC's)

Vulnerable clusters are networks consisting of states, issues, tensions (entropy) and their interactions. VC's can be considered "stocks and EMIS-flows". Chaotic non-systemic KA/wars contribute to the forming/creation of VC's with fractal structures, required for the System to (eventually) become critical. VC's contain - store - information and serve as a "memory" of the State-System. A distinction can be made between the dynamics *of* the network (e.g. in terms of nodes and their relationships) and the dynamics *on* the network of VC's: e.g. KA. The connectedness of the network of VC's and the (decision) thresholds states apply to the use of KA (war) in response to issues, determine the dynamics on the network of VC's (KA/war dynamics). Increasing connectedness (interdependencies) of societies/states and VC's reinforce the constraint and collective dimension. Solutions to non-systemic KA (during RSP's) and 'innovations' are embedded in the network of VC's. The VC's constitute a gateway to the next systemic KA/war, and to the next (upgraded) order.

War

Levy (48) defines war as "a substantial armed conflict between the organized military forces of independent political units." Levy distinguishes between two subsets of wars: (1) wars involving the Great Powers and (2) interstate wars involving the Great Powers that "consists of wars with at least one Great Power on each side of the conflict. These wars are labeled Great Power wars." Levy operationalizes the criterion "substantial" by requiring a minimum of 1000 battle-deaths, defined as the number of deaths of military personnel. See also: *Kinetic activity*.
In this study, war is also referred to as kinetic activity (KA).

War-cluster

A war-cluster consists of a group of non-systemic KA/wars during LCR's or HCR's of RSP's/cycles. Each RSP/cycle contains two war-clusters; a LCR- and a HCR-war cluster.

War-cycle

See: *KA/war-cycle*.

War-engine

See: *FTS-engine*.

War frequency

See: *KA/war-frequency*.

War-size

See: *Size*.

Work (W)

The work $\boldsymbol{W}$ is the product of the force $\boldsymbol{F}$ that is applied and the distance $\boldsymbol{s}$ that is travelled: $\boldsymbol{W} = \boldsymbol{F}\Delta\boldsymbol{s}$.
I assume that the amount of "battle casualty deaths" (BCD) is indicative for the energy that is put to use by states in the State-System and for the forces that are exerted on the Sate-System; in other words, for the Work performed on/by the (State-)System.

Zero entropy

Zero-entropy refers to a state of a system with (near) zero-entropy, which is 'fully' organized and structured, and consequently lacks all flexibility and adaptation. In 1939 - the critical point of the European State-System - the European State-System reached zero entropy.

Appendix B. War-data

The data used in this study consists of Levy's data-set (48), concerning the period 1495-1975, and a complementary data-set (from various sources), for the period 1975-2018.
Levy assumes the Great Power System started in 1495; however, research shows (59), that the Great Power System started around 1480. I assume that during the period 1480-1495, 6 non-systemic KA/wars took place (59).

TABLE B-1: Data-set Levy, period 1495-1975, (48). Systemic KA/wars are marked with red: Numbers 46-49 concern the 1st systemic KA/war; numbers 84-85 concern the 2nd systemic KA/war; number 107 concerns the 3rd systemic KA/war, and number 113 concerns the 4th systemic KA/war. Numbers 58-77 concern non-systemic KA/wars, during the 1st exceptional period (1657-1763) and are marked with blue. KA/Wars marked with grey concern expansions wars, during the transient period (1480-1945); KA/wars marked with grey/blue (numbers 115-119 in this data-set) are KA/wars that took place during the 2nd exceptional period (period 1945-1975 of 1945-1989). For names see below table B-3.

Nr. Levy	Start	End	Duration	Number GP	Extent	Fraction	Magnitude	Concentration	Intensity	Severity
1	1495	1497	2,0	5	3	0,60	1,20	1.333	119	8.000
2	1497	1498	1,0	5	1	0,20	0,20	3.000	45	3.000
3	1499	1503	4,0	5	1	0,20	0,80	1.000	60	4.000
4	1499	1500	1,0	5	1	0,20	0,20	2.000	29	2.000
5	1501	1504	3,0	5	2	0,40	1,20	3.600	269	18.000
6	1508	1509	1,0	5	3	0,60	0,60	3.333	145	10.000
7	1511	1514	3,0	5	4	0,80	2,40	1.500	261	18.000
8	1512	1519	7,0	5	2	0,40	2,80	1.714	343	24.000
9	1513	1515	2,0	5	1	0,20	0,40	2.000	57	4.000
10	1515	1515	0,5	5	3	0,60	0,30	2.000	43	3.000
11	1521	1526	5,0	4	3	0,75	3,75	2.000	420	30.000
12	1521	1531	10,0	4	2	0,50	5,00	3.400	958	68.000
13	1522	1523	1,0	4	1	0,25	0,25	3.000	41	3.000
14	1526	1529	3,0	4	3	0,75	2,25	2.250	249	18.000
15	1532	1535	3,0	4	2	0,50	1,50	4.667	384	28.000
16	1532	1534	2,0	4	1	0,25	0,50	2.000	55	4.000
17	1536	1538	2,0	4	2	0,50	1,00	8.000	438	32.000

TABLE B-1: Continued.

Nr. Levy	Start	End	Duration	Number GP	Extent	Fraction	Magnitude	Concentration	Intensity	Severity
18	1537	1547	10,0	4	2	0,50	5,00	4.850	1.329	97.000
19	1542	1550	8,0	4	1	0,25	2,00	1.625	176	13.000
20	1542	1544	2,0	4	2	0,50	1,00	11.750	629	47.000
21	1544	1546	2,0	4	2	0,50	1,00	2.000	107	8.000
22	1549	1550	1,0	4	2	0,50	0,50	3.000	79	6.000
23	1551	1556	5,0	4	2	0,50	2,50	4.400	578	44.000
24	1552	1556	4,0	4	2	0,50	2,00	6.375	668	51.000
25	1556	1562	6,0	5	2	0,40	2,40	4.333	676	52.000
26	1556	1559	3,0	5	3	0,60	1,80	3.000	316	24.000
27	1559	1560	1,0	5	2	0,40	0,40	4.000	78	6.000
28	1559	1564	5,0	5	2	0,40	2,00	2.400	310	24.000
29	1562	1564	2,0	5	2	0,40	0,80	1.500	77	6.000
30	1565	1568	3,0	5	2	0,40	1,20	4.000	306	24.000
31	1569	1580	11,0	5	2	0,40	4,40	2.182	608	48.000
32	1576	1583	7,0	5	2	0,40	2,80	3.429	600	48.000
33	1579	1581	2,0	5	1	0,20	0,40	2.000	50	4.000
34	1583	1590	7,0	5	1	0,20	1,40	2.429	210	17.000
35	1585	1604	19,0	5	2	0,40	7,60	1.263	588	48.000
36	1587	1588	1,0	5	1	0,20	0,20	4.000	49	4.000
37	1589	1598	9,0	5	2	0,40	3,60	889	195	16.000
38	1593	1606	13,0	5	2	0,40	5,20	3.462	1.086	90.000
39	1600	1601	1,0	5	1	0,20	0,20	2.000	24	2.000
40	1610	1614	4,0	6	2	0,33	1,33	1.875	175	15.000
41	1615	1618	3,0	6	1	0,17	0,50	2.000	70	6.000
42	1615	1617	2,0	6	1	0,17	0,33	1.000	23	2.000
43	1617	1621	4,0	7	1	0,14	0,57	1.250	58	5.000
44	1618	1619	1,0	7	2	0,29	0,29	3.000	69	6.000
45	1618	1621	3,0	7	1	0,14	0,43	5.000	173	15.000
46	1618	1625	7,0	7	4	0,57	4,00	20.267	3.535	304.000
47	1625	1630	5,0	7	6	0,86	4,29	11.615	3.432	302.000
48	1630	1635	5,0	7	4	0,57	2,86	15.700	3.568	214.000
49	1635	1648	13,0	7	5	0,71	9,29	17.708	12.933	1.151.000

TABLE B-1: Continued.

Nr. Levy	Start	End	Duration	Number GP	Extent	Fraction	Magnitude	Concentration	Intensity	Severity
50	1642	1668	26,0	7	1	0,14	3,71	3.077	882	80.000
51	1645	1664	19,0	7	1	0,14	2,71	3.790	791	72.000
52	1648	1659	11,0	7	2	0,29	3,14	4.909	1.187	108.000
53	1650	1651	1,0	7	1	0,14	0,14	2.000	22	2.000
54	1652	1655	3,0	7	2	0,29	0,86	4.333	282	26.000
55	1654	1660	6,0	7	3	0,43	2,57	1.833	238	22.000
56	1656	1659	3,0	7	2	0,29	0,86	2.500	161	15.000
57	1657	1661	4,0	7	1	0,14	0,57	1.000	43	4.000
58	1657	1664	7,0	7	3	0,43	3,00	8.385	1.170	109.000
59	1665	1666	1,0	7	1	0,14	0,14	1.000	11	2.000
60	1665	1667	2,0	7	3	0,43	0,86	6.167	392	37.000
61	1667	1668	1,0	7	2	0,29	0,29	2.000	42	4.000
62	1672	1678	6,0	7	6	0,86	5,14	10.364	3.580	342.000
63	1672	1676	4,0	7	1	0,14	0,57	1.250	52	5.000
64	1677	1681	4,0	7	1	0,14	0,57	3.000	125	12.000
65	1682	1699	17,0	7	2	0,29	4,86	11.294	3.954	384.000
66	1683	1684	1,0	7	2	0,29	0,29	2.500	51	5.000
67	1688	1697	9,0	7	5	0,71	6,43	15.111	6.939	680.000
68	1700	1721	21,0	6	2	0,33	7,00	2.370	640	64.000
69	1701	1713	12,0	6	5	0,83	10,00	20.850	12.490	1.251.000
70	1716	1718	2,0	5	1	0,20	0,40	5.000	98	10.000
71	1718	1720	2,0	5	4	0,80	1,60	3.125	245	25.000
72	1726	1729	3,0	5	2	0,40	1,20	2.500	144	15.000
73	1733	1738	5,0	5	4	0,80	4,00	4.400	836	88.000
74	1736	1739	3,0	5	2	0,40	1,20	6.333	359	38.000
75	1739	1748	9,0	6	6	1,00	9,00	8.159	3.379	359.000
76	1741	1743	2,0	6	1	0,17	0,33	5.000	94	10.000
77	1755	1763	8,0	6	6	1,00	8,00	26.105	9.118	992.000
78	1768	1774	6,0	6	1	0,17	1,00	2.333	127	14.000
79	1768	1772	4,0	6	1	0,17	0,67	3.500	149	14.000
80	1778	1779	1,0	6	2	0,33	0,33	150	3	300
81	1778	1784	6,0	6	3	0,50	3,00	2.267	304	34.000

TABLE B-1: Continued.

Nr. Levy	Start	End	Duration	Number GP	Extent	Fraction	Magnitude	Concentration	Intensity	Severity
82	1787	1792	5,0	6	2	0,33	1,67	192.000	1.685	192.000
83	1788	1790	2,0	6	1	0,17	0,33	1.500	26	3.000
84	1792	1802	10,0	6	6	1,00	10,00	13.000	5.816	663.000
85	1803	1815	12,0	6	6	1,00	12,00	32.224	16.112	1.869.000
86	1806	1812	6,0	6	2	0,33	2,00	6.429	388	45.000
87	1808	1809	1,5	5	1	0,20	0,30	4.000	51	6.000
88	1812	1814	2,5	5	1	0,20	0,50	1.600	34	4.000
89	1815	1815	0,5	5	1	0,20	0,10	10.000	17	2.000
90	1823	1823	0,9	5	1	0,20	0,18	667	3	400
91	1827	1827	0,1	5	3	0,60	0,06	1.800	2	180
92	1828	1829	1,0	5	1	0,20	0,20	35.714	415	50.000
93	1848	1849	1,0	5	1	0,20	0,20	5.600	45	5.600
94	1849	1849	1,2	5	1	0,20	0,24	2.083	20	2.500
95	1849	1849	0,2	5	2	0,40	0,08	1.500	4	600
96	1853	1856	2,4	5	3	0,60	1,44	35.000	1.743	217.000
97	1856	1857	0,4	5	1	0,20	0,08	1.250	4	500
98	1859	1859	0,2	5	2	0,40	0,08	50.000	159	20.000
99	1862	1867	4,8	6	1	0,17	0,80	1.667	64	8.000
100	1864	1864	0,5	6	2	0,33	0,17	1.500	12	1.500
101	1866	1866	0,1	6	3	0,50	0,05	113.333	270	34.000
102	1870	1871	0,6	6	2	0,33	0,20	150.000	1.415	180.000
103	1877	1878	0,7	6	1	0,17	0,12	171.429	935	120.000
104	1884	1885	1,0	6	1	0,17	0,17	2.100	16	2.100
105	1904	1905	1,6	7	1	0,14	0,23	28.125	339	45.000
106	1911	1912	1,1	8	1	0,13	0,14	5.454	45	6.000
107	1914	1918	4,3	8	8	1,00	4,30	258.672	57.616	7.734.300
108	1918	1921	3,0	7	5	0,71	2,14	385	37	5.000
109	1931	1933	1,4	7	1	0,14	0,20	7.143	73	10.000
110	1935	1936	0,6	7	1	0,14	0,09	6.667	29	4.000
111	1937	1941	4,4	7	1	0,14	0,63	56.819	1.813	250.000
112	1939	1939	0,4	7	2	0,29	0,11	22.857	116	16.000
114	1939	1940	0,3	7	1	0,14	0,04	166.667	362	50.000

TABLE B-1: Continued.

Nr. Levy	Start	End	Duration	Number GP	Extent	Fraction	Magnitude	Concentration	Intensity	Severity
113	1939	1945	6,0	7	7	1,00	6,00	462.439	93.665	12.948.300
115	1950	1953	3,1	5	4	0,80	2,48	84.510	6.821	954.960
116	1956	1956	0,1	6	1	0,17	0,02	70.000	50	7.000
117	1956	1956	0,1	6	2	0,33	0,03	300	0	30
118	1962	1962	0,1	6	1	0,17	0,02	5.000	1	500
119	1965	1973	8,0	6	1	0,17	1,33	7.000	90	56.000

TABLE B-2: Complementary data-set, period 1975-2018.

Based on Levy (no's 115-119), Sarkees et al. (no's 120-128), and other resources (no's 125-134)). The wars marked in blue (numbers 115-123), occurred during the 2nd exceptional period (1945-1989). This data-set includes an extension of the war data of Levy (48) (numbers 124-134). To ensure consistency and avoid bias, I have used Levy's definitions for Great Powers, Great Power war, and battle-deaths, in my interpretation of the data-sets compiled by Sarkees et al. (68) and data from numerous sources; however, validation of the dataset is required. Sarkees qualifies the Intervention in Bosnia in 1995 by the United States and NATO, including Great Britain and France, (War no. 125) as a phase in an intra-state war (The Bosnian-Serb Rebellion of 1992-1995). This intervention, also referred to as 'Operation Deliberate Force,' qualifies - I assume - as a war involving Great Powers. Sarkees classifies the 'Soviet Quagmire of 1980-1989' as an 'extra-state war.' Because this war meets Levy's requirements, I added it to the data-set. Wars no's 116-123 took place - constitute - the 2nd exceptional period (1953-1989) and are shaded in grey. If the First and Second Chechnya War (respectively periods 1994-1996 and 1991-2003) qualify as interstate wars needs validation: These wars cause distortions in the circular trajectories in phase state. However, if excluded, their exclusion does not impact on the outcome of the assessment and predictions. The 'War of Afghanistan' (no. 129) is arguably still ongoing, although France's involvement ended in 2012 and Great Britain's involvement ended in 2014. The Russian-Ukraine War (no. 133) includes the annexation of Crimea by the Russian Federation (20 February - 20 March 2014) and the Russian military intervention in Ukraine (ongoing since 20 February 2014). GP: Great Powers, Fr: France, GB: Great Britain, SU: Soviet Union. The data for the remaining wars (no's 127-134) were collected from: War no. 129: "Afghanistan: Fatalities by year", icasualties.org 9 September, retrieved 14 September 2013; www.defense.gov/casualty.pdf, retrieved 29 June 2016 (through Wikipedia, retrieved 21 August 2016). War no. 130: "Fact Sheets/Operations Factsheets/Operations in Iraq: British Fatalities", Ministry of Defence of the United Kingdom, archived from the original on 11 October 2009, retrieved 17 October 2009 (through Wikipedia, retrieved 21 August 2016). War no. 132: retrieved 12 August 2016 (through (96), retrieved 21 August 2016). War no. 133: "Nuland Claims 400-500 Russian Soldiers Killed in Eastern Ukraine" (Sputnik News). KA/wars marked with grey/blue (numbers 115-123 in this data-set) are KA/wars that took place during the 2nd exceptional period (1945-1989).

No.	War	Dates	Duration (Years)	Extent (No of GP's)	Severity (in BCD)	Size (Fraction)	GP's
115	Korean War	1950-1953	3,1	4	954.960	0,67	US, China, Fr, GB
116	Russo-Hungarian War	1956-1956	0,1	1	7.000	0,17	SU
117	Sinai War	1956-1956	0,1	2	30	0,33	GB, Fr
118	Sino-Indian War	1962-1962	0,1	1	500	0,17	China
119	Vietnam War	1965-1973	8,0	1	56.000	0,17	US
120	Sino-Vietnamese Punitive War	1979-1979	0,1	1	13.000	0,17	China
121	The Soviet Quagmire	1980-1989	9,0	1	40.000	0,17	USSR
122	Falklands War	1982-1982	0,3	1	255	0,17	GB
123	Sino-Vietnamese Border War	1987-1987	0,1	1	1.800	0,17	China
124	Gulf War	1990-1991	0,7	3	402	0,5	US, GB, Fr
125	The First Chechnya War of 1994-1996	1994-1996	2,8	1	4.000	0,17	Russia
126	Intervention in Bosnia	1995	0,1	3	27	0,5	US, GB, Fr
127	War for Kosovo	1999-1999	0,2	3	2	0,5	US, GB, Fr
128	The Second Chechnya War of 1999-2003	1999-2003	4,2	1	5.000	0,17	Russia
129	War of Afghanistan	2001-2014	13,2	4	2.955	0,67	US, GB, Fr, Germany
130	Iraq War	2003-2011	8,7	2	4.676	0'33	US, GB
131	Intervention in Libya	2011-2011	0,6	3	0	0,43	US, GB, Fr
132	War for Syria	2011-ongoing	7	5	20	0,71	US, GB, Fr, Iran, Russia
133	Russian-Ukraine War	2014-ongoing	6	1	450	0,14	Russia
134	Iranian Intervention in Iraq	2014-ongoing	4	1	11	0,14	Iran

TABLE B-2: Names of wars (48).

1	War of the League of Venice*	61	Devolutionary War*
2	Polish-Turkish War	62	Dutch War of Louis XIV*
3	Venitian-Turkish War	63	Turkish-Polish War
4	First Milanese War	64	Russo-Turkish War
5	Neapolitan War*	65	Ottoman War*
6	War of the Cambrian League	66	Franco-Spanish War*
7	War of the Holy League*	67	War of the League of Augusburg*
8	Austro-Turkish War*	68	Second Northern War*
9	Scottish War	69	War of the Spanish Succession*
10	Second Milanese War*	70	Ottoman War
11	First War of Charles V*	71	War of the Quadruple Alliance*
12	Ottoman War*	72	British-Spanish War*
13	Scottish War	73	War of the Polish Succession*
14	Second War of Charles V*	74	Ottoman War
15	Ottoman War*	75	War of the Austrian Succession*
16	Scottish War	76	Russo-Swedish War
17	Third War of Charles V*	77	Seven Years' War*
18	Ottoman War*	78	Russo-Turkish War
19	Scottish War	79	Confederation of Bar
20	Fourth War of Charles V*	80	War of the Bavarian Succession*
21	Siege of Boulogne*	81	War of the American Revolution*
22	Arundel's Rebellion*	82	Ottoman War
23	Ottoman War*	83	Russo-Swedish War
24	Fifth War of Charles V*	84	French Revolutionary Wars*
25	Austro-Turkish War*	85	Napoleonic Wars*
26	Franco_Spanish War*	86	Russo-Turkish War
27	Scottish War*	87	Russo-Swedish War
28	Spanish-Turkish War*	88	War of 1812
29	First Huguenot War*	89	Neapolitan War
30	Austro-Turkish War*	90	Franco-Spanish War
31	Spanish-Turkish War*	91	Navarino Bay
32	Austro-Turkish War*	92	Russo-Turkish War
33	Spanish-Potuguese War	93	Austro-Sardinian War

TABLE B-2: Continued.

34	Polish-Turkish War	94	First Schleswig-Holstein War
35	War of the Armada*	95	Roman Republic War
36	Austro-Polish War	96	Crimean War*
37	War of the Three Henries*	97	Anglo-Persian War
38	Austro-Turkish War*	98	War of Italian Unifification*
39	Franco-Savoian War	99	Franco-Mexican War
40	Spanish-Turkish War*	100	Second Schleswig-Holstein War
41	Austro-Venetian War	101	Austro-Prussian War*
42	Spanish-Savoian War	102	Franco-Prusssian War*
43	Spanish-Venetian War	103	Russo-Turkish War
44	Spanish-Turkish War*	104	Sino-French War
45	Polish-Turkish War	105	Russo-Japanese War
46	Thirty Year's War - Bohemian*	106	Italo-Turkish War
47	Thirty Year's War - Danish*	107	World War I*
48	Thirty Year's War - Swedish*	108	Russian Civil War*
49	Thirty Year's War - Swedish-French*	109	Manchurian War
50	Spanish-Portuguese War	110	Italo-Ethiopian War
51	Turkish-Venetian War	111	Sino-Japanese War
52	Franco-Spanish War*	112	Russo-Japanese War*
53	Scottish War	114	Russo-Finnish War
54	Anglo-Dutch Naval War*	113	World War II*
55	Great Northern War*	115	Korean War*
56	English-Sopanish War*	116	Russo-Hungarian War
57	Dutch-Portuguese War	117	Sinai War
58	Ottoman War*	118	Sino-Indian War
59	Sweden-Bremen War	119	Vietnam War
60	Anglo-Dutch Naval War*		

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On the Thermodynamics of

War and Social Evolution,

Presents a fundamentally different perspective on war and social evolution.

This study shows that nonequilibrium thermodynamics applies to the System of which humans are integral parts, and that:

- Tensions produced in the System constitute entropy and serve as a source of social order.
- During the period 1480-1945, the System produced a first dissipative structure that was instrumental in a phase transition and resulted in thermodynamic equilibrium in Europe; the core of the System during that period of time.
- The first dissipative structure (1480-1945) was accompanied by four accelerating war-cycles; each cycle consisting of a relatively stable period, followed by systemic kinetic activity (systemic war).
- Presently, the System is in the first war-cycle of a second dissipative structure (1945-....) that will be instrumental in accomplishing thermodynamic equilibrium at a global scale, in due time.
- Social structures can be understood as "institutionalized" thermodynamic potentials.
- Normally non-systemic wars the System produced - and still produces - are chaotic in nature.
- Technology does *not* impact on the war dynamics of the System, and that:
- In its basic responses, the System resembles a primitive organism.

On the Thermodynamics of War and Social Evolution contributes to a most urgent discussion to improve our understanding of war and social evolution, to avoid the self-destruction of humanity.

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