'Turing-societies' in the making: basic architectures, new risk-potentials and new coordination problems ; theoretical explorations into the y2k-problem

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Theoretical Explorations into the y2k-Problem

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Abstract

Within this paper, a large number of uncommon perspectives for the analysis of contemporary societies will be introduced which run under the heading of a so-called "epigenetic research program". The main emphasis of the epigenetic program lies in a conscious attempt to shed fresh or innovative light on the co-evolution between "knowledge and society". More conventionally, the main focus of this perspective lies in basic innovation processes as well as in the "core dynamics" within socio-economic domains both nationally and globally. Among these innovative conceptual features, one will find unfamiliar notions like "Turing societies", "epigenetic regimes" or "four different layers of societal knowledge bases", or "societal substitution power". Moreover, one will be confronted with a wave of unusual assessments of risk potentials, risk-incidences as well as of the substitution and repair processes inherent in today's societal "fabric". Finally, one will find a comprehensive analysis of the so-called "year 2000-problem" which will be treated as a significant instance in a much wider class of "knowledge based risks" and, above all, of "knowledge based-failures".

Zusammenfassung

Mit diesem Reihenpaper soll eine größere Anzahl an neuartigen Perspektiven für die Analyse gegenwärtiger Gesellschaften vorgestellt werden, die unter der generellen Bezeichnung eines "epigenetischen Forschungsprogramms" stehen. Die hauptsächliche Betonung im epigenetischen Programm liegt in einem bewussten Versuch, mehr und vor allem: neuartiges Licht auf die weitgehende unbekannte Ko-Evolution von "Wissen und Gesellschaft" zu werfen. In einer etwas konventionellen Phrasierung liegt das Hauptaugenmerk der epigenetischen Schwerpunktsetzung auf laufenden Innovationsprozessen beziehungsweise auf den "Kerndynamiken" in sozio-ökonomischen Feldern sowohl im nationalen wie im globalen Maßstab. Unter den ungewohnten begrifflichen Merkmalen bündeln sich dann Konzepte finden wie das von "Turing-Gesellschaften", von "epigenetischen Regimes", von "vier Schichten an gesellschaftlichen Wissensbasen" oder von einer "gesellschaftlichen Substitutionskraft". Darüber hinaus wird man mit einer ganzen Reihe an unbekannten Bewertungen von Risiko-Potentialen, Risiko-Inzidenzen oder von laufenden Substitutions- und Reparaturprozessen innerhalb der "Texturen" gegenwärtiger Gesellschaften konfrontiert. Und schließlich findet sich noch eine umfangreiche Analyse des sogenannten Jahr 2000-Problems, das als signifikantes Beispiel in einer viel weiteren Klasse an "wissensbasierten Risiken" und vor allem an "wissensbasierten Fehlern" behandelt wird.

Contents

Introduction

Within this paper, a large number of new perspectives for the analysis of contemporary societies will be introduced which might shed fresh and additional light on ongoing basic transformation processes as well as on the "core dynamics" within socio-economic domains. Among these innovative conceptual features, one will find unfamiliar notions like "Turing societies", "epigenetic regimes", "evolutionary risks", "risk potentials" or "substitution power" which stand at the core of this new "epigenetic program[1]". Moreover, one will be confronted with a wave of unusual assessments of new risk potentials inherent in today's societal "fabric" as well as on the so-called "year 2000-problem" which will be treated as a significant instance in a much wider class of "knowledge based risks" and, above all, of "knowledge based-failures". More concretely, the subsequent three parts will present the following contents.

Part I will give a short summary of basic changes in societal architectures from a very long-term evolutionary perspective. In particular, a new research program on the co-evolution of "knowledge and society", running under the title of an "epigenetic program"[2], will be introduced, which has been specifically aimed at offering a "transdisciplinary view" on the emergence of different "knowledge based" societal formations.

Part II will offer a generalized notion of "evolutionary risks" and "evolutionary chances" which, due to its generality, may be applied to socio-technological domains but also to socio-technological fields or to the different layers of societal "knowledge pools". In particular, the new concept of risks and chances from an evolutionary point of view can be used directly for a risk assessment of the y2k-problems on a regional, national and global scale.

Finally, Part III will deal with the y2k-problem in particular and will make ample use of the conceptual framework, developed under Part I and Part II. Thus, the y2k-problem will move from a seemingly peripheral problem of insufficient program space to a "central" societal coordination problem. Moreover, the epigenetic framework will present "y2k" as a single instance of a wider class of societal coordination problems in the future which arise from encoding problems as well from embeddedness problems of a new layer within the societal "knowledge bases" or "knowledge pools".

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1 On the current status of the "epigenetic research program", see Appendix I.

2 It should be stated right from the beginning that the "epigenetic program" uses its defining core-term, namely epigenesis, in a very general sense. Following the Webster's definition, epigenesis refers to any type of "development in which an initially unspecialized entity gradually develops specialized characters". (Webster's 1993:337) Even more generally, epigenesis is to be understood here as any development process in which evolutionary ensembles gradually acquire new or, alternatively, innovative features. In a second general understanding, the "epigenetic research program" refers to an integrated or transdiciplinary view on the "emergence of the new" which stresses the interplay of various separated "knowledge bases", including the domain of the genetic pools.

By the end of Part III, a new general perspective will be established which will highlight distinctively new features and the new “architectures” of contemporary societies around the world as well as several of their potentially or actually “risky” characteristics. In turn, these new risk potentials culminate and manifest themselves in those strange challenges as well as in those unfamiliar coordination problems that constitute the wide arrays of vertical and horizontal y2k-conversion problems.

1. The New Architecture of Turing- Societies

From an evolutionary perspective, seemingly familiar concepts like "societies" seem to lack a precise meaning since "societal ensembles" can be found throughout the world of living systems in a huge variety of forms. Likewise, the notion of "knowledge" is strongly linked to long-standing traditions in Western philosophy which makes it almost impossible, at least at first sight, to develop precise and useful definitions of "evolutionary knowledge" or "evolutionary knowledge pools". Nevertheless, it will be shown that basically four different "architectures" can be identified which characterize the main groups or "forms" of societies and their "knowledge pools" along an evolutionary time scale. Moreover, the joint emphasis on "knowledge and society" as well as the importance of the co-evolution of "knowledge pools" and "societal formations" stand at the very core of the epigenetic program.

1.1. Societal Formations along an Evolutionary Time-Scale

In order to differentiate between distinctive forms of "societies" and their "knowledge bases", an unusual time perspective will be chosen which does not take its starting point in medieval or ancient times, but in considerably longer periods. The time-scale used will be "evolutionary time" and its initial point is thus marked by the beginning of life on earth. For more than half of the evolutionary time scale so far, one can observe processes of symbiontic "assembling" of self-reproducing units into more complex formations, culminating in the building of single cells (See especially Margulis 1999). After a long period of more than two billion years one can observe a profound re-organization in terms of an emerging duality between the genetic code, encapsulated within the cell-nucleus, and single cell-organisms on the other hand and their interactions with their bio-chemical environments. It seems plausible at first sight, to associate the genetic code with its "recipes" for generating and maintaining organisms as the first "knowledge pool" proper (C) and to link the world of single cell organisms as "actor networks" (N).[3] Arranging the well known evolutionary "chains of becoming" in a slightly similar fashion to Beninger (1986:63), one arrives at Table 1, where basically four societal stages of the extremely long evolutionary run have been identified, where each stage develops a characteristic interaction pattern between "societies" and their respective "knowledge bases". (On this point, see also Wills 1998) These four stages, "types of societies" or "epigenetic regimes"[4] are differentiated by significant differences and discontinuities in terms of changes in the nature of "knowledge bases" and in the nature of the relationship between ever-extending code system bases and actor network-ensembles. The general features of each type of society

[3] In biology, this distinction has a well-defined meaning, since, following Feldman 1988:43 and many others, the observable properties, structures and processes of an organism belong to its "phenotype" and the sequence of nucleotides, forming the DNA of an "organism" are qualified as its "genotype".

[4] For the term "regime", one may refer to Spier 1996 or Wittrock 1993 who use the notion of "regimes" to distinguish long-term stages which are characterized by a small number of unique characteristics.

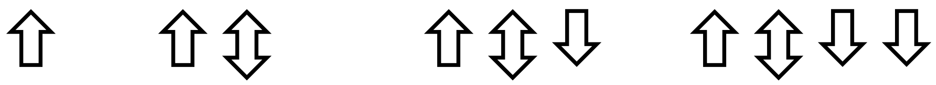
or, alternatively, of each "regime" are summarized in Table 2 and Table 3 and can be described briefly in the following manner.

Table 1: The Long-Term Evolutionary Chains

YEARS AGO (logarithmic)	
4 billion	STAGE 0: PROTO-SOCIETIES Replication, Nucleotide-Chains, "Self-Assembly" of Network Actors
1 billion	STAGE I: DARWIN-SOCIETIES Actor Networks with Relatively Simple Organisms ("Darwin-Creatures") and Surface Behavior DNA-Code (Genetic Code) for Production and Maintenance of Darwin Creatures "Cambrian Explosion"
100 million	STAGE II: POLANYI-SOCIETIES Actor Network ⇔ Actor Network Interactions Learning by Imitations ("Implicit Knowledge") Embedded within the Neural Organization of Multi-Cell Organisms ("Polanyi-Creatures")
10 million	
1 million	
100.000	STAGE III: PIAGET-SOCIETIES Actor Network ⇒ Symbolic Code Productions Learning by Encoding (Constructions of Human Codes especially Natural Languages and Number Codes)
10.000	Emergence of "Piaget Creatures" with Symbol-Processing Capacities Non-Pictorial Scriptures
1000	
100 years	
10 years	STAGE IV: TURING-SOCIETIES Actor Network ⇒ Machine Code Production Evolutionary Information Processing Systems, Based on Actor Network- Interfaces and Machine Code Programs ("Turing-Creatures")
100 years +	

Table 2: Actor Network Formations within four Epigenetic Regimes

Darwin Societies (Epigenetic Regime I)	Polanyi Societies (Epigenetic Regime II)	Piaget-Societies (Epigenetic Regime III)	Turing Societies Epigenetic Regime IV
Actor Network–Formations			
Simple Routines (Darwinian Creatures)	Simple Routines Implicit Routines (Learning, Imitation, etc.) (Darwinian Creatures) (Polanyi Creatures)	Simple Routines Implicit Routines (Learning, Imitations, etc.) Encoding Routines (Language, Formalisms, Music, etc.) (Darwinian Creatures) (Polanyi Creatures) (Piaget Creatures)	Simple Routines Implicit Routines (Learning, Imitations, etc.) Encoding Routines (Language, Formalisms, Music, etc.) Encoding Routines of the Genetic Code and of Machine Code (Darwinian Creatures) (Polanyi Creatures) (Piaget Creatures) (Turing Creatures)



			Machine Programs Bio-Tech-Programs of the Genetic Code
		Human Code Programs	Human Code Programs
	Neural Programs	Neural Programs	Neural Programs
Genetic Programs	Genetic Programs	Genetic Programs	Genetic Programs
Knowledge Bases			

Table 3: The Basic "Epigenetic Structures" for four Societal Architectures

Table 3a: The Basic "Epigenetic Structures" for Darwin-Societies

NETWORK- LEVELS (N) Action and Interaction Patterns of Darwinian Creatures

N ⇔ N

Decoding of

⇑

Genetic Programs

C ⇔ C

CODE- LEVELS (C) Programs and Their Interactions and Adaptations:
{Genetic Code}

Table 3b: The Basic "Epigenetic Structures" for Polanyi-Societies

NETWORK- LEVELS (N) Action and Interaction Patterns of Darwin/Polanyi Creatures

N ⇔ N

Decoding of | Co-Activation of

⇑ | ⇕

Genetic Programs | Action Patterns and Neural Programs

C ⇔ C

CODE- LEVELS (C) Programs and Their Interactions and Adaptations:
{Genetic Code}, {Neural Code}

Table 3c: The Basic “Epigenetic Structures” for Piaget-Societies

NETWORK- LEVELS (N)	Action and Interaction Patterns of Darwin/Polanyi/Piaget Creatures		
	N	⇔	N
	Decoding of	Co-Activation of	Encoding of
	⇑	⇕	⇓
	Genetic Programs Symbolic Programs	Action Patterns and Neural Programs	Programs (Language, etc.)
	C	⇔	C
CODE- LEVELS (C)	Programs and Their Interactions and Adaptations: {Genetic Code}, {Neural Code}, {Symbolic Codes}		

Table 3d: The Basic “Epigenetic Structures” for Turing-Societies

NETWORK- LEVELS (N)	Action and Interaction Patterns of Darwinian/Polanyi/Piaget/Turing Creatures		
	N	⇔	N
	Decoding of	Co-Activation of	Encoding of
	⇑	⇕	⇓⇓
	Genetic Programs Symbolic Programs Machine Programs	Action Patterns and Neural Programs	Programs (Language, etc.) (Biotech ⇒ Genes)
	C	⇔	C
CODE-LEVELS (C)	Programs and Their Interactions and Adaptations: {Genetic Code}, {Neural Code}, {Symbolic Codes}, {Machine Code}		

"Darwin-Societies" (Epigenetic Regime I): The first societal formation consists of populations whose network actors are structured mainly as single cell organisms which, in turn, exhibit a dual level split between their DNA-base inside the cell-nucleus and their surface interactions with their wider environment. Here, the main source of innovation lies within the genetic code systems which, through their recombinative repertoire, become the primary source for variations in organisms. Moreover, interaction patterns at the actor network levels turn out to be relatively simple and confined to the senso-motoric realm only. Thus, the first epigenetic regime is populated by, borrowing Daniel C. Dennett's term, "Darwinian creatures" (1997) and, moreover, by Darwinian evolution. While the exact nature of the relations between the genetic pool and actor network formations remains a center of heated controversies in developmental biology (See e.g., Gould 1996, 1998a,c, Rosen 1997, Wilson 1998), the simple separation requirement between these two levels is sufficient for the basic architecture of Darwin-societies, as they are depicted in Table 3a.[5]

"Polanyi-Societies" (Epigenetic Regime II): After the "punctuated" emergence of new groups of multi-cellular organisms with a "runaway brain", i.e. with a growing neural interface between their sensory and motoric capabilities, new types of societies could be formed. Here, a trias of "sensing", "imitating" and "learning" on the network level as well as new encoding mechanisms within the "language of the brain" (Calvin 1998) give rise to new ways for the diffusion as well as the conservation of new action sequences and routines (See also Table 3b). The major type of evolution changes from a Darwinian dynamic to a Baldwinian one where network actors are able to change and alter the "selection pressures". Since learning and implicit knowledge become the dominant features of the epigenetic regime II, the dominant types of organisms can be characterized, in honor of Michael Polanyi's stimulating explorations on "implicit knowledge" (Polanyi 1985), as "Polanyi-creatures". Polanyi-societies are distributed over a wide range of species, covering the evolutionary kingdoms of mammals, birds, fish or special insect formations like ant societies. Thus, within the second epigenetic regime, the primary source of innovation moves up to the learning and imitation capacities of the organisms themselves. Viewed in terms of "innovations", the second epigenetic regime produces a rich repertoire of "implicit" or "tacit" knowledge of communication patterns within or between species (See, e.g., Hauser 1997).

"Piaget-Societies" (Epigenetic Regime III): While processes of communication and comparatively complex network formations have already been accomplished under the old epigenetic regime, a new type has come into existence, associated with the emergence of languages and scriptures which, in their fully developed format, exhibits two novel features. First, language is the only type of communication system which is able to talk about itself (Deacon 1997, Foerster 1997). And second, the evolution of languages and scriptures diffuses

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[5] It should be added that the differentiation between these two domains is the necessary pre-condition for introducing the notion of "co-evolution". Moreover, an interesting point could be made that evolutionary theory from its very outset is co-evolutionary in nature. On this point, see esp. Margulis 1981, 1993, 1999.

within public domains, separating effectively the contexts of encoding, storage, and utilization (See also Table 3c). The type of evolution shifts from an "implicit knowledge stance" to one of "explicit knowledge", thereby speeding up the evolutionary time-scale significantly. Moreover, the new species within actor-networks are labeled, in honor of Jean Piaget (Piaget 1973, 1983, Piatelli-Palmarini 1980), "Piaget creatures" (humans) and "Piaget societies" (language-processing societies).

"Turing-Societies" (Epigenetic Regime IV): Finally, in recent decades a remarkable shift has been accomplished in two seemingly unrelated areas which are clearly moving along a converging trajectory. The first area is associated with the scientific encoding of the genetic code itself (see, *e.g.*, Päun/Rozenberg/Salomaa 1998). Here, one observes a new type of N $\Rightarrow$ C relations in which the variations at the level of the genetic code become gradually accommodated to the rhythms of global societal development and, thus, to the actor-network formations. As a second characteristic for Turing societies, new types of evolutionary ensembles are slowly emerging, namely self-adapting and learning machines, consisting of machine codes and of surface interaction capacities at the network levels (See Table 3d). While not fully realized at the current stage, "information processing machines" are gradually moving along the process of building up a sufficient amount of diversity – *e.g.*, a learning potential, maintenance and repair-systems, senso-motoric capabilities, and the like. Within an extremely short period of evolutionary time, new evolutionary units -"Turing creatures" – are becoming characteristic components within actor-networks too, equipped with the major capabilities of evolutionary creatures so far, namely self-(re)production, "implicit knowledge", and languages.[6] Table 3 offers a schematic summary of the innovation and (re)production cycles, associated with each of the four societal types or regimes.

1.2. The Basic Epigenetic Architectures of Evolutionary Societies

Taking the dualism between actor networks and knowledge bases seriously, one arrives at a general scheme for the basic architecture of any type of society from Darwinian formations up to present day Turing societies. The general scheme for five potential societal core structures has been reproduced in Table 4. Here, one can see two main epigenetic levels (C,N) which can be constructed for any type of evolutionary society as well as a maximum of five characteristic "binding structures" which constitute the core of societal architectures.[7]

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[6] It is probably interesting to realize that Turing creatures are climbing the evolutionary ladder in "reverse fashion", with high level language processing capabilities as a starting point in Artificial Intelligence during the 1960ies and walking down the evolutionary rungs towards "implicit" knowledge routines and, finally, down to senso-motoric capabilities and a self-reproduction potential.

[7] Once again, the five potential domains for "binding structures" lie in the following configurations: N $\Leftrightarrow$ N, N $\Rightarrow$ C, C $\Leftrightarrow$ C, C $\Leftrightarrow$ N, N $\Rightarrow$ C. It can be the case that a single binding structure has a variety of core-connections. Take the N $\Rightarrow$ C structure within contemporary Turing societies, then it is possible to identify at least three main "binding structures", namely the encoding structure for language based programs, the encoding structure for the genetic pool (bio-technology) and, finally, the encoding structure for machine code programs.

Table 4: The Core "Binding Structures" in the Societal Architecture of Piaget- and Turing-Societies

		Network Actors, Their Action Patterns and Their Interactions and Adaptations ACTOR NETWORK-DIMENSION	
NETWORK-LEVELS (N)	N	⇔	N
	Decoding of	Co-Activation of	Encoding of
	⇑	⇕	⇓
	Programs	Action Patterns and Neural Programs	Programs
	DECODING DIMENSION	IMPLICIT DIMENSION	ENCODING DIMENSION
CODE-LEVELS (C)	C	⇔	C
		Programs and Their Interactions and Adaptations: Genetic, Neural, Symbolic Codes, Machine Codes DIMENSION OF PROGRAM POOLS	

From Table 4 it becomes clear that an epigenetic study of Darwin-, Polanyi-, Piaget- or Turing-societies requires the recognition of a different constitution for each of the four societal types.

Thus, the range of core-structures goes from three basic binding structures (changes in the genetic pool (C ⇔ C), decoding of the genetic programs (C ⇒ N), changes in the actor networks (N ⇔ N) in Darwin societies up to the comparatively large number of eighteen core binding structures in contemporary Turing societies, namely processes of "program building" (symbolic code production, biotech-engineering of the genetic code, manufacturing of Turing programs, 3 X N ⇒ C), of "implicit practices" stored in the neural organization of Polanyi- and Piaget creatures (2 X N ⇔ C), of knowledge pool utilizations (basically, the four utilization channels from the genetic pool, the neural pool, the symbolic pool and the pool of Turing programs, 4 X C ⇒ N), of autonomous changes in the four distinctive knowledge pools (genetic, neural, symbolic, machine code) themselves (4 X C ⇔ C) and, finally, of a wide variety of "inter-actions" at the network levels where actor networks may comprise as much as four different "evolutionary creatures" (Darwin-, Polanyi-, Piaget- and Turing-creatures) and may be counted, thus, as five different types, namely one binding structure for each type of creature and one for the combination of at least two different evolutionary creatures (5 X N ⇔ N).

1.3. Basic Building Blocks: "Embedded Code Systems" and "Actor-Networks"

Following the basic structural framework for epigenetic analyses, the core units or, alternatively, building blocks have been introduced already which are capable to enter into a permanent "game" (Eigen/Winkler 1979) of recombinations, reconfigurations and structure building. Actor-networks at the N-levels and embedded code systems at the C-levels can be regarded as the "conceptual machinery" which is both necessary and sufficient to perform the descriptive or explanatory "tasks" of evolutionary analyses across various domains. These two transdisciplinary core concepts have been labeled as "embedded code systems" (C) and as "actor networks" (N). For the code levels, the unified concept of "embedded code systems" ranges over all four code-systems and program bases, namely over the genetic code, the neural code, the symbolic codes as well as over the machine code. Moreover, the main definitional requirements, following Umberto Eco (1972, 1981), Nelson Goodman (1973), Sue-Savage-Rumbaugh (1995) and many others, can be summarized in the following manner. An embedded code system across the four main domains has to exhibit the following features.

– Indifference of Code Elements – the exchangeability of specific "marks" of a basic component or building block in a code system

– Finite Differentiation – an efficient decision procedure whether, in principle, a given "mark" belongs to a specific code-element

– Combination of Code-Elements – the formation of composite sequences of code-elements

– Comparative Advantages – the evaluation of code-sequences or code-based “drifts” in terms of specific evaluation measures

– Dynamic Embeddedness – the embeddedness of code-system in a wider environment (On this point, see especially Müller 1996a,b)

– Likewise, the network levels have to use a single unifying concept across various domains, namely, not particularly surprising, the notion of “actor-networks” (Latour 1987, 1988, 1992) which have to fulfill the following five conditions.

– Variability of Components – the composition of actor networks with highly heterogeneous classes and numbers of actors

– Finite Differentiation – observable and measurable exchange and transfer relations between network actors as well as between an actor network and its environment

– Coupling of Actor-Networks – the formation of larger actor-networks, consisting of smaller ones

– Comparative Advantages – the evolution of network arrangements and network “drifts” in terms of specific “evaluation measures”

– Dynamic Embeddedness – the dependence of changes in a network domain from changes in other network areas as well as from changes in the knowledge pools

– Two remarks must be added immediately in order to clarify the differences and similarities between these two core concepts.

First, the differences between both core concepts are comparatively weak since, following Mario Bunge (1977, 1979, 1983a,b), embedded code systems as well as actor networks both qualify as “systems” in the established sense of the word. Due to their systemic character, both levels of investigation can be combined in a rather convenient and straightforward fashion. Second, the differences between these two main levels should be qualified more as epistemological ones than as ontological in character. In the end, the separations between ensembles at the code levels and formations at the network levels turn out to be, basically, a functional one, differentiating “recipe-collections” of various forms – genetic, neural, symbolic, machine-based – as units at the extended code levels and processes within the various (re)production domains as actor-networks at the network levels.

Actor-networks, due to their generality, can be identified for any type of small or large-scale configuration, ranging from the biological, ecological to societal domains, extending, within the societal area alone, from actor networks of varying building blocks in the science arena, to the building blocks for actor network in economic ensembles or to the actor networks of private households. Moreover, due to the spatio-temporal dimension and its differentiations into short, medium and long-term processes and into global, national or regional levels, one arrives at a hyper-complex configuration of actor networks of actor networks ... of actor networks, entangled in all sorts of strange loops, strange hierarchies and strange attractors.

Table 4 gives rise to a dimensional scheme (Table 4), where the relations between embedded code and actor network levels occupy the center stage. This new scheme runs under the heading of the "epigenetic square" and can be considered as the basic element within the epigenetic core heuristics. Moreover, the five epigenetic dimensions, building up the epigenetic square, can be used for an evolutionary analysis in a wide variety of domains – be they biological, anthropological, economic or social in nature. As one can see from the epigenetic square in Table 4, the five dimensions exhibit an interesting connection to the stages in Table 1, since the program as well as the decoding dimension have been laid out during the early stages of life already, whereas the "implicit dimension" is of comparatively younger origin (100 million years ago). Finally, the encoding dimension must be considered to be a human achievement only, coming into existence with the gradual emergence of pictorial codes and written code systems. (See also Deacon 1997, Gibson/Ingold 1994, Hurford/Studdert-Kennedy/Knight 1998)

It must be added, at this point, that the two basic concepts – embedded code systems (ECS) for the extended code levels and actor networks (AN) for the extended network levels – are sufficient to analyze any context, in which knowledge, information or scientific production may play a central role. In other words, current utilizations of "knowledge" can be articulated and rephrased in terms of ECS- and AN-interactions. (For a detailed discussion, see Müller 1996a:142pp.) Whatever determines the shape and the dimensions of "knowledge-based processes", they can be formulated within the epigenetic framework, too.

1.4. Knowledge, Knowledge Pools and Innovations

Epistemological traditions in the Western world rely by and large on a special "filter" which for obvious reasons may be characterized as "Plato's demon". The main task for Plato's demon lies in the clear separation between two classes of beliefs, namely between beliefs as carriers of "true knowledge" on the one hand and beliefs, reflecting "unjustifiable", "false" or "erroneous" propositions on the other hand. Here, knowledge is intimately linked with very special subsets within the language spaces. More generally, since logic, geometry or mathematics fall under the "regime" of the Platonic demon, too, the operational domain for "Plato's demon" is situated within the landscapes of "symbolic spaces" which have been built up within the period of Piaget societies. The new epigenetic perspectives, established so far, have already introduced a radical departure from the "knowledge trias" consisting of truth, justification and symbolic belief systems. Instead, the epigenetic perspective will focus on an entirely different way of "knowing knowing" or of "understanding understanding" for that matter.

Table 5: A World of Embedded Code-Systems

Domain	Code-System	Code-Elements	Extended Code-Organization
Darwin/ Polanyi/ Piaget/ Turing-Societies	Genetic Code	Four Bases: Adenin, Cytosin, Guanin, Thymin	Double Helix-Configuration
Polanyi/ Piaget/ Turing-Societies	Neural Codes	"Mental Agents" or "Neural Groups" within Actors	Cognitive Architectures
Piaget/ Turing-Societies	Natural Languages	Letters of an Alphabet	Grammars
Piaget/ Turing-Societies	Number Codes	Sets of Various Numbers {N}, {ℜ}, etc.	Algorithms
Piaget/ Turing-Societies	Pictorial Codes	Symbols from a Symbol-Library	Picture Programs[8]
Piaget/ Turing-Societies	Musical Codes	Musical Notes	Musical Schemes
Piaget/ Turing-Societies	Rule-Codes	Rule-Components	Encoded Rule Systems
Turing-Societies	Scientific Language in Bio-Tech (Biotech-Code)	Letters of an Alphabet, Numbers, Strings	Grammars, Transcriptions,
Turing-Societies	Machine Codes	Strings, Alphabets	Grammars, Translations"

[8] So far, very few explicit picture schemes are available at the moment, one of the most prominent being ISOTYPE (International System of Typographic Education) by Otto Neurath, Gerd Arntz et al. in the 1930's. (Müller 1991b,c) It should be added though that the early code-systems within human history had been devised as pictorial or symbolic codes (White 1995, Calvin 1996)

Table 6: The Growing Importance of Network-Levels in Evolutionary Time

DOMINANT "KNOWLEDGE BASE"	PRIMARY "SOURCE OF INNOVATIONS"	CHARACTERISTIC RELATIONSHIP BETWEEN DUAL LEVELS
	"DARWIN-SOCIETIES" (EPIGENETIC REGIME I)	
Genetic Programs	Variations in the Genetic Code	Dominance of the Embedded Code-Levels
	"POLANYI-SOCIETIES" (EPIGENETIC REGIME II)	
Neural Programs Genetic Programs	Learning, Communications and Imitations within Actor Networks; Tool Utilizations; Variations in the Genetic Code	Dominance of the Interactions between Embedded Code and Network-Levels
	"PIAGET-SOCIETIES" (EPIGENETIC REGIME III)	
Encoded Human Programs	Encoding and Decoding Routines in Actor Networks	Weak Dominance of the Network-Levels
	"TURING-SOCIETIES" (EPIGENETIC REGIME IV)	
Encoded Programs of the Genetic Code Machine Codes Encoded Human	Encoding Routines of the Genetic Code Machine Learning Encoding and De-Coding Routines in	Strong Dominance of the Network-Levels

Programs Actor Networks

Contrary to the widely accepted Western tradition on the “nature of knowledge” and the self-evident role of “Plato’s demon”, the epigenetic conception of knowledge starts with a slippery slope argument down the evolutionary road, focusing its attention on the concept as well as on the status of “tacit knowledge” (Michael Polanyi). “Implicit or tacit knowledge”, apparently, is based on the peculiar fact that we do “know” more than we can “say” that we “know”. In the same manner one can add the definition for “implicit knowledge” as developed by Michael Gibbons and others and which states very clearly that implicit knowledge is essentially and characteristically located beyond texts, scriptures or languages, i.e., beyond the realm of “symbolic spaces”. “Implicit” or “tacit” knowledge is qualified as “knowledge not available as a text and which may conveniently be regarded as residing in the heads of those working on a particular transformation process, or to be embodied in a particular organizational context”. (Gibbons et al. 1994:167p.) Here, one arrives at an essential “bifurcation point” between two “ways of knowing knowing”. Along the well established Western path from Plato and Aristoteles to the “linguistic turn” with the 20th century philosophy, knowledge is to be restricted to explicit knowledge only (See, for example, Burke 1999, Doren 1996, Schwanitz 1999). “Implicit knowledge”, thus, must and should be considered, at least from the perspective of Plato’s demon, as a dangerous metaphor for technical competencies and routines outside the knowledge domains proper.

Along the epigenetic trajectory, “knowledge” and related concepts like “knowledge bases” go far beyond the domains of symbolic code spaces. From an epigenetic point of view, knowledge or knowledge bases are to be understood in a functional manner. Here, “knowledge” is to be defined as a generic term for embedded or encoded programs which play a non-trivial role in the production or maintenance of network actors as well as of entire actor networks. Thus, “implicit knowledge”, encoded in the brains or the neural organization of network actors, constitutes but one distinctive “knowledge kingdom” outside the symbolic knowledge domains. Going, once again, back to the long evolutionary time scale, one arrives at the unfolding of four different stages of knowledge bases which can be summarized in Table 7 and Table 8.

Table 9 makes it clear that different contexts which have been developed for the concepts of knowledge, information or scientific production can be well integrated and included into the basic concepts of the epigenetic program.

Finally, sticking to the format of a meta-theoretical exposition of the epigenetic core program, one can refer to a universal mode of recombinations or, alternatively, of innovations across different embedded code systems and across actor-networks. Here, the central point lies in a definition of “recombinations” – the generalized successor of the classic idea of “mutation” – across the multiplicity of code or network levels. In sum, the following set of requirements must be fulfilled for recombinations and, thus, for changes or innovations in any type of evolutionary system. The starting point lies in a basic guideline for the analysis of recombinations which itself has been obtained by recombining a core-definition for creativity.

Table 7: The Long-Term Evolutionary Chains in the Unfolding of Societal Knowledge Pools

Years ago (logarithmic)	
4 billion	Stage 0: Proto-Knowledge-Pools Nucleotide-chains, RNA-Code
	Stage I: Genetic Knowledge Pools
	DNA-Code and DNA-Code-Differentiation
	C ⇔ C Recombinations (Genetic Code)
	C ⇒ N Production and Maintenance (Genetic Code)
1 billion	
	"Cambrian Explosion"
	Stage II: "Implicit" Knowledge Pools
	Learning by Imitations ("Implicit Knowledge")
100 million	Neural Code and Differentiation of the Neural Code
	C ⇔ N Recombinations
	C ⇔ N Maintenance ("Eigen-Behaviors" of Network-Actors)
10 million	
1 million	
	Stage III: Symbolic Knowledge Pools (Language, Scriptures)
	Learning by Encoding (Constructions of Symbolic Codes
100.000	especially Natural Languages and Number Codes)
	Differentiation of Symbolic Codes
	N ⇔ C Recombinations
	N ⇔ C Maintenance of Actor-
10.000	Networks (Piaget-Societies)
	Non-Pictorial Scriptures
1000	
100 years	
	Stage IV: Machine-Code Pools (Machine Code)
	by and through Evolutionary ("Dual Level")
	Information Processing Systems
10 years	Differentiation of Machine-Code Programs [9]
	Genetic Code (GC) ∠ Bio-Tech Language)
	Symbolic Code ∠ Machine Code
	N ⇔ C Recombinations as well as
100 years +	C ⇔ C Recombinations (Machine Code)

[9] ∠ stands for a "transcription relation", implying that a specific code-system has been transcribed or, alternatively, translated into another code-system. "Transcription relations" occur quite frequently like in the case of "morse code ∠ language code", etc. More specifically see *e.g.*, Paun/Rozenberg/Salomaa 1998.

Table 8: Four Layers of Knowledge Pools

KNOWLEDGE POOL	MAIN FUNCTION	INNOVATION
	KNOWLEDGE LAYER I (DARWIN-, POLANYI-, PIAGET-, TURING-SOCIETIES)	
Genetic Programs	Production and Maintenance of Network Actors (Darwin-, Polanyi-, Piaget Creatures)	Recombination of Genetic Programs (Recombination Operators)
	KNOWLEDGE LAYER II (POLANYI-, PIAGET-, TURING-SOCIETIES)	
Neural Programs	“Implicit Routines” of Network Actors (Polanyi- and Piaget Creatures)	Recombination of Neural Programs (Recombination Operators)
	KNOWLEDGE LAYER III (PIAGET-, TURING-SOCIETIES)	
Symbolic Programs (Language, Music, Mathematics, Logic, Dance, etc.)	Maintenance of Large-Scale Actor-Network (Piaget-Societies, Turing-Societies)	Recombination of Symbolic Programs (Recombination Operators)
	KNOWLEDGE LAYER IV (TURING-SOCIETIES)	
Machine Programs	Production and Maintenance of Turing-Actors and Large-Scale Actor Networks (Turing-Societies only)	Recombination of Machine Programs (Recombination Operators)

Table 9: Knowledge, Information and Scientific Production within the Epigenetic Research Program

CONTEXTS FOR KNOWLEDGE, INFORMATION AND SCIENCE PRODUCTION	SPECIAL UTILIZATIONS	CORRESPONDING ERP-CONTEXTS
KNOWLEDGE	Knowledge as "Construction"	Analysis of Code-based Recipes and Implicit Routines (Code and Network-Centered)
	Knowledge as "Implicit" Process	Analysis of Neural Codes, Observable Routines and Symbolic Codes (Code and Network-Based)
	Knowledge as "Learning and Adaptation Process"	Development of Learning Algorithms and of Evaluation Measures; (Code and Network-Based)
	Knowledge as "Attribution"	"Description Device" for Actor Networks
	Knowledge as "Justified True Belief"	Development of Criteria or Evaluation Measures; Code-based as well as Actor-based
	Knowledge as "Growth of Knowledge"	Development of Evaluation Measures for Hypotheses, Theories or Research Programs Mainly Code-based
	Knowledge as Scientific "State of the Art"	Analysis of Representative Volumes, Textbooks; Mainly Code-based Forms of Investigations
	Knowledge as Development of "Knowledge Domains"	Development of "Hot Fields" in Science; Code-based Analyses of Journals, Articles, Citations
	Knowledge "Attractors"	Development of Criteria for a Cognitively "Stable States"; Code and Actor-based
	Knowledge as "Cyclical Process"	Development of Evaluation Measures of "Open" and of "Closed" Cognitive Horizons Code- or Actor-based
INFORMATION	Information as a Measure of Distribution	Analyses of Code-Systems with Respect to Their Distribution Characteristics
	Information as Content Measure	Analyses of Code-Systems with Respect to a "Content Measure"
	Information as Transmissionrate	Analyses of Code-Systems with Respect to Their Transfer-Velocities
SCIENTIFIC PRODUCTION	Science as "Text"	Analyses of the Codified Scientific Output
	"Science in Action"	Analyses of Scientific Production Processes within Scientific Actor Networks

"Full-scale recombination potential for an embedded code-system or an actor-network consists in having a rich repertoire of applicable "recombination operators", following them recursively, utilizing them at the meta-levels as well, and modifying them accordingly."[10] For the general case one can identify six conditions which must be present simultaneously.

The first set of basic requirements is given by a "rich repertoire-condition" which states that successful recombinations are dependent on a "requisite variety" (Ross Ashby) or on a rich recombination potential of the embedded code system or the actor networks. In other words, an embedded code-system or an actor-network with only random mutations as sole source of recombinations must be considered as a very poorly equipped recombination repertoire, whereas a "pandemonium of (recombinative) demons" (Daniel C. Dennett) across different levels fulfills the first requirement in an optimal way.

The "rich repertoire-requirement" needs, second, the availability of code- or network spaces, which should have, in the general case, a single distinctive feature, namely a comparatively large area of unrealized code- or operation sequences and, thus, a high potential for new sequences.

The central area for recombinations resides, however, in the third requirement, namely in the availability of "recombination operators" which are able to generate in a recursive manner, starting from an initial scheme, new code-strings or programs at the code levels or new action patterns at the network levels. For the general case, one is able to distinguish at least ten recursive operators which, following mostly Douglas R. Hofstadter (1995:77), can be recombined by using some "adding operations" and which, then, can be presented with the help of Table 10.

Table 10: Recombination Operators

- Adding, the integration of new building blocks into an existing scheme
- Breaking, the differentiation of at least one scheme into two disjunctive building blocks
- Crossing-over, the breaking of at least two schemes and their merging into a new ensemble
- Deletion, the destruction of a specific building block from a set of schemes
- Duplication, the repeated insertion of at least one identical scheme
- Inverting, the making of copies with an opposite sequence of elements
- Merging, the integration of two or more schemes into a new one

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10 The sentence above is a variation on a definition which Douglas R. Hofstadter has proposed for "creativity". "Full-scale creativity consists in having a keen sense for what is interesting, following it recursively, applying it at the meta-level, and modifying it accordingly." (Hofstadter 1995:313) It will become one of the main targets of a special journal edition on innovations (Müller/Müller 2000) to demonstrate the very close "family resemblances" (Ludwig Wittgenstein) between recombinations at different levels of embedded code-systems as well as at the levels of actor networks.

- Moving, the shifting of building blocks or of established boundaries
- Replacing, the substitution of a building block by another one
- Swapping, the movement from a level L_i to a different level L_j

The requirements four and five demand a sufficient degree of flexibility – a capacity to “salient” adaptations (requirement four) – as well as of efficiency in approaching the target domains within a relatively small amount of time (requirement five).

Finally, a control-capacity as well as a sufficiently powerful support system must be present which are not only able to secure the partial gains reached so far, but which, furthermore, develop at least some “gate-keeping”-functions and safe-guards against detrimental trajectories. (requirement six)

The important point which cannot be over-emphasized lies in the universality of these recombination operations across various embedded code-systems – and across the many levels of actor networks.

In this manner, a new perspective on “knowledge formation”, “knowledge bases” and, finally, on “innovations” or, alternatively, on the “emergence of the new” (Thomas S. Kuhn)[11] has been gained which will become of central importance when discussing the y2k-issues.

1.5. The Transition from Piaget- to Turing-Societies

Tables 11 and 12 present essential hints on the “hidden co-evolution” between the two main epigenetic levels in modern societies, i.e., between the actor network formations and the “knowledge bases”. Moreover, these self-organizing and co-evolutionary movements within modernity may be seen as a recombination of the epigenetic approach with fundamental insights from Karl Polanyi on societal formations (1978, 1979) , Immanuel Wallerstein (1979, 1984, 1991, 1995) on the emergence of the “modern world system” and, finally, Joseph A. Schumpeter (1961, 1975) on the “engines of economic creation and destruction”.[12] Thus, the subsequent spatio-temporal orderings should provide a useful basis for contemporary discussions on periodizations.[13] From Table 11, one can derive four important assertions for the long-term stages at the network levels of Piaget societies.

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[11] The German edition of a collection of Thomas Kuhn’s articles has an interesting title, namely “The Emergence of the New” (“Die Entstehung des Neuen”). (Kuhn 1978)

[12] Quite obviously, the rich repertoire from current theorizing on societal development has been considered as well in shaping the epigenetic transfer modules of Part II. But assessing the relative importance of various contributions, the classical “visions” by Polanyi, Schumpeter and Wallerstein should be viewed of central relevance.

[13] On some of the fundamental problems in this area, see esp. Aveni 1989.

First, the basic difference between societal formations prior to 1450/1500 and the modern world-system emerging in a seemingly irreversible manner during the "long 16th century" must be seen in the rapid evolution of global economic actor-networks with limited regional controls at the level of political systems only. In other words, self-organization and self-regulation have established themselves as the principal ways of societal differentiation and development at the network levels, coordinating not only the production and flows of goods and services, but also of labor, land, natural resources and the state of the environment.

Second, the world-historic turn towards self-organizing markets does not start in the 18th or even 19th century but should be viewed, following the analyses of Immanuel Wallerstein or, alternatively, Fernand Braudel[14], as an emerging process from the early decades of the 16th century onwards. With the death of Charles V. in 1531 at the latest, the modern world system had reached its supra-critical stage[15] upon which no reverse trajectory back to redistributive formations lay in the reachability of the ongoing market-evolution. Consequently, the core actor networks of the world system in North-Western Europe entered a continuous process of becoming economically stronger integrated and interlinked.[16] To follow the insights of Karl Polanyi, "the economy is no longer embedded in social relations, but the social relations are embedded into the economic system (Polanyi 1978:88f.)[17]

Third, a global process of economic network integration can be observed, differentiating the external regions of the world system either in a semi-peripheral or, most frequently, into a peripheral position and role. This global absorption process has seen some spectacular "big spurts" and upward-mobility from external to semiperipheral and, finally, to core status like the case of Japan or from peripheral to semi-peripheral level like the "big jump" of South Korea after 1945. Surprisingly, no downward mobility of significant dimension can be recorded within the evolving world system since the core regions of the 16th century still belong to the core or to important semiperipheral areas of the world system five centuries later.

Fourth, a final remark must be reserved to the future developmental potential of the worldwide market networks. According to Table 11, the half millennium or so of global evolution through self-organizing markets which, by its very nature, was drifting towards "globalization" already has entered the stage of "transnational" evolution in which the important political actors are located at inter- or transnational levels as well. This new "transnational" stage possesses, quite

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14 Here, one must refer to the impressive work by Braudel 1982, 1986.

15 It would be an extremely challenging research task to introduce the *metaphorical* notions of supra- and subcriticality to the *market network* developments in the Mediterranian region, centered around Venice, Genoa, etc. around the 12th and 13th century and the subsequent pattern in North-Western Europe, especially between Northern France, the Netherlands and the Southern and Middle parts of England. The most interesting problem in this area has to do with the question whether essential systemic indicators can be identified which would indicate subcritical and supracritical masses for a successful and expansion-driven market network-development.

16 For a similar "developmental vision", see also Perroux 1983, Pollard 1981 or Rostow 1978.

17 Translation by K.H. Müller from Polanyi 1978.

naturally, a vast array of upward trajectories too which can give rise to new forms of global stabilization. Looking back to two historical periods, namely to the period from 1880 to World War I and to the three decades after WW II, an additional important feature of the evolving market network formations must be stressed.

A closer inspection of the second half of the 19th century reveals the emergence of both intended" and "unintended" global stabilisators like, following Karl Polanyi, the "liberal state" and, on the "non-intended side", the gold-standard, or an international equilibrium of great powers (Polanyi 1978:59pp.) which have came into existence not by "design" but as a "side-effect" of trade arrangements or of industrialization processes worldwide. Likewise, in the thirty years after 1945 the world-economic ensemble stood under the heavy influence of an "intended" as well as an "unintended" stabilization arrangement which consisted of free trade, the Bretton Woods agreements and, on the non-intentional side, a "pax americana", reflecting the unique and dominant position of the United States within the global market networks after 1945. Thus, it should be viewed as highly probable that in the future, too, new "intended" as well as "unintended" global mechanisms for coordination and "supervision" (Helmut Willke) will accompany the ongoing transnational evolution and the resulting high horizontal mobility of production, service and distribution processes around the globe. The "Great Transformation" will continue its great transformations ... (Polanyi, 1978:295)

In a similar manner, a spatio-temporal map for the knowledge pools can be constructed which is then depicted in Table 12. Unfortunately, due to the novelty of the overall epigenetic framework, many linkages between knowledge base – actor network relations are not particularly well understood or even analyzed in a rudimentary manner. Nevertheless, four important characteristics of Table 12 can be mentioned.

First, the most surprising feature of Table 12 lies in the fact that the essential spatio-temporal network differentiations can be applied to the symbolic knowledge pool as well. Although some important differences prevail, the deep similarity in the evolutionary development patterns of symbolic knowledge pools and actor network formations remains unaffected. Thus, it is not only possible and heuristically fruitful, to differentiate between symbolic core, semiperipheral and peripheral knowledge pools, but it is also rewarding from a cognitive point of view, to introduce pre-capitalist forms of symbolic knowledge production of the "distributed" and "centralized" variety and to define periods and stages like an "age of global distribution", and, for the 20th century, an "age of transnational evolution".

Second, the scientific production has always carried with it a strong tendency toward globalization", although "globalization" is to be understood in terms of the evolving world-economy only (See also Merton, 1985). Thus, despite the seemingly global discourses between scientific centers throughout the 18th century in Paris, London, Edinburgh, Berlin, the American East Coast or St. Petersburg, many external territories and their knowledge traditions, especially in Africa, India or China, have not only been excluded, but also de-qualified and mis-understood in a very profound manner. (See, e.g., Raynal and Diderot 1988, Hegel 1956)

Third, following the last point, it becomes possible in a non-trivial manner to differentiate between three regional types of "knowledge bases" within the global symbolic knowledge pools. Utilizing the same spatial distinctions which have been employed for actor network formations, an analogous separation can be made for the symbolic code levels and, thus, for the symbolic knowledge bases, too.

Table 11: Main Evolutionary Actor-Network Stages in the Great Transformations of Piaget-Societies

SOCIETAL ACTOR-NETWORK FORMATIONS

Reciprocal	**Redistributive**	Þ	**Capitalist**
Formations	**Formations**	Þ	**Formations**
Societies under	Societies under	Þ	Societies under
Dominance of	Dominance of the	Þ	Dominance of
Personal	*Political* System	Þ	*Markets*
Exchanges		Þ	
			ß ß ß ß ß ß

CAPITALIST TRANSFORMATIONS

THE GLOBAL DEVELOPMENTAL STORY	
	Initial Phase I: 1450 – 1600: *(Ir)reversible Expansion*
	Initial Phase II: 1600 – 1760: *Consolidation*
Gradual integration of reciprocal as well as re-distributive network formations;	**Global Diffusion** (1760 – 1920)
Global differentiation into three distinct regions: c*ore regions, semi-peripheries* and *peripheries.*	*Industrial Revolution*: 1760 – 1820 Prosperity 1780/90 – 1820
Specific development patterns in each of the three global regions, ranging from differences in the world trade-relations to significantly different roles and capacities of natio-nal governments or to different compositions with respect to socio-economic status-groups or classes;	*Global Diffusion*: 1820 – 1913/20 Depression 1820 – 1842/50 Prosperity 1850 – 1870/73 Depression 1873 – 1893/96 Prosperity 1896 – 1913/20 **Transnational Evolution** (1920 – 1973)
Emergence of global instruments for coordinating and balancing the world-system, leading, in the *very* long run, to the development of global institutions and organizations; emergence of new types of "knowledge societies";	Depression 1920 – 1938/48 Prosperity 1948 – 1966/73
Dense intra-systemic and inter-	Depression 1973 – 1993/97

systemic networks in production processes; integration of global and local accessibilities, etc.	Prosperity	1997 –	???[18]

[18] For the special choice of periods, the selections have been undertaken with respect to the common upper and lower boundaries of "long swings". On this point, see especially Freeeman 1983, 1986, Freeman and Soete 1994 or Kleinknecht 1987.

Table 12: Main Evolutionary Knowledge Base-Stages in the Great Transformations of Piaget-Societies

SOCIETAL KNOWLEDGE BASE-FORMATIONS

Distributed Knowledge Bases	**Centralized Knowledge Bases**	Þ Þ Þ	**Capitalist Knowledge Bases**
Knowledge Bases under the Dominance of Special Persons or "Distributed"	Knowledge Bases under the Dominance of a Symbolic Knowledge Generating System	Þ Þ Þ Þ	Knowledge Bases under the Dominance of Modern Forms of Symbolic Knowledge Generation
			ß ß ß ß ß ß

CAPITALIST TRANSFORMATIONS

THE GLOBAL DEVELOPMENTAL STORY	*Initial Phase* : 1450 *(Ir)rev.* 1760: *Expansion* and *Consolidation*
Gradual integration of distributed as well as centralized knowledge bases; Global differentiation into three distinct knowledge pools with respect to the (re)production and to the accessibilities of local or global knowledge bases: *Core, Semi-Peripheal* and *Peripheral Knowledge Pools;* Specific development patterns in each of the three symbolic knowledge-pools, ranging from differences in functional roles- and capacities for "knowledge production" at the level of firms and institutes; Differential access to the symbolic knowledge bases; Development of limited local knowledge traditions and "subversive knowledge" against the established forms of symbolic programs within core-knowledge pools; Emergence of new types of "knowledge societies"; Decisive steps towards globalized program pools due to the formation of globalized IT-infrastructures, integrating the global *and* the local program production, etc.	**Global Distribution** (1760 – 1920) *"Institutional and Organisational Revolution"*: 1760 – 1820 Emergence of New Types of Universities (Combination of Research and Education) *Global Diffusion*: 1820 – 1913/20 Gradual Recombination of R&D and Firms through Firm-Specific Research Laboratories **Transnational Evolution** (1920 – 1973) Phase Transition from "Little Science" to "Big Science" Compounds (1973 – ???) New Stages, due to the Emergence of Bio-Technology and a Global "Knowledge System" based on "Machine Codes"

Core Symbolic Knowledge Bases: In the first instance, symbolic knowledge production within specific regions is highly distribution-oriented, setting the standards of the "state of the art" within specific fields of inquiry elsewhere, too. Judged from an "intellectual balance of international exchanges", the core symbolic knowledge base is "diffusion driven", exhibiting a global diffusion potential but being highly selective, in turn, with respect to symbolic knowledge bases and symbolic programs from other regions. In terms of operationalizations and measurements for the present time, SCI-groups (science citation indicators) must exhibit a clearly asymmetrical pattern in which the symbolic production from core regions (scientific articles and publications) quote mainly other core publications while, in turn, they are being quoted throughout the semiperipheral or peripheral knowledge bases.

Semiperipheral Symbolic Knowledge Bases: For the second type, a genuine mixture between core features and peripheral characteristics can be recorded, since semiperipheral knowledge bases show areas of high global competence with a correspondingly high diffusion potential as well as research fields with predominantly reception-centered features only.

Peripheral Symbolic Knowledge Bases: The third type, finally, is mainly reception driven, exemplifying a high reception potential but being only marginally reproduced and recombined in other regions. Once again seen from an "international balance of international exchanges", the peripheral knowledge base is characterized by a local diffusion potential only, although it is able, albeit with a certain time lag, to reproduce the state of the art-standards set in core or semiperipheral knowledge bases. Again, peripheral knowledge production is highly asymmetrical in terms of SCI-values, exhibiting comparatively low impact values for other knowledge pools of the world.

In this manner, an empirical basis for main types of regional symbolic knowledge pools can be established which, following this footnote[19], can be extended to the "implicit" and to the

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[19] In a similar manner to the regional differentiation of symbolic knowledge domains, the "implicit" knowledge pools can be separated into three distinct regional ensembles, too.

Core Implicit Knowledge Bases: In the first instance, knowledge-based routines within specific regions are highly concentrated in core-actor networks. Here, "implicit" operations within core actor networks and, above all, their neural "embeddedness" qualifies as membership in the core implicit knowledge pools. More concretely, the core "implicit" knowledge pool comprises the neural bases for all types of operations, routines or interactions which are necessary for the maintenance, for the repair and for innovation processes within core actor networks. In terms of operationalizations and measurements for the present time, organizational studies on core actor-networks should exhibit the amount and the types of "implicit" knowledge in operation.

Semiperipheral Implicit Knowledge Bases: For the second type, a similar analysis must be performed for typical semiperipheral actor-network formations or, more concretely, for typical actor-networks in semiperipheral regions. Once again, the investigation must center on the relations between encoded or symbolic knowledge on the one hand and the amount and the types of implicit knowledge on the other hand.

Peripheral Implicit Knowledge Bases: Finally, the third regional type of implicit knowledge pools is directly linked with peripehral actor networks or, more to the point, with typical actor netw ork ensembles within peripheral regions. Once again, the sheer amount and the differences between available symbolic knowledge bases and the actual operations necessary for maintaining, repairing, changing or innovating such networks become the central areas of analysis in order to arrive at the empirical dimensions of peripheral implicit knowledge pools.

machine code-based knowledge pools as well. Moreover, the regional differentiation between core/semiperipheral/peripheral regions at the actor networks, between core/semiperipheral/ peripheral symbolic knowledge pools, between core/semiperipheral/peripheral implicit pools and, finally, between core/semiperipheral/peripheral machine code pools should turn out to be significantly correlated in a positive way although no specific symbolic (“implicit”)(machine code-based) “knowledge maps” or detailed “actor network maps” are available at the present time.

Fourth, symbolic program production for regional, national or for the global knowledge pools became, seen in the very long perspective of globalizing Piaget societies, closed and confined to specialized societal segments regionally, nationally and globally, namely to a dense network of scientific and technical organizations at the clear exclusion and expense of “local” or “non-professional” knowledge traditions, of local “knowledge producers” and of the public sphere in general. Here, a successful “closure movement” has set in which fulfills by and large successful “gate-keeping operations” against private scholars or non-scientific practitioners in science, technology or medicine.

In this sense, some essential development patterns in the evolution of knowledge pools have been described which can be viewed as the “knowledge corollaries” to the far better known trajectories of actor-network formations.

Likewise, machine pools can be separated into three regional units as well. Before starting with the specific definitions, a short additional note must be given with respect to the “centrality” of available Turing programs. Thus, core machine code programs can be defined with respect to their domains, to the sheer amount of distribution and to their performance features. Consequently, operating programs, mathematical/statistical programs, word processing programs, graphical programs, accounting programs and the like fall under the category of important domains since they are embedded, on the whole, in maintenance, innovation or repair operations in actor-networks. Likewise, the distribution of Turing programs can be characterized by a continuum from local to global. In this manner, core programs (Turing programs in central domains, globally distributed with rich program features) can be separated from their counterparts, namely programs in non-essential domains of local character only with poor program performances.

Core Machine Program Bases: In the first instance, core machine code pools are concentrated in those physical places around the world in which the “encoding routines” – the design, the development of program architectures, etc. – for essential and globally utilized Turing programs are taking place. Thus, places like Silicon valley become part of the core machine code knowledge pool since the program production within this relatively small region figures prominently in the proliferation of essential global Turing programs.

Semiperipheral Machine Program Bases: For the second type, a genuine mixture between core features and peripheral characteristics can be found, since semiperipheral machine program bases show areas of high global program proliferation with a correspondingly high diffusion potential as well as program fields with predominantly reception-centered features only.

Peripheral Machine Program Bases: The third type, finally, is mainly reception driven, exemplifying a high reception potential only. A peripheral program pool is hardly engaged in the production of essential and globally utilized Turing programs since the programs which are developed within a peripheral machine code base are only marginally in operation in other regions. Once again seen from an “international balance of international software exchanges”, the peripheral knowledge base is characterized by a local diffusion potential at best, relying predominantly on importing Turing programs without major “endogeneous” export contributions in the program fields.

1.6 Epigenetic Outlooks

Summing up the main achievements and perspectives reached in Part I, one can stress the following essential points. Moreover, the new epigenetic perspective on different basic societal architectures will become of prime importance when discussing both the new risk potentials of contemporary Turing societies and the scope and dimensions of the y2k-problem.

First, a new epigenetic theory background has been built up in which conflicting views on knowledge, information or scientific production have been combined under partially new headings like "code and network levels", "embedded code systems", "actor network-formations", "code-network-interactions" and the like.

Second, the "great evolutionary vision", or, to quote Daniel C. Dennett, "Darwin's dangerous idea" (Dennett 1995), has been taken very seriously, furnishing a homogeneous epigenetic basis which serves, inter alia, as a comprehensive foundation for the subsequent empirical investigations and, more generally, for analyses in the area of evolutionary economics, evolutionary sociology or, most generally, of epigenetic social sciences for that matter.

Third, the epigenetic perspective on code-based reproductions of embedded or dual level systems, i.e., on the "Two Great Chains of Becoming", has opened up radically new pathways for the comparative analysis of socio-technical and of biological evolution, beautifully summarized in a sentence by Stuart Kauffman. "Organisms arise from the crafting of natural order and natural selection, artifacts from the crafting of Homo sapiens. Organisms and artifacts so different in scale, complexity and grandeur, so different in time scales over which they evolved, yet it is difficult not to see parallels." (Kauffman 1995:191)

Fourth, the present epigenetic framework allows, moreover, a transdisciplinary model-analysis on changing development patterns in contemporary Turing societies. Why? Simply because a heavy emphasis has been placed on the construction of a meta-theoretical framework or, alternatively, of a core-apparatus which should be applicable, *mutatis mutandis*, for any type of evolutionary configuration. Since a variety of complex models have been successfully applied to the biological, the ecological or the neural domains already (See, e.g., Gale 1990, Kosslyn/Andersen 1992), the "transdisciplinary apparatus" should serve as an appropriate "bridging component" for the utilization of complex models in socio-technical systems or in different aspects of knowledge and information societies, too.

Fifth, the new theoretical perspective becomes of tantamount importance in a radical shift with respect to the formation of societal "policies" and "policy regimes".[20] Here, the dual level architecture of present day Turing societies has already opened up entirely new and more

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[20] A concrete attempt with respect to science and technology policies has been undertaken in Müller 1996c.

"indirect" ways for establishing a higher densities in embedded code-ensembles, for more closely inter-linked actor networks and the like.

Thus, within the new framework complexity and code systems, epigenesis and evolution, pattern formation and historical development, innovation and diffusion, and, finally, "agencies" and "structures" have been re-combined into a new transdisciplinary ensemble. This new epigenetic perspective has effectively left behind the traditional confines of social science-frameworks and, by doing so, is offering new and highly promising trajectories within the "spaces" of possible investigations on "knowledge based processes".

It will become the main task of Part II and of Part III to demonstrate the fruitfulness and the usefulness of this new epigenetic perspective for the analysis of contemporary Turing societies and the new risk-potentials as well as the uncommon coordination problems, inherent in these new societal Turing architectures. Thus, it is hoped that Part II on evolutionary risks or risk potentials and Part III on the nature of the y2k-problem will offer sufficiently new insights which, in turn, help to support the overall epigenetic framework.

2. Societal Risks and Chances in Epigenetic Perspective

Within Part II, a new perspective on risks, on risk formation as well as on risk substitution will be introduced which will provide a considerably more general framework for the meanwhile popular notion of "risk-societies" than the original "paradigm", as developed by Ulrich Beck (Beck 1986, 1997, 1999, Bernstein 1996, Giddens 1997, Lash/Szerszynski/Wynne 1996). In Part I, the concept of "evaluation measures" has been mentioned already both for actor network formations as well as for embedded code systems. The importance of evaluation measures for evolutionary ensembles, if properly constructed, lies in a unique feature. Evaluation measures, suitably embedded, constitute a genuine "arrow" or a "drift" which runs from the low domains of the evaluation measure in question to its high areas. In biology, "natural drifts" (Maturana/Varela 1987:119pp.) have been defined as the general directions and tendencies in the results of repeated replications of the genetic "make-up" of biological species and organisms. (See also Kauffman 1993, 1995, Holland 1988, 1995) Thus, evaluation measures in terms of "genetic fitness" are able to differentiate between low and high regions within genetic code-spaces. It must be added immediately that even for Darwin societies and, *a fortiori*, for Polanyi, Piaget or Turing societies, evaluation measures cannot be identified with the help of simple measurement processes. Even in the apparently straightforward case of the genetic code, genetic fitness "applies principally to an entire organism. It has components of fecundity, fertility and other factors leading to reproductive success. These include complex issues such as the frequency of each genotype variant of the organism in the population, the density of each genotype variant in a region, and even the entire ecosystem with which each organism interacts. Therefore, in the general context, it is difficult to assign a fitness to a gene or even to a genotype, since all these factors depend upon the other organisms in the population." (Kauffman 1993:37)

It is interesting to note that evaluation measures for Piaget- and Turing societies like utility/disutility" (Page 1968) or "just/unjust" have a long-standing history and have been widely used and propagated also within the social or economic sciences. In a formal manner, an evaluation measure attributes a qualitative or quantitative value to a wide range of societal configurations. Moreover, an evaluation measure is to be qualified as "epigenetic" if and only if it can be applied to the two main levels of epigenetic analysis or, alternatively, to the basic building blocks of "embedded code systems" and of "actor network formations". Likewise, the term "epigenetic drift" may be labeled as the general direction inherent in any of the epigenetic evaluation measures. In this general sense, action patterns or operation sequences by network actors or embedded code-systems can be characterized by a multiplicity of different "epigenetic drifts", depending on the choices of evaluation measures. It will be shown that the new risk/chance[21] dimension can be interpreted in a "uni-directional mode" as well which manifests itself in the course of recurrent processes like genetic replications, investment decisions or day to day practices. Consequently, the new risk/chance axis counts as one among a multitude of evaluative directions and, thus, of evaluation measures. This, in turn, implies that network actors or embedded code systems across modern knowledge societies can be characterized in an (almost) tautological sense by a "risk/chance arrow" and by a general "disposition" or "preference" for the search of chance-domains whenever such a search process is not restricted by the inner operations or by the outer environment of the evolutionary ensemble under consideration.

2.1 Evolutionary Risks and Evolutionary Chances as Generalized Evaluation Measures

Notions like "risks" or "life chances", while not at the core of social science concept formations, have been situated at the conceptual margins at least for the last two hundred years. In the subsequent explorations, the generalized concepts of evolutionary risks and evolutionary chances will be introduced in a new and transdisciplinary way at the intersection of socio-economic and biological analyses, applicable to all four societal formations (Darwin-, Polanyi-, Piaget- and Turing-societies). Moreover, the new concepts of evolutionary risks and evolutionary chances will be defined in a sufficiently precise and encompassing manner. Additionally, the concepts of evolutionary risks and evolutionary chances will be linked directly to two different forms of empirical analysis, namely to ex post-investigations as well as to ex ante studies. In the latter instance, the risk and chance assessments will utilize probability measures as well.

With respect to an initial understanding of the concepts of risks and chances, one may refer to one of the Webster's definitions. Here, "chance" is to be understood in terms of "opportunity", "a slight possibility of a favorable outcome" (Webster's 1993:162) or "the more likely of possible outcomes" (Ibid.). The risk concept, on the other hand, is linked, again following Webster's, to the "possibility to loss or injury" (Webster's 1993:881)[22]. In both instances, the concepts of chances and risks can and should be seen as following a continuum, ranging from high risks, small risks, an indifference domain up to small chances and, finally, to high chances.

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[21] For the concept of "chance", see, aside from the Weberian notion of "life chances", also Anthony Giddens and the "politics of life chances" (Giddens 1997). It should be added though, that the subsequent operationalizations will offer new attempts to link the new "risk"/"chance"-based dimension with basic societal architectures as well with a large amount of available empirical data.

[22] In Webster's, one finds, additionally, risk as "the chance(!!!) of loss or perils to a person or thing" which, however, would be too misleading to be included in the beginning. (Webster's 1993:881)

Table 13: The Risk/Chance Distribution within the Basic Architecture of Turing-Societies (Ex post-Analyses)

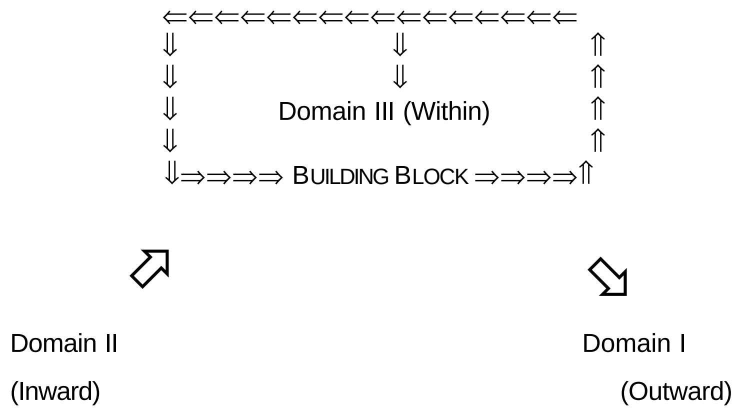
Risk/Chance Distribution for Actor-Networks
ACTOR NETWORK-DIMENSION

NETWORK-LEVELS (N)	N	⇔	N
	Risk/Chance Distribution in the Decoding of Programs	Risk/Chance Distribution in the Co-Activation of Action Patterns and Neural Programs	Risk/Chance Distribution in the Encoding of Programs
	⇑	⇕	⇓⇓
	DECODING DIMENSION	IMPLICIT DIMENSION	ENCODING DIMENSION
CODE-LEVELS (C)	C	⇔	C

Risk/Chance Distribution in the Four Layers of the Knowledge Bases:
{Genetic Code}, {Neural Code}, {Symbolic Codes}, {Machine Codes}
DIMENSION OF PROGRAM POOLS

More specifically, the terms of evolutionary risks and evolutionary chances are to be introduced in the following "systemic" way. (For a historical summary, see Bonß 1995) For any building block used in societal analysis, be it a network actor or an embedded code system, one can, in principle, differentiate between three main areas for risk and chance assessments evolutionary style, namely the interaction to and from the environment of the building block under consideration (Domain I and Domain II) and, third, the internal organization of the building block itself (Domain III). Table 14 provides a first graphical summary of the main domains for evolutionary risks and chances.

Table 14: Three Main-Domains for Evolutionary Risks and Evolutionary Chances



More concretely, the three basic domains for risks and chances can assume a variety of different forms, depending on the specifications for actor networks or for embedded code systems.

From an actor-network perspective[23], any network actor is linked, by definitional or systemic necessity, to three different domains which can be evaluated by the risk/chance dimension. Thus, one may differentiate between the interactions with the network environments (risk/chance domain I), the disturbances, shocks from the network environments as well as the degree of "relative autonomy" in relation with the network environment (risk/chance domain II) and, finally, the specific organization of task-coordinations within the network actors themselves (risk/chance domain III). To give some concrete examples from contemporary Turing societies and from network actors like persons or households, monetary interactions and transactions can be assessed in terms of risk/chance (Area I), noise and pollution around a private household can be evaluated along a risk/chance dimension (Area II) and, finally, the degree of stress-integration at work or at home can be evaluated in risk/chance dimensions, too. (Area III). More specifically, relatively few monetary resources fall under the risk label, large

[23] It must be stressed, once again, that the subsequent remarks apply, in principle, to all types opf societal network actors, ranging from the Darwin variety up to the Polanyi-, Piaget and to the present day Turing configurations.

monetary resources of persons or households under the chance domain, heavy disturbances *via* noise and pollution around a household qualify as societal risk area, no outside disturbances as chance domain. Likewise, well-organized individual coping strategies can be characterized as a chance element, whereas coping deficiencies fall under the risk segment.

Table 15: The Three Main-Domains of Evolutionary Risks and Evolutionary Chances for Contemporary Households

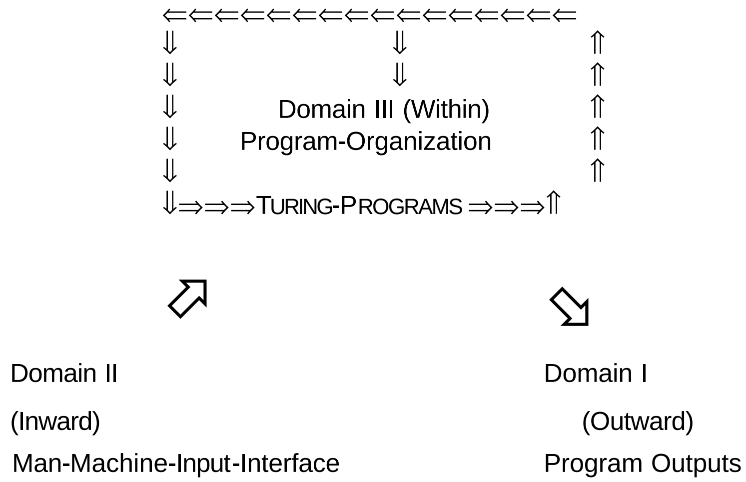
```
⇐⇐⇐⇐⇐⇐⇐⇐⇐⇐⇐⇐⇐⇐⇐⇐
⇓                 ⇓                 ⇑
⇓                 ⇓                 ⇑
⇓        Domain III (Within)        ⇑
⇓      Household-Organization       ⇑
⇓                                   ⇑
⇓⇒⇒⇒⇒     HOUSEHOLD      ⇒⇒⇒⇒⇑

   ⇗                                      ⇘

Domain II                                  Domain I
(Inward)                                  (Outward)
Outside Dependencies, "Shocks",   (Inter)action Potential of
Relative Autonomy of Households                Households
```

Likewise, a software-program for Turing machines can be assessed in terms of evolutionary risks or evolutionary chances as well. Thus, a program which produces a comparatively large number of erroneous outputs will fall under the risk category whereas a large number of new and qualitatively outstanding output features will belong to the chance assessment. Similarly, complicated and tedious input-interactions can be characterized as "risk" and "user-friendly" man-machine interfaces as a typical "chance"-assessment. Finally, relatively long periods of task integration can be qualified as risk whereas a quick integration even of a large number of internal tasks as a "chance"-evaluation. Once again, Table 16 offers a more systematic view of risks and chances for Turing programs.

Table 16: The Three Main-Domains of Evolutionary Risks and Evolutionary Chances for Turing Programs



In sum, the following five general specification steps must be used which become essential for the construction of assessments in terms of evolutionary risks and evolutionary chances.

1. Selection of a population of evolutionary ensembles (network actors or programs)
The first step lies, quite obviously, in the specification of a specific group or class of ensembles for which a comprehensive risk/chance-evaluation should be undertaken. Thus, individuals or households in a city, a region or a nation, groups of specific organizations, but also socio-technical systems like the class of electric or nuclear power plants, sets of specific computer programs, classes of genetic programs or even books, reports and articles on a specific topic may be chosen as basic units for an evolutionary risk/chance analysis. It must be stressed that the "populations" under consideration can be chosen basically from any of the available actor network or program formations.

2. Choice of domains $\{D_{i,j}\}$ for evolutionary risks and evolutionary chances along the three main risk/chance areas
Within the next step, the choice of specific attributes or processes must be undertaken which characterize essential inward, outward or within features of the evolutionary units under investigation. Two heuristic devices can be given which should become relevant for the selection processes. On the one hand, the choices should concentrate on essential features which can be justifiably placed in the core of (re)production and maintenance requirements of the units in question. On the other hand, the choices should reflect a sufficient amount of diversity, concentrating on a rich variety of different aspects for outward, inward or within areas.

– Risk/chance domain I (Outward linkages): Here, the main emphasis lies in the identification of routines and resources by the evolutionary building blocks under consideration (network actors, programs) which are relevant for and in the "outward" interactions with the environment. Table 17 offers three paradigmatic examples for individuals, socio-technical systems[24] and, finally, for programs[25] with their differing specifications for typical "outward" domains.

– Risk/chance domain II (inward linkages): The second area for evolutionary risks and evolutionary chances comes into play whenever the relative autonomy of the evolutionary ensemble and outside "disturbances" is to be assessed. Thus, it becomes a core issue whether outside "shocks" exert a major impact on the routine potential by network actors or not. As a general direction, outside disturbances are characterized by their "unwanted nature" and qualify, thus, as a genuine risk element. Here, the chance domain lies then, quite naturally, in the absence of "risky" disturbances and in a high degree of autonomy. Examples like noise and pollution within one's housing environment or at the working place, dependence on non-renewable resources for a technological system or a large amount of manpower needed to work on a specific program qualify as paradigmatic examples within the risk/chance domain II.

– Risk/chance domain III (intra-linkages): For the final area of risk/chance attributions, the routines and operations "within" stay at the center of the risk/chance evaluation. For example, the cognitive-emotional constitution of human network actors assumes a vital role in domain III, differentiating, for example, network actors with a high degree of overall "life satisfaction" (chance) from actors with a low degree of "life satisfaction" (risk). On the other hand, difficult coordination procedures within socio-technical systems or relatively long-time intervals for task completions in the program domains mark another vital ingredient for a risk/chance assessment.

To sum up, routines or attributes by societal network actors like individuals, households, groups, organizations, etc., by socio-technical systems or by programs can be evaluated in terms of risks and chances by referring to significantly different degrees of barriers, restrictions and access possibilities (Area I), to clearly distinguished amounts of outside shocks, disturbances and relative autonomy (Area II) and, finally, to very different patterns of routine intensities or integration problems.

3. Calculation of average values for the domains $\{D_{i,j}\}$ *under consideration*

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[24] With respect to socio-technical systems, one may think of diverse ensembles ranging from electronic type-writers, high speed planes to television sets or sewage systems.

[25] Once again, the scope of programs should be taken in a very general sense, ranging over the four layers of societal knowledge pools. Thus "programs" may be found, for example, within the current literature on organizational design and innovation (Pool III), within the genetic program for a specific species (Pool I), within the "implicit routines" for repairing and handling a special organizational task (Pool II) or within currently available special purpose software programs (Pool IV).

Given a set of domains $\{D_{i,j}\}$ with measurements $\{M_{i,j}\}$, it becomes possible, at least in principle, to calculate the mean value as well as the overall distribution pattern. Take an essential interaction feature for individuals, namely the disposable private income, then it is relatively easy, given appropriate survey or census data, to calculate the mean value for income, to find out the average value for the lowest 5%, the highest 10%, the lower 25% and so on. In this manner, the available data on essential risk/chance features should provide basic information both on average values as well on the distribution. Thus, within step 3 it should be recognizable whether a specific measurement follows a normal distribution, a bi-peak-distribution or some other pattern, where the mean value lies, how the lowest and the highest quintile or decile are, etc.

4. Definition of a homogeneous criterion of demarcation between risks, indifference and chances

One of the core requirements of the assessment procedure lies in the definition and in the justification of a demarcation criterion which separates risk from chance domains. The continuum of risks and chances should be arranged by introducing a “neutral” or “indifferent” zone between risks and chances around the mean values and by defining sufficiently broad demarcation criteria for risk domains below the mean values and for chance areas above the mean value. In this manner, it becomes possible to furnish a more stringent version for attributing evolutionary risks.

– A building block (network actor, program) is in a position of evolutionary risk within a special domain $D_{1,j}$ if one can assign a significantly lower access to the outward environment or, alternatively, clearly recognizable barriers and restrictions. (Risk/chance domain I)

– A building block (network actor, program) is in a position of evolutionary risk within a special domain $D_{2,j}$ if one can assign a significantly lower autonomy or distinctly more “disturbances” or “shocks” from the environment. (Risk/chance domain II)

– A building block (network actor, program) is in a position of evolutionary risk within a special domain $D_{3,j}$ if one can find significantly more integration problems within the building block under consideration. (Risk/chance domain III)

Following the redefinitions for evolutionary risks, the definitions for evolutionary indifference and evolutionary chances can be constructed in an analogous manner.[26] In sum, the risk/chance

[26] For evolutionary chances, the definitions are as follows.
A building block (network actor, program) is in a position of evolutionary chance within a special domain $D_{1,j}$ iff one can assign a significantly higher access to the outward environment or, alternatively, small recognizable barriers and restrictions only. (Risk/chance domain I)

evaluation can be undertaken for practically any evolutionary ensembles and for large classes of essential attributes or processes in terms of significantly below average (risk) or distinctly above average (chance) characteristics, operations or routines.

5. Risk/chance profiles for the evolutionary ensembles (network actors or programs) under consideration

As a final step, the rich variety of risk/chance profiles for the evolutionary units under consideration can be constructed. Given the fact that three main domains have been selected and that for each of these areas a certain number of essential features has been provided, it should be possible to arrange an appropriate risk/chance profile, pointing to essential outward, inward or within features and their risk/chance assessments.

Table 17: Main Areas of Evolutionary Risks and Evolutionary Chances

	Socio-economic Processes or Attributes	
	Risk	Chance
Area I (Outward)	High Barriers,	Low Barriers
	High Restrictions	Low Restrictions
	Low Access	High Access
	Low Action-Potential	High Action Potential
Area II (Inward)	High Degree of Disturbances and "Shocks"	Low Degree of Disturbances and "Shocks"
	Low Degree of Autonomy	High Degree of Autonomy
Area III (Within)	High Intensities	Low Intensities
	Large Difficulties for Coping and Integration	Small Difficulties for Coping and Integration

---

A building block (network actor, program) is in a position of evolutionary chance within a special domain $D_{2,j}$ iff one can assign a significantly higher autonomy or distinctly less "disturbances" or "shocks" from the environment. (Risk/chance domain II)

A building block (network actor, program) is in a position of evolutionary chance within a special domain $D_{3,j}$ iff one can find significantly less integration problems within the building block under consideration. (Risk/chance domain III)

Likewise, the definitions for evolutionary indifference assume the following form.

A building block (network actor, program) is in a position of evolutionary indiffence within a special domain $D_{1,j}$ iff one can assign an average access to the outward environment or, alternatively, a medium degree of recognizable barriers and restrictions. (Risk/chance domain I)

A building block (network actor, program) is in a position of evolutionary indifference within a special domain $D_{2,j}$ iff one can assign an avergae autonomy or an average amount of "disturbances" or "shocks" from the environment. (Risk/chance domain II)

A building block (network actor, program) is in a position of evolutionary indifference within a special domain $D_{3,j}$ iff one can average integration problems within the building block under consideration. (Risk/chance domain III)

Table 17a: Selected Examples for Societal Risks and Societal Chances (Network Actors)

INDICATORS	RISK DOMAIN	INDIFFERENCE DOMAIN	CHANCE DOMAIN
Income (Area I)	Low	Medium	High
Qualifications (Area I)	Low	Medium	High
Job Security (Area II)	Low	Medium	High
Work-Stress (Area III)	High	Medium	Low
Coping-Abilities (Area III)	Low	Medium	High
Security of Household Environment (Area II)	Low	Medium	High

Table 17b: Selected Examples for Socio-Technological Risks and Chances (Socio-Technical Systems)

INDICATORS	RISK DOMAIN	INDIFFERENCE DOMAIN	CHANCE DOMAIN
Quantity of Output (Area I)	Low	Medium	High
Quality of Output (Area I)	Low	Medium	High
Utilization of Non--Renewable Resources (Area II)	High	Medium	Low
Dependence on Few Input-Providers (Area II)	High	Medium	Low
Task Coordination- (Area III)	Low	Medium	High
Internal Failure Rate (Area III)	Low	Medium	High

Table 17c: Selected Examples for Knowledge-Based Risks and Chances (Turing Programs)

INDICATORS	RISK DOMAIN	INDIFFERENCE DOMAIN	CHANCE DOMAIN
Quantity of Output (Area I)	Low	Medium	High
Quality of Output (Area I)	Low	Medium	High
Dependence on Outside Expertise (Area II)	High	Medium	Low
Size of Manpower for Task Completion (Area II)	High	Medium	Low
Task Integration (Area III)	Low	Medium	High
Implicit Changes (Area III)	High	Medium	Low

At this point, it might be useful to differentiate between the risk/chance dimension and the luck/bad luck (misfortune) dimension, offered by Nicholas Rescher. (Rescher 1996) In Rescher's case, luck and bad luck (misfortune) are positive and negative evaluations based on random events, unpredictable and unknowable for the actors in question, whereas the risk/chance dimension, developed here, is based on an evaluation of socio-economic attributes or processes which are partly known to network actors and partly of an unforeseeable character only. Thus, traffic noise may be a constant disturbance to the household area of a specific network actor whereas the sudden death of a family member falls under the random category. Additionally, both dimensions are entangled in a variety of "strange loops" (Douglas R. Hofstadter), where "bad luck" in a socio-economic situation, e.g. a traffic accident, may lead to injuries and bad health conditions which seriously hamper and restrict the day to day routines and give rise to new social risks like reduced social contacts. These newly acquired risks, in turn, bring about new socio-economic random configurations in which "bad luck" or "good luck" can operate again.

A final remark must be added with respect to the range of the new risk/chance-dimension. This new evaluation measure is not to be understood as a universal societal "reference frame", being applicable to all possible configurations within knowledge societies past, present and future, but only to restricted domains. And even within the restricted areas specified above clear limitations can be identified immediately. Take for example the first risk/chance domain on the outward linkage patterns of network actors, one will find a large number of cases which are obviously situated beyond a "salient" utilization of a risk/chance evaluation measure. For a core issue like "partnership", it would be extremely difficult to attribute risk/chance values to the status of being single, married, living together with a partner, etc. Likewise, the fact that partnerships can be maintained without children, with a single child, with two children or with more than two children, cannot be transformed directly along the risk/chance dimension. Thus, even within some core "linkage issues" of network actors, no "meaningful" or justifiable risk/chance attributions can be performed. Nevertheless, the notion of evolutionary risks and chances can be applied in sufficient generality across the main epigenetic levels in order to identify a typical "epigenetic drift" across and within the basic architecture of Turing societies.

2.2. New Ways for Conceptualizing Evolutionary Risk/Chance Incidence and Evolutionary Risk/Chance Potentials

The main purpose of the present chapter is to extend the assessments of evolutionary risks and evolutionary chances into a new temporal as well as a new modal terrain, namely into the domains of risk/chance dynamics in the past and into the area of future risk/chance potentials. With the help of the conceptual apparatus developed so far, it becomes relatively easy to include the time dimension and to differentiate, in principle, between three main changes between risk and chance positions evolutionary style, namely changes from

Risks ⇔ Chances
Risks ⇔ Indifference
Indifference ⇔ Chances

Moreover, the time dimension can be separated into two main directions, the first being an "ex post" version, ranging from the present time to the (in)finite past $t_{\infty} < t < t^*$, the second one qualifies as an "ex ante" perspective and ranges from the present into the (in)finite future $t^* \leq t < t_{+\infty}$.

Tables 18a and 18b provide a graphical summary of the main changes between evolutionary risk and chance positions both in the ex post and in the ex ante version.

Table 18: Three Main Changes between Evolutionary Risk Positions and Evolutionary Chance Positions (ex post)

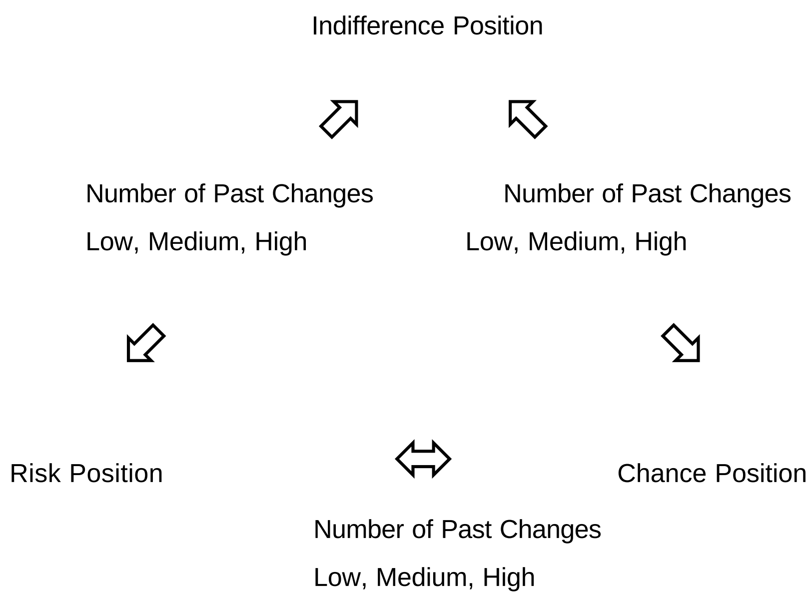
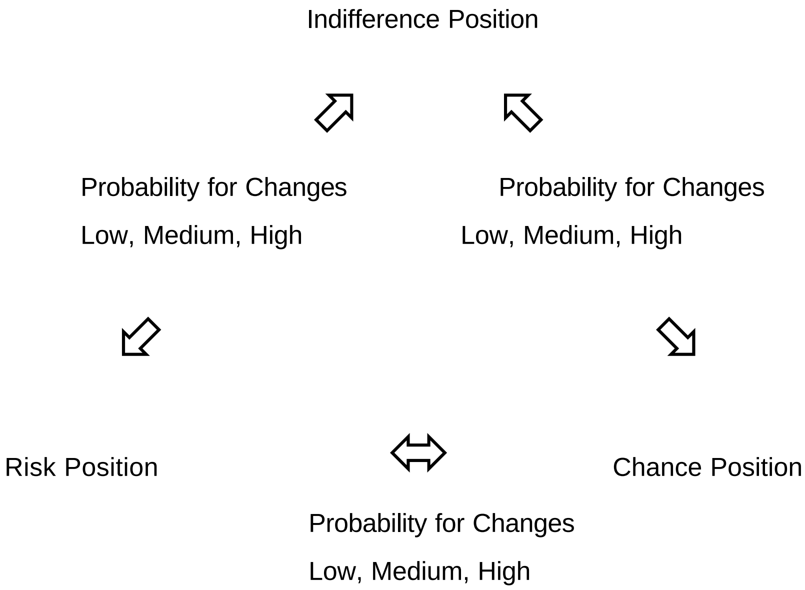


Table 18b: Three Main Changes between Evolutionary Risk Potentials and Evolutionary Chance Potentials (ex ante)



More concretely, the three basic types of changes between risks, indifference and chances can assume a variety of different forms, depending, on the one hand, on the specifications for actor networks or for embedded code systems and, on the other hand, on the temporal perspective.

From an actor-network perspective[27], any network actor is moving or shifting permanently between the three domains of evolutionary risks, indifference positions and chances. To give some concrete examples from contemporary societal changes, network actors like persons or households, exhibit within time intervals of a single year or even within five years a relatively modest movement in their monetary resources from risk to chance positions and *vice versa*.[28] At the same time, attitudes, assessments and other “underlearned” areas exhibit a relatively greater degree of changes, sometimes within a year, within a month or even within one hour.[29] In sum, actor networks are moving across time with varying velocities between risks and chances in their essential outward, inward or within features.

[27] It must be stressed, once again, that the subsequent remarks apply, once again, to all types of societal network actors, ranging from the Darwin variety up to the Polanyi, Piaget and to the present day Turing configurations.

[28] Referring to the German Socio-Economic Panel, one can see that income levels (low/medium/high) remain relatively stable even within a five year interval.

[29] One of the most interesting, revealing and at the same time most mysterious cases comes from the German Welfare Survey in 1984. (Glatz 1984) Here, respondents were asked twice the same question with respect to their overall life satisfaction. The correlation between these two identical answers within one hour was far from a perfect 100%, it reached roughly 60% only.

Table 19: Three Main Changes between Evolutionary Risks and Evolutionary Chances for Private Households (ex post and ex ante)

Indifference Position (Private Households)

⇗ ⇖

Probability for (Number of) Changes
Low, Medium, High

Probability for (Number of) Changes
Low, Medium, High

⇙ ⇘

Risk Position
(Private Households)

⇔

Chance Position
(Private Households)

Probability for (Number of) Changes:
Low, Medium, High

In a similar fashion, a software-program for Turing machines can be assessed in terms of its changes as well. Thus, a new program or a group of new program families might render a well-established program with a lot of chance features in the past as obsolete and might move it into a risk position. Likewise, "risky" programs might turn, after a new round of modifications and upgrading, into programs with comparatively large advantages and, thus, of chances.

Table 20: Three Main Changes between Evolutionary Risks and Evolutionary Chances for Turing Programs (ex post and ex ante)

Indifference Position (Turing Programs)

⇗ ⇖

Probability for (Number of) Changes
Low, Medium, High

Probability for (Number of) Changes
Low, Medium, High

⇙ ⇘

Risk Position
(Turing Programs)

⇔

Chance Position
(Turing Programs)

Probability for (Number of) Changes
Low, Medium, High

With the inclusion of the temporal dimension, it becomes possible to introduce the notions of risk/chance incidence" and "risk/chance potential" which can be summarized in the following way. An evolutionary ensemble has a high risk (chance) incidence over a past time interval if and only if one can assign a high value for changes into the risk (chance) domains. Likewise, an evolutionary unit has a high risk (chance) potential over a future time interval if and only if it has a high risk (chance) incidence in the past. Table 20 gives a more systematic overview of the new concepts of risk/chance incidence as well as risk/chance potentials and of their low or high magnitude.

Table 21: Basic Definitions for Risk Incidence/Risk Potentials and Chance Incidence/Chance Potentials

High Risk Incidence:	Large Number of Changes	Chance ⇨ Risk
	in the Past between	Indifference ⇨ Risk
		Risk ⇨ Risk
High Risk Potential:	High Probability for Changes	Chance ⇨ Risk
	in the Future between	Indifference ⇨ Risk
		Risk ⇨ Risk
Low Risk Incidence:	Small Number of Changes	Chance ⇨ Risk
	in the Past between	Indifference ⇨ Risk
		Risk ⇨ Risk
Low Risk Potential:	Low Probability for Changes	Chance ⇨ Risk
	in the Future between	Indifference ⇨ Risk
		Risk ⇨ Risk
High Chance Incidence:	Large Number of Changes	Risk ⇨ Chance
	in the Past between	Indifference ⇨ Chance
		Chance ⇨ Chance
High Chance Potential:	High Probability for Changes	Risk ⇨ Chance
	in the Future between	Indifference ⇨ Chance
		Chance ⇨ Chance
Low Chance Incidence:	Small Number of Changes	Risk ⇨ Chance
	in the Past between	Indifference ⇨ Chance
		Chance ⇨ Chance
Low Chance Potential:	Low Probability for Changes	Risk ⇨ Chance
	in the Future between	Indifference ⇨ Chance
		Chance ⇨ Chance

It should be emphasized, once again, that the concepts of evolutionary risk/chance incidence/potentials must be linked to specific time periods and time intervals. Thus, speaking of a high risk incidence/potential for an evolutionary building block, one must specify at least two time periods. First, the assessment of a high risk incidence must be based on a past record from t_{-n} up to t_0 which serves as the required data base. Second, the risk potential refers to a specific time interval t_1, t_k for which, relying on the past risk incidence, a high probability for changes into a risk position for the evolutionary ensemble under consideration can be assumed.

Table 22: The Risk/Chance Incidence and Risk/Chance Potentials within the Basic Architecture of Turing-Societies (Ex ante- and Ex post-Analyses)

Risk/Chance Incidence/Potentials for Actor-Networks
ACTOR NETWORK-DIMENSION

NETWORK-LEVELS (N)	N	⇔	N
	Risk/Chance Incidence and Potentials in the Decoding of Programs	Risk/Chance Incidence and Potentials in the Co-Activation of Action Patterns and Neural Programs	Risk/Chance Incidence and Potentials in the Encoding of Programs
	⇑	⇕	⇓⇓
	DECODING DIMENSION	IMPLICIT DIMENSION	ENCODING DIMENSION
CODE-LEVELS (C)	C	⇔	C

Risk/Chance Incidence and Potentials in the Four Layers of the Knowledge Bases:
{Genetic Code}, {Neural Code}, {Symbolic Codes}, {Machine Codes}
DIMENSION OF PROGRAM POOLS

More specifically, the following five general specification devices must be used which become essential for the construction of assessments in terms of evolutionary risk incidence or of evolutionary chance incidence.

1. *Selection of a single or of several time intervals in the past which becomes the necessary data base for intertemporal development patterns both for network actors or for programs.* The first step lies, quite obviously, in the specification of a specific time period for which the necessary incidence values can be calculated. Thus, individuals or households in a specific province or region, groups of specific organizations worldwide, but also socio-technical systems like water/sewage plants across Europe, classes of computer operating systems, sets of genetic programs or even partitures or pictures may be chosen as basic units for an evolutionary risk/chance incidence-analysis. It must be stressed that the "populations" under consideration can be chosen basically from any of the available actor network or program formations.

2. *Calculation of incidence values for small periods within the time-interval chosen.* Given a set of domains $\{D_{i,j}\}$ with measurements $\{M_{i,j,t}\}$ over a single time interval t_n to t_0 or several time intervals, then it becomes possible, at least in principle, to calculate the average changes between risks and chances. Thus, taking disposable private income as reference case once again for the time interval between, say, 1960 and 1999 and assuming, moreover, the availability of yearly panel data, then it is relatively easy to calculate the numbers for each consecutive year for a move from risk status to a chance position and vice versa.

3. *Demarcation for high, medium and low values for risk/chance incidence.* The third step assumes, once again, a context-sensitive criterion, distinguishing between high, medium and low values for risk/chance changes. Like in the case of risk/chance assessments, it seems advisable to develop a criterion which depends on the relative number of changes and not on an a priori or absolute demarcation criterion. Thus, starting with the average value for risk transitions over the interval t_n, t_0 for a single feature and calculating all average values for risk transitions across the three main risk/chance domains, one can qualify the upper third of transitions as "high", the lower third as "low" and the intermediate segment as "medium".

4. *Definition of the term risk/chance-incidence.* The notion of "risk/chance incidence" refers, in principle, to the ex post analysis only. For the attribution of a certain degree or level of risk/chance incidence it is necessary to have all the available information, obtained through step 1 to step 3. Then it becomes feasible to assign a special risk/chance incidence for an evolutionary building block if and only if the unit under consideration has exhibited a characteristic risk/chance performance during the period t_{-n}, t_0. More formally,

the notions of "evolutionary risk incidence" or of "evolutionary chance incidence" can be defined as follows.

- A building block (network actor, program) has a high (medium, low) risk incidence in the domain Di,j for a time interval t-n, t0 if one can assign a high (medium, low) number of changes from C $\Rightarrow$ R, M $\Rightarrow$ R or R $\Rightarrow$ R within the time interval t-n, t0 in domain Dij.
- A building block (network actor, program) has a high (medium, low) chance incidence in the domain Di,j within a time interval t-n, t0 if one can assign a high (medium, low) number of changes from R $\Rightarrow$ C, M $\Rightarrow$ C or C $\Rightarrow$ C within the time interval t-n, t0 in domain Dij.

Table 23 summarizes some of the new features for risk/chance incidence developed so far.

Table 23: Main Dynamics for Risk/Chance Incidence (ex post Analysis)

	MAIN TYPES OF CHANGES	
	HIGH RISK-INCIDENCE	HIGH CHANCE-INCIDENCE
AREA I (Outward)	Large Number of Instances for Falling into Barriers, Restrictions, Access Problems, etc.	Large Number of Instances for Overcoming Barriers, Restrictions, Access Problems etc.
AREA II (Inward)	Large Number of Instances for Encountering Substantial Degrees of Disturbances and "Shocks" Frequent Changes into Low Degree of Autonomy	Large Number of Instances for Overcoming Substantial Degrees of Disturbances and "Shocks" Frequent Changes into a High Degree of Autonomy
AREA III (Within)	Large Number of Instances for Getting into Difficulties with respect to Coping and Integration	Large Number of Instances for Overcoming Difficulties in Coping and Integration

5. *Profiles for Risk/Chance Incidence.* As a final step, the profiles for risk and chance incidences for a specific evolutionary ensemble can be summarized for each of the changes in its essential outward, inward or within features. In doing so, profiles on the risk/chance incidence can be obtained which range from a single evolutionary ensemble to groups of evolutionary units up to even larger and higher levels.

Likewise, the same general specification steps must be undertaken for an ex ante analysis of risk potentials or chance potentials as well.

1. *Selection of a time interval in the future which qualifies as the temporal reference frame.* The first step consists, once again, in the specification of a specific time period for which the necessary probability assignments should be performed. Thus, network actors like individuals, socio-economic organizations like firms or government agencies, socio-technical systems like the group of oil-pipelines, sets of special purpose computer programs, groups of genetic programs or even movies or television programs may be chosen as basic units for an ex ante analysis of evolutionary risk/chance potentials. It should be emphasized, once again, that the "populations" under consideration are constrained by a trivial requirement only, namely by the operationalization of a suitable group membership or, alternatively, by the ability to "make a distinction". (Spencer Brown 1997)

2. *Calculation of probability values for small periods within the time-interval chosen.* Given a set of domains $\{D_{i,j}\}$ with measurements $\{M_{i,j,t}\}$ over a time interval t_{-n} to t_0, then it becomes possible, at least in principle, to calculate the average changes between risks and chances for the future interval t_1 to t_k. Thus, taking disposable private income as reference case once again for the time interval between, say, 2000 and 2010 and assuming, moreover, the availability of risk incidence data, then a comparatively large number of statistical methods like regression models, time-series analysis and the like are available to calculate the probabilities for each consecutive year for a move from risk status to a chance position and vice versa.

3. *Demarcation for high, medium and low probabilities for risk/chance potentials.* The third step demands, once again, a context-sensitive criterion, distinguishing between high, medium and low probabilities for risk/chance changes. In the case of the ex ante analysis too, it seems advisable to select a criterion which depends on the relative probabilities and not on an a priori or absolute demarcation criterion. Thus, starting with the average value for risk transitions over the interval t_1, t_k for a single feature and calculating all average values for transition probabilities across the three main risk/chance domains, one can classify the upper third of transition probabilities as "high", the lower third as "low" and the intermediate segment as "medium".

4. *Definition of the term risk/chance-potential.* The concept of "risk/chance potentials" refers, in principle, both to ex post and ex ante analyses although the ex ante case may be considered as the reference instance. In a formal manner, the notions of evolutionary risk potentials" or of "evolutionary chance potentials" can be defined as follows.
   – A building block (network actor, program) has a high (medium, low) risk potential in the domain $D_{i,j}$ for a time interval t_1, t_k if one can assign a high (medium, low) incidence to a change from $C \Rightarrow R$, $M \Rightarrow R$ or $R \Rightarrow R$ within the time interval t_{-n}, t_0 in domain D_{ij}.

– A building block (network actor, program) has a high (medium, low) chance potential in the domain $D_{i,j}$ within a time interval t_1, t_k if one can assign a high (medium, low) incidence to a change from R ⇒ C, M ⇒ C or C ⇒ C within the time interval t_{-n}, t_0 in domain D_{ij}.

Table 24 summarizes the essential features for the concept of risk/chance potentials which have been introduced through step 1 to step 4.

5. Profiles for Risk/Chance Potentials. As a final step, the potentials for risks and chances for a specific evolutionary ensemble can be grouped for each of the essential outward, inward or within features.

Table 24: Main Dynamics for Risk/Chance Potentials (ex ante Analysis)

	Main Types of Changes	
	High Risk-Potential	High Chance-Potential
Area I (Outward)	High Probabilities for Falling into Barriers, Restrictions, Access Problems, etc.	High Probabilities for Overcoming Barriers, Restrictions, Access Problems etc.
Area II (Inward)	High Probabilities for Encountering High Degrees of Disturbances and "Shocks" as well as for Falling into a Low Degree of Autonomy	High Probabilities for Overcoming High Degrees of Disturbances and "Shocks" as well as a Moving into a Position of High Degree of Autonomy
Area III (Within)	High Probabilities For Getting into Large Difficulties for Coping and Integration	High Probabilities for Overcoming Large Difficulties for Coping and Integration

In this manner, an interesting data base on evolutionary risks and chances, on the evolutionary risk/chance incidence and on evolutionary risk/chance potentials basis have been constructed which could serve as an indispensable platform for describing the risk/chance profiles for contemporary Turing societies, for Piaget societies of the past or for other societal formations of the Polanyi or the Darwin variety as well.

2.3. The Substitution Power between Evolutionary Risks and Evolutionary Chances

In the third chapter of Part II, the new perspective on evolutionary risk and chance analysis will be carried one step further by asking for the substitution processes between risk and chance formations. Here, several different basic types of evolutionary ensembles in contemporary Turing societies will be distinguished in order to arrive at more homogeneous and specific assessments for risk/chance substitutions, for substitution potentials as well as, finally, for an empirically accessible and measurable version of the important concept of substitution power.

With respect to the basic concept of "substitution", one can provide a most general definition by referring to two building blocks A and B, to a single linkage[30] $\Rightarrow$ from A to B and, finally, to a failure in the relation which can be attributed either to A or to B. Then substitution refers to one of the following ten possibilities:

(1) Substitution by Instant-Repair
(2) Replacement of the Failure Source
(3) Substitution by Compensation[31]
(4) Sustainable Inventory Building
(5) Substitution by Contingency Measures
(6) Substitution of A by a different building block C
(7) Substitution of B by a different building block D
(8) Substitution of A $\Rightarrow$ B by C $\Rightarrow$ D
(9) Building block substitution from the network environment
(10) Linkage substitution from the network environment

Thus, substitution stands for the replacement or, alternatively, for the re-establishment of any linkage-consequence resulting from a failure within a larger actor network or within an embedded code system. Non-substitutability or, alternatively, non-re-establishment, comprises all those failures whose consequences cannot be adjusted by the larger actor network or by the overall embedded code-system.

Second, the term "substitution power" refers to the degree or to the capacity for self-repair and for failure adjustment inherent in any evolutionary ensemble. Basically, it is possible to set up ten basic parameters which define the substitution power. Table 25 summarizes the ten main

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[30] It should be emphasized that any type of "linkage" between two building blocks can be assumed for the relation A $\Rightarrow$ B, ranging from exchange relations to communications and other forms of interactions.

[31] Here, the linkage between A and B is substituted by a "failure line" which, however, has no further consequence for the outward relations of B. Suppose B as customer buys a new electronic equipment with a serious damage from A, B's regular electronic retailer. B accepts the damaged product and gets a substantial reduction in price. Moreover, B has enough time for repairing the equipment which B plans to use in several months from now.

ingredients and gives short indications for the minimal and the maximum values for the basic parameters. Moreover, in Table 25 one can observe a distinction between three different types of substitution, namely substitution within components (repair, replacement, inventory, contingency), leaving the A $\Rightarrow$ B linkage basically intact, substitution between components where either A or B become substituted by existing or new units and finally, substitution outside the available network units where transfers from the network environment are the main ingredients for substitution processes. Consequently, an evolutionary ensemble possesses a maximal substitution power, if and only if it can replace any of its outward, inward or within linkages within a very short or, alternatively, in an "undercritical" fashion.

Table 25: Basic Characteristics and Parameters for Substitution Power

	MINIMUM	MAXIMUM
SUBSTITUTION WITHIN COMPONENTS		
Repair Capacity	Low, Repair not Possible	High, Efficient and Complete Repairs
Replacement Capacity	Low, Replacement Not Possible	High, Replacement Possible
Capacity for Inventory Building	Low, not Feasible	High, Organizable in a Sustainable Fashion
Capacity for Compensation	Low, not Feasible	High, Various Alternatives for Compensation
Contingency Capacity	Low, Contingency Operations not Feasible	High, Contingency Operations Feasible
SUBSTITUTION BETWEEN COMPONENTS		
Substitution of Network Component	Small Range, Critical Thresholds	Full Range, No Critical Thresholds
Formation of a Single New Building Block	Slow, Impossible, Critical Entrance Barriers	High, No Critical Entrance Barriers
Formation of New Building Blocks	Slow, Impossible, Critical Entrance Barriers	High, no Critical Entrance Barriers
SUBSTITUTION OUTSIDE OF NETWORK COMPONENTS		

External Transfers of Linkages	Non-effective, non-sustainable	Effective, sus-tainable
External Transfers of Building Blocks	Non-effective, non sustainable	Effective, sus-tainable

Likewise, an evolutionary ensemble has a minimal substitution power only, if and only if a small or marginal disturbance in its outward, inward or within linkages leads to a breakdown of the entire ensemble. It is relatively easy to see that living systems are situated between the minimal and the maximal range since no evolutionary ensemble is capable to substitute all of its linkages within a small time interval.

It is extremely interesting to note however, that different ensembles of Turing societies have acquired typical profiles with respect to their overall substitution power. For reasons of focusing on the y2k-issue, it is advisable to concentrate on six groups of large-scale actor networks, five at the network levels and one on the program levels. These six classes of evolutionary units comprise

(1) Market Networks for Goods and Services
(2) Market Networks for Infrastructure
(3) Non-Market Networks for Infrastructure
(4) Government and Administrative Networks
(5) Private Households
(6) Turing Programs

These six groups will be analyzed briefly for detecting the main similarities as well as the main differences in terms of their overall substitution power.

Starting with market networks for goods and services, one should draw a distinction between two substitution domains, namely between goods and services on the one hand and infrastructure, as defined below, on the other hand. With respect to the substitution power for goods and services at the global or even at the national levels, market networks have developed a remarkable substitution capacity in all of its ten main parameters. Especially the substitution capacity between components and the substitution power through the network environment – the risks of one unit become the chance for another one within or outside the network – has become particularly well advanced so that even a sudden, non-replaceable and non-reparable breakdown of 10%, 15% or even more of market network actors can be substituted within short time intervals. On the average, the overall market network performance, evaluated in general performance indicators like GDP per capita or the volume of exports or imports, will exhibit no significant breakdowns or disruptions, although features like market concentration or massive bankruptcies may and will accompany any large-scale substitution process. [32]

With respect to infrastructure substitution, the situation changes drastically. Before entering into a concrete discussion, some general remarks become necessary with respect to the extent and the amount of the existing infrastructure. From an evolutionary perspective, it is highly interesting to note that within a relatively short period of two hundred years only, special network segments have emerged which provide vital services in the area of energy/water, information, transport and monetary exchanges for the economic system, the political sphere, the private households and other societal segments as well. Due to the high degree of diffusion across contemporary Turing societies and due to the focus on energy/water, information, transport and monetary exchanges, the market and non-market networks engaged in the provision of these products and services are qualified as "infrastructural segments" or, alternatively, as "infrastructure". In general, market networks for goods and services have no sustainable internal capacities for substitution (no repair, no long-term contingency, no replacement) and possess, moreover, very limited and restricted substitution powers as overall networks for major infrastructural failures. Take a large-scale breakdown in electricity as prime example, market networks for goods and services have an extremely restricted substitution power at the overall network level since two of the three remaining parameters – network substitution or the emergence of new building blocks – turn out to be not viable strategies in most instances. Thus, the only remaining substitution alternative lies in outside transfers which, however, must be qualified as non-effective especially in the medium and long run and, thus, as minimal only.

Shifting to the infrastructural segments themselves, a division should be made between infrastructure products or services organized as market networks (especially banking and finance) and those domains which are mainly organized as non-market networks (especially water, public transport systems, etc.) With respect to the former group, these infrastructural market networks have acquired a relatively large degree of substitution power for their infrastructural goods and services themselves. With respect to failures in the banking and finance sector or in energy, it becomes easy to see that the internal as well as the external substitution power has increased over the last decades. Moreover, the globalization effort and "going global"-strategies, pursued by the global network actors, have added a massive amount of effective external transfers and "redundancies" into the overall networks. Thus, from the perspective of substitution power, the overall effects of a failure rate of 5% to 10% of network actors over a period of, say, two to three years, can be effectively "mastered", albeit with massive structural changes and concentration processes, by the inherent self-organizing capacities of the overall energy or finance networks.

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[32] Here, a historical as well as contemporary reference can be given to the occurence of natural desasters (earthquakes, floods, etc.) which destroyed five, ten or even more percent of small, medium and large-scale enterprises within a region without having a five, ten or more percent effect on GDP, exports and the like.

The third ensemble under consideration consists of non-market networks for infrastructure where, by and large, a somewhat more limited and restricted assessment with respect to the substitution power of infrastructural goods and services emerges. While not at the level of minimal substitution capacities, the situation with respect to water or sewage shows that the substitution power with respect to its own domain, namely for water and sewage, is strictly limited. A major long-term breakdown in a specific region can only be compensated in an inefficient and non-sustainable fashion.

In the fourth large-scale ensemble, one finds all those services which are organized by a single public provider, distributed in some instances over a larger territory or being concentrated in a single location only. While not included in Table 27, the most interesting aspect here lies in the substitution power of the very heterogeneous package of services generated by these political/administrative networks themselves. It becomes highly revealing to note that a very low substitution profile emerges. Vital political/administrative services are, due to the size of many existing programs, difficult to repair or to replace, they have virtually no inventory capacity, and there are, again due to the magnitude of the programs, few alternative and, thus, “contingency routes” open. It fits to the assessment so far that the overall network capacities for substitution are at extremely low levels since most of these programs cannot be shifted to other units or be re-distributed within the networks.

Table 26: Substitution Power for Public Services

Repair	Low/Medium
Replacement	Low
Compensation	Low
Inventory	Minimal
Contingency	Low/Medium
Other Component	Minimal
New Component	Minimal
New Components	Impossible/Minimal
External Building Blocks	Impossible
External Linkages	Impossible/Minimal

Fifth, private households occupy a peculiar position since they have some options open in terms of compensation, contingency planning and, above all, in the area of inventory building which are generally not available for market networks and especially for large-scale network actors. Likewise, private households possess a relatively larger degree of substitution power in their infrastructural domains although the contingency/inventory capacities have clearly recognizable limits especially in areas like information infrastructure or water.

Sixth, it becomes interesting to shift the attention to the single layer most affected by y2k-problems, namely to the level of Turing programs which contain, *inter alia*, the crucial and critical time-codes. On the one hand, one can easily see from Table 26 that programs themselves are utterly dependent on a functioning infrastructural environment since programs by themselves do not possess any type of substitution power for their continued energy/information maintenance. On the other hand, programs have a considerable substitution power at the levels of program components while being severely restricted by a small network substitution power only.

Table 27: Substitution Power in Turing Societies

	Substitution Power for	
	Goods and Services	Infrastructure
Groups of Ensembles		
Market Networks		
Repair	Low/Medium	Minimal
Replacement	High	Minimal
Compensation	Low	Minimal
Inventory	Low	Minimal
Contingency	Low/Medium	Minimal
Other Component	High	Minimal
New Component	High	Minimal
External (Linkage/Building Block)	High	Minimal
Market Networks for Infrastructure		
Repair	Low/Medium	Medium/High
Replacement	High	High
Compensation	Low	Low
Inventory	Low	Medium/High
Contingency	Low/Medium	Medium
Other Component	High	Low
New Component	High	Low
External (Linkage/Building Block)	High	Low/Medium
Non-Market Networks for Infrastructure		
Repair	Low/Medium	Low/Medium
Replacement	High	Medium/High
Compensation	Low	Minimal/Low
Inventory	Low	Low/Medium

Contingency	Low/Medium	Low
Other Component	High	Minimal
New Component	High	Minimal
External (Linkage/Building BLOCK)	High	Minimal

Table 27: Substitution Power in Turing Societies (Continued)

	SUBSTITUTION POWER FOR	
	GOODS AND SERVICES	INFRASTRUCTURE
GROUPS OF ENSEMBLES		
POLITICAL/ADMINISTRATIVE NETWORKS		
Repair	Low/Medium	Minimal
Replacement	Low/Medium	Minimal
Compensation	Minimal/Low	Minimal
Inventory	Minimal/Low	Minimal
Contingency	Low/Medium	Minimal
Other Component	Minimal/Low	Minimal
New Component	Minimal/Low	Minimal
External (Linkage/Building Block)	Minimal/Low	Minimal
PRIVATE HOUSEHOLDS		
Repair	Medium/High	Minimal
Replacement	High	Minimal
Compensation	Medium/High	Minimal
Inventory	High	Low/Medium
Contingency	High	Low/Medium
Other Component	High	Minimal
New Component	High	Minimal
External (Linkage/Building BLOCK)	High	Minimal
TURING PROGRAMS		
Repair	Medium/High	Minimal
Replacement	High	Minimal
Compensation	Minimal	Minimal
Inventory	Minimal	Minimal
Contingency	Low	Minimal
Other Component	Low	Minimal
New Component	Low	Minimal

External (Linkage/Building Block)	Low	Minimal

Finally, it could be useful to distinguish between two types of substitution power across time. With the term “substitution power incidence” one can refer to the past levels and dynamics of substitution power development, the concept of “substitution power potential” is to be used primarily for the purpose of ex ante analyses only. In this way, three basic families of concepts have been introduced, namely -

evolutionary risks and evolutionary chances
evolutionary risk/chance incidence, evolutionary risk/chance potential
substitution power
substitution power incidence, substitution power potential

It is hoped that the availability of this new “conceptual machinery” – in conjunction with the new epigenetic architecture for “Turing societies – will enable a more profound and more complex picture on the potential damages and on the likely overall societal effects, induced by the y2k-problem.

3. Assessing The New Risk-Potentials of "Turing-Societies": The y2k-Problem

The final part is devoted, then, to a detailed analysis of a new type of societal problem and to a new risk potential for Turing societies, namely to the so-called year 2000 conversion problem or y2k problem for short. (For a survey, see *e.g.*, Kappelman 1997, Keogh 1997, Müller/Purgathofer/Vymazal 1999, Ragland 1997, Webster 1999, Yourdon/Yourdon 1999)

3.1 The Dimensions of the y2k-Problem in Epigenetic Perspective

At the outset, ten basic propositions can be put forward which characterize the co-evolutionary dimensions of y2k-problems and their threatening impact for societal development in general. Table 28 summarizes the central assertions which may be viewed as an overall epigenetic risk assessment of the unavoidable y2k crisis ahead.

Table 28: Ten Basic y2k-Propositions

(1) The y2k problem is the first major challenge of modern knowledge societies or, alternatively, of contemporary Turing societies. The challenge is global and runs throughout all Turing societies of the world. Moreover, the challenge is universal and affects industrial enterprises, the service sector, utilities and infra-structure, private households or local and state administrations. Thus, y2k should be viewed as the first universal and global coordination problem for Turing societies.

(2) The challenge poses a new type of societal coordination problem which is characteristic for Turing societies and which has not been encountered in previous societal formations.

(3) The y2k-problem results from an erroneous embedding of time-measurements and time-coordination into the basic architecture of Turing societies. More specifically, y2k results from codifying time as a relatively short "cycle" within the new machine code bases.

(4) The challenge belongs to the class of most complex and most densely coupled socio-technological problems. It affects the machine code bases and their embedded hardware components, *i.e.*, chips throughout the socio-technical systems of contemporary Turing societies. In this sense, y2k must be considered as a rare challenge across the two main epigenetic levels of actor networks and knowledge bases.

(5) Evaluated in terms of risk potentials, y2k is to be considered the first coordination problem of the type $SPW_{t < t(mr)} < RPOT_{t < t(mr)}$. This inequality states, quite generally, that the available societal substitution power for the very short (one month) or short run (one year) is smaller than the y2k-induced risk potential or, alternatively, the expected risk incidence.

(6) Due to the global inequality $SPW_{t < t(mr)} < RPOT_{t < t(mr)}$, the period following January 1, 2000 has, with respect to the overall consequences and damages, an irreducible element of randomness and uncertainty. Thus, y2k can be qualified as the first "global lottery" for contemporary Turing societies.

(7) The "global y2k-lottery" with respect to damages and overall performances will exhibit a new set of uncommon features like an indirect linkage between damages and overall performances and y2k-remediation efforts, a large number of context effects and the like.

(8) The y2k-failure is a self-inflicted and self-propagated "error" in the machine code. This "error" can be qualified as a typical "frame problem error", resulting from improper solutions with respect to time coordination and time horizons.

(9) The y2k-failure has become potentially "central" both to the exchanges and transfers of actor networks and of the knowledge pools.

(10) Due to the shortage of time left, the potentially central error has become" intractable" by now.

At the outset, the first proposition is devoted to the scope and to the dimensions of the y2k problem and is only partially surprising or new.[33] Y2k has its origins in the machine codes or, alternatively, in Turing programs. Due to the embeddedness of Turing programs in steering and electronic control processes, the y2k challenge is situated at the hardware level as well. Moreover, due to the high degree of diffusion of Turing programs and embedded chips across the socio-technical systems in agriculture, industry and services around the world, the y2k problem affects the fundamental metabolic exchanges and transformations within global market networks and other global societal network formations. (Proposition 1)

Second, y2k must be viewed as a new type of societal coordination problem which re-combines three separated features, namely complete predictability, a necessity for effective problem-solutions and a universal and global threat or involution potential. Table 29 highlights in a morphological manner different groups of societal coordination problems.

Table 29: Major Types of Societal Coordination Problems

	Predictability			
	Yes		No	
	Local	Global	Local	Global
Transferable in Time	Problem I	Problem II	Problem III	Problem IV
Non-Transferable in Time	Problem V	Problem VI	Problem VII	Problem VIII

[33] The Senate report on y2k from February 1999 starts out with the phrase that "y2k is the first big challenge of the information society." (Bennett 1999)

From Table 29, the notion of "transferability in time" seems to require some additional comments. In general, a societal coordination problem is to be qualified as time-transferable if it can be delayed or reproduced in time without specific temporal boundary conditions or limits. Take unemployment as reference case, then a substantial unemployment reduction is one trajectory among many possible national pathways only. In principle, unemployment may persist in time indefinitely, sometimes at high levels, sometimes at lower ones, sometimes rising, sometimes falling. In this manner, consumption of heavy drugs, fatal traffic accidents, violent crimes and many other societal phenomena are to be qualified as time-transferable coordination problems since they are reproduced anew from year to year without any temporal limit imposed on their effective reduction or abolition. Consequently, y2k belongs to the rare occurrences of non-transferable coordination problems, having an exact and insurmountable "expiration date", namely the time interval from 23.59 p.m. on December 31, 1999 to 0.00 a.m. on January 1, 2000.

Moreover, y2k-solutions must be of an effective nature, too. An "effective problem solution" is to be understood as a substantial reduction or dissolution of a specific problem. To be more concrete, an effective solution of unemployment implies a radical reduction to frictional unemployment or even a dissolution of the number of involuntarily unemployed persons. An effective solution of heavy traffic accidents lies in the radical reduction of accidents below a marginal and irreducible threshold value. In this sense, y2k requires effective problem solutions for each network actor which must be in operation prior to a non-transferable point in time.

Likewise, non-transferable societal coordination problems with a threatening global impact have been, so far, of an unpredictable nature only. Take fatal high-technology accidents, earthquakes, floods or other catastrophic events as "paradigmatic cases", then one recognizes immediately that in all these instances the element of non-predictability plays a significant role. A high technology disaster like Seveso or Three Mile Island imposes a large amount of immediate and non-transferable coordination problems like rescue operations, safeguarding the social and natural environment and the like. In fact, advanced societies are equipped with a sufficiently developed protective capacities which safeguard their normal functioning in the case of minor or even medium disruptions.

Viewed in this light, y2k must be considered as an entirely new type of coordination problem, being totally predictable, requiring effective solutions and being non-transferable at the same time. Additionally, due to its machine code basis, y2k poses a new coordination problem for the epigenetic regime IV. (Proposition 2)

Furthermore, the core of the y2k-problem consists of a highly revealing inversion of the traditional modes of time-encodings and time-measurements. More specifically, time has been structured or, alternatively, "structurated" (Anthony Giddens) towards the end of Piaget societies around circles of minutes (60 seconds), hours (60 minutes), days (24 hours), years

(365 days) and a linear ordering of years, relying on a scale with a strange reference point (transition between – 1 B.C and + 1 A.C.) Despite this heterogeneous set of counting devices with their origins in the Egyptian, Mesopotamian, Greek and Roman time culture, the basic units of time measurement have been set, towards the transition from Piaget to Turing societies, in an exact and uniform manner. The definition for a second was "9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom" (Barnett 1998:157), and the day has been defined "bottom up" as 86.400 atomic seconds. In this way, a sound and, above all, failure-free basis for measuring time has been established. Moreover, the introduction of radioactive clocks has enabled to determine the age of the earth itself in a sufficiently precise and consistent manner in the magnitude of 4,5 billion years (± 100 million years). In this way, a heterogeneous mix of circular-linear encodings as well as of administrative synchronizations like the global agreement on time 24 zones[34] has led to a uniform and successfully embedded "world-time" for Piaget societies. While by the end of the 1960's, time has been successfully encoded in a circular-linear fashion, the machine-code programs have utilized a relatively short two digit (99 year) and a relatively long four digit (9999 years) linear circle version. Thus, the encoding of "real time clocks" within the Turing program base has been undertaken both in both the long and the short version as a linear sequence of seconds/minutes/hours/days/months/years within a two digit year counter and thus a one hundred year circle (the short version with the imminent y2k-problem) or within a four digit and, thus, ten thousand year circle (the long version with a far away y10k-problem). In both cases, a circle repeats itself indefinitely into the future. In addition, the in-built temporal machine code circle is strictly "memory-free", having no additional "counter" at its disposal for the number of circles. Thus, time differences within a single circle are recorded in the traditional and well-established ways of Piaget-societies, while time-differences between two circles pose all kinds of anomalies. The single second jump from 23:59:59 on December 31, 99 (circle I) to 00:00:00 on January 1, 00 (circle II) becomes the maximum time interval for this type of temporal encodings and the long interval between 00:00:00 on January 1, 00 (circle I) and 00:00:01 on January 1, 00 (circle II) is recorded as a single second jump only. It must be added that the y2k-paradoxes with respect to time-differences are structurally similar to the "Goodman paradox" on induction, which has been generated via the introduction of new time-dependent predicates. [35]

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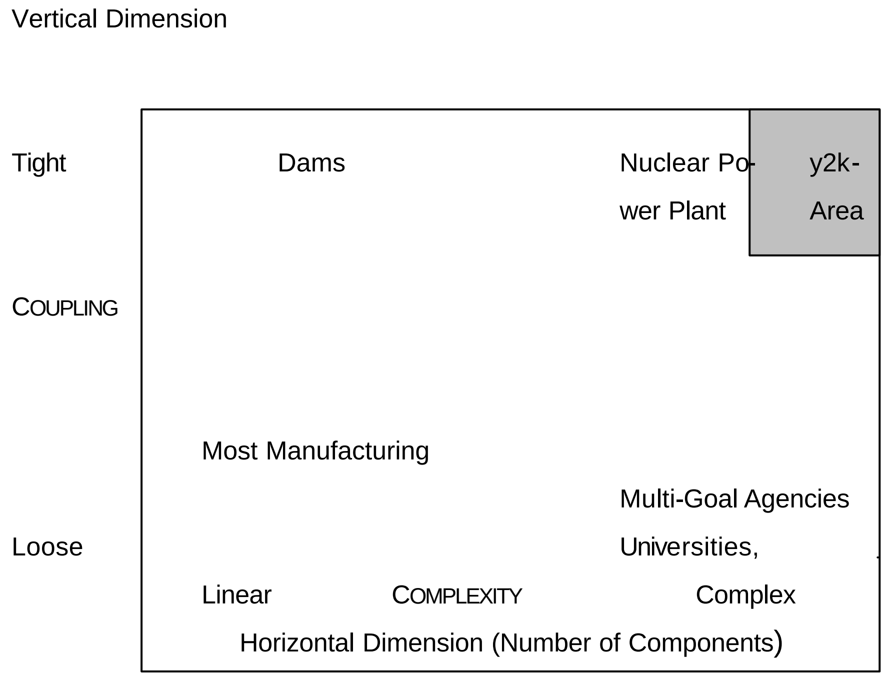
[34] From 1848 onward with the establishment of a uniform time zone for Great Britain, a homogeneous system of time-zones has been reached, following an overall agreement in 1883 which, then, has been set in practice by Canada and the United States (1883) and, following the Britain-American lead, by countries like Italy, Germany and Austria Hungary (1893), by Australia and New Zealand (1895), by India (1906), by France (1911), by the USSR (1924) and, finally, by Liberia in 1972. (On the shift towards homogeneous time-zones, see Barnett 1998:128pp.)

[35] This analogy applies, above all, to the similarities around the sensitive time-turning point. Around this point, the time-sensitive predicates develop all sorts of confirmation paradoxes. And it is exactly around the tuning point in the 99-year cycle that a large number of failures, anomalies and misleading "default options" come into operation.

To continue the justification of the relevant y2k-propositions, one can shift to Table 30 which exhibits, following basically a taxonomy developed by Charles Perrow (1984), two basic dimensions for evaluating and for distributing socio-technical systems. According to Table 30, one is invited to distinguish between four different clusters of socio-technological ensembles, namely between linear/loose, linear/tight, complex/loose and complex/tight systems. Moreover, each of the attributes can be scales according to different degrees so that one is confronted with a continuum ranging from minimally loose to maximally tight on the one hand and from minimally linear to maximally complex on the other hand. (Perrow 1984:97)

Table 30: Two Dimensions for Socio-Technological Systems



Using these two dimensions of coupling and complexity, the y2k problem must be qualified as the most complex and most tightly coupled technology problem for a very simple reason. On the one hand, y2k affects all possible combinations of technological coupling and complexity and extends over the whole range of very complex and tight ensembles like nuclear plants or nuclear weapons, of linear and tight socio-technological configurations like dams or continuous processing, of loose and complex units like R&D firms or multi-goal government agencies and, finally, of loose and linear assemblies like most manufacturing. (Perrow 1984:97) In this sense, y2k must be considered as a global and universal coordination problem. On the other hand, y2k has a direct impact on the connections between these four possible socio-technological configurations as well. In this sense, y2k belongs to the special or "singular" class of most complex and most tightly or densely linked socio-technological problems. (Proposition 4)

Moreover, the y2k problem reveals a fascinating "mimicry" which is partly responsible for the slow societal reaction to the problem at hand. As an isolated problem of program conversion, y2k must be qualified as highly trivial and as effectively solvable. Given a well-defined program, using two digit year codes, it is a matter of utmost simplicity to transform the program into a four digit version. In this sense, the y2k-problem appears, at first sight, in as a minimally linear and minimally loose technology issue. But y2k is not to be considered as an isolated conversion routine but has become a highly embedded and widely distributed societal problem. Two digit codes have been used, according to proposition one, in a vast number of embedded chips for electronic control and steering. Likewise, y2k conversion problems appear, quite naturally, at the level of the machine codes and, thus, of the program level as well. Consequently, y2k poses the rare occasion of a dual-level technology problem, distributed both across actor-networks and across the knowledge bases. [36]

Referring to the discussion on risks and chances within Turing-societies, it becomes relatively straightforward to demonstrate that problems of the y2k-type assume a large number of inverted relations between societal risk incidences, societal risk potentials and societal substitution powers, past and future. Following the second y2k-proposition as well as the definitions for risk incidence and substitution power, introduced in Part II, one can show that the substitution, and thus, the coordination efforts have operated under the following inequalities. For desasters in socio-technological systems, for "natural catastrophes" (earthquakes, floods, storms, etc.) and for socio-ecological disruptions (famine, epidemics, etc.) one can postulate the following inequalities.[37]

Table 31: Basic Inequalities for "Normal Accidents" in Piaget-Societies in the 19th and 20th century

	TEMPORAL DIMENSION		
	VERY SHORT TERM (DAYS/WEEKS/MONTH)	SHORT TERM (< ONE YEAR)	MEDIUM TERM (< THREE YEARS)
LOCAL	RI > SPW	RI < SPW or RI > SPW	RI < SPW or RI > SPW (seldom)

[36] An analogy for a similar configuration within epigenetic regime III may be constructed as follows. Suppose, a miracle substance, called "duront", has been invented around 1850 and has helped significantly to reduce the costs in paper production. Moreover, due to its miracle capacities, duront is utilized as a conservation ingredient in domains outside the paper production as well and becomes "embedded" in machines, machine tools, even in buildings, housings, in railroads, etc. The only disadvantage of duront lies in the peculiar fact that the miracle conservation ingredient looses its conservation capacity at a specific point in time irrespective of its utilization or production period. What would be the most rational way of dealing with the "duront problem", given the fact that the "expiration date" of duront is known thirty or forty years in advance? And what would be the most likely diffusion path for a product like duront?

[37] A special reference must be made that the periods of military destruction or wars should be considered as special cases in which, with World War II as the most dramatic example, even the medium global substitution power was definitely below the war-induced risk-incidences.

GLOBAL IN TIME	RI < SPW	RI < SPW	RI < SPW

From Table 31, one obtains basically the same result which can be found in the previous Table 29 on different types of coordination problems already. Local catastrophes or desasters like large earthquakes, floods and the like have had a considerable local impact for (very) short, short or, although seldom, for very long-term periods, but they do not exert any significant global effect on the overall performance of global actor networks. In this sense, Piaget-societies which in the course over the last five hundred years have been undergoing a self-organized process towards "globalization", have been exposed, under conditions of "normal accidents", to local, regional, national or restricted international crises only.[38] Towards the end of Piaget societies, one finds an obvious exception to the general inequalities in Table 31, namely the military build up and the military destruction potential which in the case of World War II and the new generation of nuclear weapons has effectively transcended the inequalities of Table 31. The picture changes substantially if one turns to the basic inequalities for Turing societies. On the one hand, the military build-up on part of the "great nuclear powers" has reached a damage potential which even for the global very long-term stands under the basic relation of -

RI > SPW

But even for "normal accidents", the basic relations and inequalities in contemporary Turing societies are of a different format.

Table 32: Basic Inequalities for y2k-Accidents" in Turing Societies for the Period from 2000 to 2003

	TEMPORAL DIMENSION		
	VERY SHORT TERM (DAYS/WEEKS/MONTH)	SHORT TERM (< ONE YEAR)	MEDIUM TERM (< THREE YEARS)
LOCAL	RI > SPW or RI < SPW	RI < SPW or RI > SPW	RI < SPW or RI > SPW
GLOBAL IN TIME	RI > SPW	RI > SPW	RI < SPW or RI > SPW

The first obvious inversion between Table 32 and Table 31 lies in the new relation between local and global. While y2k may assume different formats at the local levels, it must be qualified by necessity as a global challenge and a global crisis where in the very short runs the occurring risk-incidence after January 1, 2000 clearly exceeds the available global substitution powers.

[38] One should add that the term "local" may comprise even regions of the size of entire nations. Nevertheless, the inequality for RI > SPW does not have a single global instance for the entire period of Piaget societies.

According to global estimates partly from government agencies (US State Department 1999) or from international consultants (Gartner Group 1999), there will be a substantial amount of very short-term risk incidence exactly in those areas for which only low or minimal substitution processes can take place, namely in the domain of non market networks for infrastructure and in the domain of government networks. The most "risky" inequality in Table 32 is the second relation in the global/short term field where the risk incidence has been assumed to be higher than the actual global substitution power. The main reasons for postulating this inequality are partly empirical, partly theoretical. From an empirical point of view, a US-State Department report identified 88 countries with a medium or high risk potential in one of five vital infrastructure areas (energy, finance, transport, water, telecommunication). Assuming that the State Department risk potential analysis can be integrated within the conceptual framework of evolutionary risk/chance incidence/potential laid out in Part II[39], then two theoretical reasons can be given for the global short term inequality in Table 32. On the one hand, the distribution of failures is not uniform over time, but has, according to expert estimates, a clearly recognizable peak around the "rollover date". This, in turn, implies that there will be, by necessity, a peak period for which the inequality has its first clearly recognizable negative "maximum". From general network theory, one can infer that for configurations of this type "downward oscillations" become the most likely trajectory of the overall network performance. On the other hand, a massive failure peak may and will have its negative or "risky" secondary, tertiary, quartary, …, n-ary effects where the term "secondary effect" can be defined as follows. Starting again from a basic network relation of the format A $\Rightarrow$ B and a non-substitutable or non-re-establishable failure in A $\Rightarrow$ B, then a negative (positive) secondary effect lies in any relation between A and its environment or between B and its environment which is negatively (positively) affected by the failure in the A $\Rightarrow$ B relation. Thus, a failure in energy transmission between a utility company and a firm will have a negative secondary effect if and only if the output relations of the firm with other firms or with private customers will be hampered. Likewise, tertiary effects can be defined in a similarly recursive manner so that it is relatively clearly recognizable that y2k-problems will send a large number of n-ary "shocks" throughout the global market networks for goods, services and infrastructure, the non market networks for infrastructure and, finally, to government services. All three reasons combined offer a basic justification for the global short term-inequality RI > SPW. (Proposition 5)

Moreover, the effects of y2k-induced damages can best be described by a "global lottery" with a large amount of strange features. First, the participants in the global lottery are not persons, but regions. These regions can be defined in the following way. Since around September/October 1999, the number of the world population has surpassed the 6 billion

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[39] In order to be "evolutionary risk/chance-compliant", the only necessary and sufficient condition lies in the following relation:
Medium Risk Potential ≡ significantly reduced inward/outward/within organization, including, *inter alia*, medium reductions in output, medium "input failures" and medium "within" damages.
High Risk Potential ≡ very severely reduced inward/outward/within organization, including, *inter alia*, high reductions in "output", strong "input failures" and high "within" damages or desasters.

threshold, it might be useful to split the global Turing society into regions of 250.000 persons respectively, dividing, thus, the global Turing society into 24.000 separate regions with a population of 250,000 each. Additionally, the lottery stretches over a 12 month period, starting on January 1, 2000 and ending on December 31, 2000. Moreover, the lottery has a peculiar distribution of gains and losses, with a very small number of "lottery gains" and a large amount of "lottery losses". The basic justification for this distribution lies, once again, in the short-term global inequality in Table 32 which implies, *inter alia*, that the overall global network performance for goods and services for the year 2000 will fall below the expected or predicted growth values. Once again, well defined "global lotteries" have not been encountered throughout the entire period of Piaget societies and must, thus, be qualified as a typical new feature of contemporary Turing societies, their new risk incidence and their new risk potentials. (Proposition 6)

Additionally, the strangest feature of the "global lottery" lies in the fact that the outcomes of the y2k-lottery will be only indirectly linked to the degree and amount of substitution efforts prior to January 1, 2000. While one can establish, on a priori grounds, a significantly positive correlation between the degree of substitution efforts and the subsequent y2k-induced damages, the correlations will turn out to be far from perfect or even far from highly significant. There will be a substantial number of regions with the combination "high substitution effort/low performance" and "low substitution effort/high performance". The main reason for the relatively weak correlation between y2k-remediation and y2k-induced risks lie in five different areas.

The first basic reason has to do with the network distribution within each of the 24.000 areas. Thus, an urban residential area of 250.000 people with minimal y2k-preparations may fall into a period of short-term inconveniencies and heavy day to day stress even for a period of several months. Nevertheless, a residential community with a normally performing infrastructure will not experience even a short-term reduction in the overall performance hile undergoing serious disruptions in life quality during an interval of several months. Thus, the first important point lies in the distribution of network actors, in the number of network actors with a high damage potential for the environment like chemical or nuclear plants and, quite generally, in the amount of Turing components within the region under consideration.

The second reason may be qualified as the uncertain "y2k-distribution effects" and can be related directly to the uncertain magnitude of negative secondary, tertiary and n-ary "shocks". Thus, a large number of y2k-induced damages and restrictions might be distributed in a local manner only, generating a large amount of single risk-incidences within a region but no large-scale chain reactions. Alternatively, a high and successful y2k-repair effort and a relatively small amount of y2k-induced damages may lead, nevertheless, to a large amount of repercussions and damage diffusion which, in turn, exert a significant downward impact on the overall performance within the region after a period of twelve months.

A different reason for indirect linkages lies in the outside dependencies for each of the 24.000 regions especially with respect to infrastructure. Thus, even a completely successful y2k-effort within a single region may lead to significant damages and to a high risk incidence, simply due to the fact of crucial outside dependencies on non-substitutable infrastructure in the domains of energy or water.

As a fourth reason, one can cite so-called "context effects". A single and at least partly self-reliant "y2k-ready" region in terms of basic infrastructure supply may still undergo a significant downturn, since its wider surrounding environment is experiencing relatively strong y2k-damages and cannot absorb or process the normal flow of inputs from the y2k-ready region. Here, the normal "outward" relations between a y2k-compliant region and its wider environment turn out to be non-sustainable and lead, in the course of several months, to a degradation of the y2k-ready region as well. Likewise, a single region with a lot of y2k-induced risk incidence and a y2k-compliant environment may re-establish its essential network operations within a relatively short period of time, adding, once again, to the indirect linkages between a priori y2k-remediation and actual y2k-risk incidence.

One may conclude the indirect relations between y2k-remediation efforts and actual risk-incidences and performance reductions with reference to a necessary and unavoidable component of "noise" and "disturbance" which comes from the repair efforts themselves. High repair and replacements projects will add, at least marginally, a new potential risk factor to the already existing y2k-risk potential since the repair and testing tasks, by their very nature, produce new non-intended consequences and, thus, another contribution to the indirect relation between y2k-repair and y2k-damage.

Thus, the effective outcome of the "global lottery" turns out to be "uncertain" at best. In this sense, terms like "chaotic expectations" or "the global time quake" (Müller/Purgathofer/ Vymazal 1999) offer an interesting and "deep" summary of the y2k-conversion challenges. (Proposition 7)

With respect to proposition eight, the type of error underlying y2k, qualified as "frame problem", requires a substantial amount of justification and commenting. "Frame problems" (see e.g., Dennett 1986b, Lormand 1991) are encountered, very generally speaking, in all those instances where two "knowledge domains" K_1 and K_2 are both relevant for a decision configuration D. By a cognitive integration failure, K_1 is used for the actual decision procedure, neglecting K_2 entirely either by "forgetting" it or by "discounting" it as irrelevant. To provide a concrete example of the "forgetful" variety, suppose you want to go shopping either tomorrow or the day after (D), you think about the possible advantages and disadvantages associated with these two alternatives (K_1), (K_2) and finally you decide to choose the latter alternative.(D(K_1)) For the selection of (D(K_1), a knowledge piece (KW) would have been highly relevant, namely the fact that there is a holiday in two days from now and that shops are closed. In the instance of arriving at (D(K_1), however, KW did not enter into the decision configuration and was "forgotten" and "left out". Quite generally, "frame problems" arise out of an insufficient or of an erroneous integration of knowledge components. As such, y2k must be qualified as a "frame problem" of the "conscious" type, generated through an insufficient integration of future time horizons and, more generally, of time and time-embeddedness into the present decision configuration. During the sixties and seventies, the "knowledge" (K_2) of a four digit change in dates in 1999 was trivially available and distributed throughout the entire community of programmers, technicians, business managers and the like. Nevertheless, immediate restrictions in computer storage capacities and resulting cost-advantages (K_1) generated such a large momentum that K_2 was somehow "left out" and was apparently considered as irrelevant for the space-times being. (Proposition 8) Moreover, y2k reveals an astonishing insight on the time horizons of human decision procedures since even knowledge with certainty about the future like the four digit change in dates in 1996, 1997, 1998 and even in 1999 could and can be discounted either as irrelevant or, more to the point, treated as time-transferable. Within the concrete programming settings in the sixties and seventies, y2k was to be considered as a time-transferable "error" or "shortcut" whose solution, due to the triviality of the y2k-conversion as an isolated problem, was postponed for the period close the millennium change.

To round up the number of ten y2k-propositions, a relatively new complex framework will be introduced now which can be applied both to the network and to the code levels. In doing so, several of the non-standard and novel features of the y2k problem dimensions will become painfully clear. Especially the notion of a "central error", having become "intractable" by now, will be established in all its unsettling and ground-shaking consequences. It may well be, following the formal part of the y2k analyses within the next two sections, that the reproduction of actor networks within contemporary Turing societies, composed of Darwin, Polanyi, Piaget and Turing creatures, turns out to be far more vulnerable than previous actor network assemblies. Millions of "Turing creatures", due to their rapid diffusion and due to their embeddedness in the metabolic exchanges of "Piaget creatures", *i.e.*, of human network actors, have become the vital threat for a continued and ongoing reproduction of contemporary Turing societies as a whole.

3.2. Actor Network Formations as MR-Ensembles (Metabolism-Repair)

To assess the potential impact of the y2k-problem in a somewhat unconventional manner, a new multi-component framework for the "Great Transformations" within co-evolutionary ensembles will be utilized (Rosen 1991, Casti 1986, 1988, 1989a,b, 1992) where a multi-component ensemble is characterized by two main attributes, namely by metabolism and by maintenance/repair. Consequently, the resulting configuration can be described as MR-networks. The following main ingredients become necessary for an appropriate MR-specification.

Starting from a national level, one can construct a self-organizing complex of five interacting market networks, consisting of agriculture (M_1), food processing (M_2), chemical industry (M_3), Turing industry (computer, electronic equipment, etc.) (M_4), other industries (M_5), household related services (M_6), retail services (M_7), Turing services (M_8), firm related services (M_9) and a domain for waste-disposal and recycling (M_{10}). Each of these ten market network segments fulfills the following conditions.

– First, inputs from other market segments or from the M-environment are transformed to new outputs, i.e., to goods and services.
– Second, the output from Mi will be purchased from other market segments or from the market environment.
– Third, a non-negative share of the monetary income from Mi is transferred to the R-segments.

It becomes quintessential, to characterize the term "market environment" in a more precise manner. The first essential environmental complex for market networks consists in a maintenance/repair segment which can be termed as the infrastructural R-complex and which is composed of five distinct components, namely of infrastructural networks in the area of energy (R_1), water (R_2), information (R_3), transport (R_4) and money (R_5). Moreover, a second non-market domain can be identified which maintains/repairs vital functions like the innovation capacity or the institutional infrastructure of market networks and consists of the education and training network (R_7), the R&D-segment (R_7), the non-profit health and insurance complex (R_8), the political-administrative ensemble (R_9) and, finally, of private households (R_{10}). It should be easy, even at first sight, to identify input-output relations between each of the market segments and the ten maintenance/repair ensembles.[40] The environmental domain outside the MR-complex is composed, inter alia, of natural resources, land or, more generally, of a variety of ecological settings. Consequently, the linkages from the ecological settings to the MR-ensemble are formed by the transfer of natural renewable or non-renewable resources or by the waste production, emissions, etc. which are produced in the course of the basic market metabolism.

Formally, the following three conditions must be fulfilled within a metabolism/repair complex.
– $Condition_1$: Each market segment receives at least one input from other market segments or from the R-sector.
– $Condition_2$: Each market segment produces at least one output.
– $Condition_3$: Each market segment has an output link with at least one of the R-sectors.

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[40] One could think on the relations between monetary flows between market networks ⇒ private households, tax flows between market networks ⇒ government, additional labour costs ⇒ state insurance or between financial contributions from market networks ⇒ national education systems or R&D departments.

In the case of the twenty-component MR-network specified above, conditions 1 to 3 are satisfied even in a highly trivial manner.

(2) The basic formalism for MR-configurations assumes two types of metabolic processes, namely the transformation of natural resources into goods and services as well as the transformation of goods and services into monetary income. Formally, each of the ten market segments transforms natural inputs Ω from the environment into monetary income flows Γ

$$f: \Omega \rightarrow \Gamma$$

This market metabolism is taking place in two steps. First, as the production of goods and services Ξ

$$g: \Omega \rightarrow \Xi$$

and, second, as a selling and distribution chain of the format

$$h: \Xi \rightarrow \Gamma$$

To safeguard this market metabolism from disturbances, a maintenance/repair system must be available which has two essential functions. On the one hand, the maintenance/repair system must be able to adjust and regulate the market metabolism *f*

$$R_r : \Gamma \rightarrow H(\Omega, \Gamma)$$

On the other hand, the intensity of the repair and adaptation process can be formalized as

$$ß_r: : H(\Omega, \Gamma) \rightarrow H(\Gamma, H(\Omega, \Gamma))$$

(3) To set the basic MR-formalism into a "working mode", the essential connections and exchanges between these twenty network components have to be laid out in greater detail.

With respect to the market segments, the metabolic transformations can be analyzed in a conventional manner, relying, for example, on input-output tables and the like. The interesting and challenging point from the specifications so far has to do with the role of the environment which enters into this scheme in an inward manner as transfers of natural resources into the MR-complex and in an outward fashion – the emissions and by-products from market segments 1 to 10 into the environment. It should be emphasized that with the inclusion of these dual exchanges one fulfills one of the core demands for an environmental and entropy-based economic analysis, set up by first and prominently by Nicholas Georgescu-Roegen. "Numerous elements of any production process are not commodities proper – tired workers, worn-out tools, and waste are normal outputs, while free goods are normal inputs." (Georgescu-Roegen 1976:41).

With respect to the relations between the R_j-segments and the M_j-sectors, a seemingly difficult problem arises since these repair and adaptation mechanisms must be included within the two metabolic transformations $g: \Omega \rightarrow \Xi$ and $h: \Xi \rightarrow \Gamma$. At this point it must be sufficient to refer back to the end of Part II as well as to the beginning of Part III where one can find a detailed discussion on the format of the infrastructure characteristic for Turing societies. Thus, it is safe to state that input-output exchanges can be observed between all ten market domains with each of the ten repair segments.

(4) Finally, the R-segments themselves are highly interconnected as well which can be easily seen from the multiplicity of exchanges and flows between two R-components like the ones between households and state, between energy and telecommunication networks, between households and the national system of education and training or between the state apparatus and R&D, etc.

Thus, a densely connected MR-web can be identified for contemporary Turing societies in which each of the twenty segments is linked to the remaining domains in a multiplicity of ways.

3.2.1. The y2k-Potential for Involutions at the Network Levels

As a "Zero-Hypothesis", a conjecture, born out of recent versions of modernization theories and Fukuyama's "End of History" (1992), will be formulated which will act as an intuitively plausible developmental vision for densely connected actor networks of the type just described.

Robustness-Theorem (Actor Network-Version): Due to the high network densities within and between the M-segments and the R-components, MR-networks are characterized by a very high degree of robustness to external or internal disturbances. Thus, the MR-configuration of contemporary societies has the quality of an evolutionary stable complex.

In light of the "Zero-Hypothesis", two theorems will be proposed which run counter to the vision of evolutionary stability, though. In order to get a proper understanding of these theorems, two new concepts must be introduced. First, the notions of a re-establishable and non-re-establishable component refer to the following configuration. A network element M_i is re-establishable if and only if there is an input relation to another network component M_j ($j \neq i$) and the R_i, the repair component for M_i, is not entirely dependent on M_i. Otherwise, a network component must be qualified as "non-re-establishable". A "central" component within an MR-ensemble is characterized, then, by two requirements. On the one hand, it must be a non-re-establishable element and on the other hand, the breakdown of the central component leads to an overall breakdown of the MR-ensemble as well. Under these conditions, the two theorems can be formulated as follows.

– Theorem_1: An MR-network in all its possible connection patterns possesses at least one non-re-establishable element.

– Theorem$_2$: If an MR-configuration has only a single non-re-establishable component, then this component will be the central one. (For more details, see Casti 1989, 1992)

Both theorems offer a counter-intuitive picture on the dynamics and on the overall direction of developmental processes in highly connected networks and their evolutionary stable character. Two points must be stressed emphatically.

The first consequence from the two theorems lies in a counter-intuitive insight on the intrinsic value of network densities. Growing interdependencies and network connectivi ties are not a safeguard from "catastrophic" disruptions. In other words, a densely connected MR-configuration is, contrary to the modernization-based "Zero-Hypothesis", not evolutionary stable. On the contrary, densely interconnected networks may even possess relatively small non-re-establishable units which, following Theorem$_2$, become the central ones for the entire ensemble.[41]

The second interesting implication has to do with the micro-constitution of the overall MR-configuration. Since each of the twenty MR-components can be conceptualized, once again, as MR-ensembles themselves, consisting of smaller MR-units which, at the level of clusters or sectors, are MR-systems themselves ... [42], a growing awareness should set in that contemporary Turing societies are inherently unstable. It might well be the case that relatively small MR-units acquire the "central" capacity to disrupt the entire MR-ensemble in an all-encompassing manner especially because the MR-network connectivities have become so dense.

Consequently, the MR-theorems offer a radically alternative view on robustness and evolutionary unstable configurations, beautifully summarized in the subsequent quotation from John L. Casti. "In order to be 'resilient' to unforeseen disturbances one would desire a system to consist of a large number of re-establishable components. On the other hand, the above results show that if only a small number of components are non-re-establishable, then there is a high likelihood that one of them will be a central component whose failure will destroy the entire industry. Thus, a system with a large number of re-establishable components will be able to survive many types of shocks and surprises, but there will be certain types of disturbances that will effectively cripple the whole system ... "(Casti 1989b:26) ... This last result has obvious implications for policies devoted to keeping every component of a system alive ..." (Casti 1992:198)

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[41] An immediate counter-argument lies in the closed specification framework, developed so far. But this argument does not hold upon closer inspection since an appropriate MR-ensemble can be constructed for a national economy by taking into account its import-export relations and by postulating, then, the two theorems for an open economy-context.

[42] Quite generally, MR systems can be regarded as "self-similar" configurations, applicable to very different network levels, ranging from the global to national, regional or even to the firm levels themselves.

Thus, network formations of the MR-type have an involutionary potential which cannot be diminished – it just can be shifted from a network type of a large number of non-re-establishable and isolated components – for example the capitalist world system in the17th or in the 18th century – to today's Turing formations with a very large number of re-establishable components and a very small number of non-re-establishable, but central segments. Centered on the y2k-problem, the following implications are very difficult to avoid.

First*,* actor network patterns within contemporary Turing societies have become more and more differentiated into all-purpose infrastructure ensembles (especially in the area of energy/water and information) on the one hand and into special purpose goods and services on the other hand. These infrastructural networks alone or in conjunction qualify for obvious reasons as potentially "central" components since they act as necessary pre-requirement for a smooth metabolic exchange and transformation within the market sectors or clusters for goods and services.

Second, the y2k-problem has become a very serious issue for the MR-infrastructure, both in its embedded chips version and in its program side. Moreover, the substitution power of the infrastructure networks outside their repair capacity are restricted and below average when compared to the substitution power for goods and services within the market networks.

Third, the increasing network densities through new production regimes like "just in time", the reliance on multiple delivery chains or on firm networks have increased the robustness of the re-establishable segments with respect to a wide range of "systemic failures". It is interesting and disturbing to note however, that errors of the y2k-type reveal clearly the vulnerable sides of the new production regimes both in their overall dependency on the MR-infrastructure as well as on a fail-free network of customers and clients in case of universal, global and non-time transferable problems, demanding effective solutions.

Fourth, contingency planning on part of network actors within an MR-ensemble would require, among other things, a complete revision of the organizational changes introduced over the last thirty years. Thus, successful or fail-free contingency planning, too, is a very unlikely occurrence given the path dependencies and "lock-ins" with respect to changes of long-term developmental "drifts" within the MR-ensembles, regional, national or global.

Finally, the y2k-problem on the actor-network side has become by now, due to the short time intervals left, an intractable problem. The term "intractable" has been borrowed from complexity theory where it refers to problem solutions which cannot be achieved in polynomial time. Here, "intractable" refers to non-time transferable coordination problems and to the fact that a special coordination problem cannot be solved effectively prior to the non-transferable point of time. Time has run out for an effective and universal problem solution. And this, in turn, is the main network message of the tenth proposition in Table 28.

3.3 Knowledge Pools as PTM-Configurations (Program-Time Maintenance-Ensembles)

From an epigenetic perspective, it becomes highly instructive, once again, to point to the parallelism between actor network formations and embedded code systems with respect to the y2k problem. The machine code layer of the knowledge pools can be described and analyzed as a multi-component configuration, consisting, on the one hand, of program segments (P) and a time maintenance part TM which regulates and maintains nothing but – time. More specifically, TM is responsible for a proper coordination of the time-related output in the global Turing program pool.

(1) The subsequent specifications are aimed at the new machine code layer in the regional, national or global knowledge bases which has been labeled as "the pool of machine code programs" or the "pool of Turing programs". In order to facilitate the subsequent definitions, this specific pool will be qualified as "Turing pool", for short. In a trivial manner, this program pool can be separated into various segments. In the present case, the program pool will be divided into those twenty segments that have been identified for the actor network-side already. Thus, the "Turing knowledge base" consists of a program pool for each of the ten market segments and for each of the ten maintenance/repair components.[43] For a single program pool component P_i, the following points become of relevance.

– First*,* inputs from other program domains are transformed into new outputs within a specific program domain.
– Second*,* the output of P_i is processed by at least one other program pool P_j as well.
– Third*,* a part of the output of P_i is connected with the TM-segment.

TM is a to be conceptualized as a very small segment of the overall program pool, organized and defined by all those program components necessary for the organization and synchronization of time within the general Turing program pool. In a formal way, the following three conditions must be fulfilled for the interactions between program pool components and the TM-element.

– Condition1: Each program segment must receive at least one input from its program environment.
– Condition2: Each program segment Pi produces at least one output.
– Condition3: Each program segment is linked at least with one of its outputs to the time maintenance segment TM.

[43] To be more precise, the program pool is composed of twenty program components and of twenty practically identical TM-elements.

It seems hardly necessary to stress the trivial fulfillment of each of the three conditions in the case of a PTM-configuration.

(2) The basic formalism for the PTM configurations postulates, once again, two types of "metabolic" processes, namely the transformation of external inputs into program tasks as well as the transformation of program tasks into a recognizable output. Formally, each of the twenty program pools transforms external inputs Ω from the environment into an externally accessible program output Γ

$$f: \Omega \rightarrow \Gamma$$

This program transformation is taking place in two steps. First, as the production of internal program tasks Ξ

$$g: \Omega \rightarrow \Xi$$

and, second, as a task completion chain of the format

$$h: \Xi \rightarrow \Gamma$$

To safeguard these program transformations and interconnections from temporal disturbances, a time maintenance system must be in operation which has two essential functions. On the one hand, the time maintenance system must be able to adjust and regulate the program transformation *f*

$$R_r : \Gamma \rightarrow H(\Omega, \Gamma)$$

On the other hand, the intensity of the time maintenance adaptation can be formalized, once again, as

$$ß_r: : H(\Omega, \Gamma) \rightarrow H(\Gamma, H(\Omega, \Gamma))$$

In other words, the intensity of the time-maintenance effort should be proportional to the transformation functions *f* and *g*.

(3) To set the basic PTM-formalism into a "working mode", the essential connections and exchanges between these program components have to be laid out in greater detail. With respect to the program pool segments, the transformations can be analyzed in a straightforward way in terms of program output and program connections. With respect to the relations between the time maintenance domains and the program pools, the time maintenance areas must be included within the two program transformations $g: \Omega \rightarrow \Xi$ and $h: \Xi \rightarrow \Gamma$. At this point it must be sufficient to state that the time maintenance segment is included in a "mission critical manner" within the input-output transformations of the program pools.

(4) Finally, the TM-segment turns out to be highly standardized and uniform, being composed of "synchronized" elements distributed in an identical fashion throughout the knowledge bases.

While notions like "local time" or "Eigenzeit" (Helga Nowotny 1989) play a vital role in the rhythms of actor networks, the TM-part has to have a unique format for the global Turing society. In other words, time has to become embedded in an identical fashion throughout the global TM-bases.

3.3.1 The y2k-Potential for Involutions at the Code Levels

Seen in this perspective, one is led to formulate another "Zero-Hypothesis" for contemporary knowledge pools which may be seen as a corollary to the "modernization vision" in the actor network part.

Robustness-Theorem (Code-Level Part): Due to dense program linkages, high replication rates and a huge amount of redundancies, program pools are highly robust to external and internal disturbances. Thus, the machine-layer of the knowledge pools can be qualified as evolutionary stable. Once again, two counter-intuitive theorems can be laid down which run opposite to this code-based stability vision.

– Theorem1: A PTM-complex in all of its possible connectivity patterns possesses a non-reproducible element.
– Theorem2: If a PTM-complex has only one non-reproducible component, then this element becomes the central one.

Both theorems open up a self-similar pattern for the co-involution of machine-based knowledge pools, matching the pattern already identified for actor network formations. Five special points are worth being emphasized.

The first one is self-similar to an argument, developed for the actor network side already. An intensification of program densities and wide program distributions does not lead by itself to an overall stabilization in the machine-based knowledge pools. On the contrary, high reproduction rates of PTM-components aggravates and intensifies the resulting repair, maintenance and coordination efforts.

Second, it would be an extremely interesting research task to study the basic architecture of the global internet in terms of its emerging hierarchical/heterarchical configurations. But even from an a priori point, one can add the observation that the differentiation pattern follows both along a vertical (hierarchical) and horizontal (heterarchical) axis which, in turn, gives additional weight to the two network theorems, introduced above.

Third, the PTM-complex is by no means the only challenge for machine based knowledge pools. Quite to the contrary, a large number of possible PXM-ensembles can be constructed in principle where X stands as a variable for a variety of domains like algorithms, time, space, common standards (currencies, weights, length, etc.).

Fourth, in all these instances of PXM-transformations, changes in the actor networks require corresponding non-time transferable and effective adaptations in the machine code bases, too. Thus, many of the new societal coordination problems will turn out to be of a non-transferable nature since any change in well-embedded X-standards like a currency change on a massive scale imposes a fixed temporal sequence of changes and adaptations which have to be undertaken by virtually all societal network actors.

Fifth, y2k should be considered as the first and probably as a very spectacular case in a series of definitely new societal coordination problems, prompted by the growing dependencies on and the increasing embeddedness of the machine code program bases. These non-transferable coordination problems will require a new set of time-dependent or temporal organizational arrangements, capable of coping with non-transferable coordination challenges and with the necessity for, effective problem dissolutions.

Thus, new coordination problems of a non time-transferable nature will lead to a radical re-definition and re-shaping of the notion of "comparative regional or national advantages" since flexibility and high adaptability in dealing with PXM-transformations will become one of the major regional or national advantages within the Turing societies of the future. To conclude, the knowledge bases of contemporary Turing societies are inherently "unstable" and "fragile" with respect to their time maintenance frames for the interval from 1999 to 2001. The actor network formations as well as the Turing program pools, both conceptualized as metabolism-repair configurations, are too densely interwoven in a non-robust manner. And with this disturbing assessment just around the millennium corner, the short paper on Turing societies, on their new risk potentials and on some theoretical y2k-explorations has reached its logical end point.

Appendix: The Epigenetic Program

The main emphasis of the epigenetic program lies in investigations on the “hidden” and largely unknown co-evolution between “knowledge and society” or, in an alternative manner, on the gradual emergence and diffusion of new components, new structures, new processes, new forms, new patterns or new dynamics.

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