The Coming of Turing Societies and Social Responsibility[1]

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ABSTRACT

Social responsibility issue is changing in the circumstances of a a multitude of fundamental reconfigurations of contemporary societies that will be laid out here, which will generate multiple great transformations or phase transitions across a wide range of societal domains and will extend also into ecological and geological spheres. More specifically, the emergence of a new type of society will be described under the heading of Turing societies which exhibit as their special characteristic new populations of creatures, which are introduced here as Turing creatures. This Turing populations will not only become more and more indispensable for societal production and reproduction processes, but will also advance to become the dominant species within Turing societies.
The article outlines the basic new architecture of Turing societies in five major aspects ranging from new perspectives on employment systems to the new and grand challenges within the science system.
Finally, this article concludes with new challenges for scientific responsibility under the horizon of the coming Turing societies.

Keywords: Turing societies, Turing creatures, Great Transformation, rare events, Science II, employment systems, evolution, complexity, scientific responsibility, social responsibility

1 INTRODUCTION

This paper presents an outline of the main features of a new type of societal organization, which was classified as Turing society and which emerged during the second half of the 20th century (Müller, 1998a,b, 1999a,b). The article is separated basically into three major parts, which highlight different aspects of the coming of Turing societies as a fundamentally new model of societal architecture, fabric and population dynamics.

The first section will provide a general description of Turing creatures, Turing populations and Turing societies, which emerged only in the course of the 1940s and 1950s. This section will point to the basic differences between Turing societies and all previous societies of the past and will produce a great evolutionary narrative of Turing creatures and their unfolding.

Second, a special aspect of the coming of Turing societies will be laid out in greater detail, namely the potential effects of Turing societies on the future of production processes, human labor and employment systems in highly advanced regions. This section offers two contrasting future perspectives, one directed towards a jobless economy, the second one to

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[1] This article is dedicated to Bill Price who in recent months was very helpful in revitalizing my work from the 1990s on the emergence of Turing societies and extending it with new contexts of robotics, Artificial Intelligence or the cognitive sciences.

long technology waves within societal infrastructures and to a long-term interplay between human and artificial skills and intelligence.
Third, the coming of Turing societies is outlined as a unique feature in human history of so far, namely as a Great Transformation of a series of great transformations which, taken in combination, exert far-reaching consequences for the future societal fabric and organization. Furthermore, this ongoing Great Transformation will be discussed in its impact on the overall science system and its notorious blind spots with respect to deep and structural changes and ends with an analysis of the widening discrepancies between this hyper-complex Great Transformation and the traditional and under-critical responses within the political sphere.

In sum, this paper continues a series of studies on the basic architectures of Turing societies (Kajfež-Bogataj & Müller & Svetlik & Toš, 2010, Müller, 2000a, b, Müller & Toš, 2012) and their huge and unforeseeable impacts on the future courses of mankind.

2 THE EVOLUTIONARY CONTEXTS OF TURING SOCIETIES

John Maynard Smith and Eörs Szathmáry (1996:5) emphasized that evolution as the history of life's terrestrial self-organization exhibits a power-law distribution, characterized by a very large number of incremental changes and by a very small number of rare events with spectacular effects. These rare evolutionary transformations and jumps can be summarized as Table 1 and they have come to an end so far with the emergence of language and of human reciprocal societies.

Table 1 Great Evolutionary Transformations in the History of Terrestrial Life

Previous State	Phase Transition	New State
Replicating molecules	→	populations of molecules in compartments
Unlinked replicators	→	chromosomes
RNA as gene and enzyme	→	DNA and protein (genetic code)
Prokaryotes	→	eukaryotes
Asexual clones	→	sexual populations
Protists	→	animals, plants and fungi (cell differentiation)
Solitary individuals	→	colonies
Primate societies	→	human societies (language)

But Table 1 can be extended with a new entry which occurred quite recently and which can be summarized as

Human societies (language)	→	Turing societies (Turing creatures)

The initial or proto stages for Turing creatures started in technological domains when calculating devices were built between the late 1930s and during the 1940s which seemed to reside far away from new species and evolution. But from 1945 to 1949 John von Neumann produced the basic architecture of a Turing creature (Neumann, 1945, 1966) which was capable, in principle, of performing elementary routines, due to its composition of a central processing unit (CPU), a memory and of input and output devices and of self-replication so that a new type of species was developed which can be described as Turing creature. Obviously, Turing creatures are named after Alan M. Turing (1912 – 1954), the British pioneer, designer and visionary of intelligent machines who became a tragic hero of the new age of smart and intelligent machines (Hodges, 1983).

The 1950s and 1960s produced the first generation of Turing creatures and the subsequent decades generated a high diversity of Turing populations with rapid and enormous advances in the storage capacities and operating capabilities, in their networking power and the promotion of the WorldWideWeb after 1989, the construction of computing languages with natural language-like statements as in FORTRAN (1957), the widening with visual and graphic components and the symbiosis with artificial intelligence, robotics and the cognitive sciences.
Meanwhile, Turing creatures comprise the digital components within the current cluster of information and communication technologies (ICT) from notebooks, smart phones, sensors, embedded systems, to robots, learning devices or the internet of things (Höller & Tsiatsis & Mulligan & Karnouskos & Avesand & Boyle, 2014) as a new information infrastructure with an estimated number of 50 billion units by 2020, outnumbering, thus, the human population by 7:1. Simple Turing creatures can be recombined to build more complex multitask and multisensory devices like robots, capable of learning and adapting their operations in the course of their operations. Turing creatures will come in new generations, crowding out older generations or restricting them to small niches of the info-sphere. Populations and generations of Turing creatures can be assumed to follow a nearly unbounded trajectory in their future evolution. Moreover, Turing creatures can also increase the human potential and its evolutionary trajectory significantly (Harary, 2016, Kurzweil, 1999, 2005, 2012), leading to multiple interplays between human and Turing or artificial intelligence.

In the long-term history of terrestrial evolution only four instances can be found where a new species was accompanied with a new code system and a new knowledge-base. These simultaneous shifts in species and knowledge bases can be qualified as great co-evolutionary transformations or as epigenetic regimes which become a subset within the group of great evolutionary transformations, outlined in Table 1.[2]

Table 2 provides an overview of these four great co-evolutionary transformations or, alternatively, epistemic regimes which have been classified in relation to preeminent scientists with highly significant contributions to the theory of evolution, to learning and to knowledge as

- Darwin-societies, based on a DNA-code and composed of Darwin-creatures and networks
- Polanyi-societies, based on a neural code and composed of Polanyi-creatures and networks with a potential for implicit knowledge, learning and imitation
- Piaget-societies, based on symbolic codes and composed of Piaget-creatures and networks (language-based human societies)
- Turing-societies, based on a machine code and composed of Turing-creatures and networks (societies since the 1940s/1950s).

[2] See also Durham, 1991, Lewontin/Oyama, 2000, Oyama, 2000 or Thompson, 1994.

Currently, we experience the initial or embryonic stages of the coming of Turing societies where the new architectures of Turing societies only have completed their first construction stages.

Table 2 Four Epigenetic Regimes in the Co-Evolution of Species and Knowledge Bases

Epigenetic Regimes			
Epigenetic Regime I (Darwin Societies)	**Epigenetic Regime II (Polanyi-Societies)**	**Epigenetic Regime III (Piaget-Societies)**	**Epigenetic Regime IV (Turing Societies)**
Actor-Networks			
Simple Routines [Darwin Societies]	Implicit Routines (Learning, Imitation, etc.) [Polanyi-Societies] Simple Creatures [Darwin Societies] [Polanyi Societies]	Complex Symbolic Routines- (Language-Based, Num-ber Base, etc.) [Piaget Societies] Implicit Routines [Polanyi Societies] Simple Routines [Darwin Societies]	Machine-Co-de Routines with an Open Complexity Potential [Turing Societies] Complex Symbolic Routines [Piaget Societies] Implicit Routines [Polanyi Societies] Simple Routines [Darwin Societies]
Genetic Programs	Neural Programs	Symbolic Programs	Machine Code Programs
Genetic Knowledge	Neural & Genetic Knowledge	Symbolic, Neural & Genetic Knowledge	Machine Code. Symbolic, Neural & Genetic Knowledge

Base	Bases	Bases	Bases

Knowledge Bases

Thus, Turing societies are characterized by a unique distribution of populations, namely by ensembles of Darwin, Polanyi, Piaget and Turing creatures, and by a new digital knowledge base which, in combination, separate Turing societies from all societies of the past, including the most advanced types of Piaget societies from the first half of the 20th century.

3 THE COMING OF TURING SOCIETIES AS A GREAT TRANSFORMATION OF GREAT TRANSFORMATIONS

Karl Polanyi introduced the term "Great Transformation" (Polanyi, 1957) for profound changes in the basic organization of societies like the emergence of market economies or of a system of national states. Great transformations, following Karl Polanyi, change the fabric and basic structures of societies and produce a drift or phase transition to new formations. The coming of Turing societies qualifies as a great transformation which changes the basic organization and the architecture of societies across multiple dimensions.

But quite independent from the coming of Turing societies the current period can be described already as a massive and ongoing societal reconfiguration of great transformations, affecting contemporary societies in highly significant ways. At least four great societal transformations occur simultaneously and constitute, thus, a great societal transformation of great transformations.

The global science system experiences a great transformation from traditional science or Science I to a new phase of Science II which started, following Nicholas Rescher (1999), in the period from 1940 to 1960 (Hollingsworth & Müller, 2008).

From the beginning of the First Industrial Revolution technology clusters moved in periods of long waves where the period from the 1990s onwards can be seen as the diffusion of a new wave of information and communication technologies (ICT) which, however, is strongly linked to the coming of Turing societies.

The financial systems has moved from a system of weakly international ensembles to a densely and globally related financial system with relatively weak forms of national or international control.

Following World War II national economic systems are more and more confronted with global economic actors and become inter-related in supra-national and global arrangements, diminishing national control capacities effectively.

Two of these great transformations can be summarized as aspects of globalization and these four societal great transformations follow by and large the patterns of great transformations in the past and lead to new stages in the ongoing modernization of societies, although their dimensions and scope must be characterized as unusually wide.

But contemporary societies are also faced with two other great transformations as well which are, once again, independent from the coming of Turing societies and which are no longer timed on a clockwork of modernization, but occur along very long time scales of evolutionary and geological time.
The environment or the eco-sphere of contemporary societies experiences a period of growing stress, due to the reproduction and expansion of societies around the globe, leading to a new period of mass-extinctions and to significant losses in bio-diversity (Kolbert, 2014), adding a sixth mass-extinction after five mass-extinctions between the end of the Ordovician (440 million years ago) and the end Cretaceous (65 million years ago).

From a very general perspective, societies of the past and their environments were organized as different mixtures of societal and natural RISC-processes (Rare Events, Strong Consequences). These RISC-processes are characterized by a power law distribution with a very large number of minor or marginal events and a very small number of rare events with very strong impacts. Societal RISC-processes comprise domains like stock exchanges, income distribution or city sizes whereas natural RISC-processes can be found in earthquakes, forest fires, tsunamis, etc.

Until recently, societal and natural RISC-processes occurred strictly independent from one another. But the reproduction and expansion of contemporary societies brings about a coupling of natural and societal RISC-mechanisms and processes, most notably in the form of climate changes, which affect the distribution of meteorological RISC-processes in the earth's atmosphere with societal RISC-processes (Kajfež-Bogataj & Müller & Svetlik & Toš, 2010).

On a geological time-scale this coupling of societal and natural RISC-processes can be qualified as the decisive feature for a new geological period, namely the Anthropocene (Ehlers & Moss & Krafft, 2006, Lewis & Maslin, 2015).

Thus, the coming of Turing societies occurs within a swarm of great transformations, some along a modernization scale and some on an evolutionary and terrestrial scale. In this way, the coming of Turing societies is embedded in a massive Great Transformation of great transformations which no human society of the past was ever confronted with.

Table 3 offers a summary of this unusually Great Transformation of great transformations, including the coming of Turing societies itself.

Table 3 A Great Transformation of Seven Great Transformations on Four Time-Scales

Systemic Domains	Traditional Phase	→	Current Phase	Time Scales
		Great Societal Transformations		
Science System	Science I		Science II	Moderni-zation
Technology	Long Waves in Energy and Mobility		Long Waves in Wave in Infor-mation	Moderni-zation

Financial	National, strong Controls	Global, weak Controls	Moderni-zation
Economic Systems	National	Global	Moderni-zation
Great Evolutionary and Geological Transformations			
Ecosystems/ Environment	Build-up of Bio-Diver-sity	Sixth Extinction	Evolutio-nary Scale
Societal Ensembles (Regional, (National Global)	Human Societies Symbolic Codes, Libraries as Knowledge Bases	Turing, Societies Turing Creatures, Digital Knowledge Bases	Co-Evolutio-nary Scale (Species Know-ledge Bases)
Societal and Natural Systems	Societal, Natural RISC-Processes Separated	Coupled Societal & Natural RISC-Processes	Geologi-cal Scale (Anthro-pocene)

Under these circumstances of a Great Transformation of great transformations the only point which can be taken for granted and certain lies in the necessity of fundamental changes. With respect to the actual directions of these transformations the future becomes highly uncertain and open, due to the interlinked nature of these great transformations.

4 THE COMING OF TURING SOCIETIES AND EMPLOYMENT SYSTEMS

From a long (co)-evolutionary perspective one can distinguish currently two prominent, but conflicting traditions with respect to the long-term directions and goals of national employment systems, leaving aside the meanwhile outdated version of a shift from 80% employment in agriculture to a new steady state of 80% service employment. While both current traditions incorporate elements from science and technology, innovation theory, micro-economic behavior patterns, macro-economic configurations, policy domains and differing societal contexts and are advanced within the context of Turing societies, these two approaches differ fundamentally with respect to their assessments of Turing creatures and their future potential to replace human labor.

- The first tradition emphasizes the rapid advances in fields like the cognitive sciences, artificial intelligence, robotics or network technologies in the creation of selforganizing networks of sensory, intelligent and learning units which change the interactions between human labor and machines from a previously dominant mode of augmentation to a new mode of substitution and crowding out, due to the advances of more and more intelligent, complex and highly interconnected digital operating systems across the entire range of production and service processes.

- The second tradition is focused on long-term technology cycles of approximately fifty years duration within the fields of societal infrastructures, namely energy, mobility and information. These technology waves are characterized by an ongoing interplay between human skills and the potentials of these new technologies where human skills and the division of labor become in general more complex and diversified. These interplays will not stop with the advancement of intelligent machines, but will develop new configurations for the comparative advantages of human intelligence and technological skills within the full scope of production and service processes.

In terms of their underlying dynamics and future directions these two traditions can be described in the following ways.

The first framework assumes a phase transition from work processes centered on human labor to machine- or Turing-driven ensembles which will transform the basic architecture and fabric of contemporary societies in fundamental ways, among them a secular transition from human-based production processes to production processes under the operation and guidance of more and more intelligent Turing creatures. The first approach will be characterized as a Turing-framework. While Alan M. Turing never wrote at length on future of national or global employment systems, he was convinced, nevertheless, that the evolution of future generations of digital creatures will be capable of approaching and surpassing the human skill set.

More specifically, the Turing-framework of a jobless economy (see, *e.g.*, Brynjofsson & McAfee, 2012, 2014, Ford, 2015, Leonhard, 2016, Price, 2014, World Economic Forum, 2016) emphasizes a life-cycle model for the evolution of employment, which is characterized by a long-term rise of employment from the 16th century onwards (Price, 2014:30p.), a contemporary turning or tipping point and a very long-term decline towards a jobless economy as the new drift for employment systems which requires decreasing levels of labor inputs and operates in a largely self-organized manner by complex networks of Turing creatures with learning, decision-making, pattern recognition, sensory, memory or moving capabilities, substituting human skills and intelligence at all levels of production and service processes, including public administration and high-qualified professions.

The rapid diversifications and complexifications of Turing creatures and their networks are based on a massive buildup of scientific disciplines and technologies around the cognitive sciences and cognitive technologies which widen significantly in scope and depth and give rise to an evolutionary dynamics of different generations of Turing creatures with varying comparative advantages.

The domains and niches for paid human work diminish irreversibly and the number of high-paid and full-time jobs becomes scarce, leaving larger and larger portions of the labor force unemployed or marginally employed at best. For the last 200 years industrial societies did not have to cope with the phenomenon of a shrinking labor economy on a secular basis, except for short episodes like the Great Depression. But in the irreversible downward phase of the life cycle employment model the job creations of new start-ups as well as the available job-offers from firms, organizations or the public administration cannot offset the reductions and job eliminations, due to the advancement of Turing creatures across the industrial and the service sector.

The national educational systems, including the tertiary systems, are confronted with increasing challenges because the strong links between multiple years and degree(s) in higher education with full-time and high-paid jobs no longer hold, even in the fields of the STEM-sciences (science, technology, engineering and mathematics).

As a long-term consequence societies of the future need a replacement from the still dominant welfare-state model after 1945, which was centered on high employment levels and a system of redistributive mechanisms, culminating in a caring state in the fields of education, health and welfare (Swaan, 1988). Due to a secularly shrinking work force transitions must be found to a new societal order and to new subsistence and welfare schemes which remain sustainable in the view of a declining number of full-time employees with medium or high salaries.

The second long-term framework on employment was offered by Joseph A. Schumpeter, who, inspired by the Soviet economist Nikolaus D. Kondratieff, presented a powerful vision of long-term economic and employment developments (Schumpeter, 1950 and 1961), which was based on the diffusion of basic and large-scale innovations (see also Mensch, 1977). Schumpeter's analyses were later formalized as "Schumpeter clock-models" (Mensch & Weidlich & Haag, 1991, Weidlich & Haag, 1983) with their respective stages of expansionary investments and rationalizations and as a dual movement of creative destructions.

These long-term Schumpeter innovation waves can be described as successions of expansions and rationalizations in investment where expansionary or rationalizing investments are undertaken on an entire new and highly interlinked technology cluster. Schumpeter describes long waves as a consequence of capitalist explorations and imitations so that the analysis of long waves reveals the nature and the mechanism of the capitalist process better than anything else. Each of them consists of an 'industrial revolution' and the absorption of its effects … These revolutions periodically transform the existing structures of industry by introducing new production methods: the mechanized factory, the electrified railway, chemical synthesis and the like; or new goods: trains, cars, electrical appliances; or new forms of organization…; or new resources: La-Plata wool, American cotton, Katanga copper, new commerce paths and markets, etc. This process of industrial change offers the basic crescendo, which gives the general tone to the economy. While these things are being introduced we find dynamic expansion and widespread prosperity, undoubtedly interrupted by the negative phases of the shorter cycles, which are superimposed on this basic crescendo. And while these processes are taking place and the results are being thrust out, the obsolete industrial structural elements are removed, and depression predominates. (Schumpeter, 1975:114)

It is of special interest that these innovation waves occurred in the three societal infrastructure domains of transport (railroads and automobiles), energy (steam engine and electricity) and information, with the current ICT-wave (Information and Communication Technologies) as the latest example. (See Table 4)

Table 4. The Concentration of Long Schumpeter Waves in Three Segments of Societal Infrastructures: Energy, Transport and Information

Long Cycle	Period	Infrastructural

		Peak		Segment
Steam engines/ Textile industry	1788	1814	1848	Energy
Railway	1848	1873	1896	Transport
Electrical industry	1896	1914	1945	Energy
Automobile	1945	1973	1996	Transport
ICT	1996	?	?	Information

So far, each of the new big innovation waves in a specific infrastructural segment was followed by another wave in a different area, which indicates that a new wave creates bottlenecks and shortages in the two other infrastructural domains, which are then overcome by a new technology wave in one of these two other infrastructural fields.

Each of these long-term technology waves exhibits a pattern of massive job creation in the relevant infrastructure domain and job destructions in other segments of the overall economy. For example, persons employed in transport increased in Germany from 132.000 in 1850 to 349.000 in 1873 and replaced a significant number of small and local firms, due to larger markets and economies of scale. The current long wave in information infrastructures exhibits the same pattern of creating large numbers of new ICT-related jobs and a significant trend towards automation and replacements of human labor across the industry and service sector.

The Nobel Laureate in economics, Herbert A. Simon described the impact of intelligent machines already in 1960 where he provided an answer on the potentials of automation and intelligent machines in the next 25 years and beyond (Simon 1960, 1965).

Herbert A. Simon was very clear from the beginning that the new wave of intelligent machines or, alternatively, of Turing creatures will not only affect unskilled or low skilled operations because we should not make the simple assumption that the higher-status occupations, and those requiring the most education, are going to be the least automated (Simon, 1960:35)

But Simon rejects the possibility of a crowding out of human labor vigorously, due to different comparative advantages of human skills in relation to Turing skills because man has retained his greatest comparative advantage in: (1) the use of his brain as a flexible general-purpose problem-solving device, (2) the flexible use of his sensory organs and hands, and (3) the use of his legs, on rough terrain as well as smooth, to make this general-purpose sensing-thinking-manipulating system available wherever it is needed. (Simon, 1960: 31)

Due to the different comparative advantages of human skills and Turing skills the evolution of production processes will lead, following Herbert A. Simon, to more differentiations and higher levels of complexity where human skills shift to areas of complex control, high-level monitoring and identity building operations and Turing skills become the *modus operandi* for production processes, including administrative and service operations.

In the framework of Stafford Beer’s viable systems model (VSM) of organizations (Beer, 1972, 1979), the comparative advantages of human intelligence, skills and operations lie in the higher strata of VSM, namely level four (monitoring the environment) and level five (identity maintenance) whereas the two lower strata (performing the functions of an organization and communication between functional units) can substitute human operations by Turing creatures and the third layer (monitoring and control of the operations of the entire organization) require a combination of human intelligence and Turing creatures. Due to these comparative advantages the overall system of production processes becomes more and more diversified, complex, requiring more and more high-skilled human labor so that an "end of work" is definitely not in sight. Herbert Simon saw the long-term evolution of the employment system as a secular rise in skills and qualifications, irrespective of the advances in artificial intelligence, robotics or the cognitive sciences.

In the entire occupied population, a larger fraction of members than at present will be engaged in occupations where 'personal service' involving face-to-face human interaction is an important part of the job. I am confident in stating this conclusion; far less confident in conjecturing what these occupations will be. (Simon, 1960:38)

Within the Schumpeter-Simon tradition we should experience, following the diffusion of the current ICT-wave, an approximately twenty year period of long-term investment rationalization and of stagnation in employment numbers which corresponds to the mode of the Schumpeter clock of long cycles of expansionary and rationalizing investments.

The very long-term projection within a Schumpeter-Simon framework places its emphasis on a new upswing or expansion period in one of the two infrastructural segments of energy or transport. Despite spectacular advances self-driving vehicles the sixth long innovation wave could and should occur most likely in a general shift toward a low carbon economy and a low carbon society which offers a wide potential for new types of jobs, requiring a complex skill set of design, technology, environmental science and implementations.

For the next two decades the Turing-framework and the Schumpeter-Simon framework are bound to make the same general predictions on a sluggish, stagnant or even declining development of employment numbers. The Turing framework emphasizes that this stagnation becomes an initial stage of a secular substitution of human labor by Turing creatures and their operations whereas the Schumpeter-Simon framework puts its emphasis on a new phase of rationalization which will give rise to a new long technology wave, most probably in the domain of societal energy infrastructures with a shift to a low carbon economy and low carbon society.
In the very long run of fifty to one hundred years, the Turing employment projections differ significantly from the Schumpeter-Simon forecasts because the Turing predictions see the broad substitution of human employment by intelligent Turing creatures as a gradual, but irreversible decline in highly qualified full-time employment, as a need for delinking welfare and social security schemes from employment and as a necessary search for new forms of societal organization for an increasing part of the potential labor force with no or only marginal access to shrinking labor market niches.

In the very long run, the Schumpeter-Simon framework can be empirically substantiated if a new cluster of basic innovations most probably within the wider contexts of a low carbon economy and society emerges and starts a new round in the interplay of advances in new generations of Turing creatures and a higher quality in the division of labor begins, creating another shift in the comparative advantages of human labor and the creation of new jobs on the higher steps of the Stafford Beer-ladder[3].

[3] It should be noted that Alfred Marshall summarized the entangled processes of an increasing use of machinery, divisions of labor and new opportunities for human skills in a similar manner already in his "Principles of Economics" from 1890.

Currently, large numbers of experimental investigations, case studies and meta- or second-order studies, are needed where these in-depth analyses could shed more light on a reliable discrimination between these two approaches for the short and medium run. These groups of studies must be focused primarily on three areas, namely:

- First, on the advances in the cognitive sciences, especially in embedded cognition (see, for example, Chemero, 2011, Clark, 2015, Noe, 2006, 2009, Robbins & Aydede, 2008, Shapiro, 2010) and robotics across a wide range of scales (see Corke, 2013, Flach, 2012, Mulhall, 2002, Murphy, 2012) with respect to their current potential for replacing humans from labor processes with Turing creatures, especially in the higher levels of Beer's viable systems model;
- Second on the actual reconfigurations of labor processes, due to advanced digitalization an automation, and the actual replacements for industrial and service sectors, including the public sphere;
- Third on emerging economic clusters with a high impact on job-creation, especially the new cluster related to the transition towards a low carbon economy. The focus of these studies should lie on the job-profiles, the distributions of high qualified and low or medium qualified jobs, its share of full-time and part-time jobs and other relevant dimensions.

This multitude of in-depth case studies should provide an evidence-based account which of the two conflicting long-term projections for advanced employment systems should prevail with a higher degree of probability in the short and in the medium run.

The next section offers an outline that the coming of Turing societies as a unique event in evolutionary time is accompanied by an enormous amount of other great transformations as well which, due to their scope and dimensions, will change the Piaget societies of the past in enormous and, in many aspects, simply unimaginable ways.

5 TURING SOCIETIES, THEIR IMPACTS ON THE SCIENCE SYSTEM AND SCIENTIFIC RESPONSIBILITY

Turing creatures and their advances in recent decades were also moving very rapidly into the sphere of traditional scientific production processes and into the domain of science writing, text production, editing, calculating, pattern formations, reading, measuring, observing, etc. As an un-intended consequence the scientific work processes shifted from their traditional laboratories of manuscripts, books, pens, pencils, and mechanical typewriters to digital work processes and to digital laboratories.

Moreover, the scientific knowledge base moved from journals, books, research reports, letters and libraries as their main sources to a digital and world-wide distributed knowledge base, which contains published and unpublished articles, journals, books, research reports, which can be accessed by millions of researchers simultaneously and which advanced very much to a digital universal library. Thus, the coming of the Turing societies has successfully

Thus machinery constantly supplants and renders unnecessary that purely manual skill, the attainment of which was, even up to Adam Smith's time, the chief advantage of division of labor. But this influence is more than countervailed by its tendency to increase the scale of manufactures and to make them more complex; and therefore to increase the opportunities for division of labour of all kinds, and especially in the matter of business management" (Marshall, 1961(orig. 1890):IV.ix.3).

transformed the scientific work process and its knowledge base from It-Science to Bit-Science.

Additionally, the science system itself underwent a critical transition as well from the 1940s onward, which has been summarized as transition from Science I to Science II (Hollingsworth & Müller, 2008) and by a significant shifts in levels of complexity and levels of reflexivity (Malnar & Müller, 2015, Müller, 2016).

But the challenges ahead during a period of a uniquely Great Transformation of great transformations are enormous and unprecedented for contemporary science as well. The coming of Turing societies must be viewed in itself as a uniquely rare event in human history where long-term stabilities, trends and patterns no longer hold and the emergence of new phenomena, relations and structures can be assumed for granted only after their manifestations, not before them.

The coming of Turing societies becomes an insurmountable problem especially for the social sciences, due to their in-built structural fixations, the blatant deficits of disciplinary boundaries, the shortage of inter- and transdisciplinary co-operation with the life sciences and the cognitive sciences, and, finally, a lack of societal imagination altogether. The social sciences so far exhibited significant weaknesses in dealing with deep structural or qualitative changes, even when they were to occur instantly. For example, despite dozens of departments and research institutes and thousands of studies on Eastern Europe and on the Soviet Union no serious discussion could be found on an imminent collapse of the Eastern European and the Soviet bloc in the course of the 1980s. Even in the first months of 1989 no increased flow of analyses could be recorded on a growing probability of a dramatic structural break. Instead, numerous studies were produced throughout the 1980s which tried to project the existing systems of relations and structures in the Soviet Union and in Eastern Europe into the medium or long-term future.

More specifically, two major phenomena, confronting the science system and especially the social sciences, must be emphasized, which become evident in the coming of Turing societies and for issues of scientific responsibility.

- First, past developments and stable patterns across economy and society cannot be assumed to hold for the future as well. On the contrary, during this unique Great Transformation of great transformations reconfigurations may occur for which the science system in general has been chronically blind and poorly equipped in the past.
- Second, science must invent new ways, methodologies and synthetic procedures to be more effective in overcoming its blind spots with respect to qualitative changes, emergent phenomena and deep structural changes. As a minimal requirement, science should be better able to see that it cannot see instead of producing seemingly plausible futures.

Dealing with deep structural changes and emergent phenomena still can be qualified as a notorious blind spot for the social sciences in particular and for the science system in general (Byers, 2011). As a consequence, the social sciences dealing with societal changes and the science system in general in analyzing deep or qualitative changes are currently rather poorly equipped when dealing with radically new phenomena and processes on a very-large scale like the coming of Turing societies, outlined in this article.

For the time being, the coming of Turing societies is accompanied with a maximum degree of blindness, ignorance and uncertainty with respect to their possible futures.

6 OUTLOOKS

The coming of Turing societies as a Great Transformation of great transformations requires a radical reconfiguration of the strategies and co-operation patterns of all the relevant stakeholders involved in order to be able to cope with this Great Transformation.

- Science has to search for new pathways for in-depth explorations into deep qualitative changes across the various dimensions of this Great Transformation and into its possible futures.
- Especially important, the social sciences, including history, can no longer rely on long-term historical patterns and trends because they no longer are realistic.

This article itself was an attempt within the science system to specify a sufficiently complex general framework to account for a massive stream of rare, surprising and un-intended events, processes and dynamics, associated with the coming of Turing societies. And it will need, within the framework of scientific responsibility, enormous efforts to transform this general framework across the (co)-evolutionary and geological time scales into likely scenarios and into successful policy experiments with a minimum degree of unintended side-effects and collateral damages.

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