Lučka Kajfež-Bogataj | Karl H. Müller
Ivan Svetlik | Niko Toš (eds.)

Modern RISC-Societies

Towards a New Paradigm for Societal Evolution

E-DOKUMENTI SJM

Modern RISC-Societies
Towards a New Paradigm for Societal Evolution

Edited by
Lučka Kajfež-Bogataj | Karl H. Müller
Ivan Svetlik | Niko Toš

Modern RISC-Societies
Towards a New Paradigm for Societal Evolution

Edited by
Lučka Kajfež-Bogataj | Karl H. Müller
Ivan Svetlik | Niko Toš

E-DOKUMENTI SJM/Ljubljana, 2022

Lučka Kajfež-Bogataj/Karl H. Muller/
Ivan Svetlik/Niko Toš (edited)
Modern RISC-Societies
Towards a New Paradigm for Societal Evolution

First electronic edition

Published by:
Univerza v Ljubljani, Fakulteta za družbene vede, IDV, CJMMK
Kardeljeva ploščad 5, Ljubljana

Ljubljana, 2022

Book Series:
E-Dokumenti SJM 10

Editor: Slavko Kurdija

Layout: Werner Korn

Text edition: Gertrud Hafner

Book edition: Hannah Elmer

Figures and Graphs: Michael Eigner

URL: https://knjigarna.fdv.si/ in www.cjm.si

DOI: 10.51936/9789612950149

Kataložni zapis o publikaciji (CIP) pripravili
v Narodni in univerzitetni knjižnici v Ljubljani

COBISS.SI-ID 101935875

ISBN 978-961-295-014-9 (PDF)

Printed edition was published by Edition Echoraum, Wien, 2010
ISBN 978-3-901941-23-8

Table of Content

To Rogers J. Hollingsworth and to Ellen Jane Hollingsworth
who enabled the formation of the RISC-Program and the
publication of this book.

To Yvonne Lucas (1922–2009) and to
Hermann Müller (1925–2010)
who would have liked to see this book come true.

Foreword

Working in an inter- and trans-disciplinary environment like in the RISC-program (Rare Incidents, Strong Consequences) at the University of Ljubljana requires a coordinated effort by a large number of persons across national boundaries and across different languages. In our case, this co-operation included several faculties at the University of Ljubljana, Ivan Svetlik as vice-rector and, subsequently, Lučka Kajfež-Bogataj from the University of Ljubljana as local coordinators and Karl H. Müller form the Wiener Institute for Social Science Documentation and Methodology (WISDOM) as external adviser. Financial support for the RISC-program was provided by the faculties of the University of Ljubljana and two Austrian ministries, namely the Federal Ministry of Science and Research and the Federal Ministry of Labour, Social Affairs and Consumer Protection (BMASK). Thus, thanks go to –

- Gertrud Hafner in Vienna who was confronted with the difficult tasks of transforming a very heterogeneous manuscript into a homogeneous format and into the new publishing program of the book series
- Ivi Kecman, Anna Polajnar and Manca Poglajen in Ljubljana who served as a vital interface between Ljubljana and Vienna
- Michael Eigner who was mainly responsible for the design and the redesign of the diagrams, figures and graphs in the book
- Hannah Elmer who helped to transform the combined German/English or Slovenian/English manuscripts into homogeneous English texts
- Andreja Kocijančič who as rector of the University of Ljubljana was an active supporter of the RISC-program from its earliest stages onwards
- Andrea Schmölzer from the Federal Ministry of Science and Research who made it possible for WISDOM, to engage in cross-border research activities
- Stefan Potmesil, Richard Fuchsbichler, Roland Hanak and Susanne Schlögl from the Federal Ministry of Labour, Social Affairs and Consumer Protection (BMASK) who continue to provide a stable support for cross-border co-operations with Slovenia
- Werner Korn who acted as an unmoved prime mover behind this book-project and behind the entire series on "Complexity, Design, Society" which has reached already its fourteenth volume
- a remarkably good spirit of stable cooperation and friendship between the editors which has overcome many obstacles and barriers and which will continue to last well-beyond the publication of this book.

This book has been the outcome of trying something new and innovative in the field of inter- and transdisciplinary research on societal issues, past, present and future. Like in most innovative attempts in this area, one should be reminded of three important features of innovation processes in general.

First, Michael Vance stresses the peculiar fact that innovation processes should not be seen as radical departures, but in an intimately close relationship with their old environments.

> Innovation is the creation of the new or the re-arranging of the old in a new way.

Consequently, the new RISC-framework takes large quantities of building blocks from traditional research across the natural or social sciences areas but provides a re-arrangement or, alternatively, a recombinative and integrative design for these many diverse and isolated components.

Second, Sir Francis Bacon [1561–1626], in his "Essay on Innovations," provides another important hint on innovation processes, namely the imperfect nature of the early stages of innovations which applies quite naturally to the emerging RISC-framework as well.

> As the births of living creatures, at first, are ill-shapen: so are all innovations, which are the births of time.

With respect to the future path of RISC-research, Woody Allen gives a consolatory assessment even for the case of failed innovations.

> If you're not failing every now and again, it's a sign you're not doing anything very innovative.

In this sense, the general new outlooks and perspectives on the evolution of RISC-societies, even in the case of their unsuccessful diffusion, remain an honest attempt to address urgent societal problems in a genuinely new way.

It should be emphasized that the present book in its final design fits very well into the overall context of the book series with its emphasis on complexity research or on new research designs, new methodologies or, as an essential element, new perspectives on the evolution of societies.

We sincerely hope that the results of this book enable researchers in the field to widen their current perspectives on societal evolution significantly and to open up new ways for an inter- and trans-disciplinary research of contemporary societies with exciting and innovative results.

Vienna, September 2010

Lučka Kajfež-Bogataj | Karl H. Müller | Ivan Svetlik | Niko Toš

Abstracts

The RISC-Program: An Experiment in Trans-Disciplinary Knowledge Production at the University of Ljubljana

Karl H. Müller | Ivan Svetlik | Niko Toš

Between 2007 and 2009, the University of Ljubljana initiated a trans-disciplinary research program on rare events with strong societal repercussions and effects, which has been labelled the RISC-program (Rare Incidents, Strong Consequences). In this process, the university established a small unit that sought to act as a catalyst for promoting trans-disciplinary research on rare events both inside and outside Ljubljana. Following an international workshop in May 2007, the RISC-unit organized a series of talks, lectures, workshops and research activities, which highlighted the current knowledge frontiers on rare events as well as the available policy recommendations and best practices in reducing hazards and disasters related to rare events. From its overall goals, these RISC-activities were intended as a model for a new type of trans-disciplinary knowledge production that draws together expertise in the social, physical, biological and technical sciences to address urgent societal problems. The present article summarizes both the advances and the shortcomings of these RISC-activities.

RISC-Processes and Societal Evolution: Towards a Common Framework

Karl H. Müller

This introductory article will present an overview of RISC-processes (Rare Incidents, Strong Consequences) and their changing relations and role in the evolution of societies, past and present. The article will make three central claims. First, RISC-processes can be considered as the missing link for an evolutionary theory of contemporary societies. Second, RISC-processes, in conjunction with additional building blocks within the wider evolutionary framework, become necessary and sufficient for a new and comprehensive theory of societal evolution. In this article, a broad outline of this new theoretical perspective on societal evolution will be provided. Third, the current stage of societal RISC-development makes it imperative to reconsider the problem of sustainability. In the light of the preceding RISC-discussion it will be argued that sustainability needs at least three main dimensions which are strictly independent from each other. The first one comprises the widely discussed sustainability issues with respect

to globalization, namely the generalizability of today's advanced development levels to the entire globe, the second one deals with the transferability of natural resources (environment, raw materials, water, air, etc) to future generations and the third main dimension of sustainability, however, must be related to RISC-processes and to the emergence of robust ensembles, resilient linkage structures and flexible support networks which, despite the impossibility to control RISC-processes locally or globally, are able to withstand most of the disastrous impacts of these rare events in the long run.

A Discussion on Zipf's Law

Heinz von Foerster et al.

This article originated at the Macy-Conferences which took place between 1946 and 1953 and which, in retrospection, can be considered as the most important incubator for the subsequent developments of cybernetics, systems theory, artificial intelligence or the cognitive sciences. This particular presentation was made by Heinz von Foerster [1911–2002], an Austrian born scientist who emigrated to the United States in 1948 and who become widely known through his Biological Computer Laboratory [1958–1976] at the University of Illinois. Von Foerster's discussion of Zipf's law took place during the 9th Macy Conference which was held in New York's Beekman Hotel on March 20 and March 21, 1952. Since Zipf's law is just another word for power-law distributions which are in the center of the RISC-program, it is rather obvious why this hitherto unpublished manuscript has been included.
The following group of persons was present at the meeting and participated briefly or extensively in the discussion on Zipf's Law: W. Ross Ashby (Psychiatry), Gregory Bateson (Anthropology), Julian Bigelow (Electrical Engineering), John Bowman (Sociology), Ralph W. Gerard (Neurophysiology), Heinrich Klüver (Psychology), Warren McCulloch (Neuropsychiatry), Margaret Mead (Anthropology), Walter Pitts (Mathematics), Henry Quastler (Medicine and Computer Engineering), Gerhard von Bonin (Neurophysiology), Jerome Wiesner (Computer Engineering) and John Z. Young (Neuroanatomy).

Bubbles Everywhere in Human Affairs

Monika Gisler | Didier Sornette

We review the "social bubble" hypothesis, which holds that strong social interactions between enthusiastic supporters of new ventures weave a network of reinforcing feedbacks that lead to a widespread endorsement and extraordinary commitment by those involved in the projects, beyond what would be rationalized by a standard cost-benefit analysis in the presence of extraordinary uncertainties and risks. Starting with analyses of previous bubbles, in particular the famous "Tulip mania," the social bubble hypothesis is illustrated by the example of the Apollo project. The social bubble hypothesis suggests novel mechanisms to catalyze long-term investments, innovations and risk-taking by the private sector, which otherwise would not be supported.

New Models for Generating Power Law Distributions

Günter Haag

Power-law distribution, rank-size distribution, Zipf's law, hierarchy as a systemic organization into levels, self organized criticality and fractal phenomena are different aspects which may belong to the same coin. New models for generating power law distributions are discussed in order to demonstrate the typical aspects and issues of different modeling points of view. Moreover, some aspects of micro and macro based modeling approaches are discussed and shown. The interpretation of the models and the outputs of the different approaches are open for discussion and further research projects.

RISC-Processes and Their Weak Societal Protection Networks

Karl H. Müller

This article provides an overview on the special relations between RISC-processes and their societal control potentials, be it at the national or at the global level. At the outset, the intricate relations between RISC-processes, controls or governance and forecasting will be discussed in greater detail and the classical equivalence of explanation control and prediction will be effectively abolished. The second major point places special emphasis on the inherent control mechanisms in self-organizing RISC-processes and their necessary failures in critical periods and stages. Finally, the third part of the article points to inherent vulnerabilities of globalized RISC-societies which lie clearly beyond any societal control.

Zipf's Law in Labor Status Transitions: New Insights from Austrian Labor Market Data

Michael Schreiber

Motivated by discussions about competitive strategies of Europe that expect member states to implement flexicurity for employers and employees we present recent findings of research into new methods, tools and procedures for RISC-processes in labor markets. We studied the transitions in the employment status in Austria for a period of six months in 2009 by analyzing monthly data according to three distinctions among target groups: age, gender and education. It turned out that frequencies of changes in employment status followed a power law during these six months. Moreover, the complexity of the status change networks was shown to be reducible by cut-off values that enable schematic classifications of the different groupings.

Self-Reflexive, Contagious, Attraction-Driven Networks (SCANs): Towards a New Transdisciplinary Framework for RISC-Modeling

Günter Haag | Karl H. Müller | Stuart A. Umpleby

This article extends the discussion of the modeling of RISC-processes to new clusters or families of network models which, so far, have not made their way to the core of socio-economic theory and model-constructions. These new network groups can be characterized as self-reflexive and contagiously attractive, *i.e.*, as driven by internal learning and by external imitation processes where contagious attractions become an intrinsic property of the network relations themselves and not an exogenous factor that can influence or disturb network actors. Usually, these networks exhibit multi-level structures and are normally marked by high degrees of observer-dependencies. In the course of this article, a more general class of models will be introduced under the heading of self-reflexive, contagious, attraction-driven networks (SCANs) which can be used for a wide variety of complex self-organizing RISC-processes across nature or society.

The Organizing of Promises: Finance Capital as Tensegrity System

Adrian Lucas

By pandering to promises of controllability, traditional analyses of financial crisis fail, and they fail to the extent that blame is attributed to subjective categories, irrespective whether the subjective scapegoats be the capitalists of Marxist analysis, or investment bankers self-rewarded for arbitraging regulatory frameworks, or over-enthusiastic credit borrowers, or whatever.

This paper instead takes its cue from Le Corbusier's desubjectifying, hence objective, reconfiguration of architecture, and applies Fuller's *tensegrity* concept to configure a more objective, since desubjectivized, analysis of financial capital as an organization of promises, whose immanent topology is that of a self-dynamic tensegrity system.

The Poverty of Economic Explanations

Peter Štrukelj

The aim of this article is to provide a thorough analysis of the current style of economic explanations for the severe global financial crisis from 2007 onwards. Until now, economists were believed to be capable of ex post explanations and, due to the complex nature of the economic system, unable to produce accurate forecasts, despite Karl R. Popper's emphasis on the symmetry of explanation and forecasting schemes.

This article tries to establish that economists, by and large, are incapable of generating reliable and robust ex post explanations. Phrased differently, although these accounts look prima facie explanatory and although their proponents believe that they have accomplished an economic explanation, these economic ex post explanation schemes should not even be considered as explanation sketches, let alone as explanations. Rather, these explanatory accounts are an expression of the nearly perfect blindness of an entire profession vis à vis the evolution of our global economic and financial system.

Weather- and Climate-Related Natural Hazards

Jože Rakovec

Global statistics on weather-related natural disasters show that, of all natural hazards leading to disasters, 90% are linked with meteorological or hydro-meteorological extremes or conditions, and 75% of economic losses as well as 70% of lost lives are due to these events [Golnaraghi, 2008]. A system of forecasts and warnings became operational on the global scale last year, with one part including a system for Europe [Meteoalarm, 2008]. The global system was developed based on a pre-existing one for the Alpine region, which had resulted from a project within the

scope of Interreg IIIb 2003–05. Some Slovenian early weather warnings [ARSO, 2008a] and earthquake warnings [ARSO, 2008b] contribute to it.
An overview of the natural causes and development of these phenomena is given, accompanied by statistics for the whole world as well as for Slovenia. The concept of the early warning system is presented as it regards the global and regional levels.
As an example, the case of the strong precipitation, flash floods and landslides on September 18, 2007 in Slovenia is discussed from the meteorological point of view, showing the main components that caused its severity: the long-lasting advection of warm, humid air ahead of a cold front and stationery convection. The components needed to help with the forecasting of such events and with real-time monitoring are briefly examined.

The RISC Potential of Converging Technologies

Toni Pustovrh

Ever since their earliest inception, science and technology have played an increasingly important role as catalysts of cultural and social change, affecting and shaping human societies and the lives of individuals. In the past two decades, the rapid pace of scientific and technological development has opened many new fields and begun experimental work on numerous applications that may radically alter existing social relationships and structures, as well as challenge contemporary moral and ethical boundaries.
The convergence of technologies, such as those arising from combinations and mutual stimulation among the rapidly growing domains of nanotechnology, biotechnology, information technology and cognitive science, is expected to yield insights and applications with the greatest transformative potential, while having a disruptive effect on existing technologies and on society as a whole [Roco and Bainbridge, 2003; Nordmann, 2004].
Of course it is also possible to claim that such a process in its essence does not represent anything new, since scientific and technological progress has always occurred by combining the findings, tools, methods and insights from a variety of different fields. But there are some aspects of converging technologies that could be seen as having deeply transformative features. Advances in converging nano-, bio-, info- and cognitive [NBIC] technologies potentially offer tools for the direct manipulation of the underlying biological mechanisms of the human mind and body, thus enabling the manipulation of the genome, the "blueprint" according to which each individual's physiology develops. Manipulations of the brain, whether involving molecular interventions in the form of psychopharmacological agents or

the implantation of cybernetic devices, could allow alterations of various cognitive functions of the human mind. Depending on whether we subscribe to a linear or an accelerating view of scientific and technological progress, we could claim that the number of innovations and their sophistication, power to manipulate and scope of influence is also increasing.

The field of synthetic biology can serve as an illustrative example. Synthetic biology (drawing from nano-, bio- and information technology) is currently striving to redesign the constituent systems of naturally occurring microorganisms, so that these can be employed to perform other functions valuable to humans. The anticipated benefits and risks, though at this time necessarily still speculative, are great. Microorganisms that could be engineered to decompose currently non-biodegradable materials such as glass and plastics or break up dangerous chemicals would greatly contribute to recycling efforts as well as to the remediation of polluted areas. Other uses could involve the production of useful materials and medicine, energy generation and the enhancement of human biological systems [Chopra and Kamma, 2006]. The risks could involve unanticipated side effects of interactions with the natural environment or the human body, the development of negative economic or social trends, or the risks emerging from intentional use of such technologies as weapons created for military or terrorist purposes [Boutin, 2006]. The release of engineered pathogens could thus present a catastrophic or even existential risk [Bostrom, 2002].

Another example is the potential ability to engineer offspring with specific physical or cognitive traits, popularly called "designer babies." While truly sophisticated genetic engineering is not yet available, pre-implantation genetic diagnosis already offers the possibility of screening embryos for various genetically-based diseases and selecting those without such disorders. Sex selection was one of the first non-health-related traits offered to prospective parents, while recently The Fertility Institutes announced they would soon be offering selection of complexion, eye and hair color, as well as other customizations as they are made available by scientific progress [TFI, 2009]. These and similar technologies have been praised by some [Savulescu, 2001] as providing deeply transformative benefits, and criticized by others [Fukuyama, 2002] as harboring the potential to destroy human nature and society.

The paper thus presents an overview of some fields and applications of converging NBIC technologies [Beckert *et al.*, 2008] that are expected to have the greatest transformative impacts on individuals and societies in the near future, and it explores some of their potential societal implications, encompassing both risks and benefits, as shown in the examples of synthetic biology and "designer babies." A special emphasis will also be given to global catastrophic and existential risks [Bostrom *et al.*, 2008] potentially inherent in these technologies, as well as to the potential ability of such technologies to mitigate or control the aforementioned catastrophic risks.

Risk, Crises and Control: Between Fear and Negligence

Marko Polič

Risk and crisis, although relatively rare for individuals, are common phenomena in human life. Ulrich Beck has even introduced the concept of a risk society. While the number of studies devoted to risk and crisis is constantly increasing, as is the understanding of these phenomena, this knowledge is still compartmentalized between different sciences, and the gap between the views of experts and those of the lay public is decreasing very slowly, if at all. Quite often, technocratic approaches prevail. Why are people sometimes afraid of matters that are not dangerous, while at the same time they ignore warnings about real dangers? Which risks are tolerable and which will provoke human actions? And what will these actions be?
Awareness of risk and crisis, as phenomena or events that threaten important human values and cause pressure and uncertainty, is necessary for beginning any action. Although actions depend on risk perception, they depend even more on subjective control, culture and social factors like trust or stigma. The mutual dependencies of these factors are discussed, especially the psychological aspects of risk and crisis management—that is, those matters that influence the decision-making and behavior of individuals and groups and depend on their psychological nature. A multidisciplinary and integrated approach will serve as the necessary context for proposing a satisfactory societal response in different emergencies in the sense of Simon's 'bounded rationality' model. Some psychological theories relevant for explaining people's behavior during disasters, which are seen as examples of crisis, are presented. These range from decision-making, bounded rationality, to the changes in the organizations.

Natural and Other Disasters: A Social Work Perspective

Romana Zidar | Mojca Urek | Vili Lamovšek | Nino Rode | Jelka Škerjanc

The majority of models for responding to natural and other disasters aim at harm reduction before, during and after the event through the four-phase model of readiness, risk reduction, response and recovery. Such interventions overlook the importance of community resilience and their ability to cope with such events. Since social work is able to function in unforeseen and unpredictable situations that demand innovative and original solutions [Flaker 2003], the role of the profession can contribute greatly to strengthening vulnerable individuals, groups and communities, when appropriately incorporated in the system of protection, rescue and relief.

Presented research entitled The Analysis and Evaluation of Needs for Social Services in Cases of Natural and Other Disasters in the Municipality of Ljubljana, conducted from 2007 to 2009, focuses on the vulnerability of individuals and groups, the accessibility of institutions and services in times of disaster, the implementation of rights for those affected by disasters, the service coordination, the voluntary initiatives, the non-discriminatory practices, and the sensitivity to the needs of the affected population. In this research we used the concept of sense-making methodology [Dervin *et al.*, 2003]. This methodology enables the individuals who survived disaster, irrespective of their role in it, to reflect on their real experiences; this allows the research to focus on the event itself instead of on the formal social structures and/or societal roles in which the individual operates, as is typically done. The methodology was applied through thirty micro-moment time-line interviews, organized with the model of simultaneous sense-making.

Results indicate that there are deficiencies in the existing formal, semi-formal and informal systems of protection, rescue and relief. Respondents identified as a gap the significant lack of community and social support. Through the research, the authors identified 10 categories of deficiencies: too great a response time, disconcerted performance of some organizations and inappropriate informing of people, lack of available staff or crucial person in some institutions, lack of clearly defined common protocols, lack of criteria for and opacity of relief distribution, imbalance of power and unequal distribution of resources and relief among the population, frequent discrimination and human rights violations, overlooking vulnerable (poor) groups of the population, inaccessibility of different forms of support in the field during and after the disaster, resorting to bureaucracy because of nonexistent protocols, lack of psychosocial support and relief for rescuers.

Secondary Disaster and Social Work

Jelka Škerjanc

In July 2004, in the Upper Soča river valley, Slovenia, the third earthquake in the last 28 years affected the living conditions of the residents. Three main facts have previously defined the support after earthquakes in the Bovec area: the support for residents has not been sufficient; the support has been short-term and focused mainly on the material living conditions of residents, and there has been almost no support for people struggling with their every-day living conditions.

Based on past experiences, the residents feared the reconstruction, claiming that for some of them, the reconstruction was itself another ordeal to be suffered. In a complex situation of extraordinary circumstances, the probabilities were high that the residents' needs would be overlooked and their expertise in their lives ignored. A three-month-long, social work volunteer camp project was set up to support residents in organizing their lives. Volunteer social workers took the side of the residents. From this perspective, the residents' situation became more visible, and some features that generate stress and concerns for the residents in reconstruction after a natural disaster were brought to light.

In the article, we address the roles and characteristics of social work performance in organizing support for residents after a natural disaster. The support was organized according to the individual resident's definition of his or her reality and the need for service provision. The tasks performed were recorded daily according to the methodology that allows further analysis about the following: the needs for citizens in organizing their lives after natural disaster; the roles of social workers in providing support; effects of stakeholders involved; the distribution of power between the citizen and structures involved in reconstruction. The statistical records of the services delivered by the project brought to light the experiences residents had with structures and institutions, political subjects, media, volunteers and charity organizations after being affected by a natural disaster. There emerged an accumulation of stress and trauma generators for residents who have little or no means of support for facing them, for reducing them or for actively coping with them. Every angle that we view the situation of the residents from shows us their loss of power in their lives and the little or no control over the solutions to improve it. At the moment when natural disaster hits citizen reality, along with the consequences that disaster creates, there emerge additional generators of trauma and distress.

The findings also lead to the conclusion that in organizing support for residents after a natural disaster, social work has an important role to play. Its place is with the residents and at their side. From this standpoint, social work acts to support residents, making sure their voices are heard and that they maintain control over the support they receive. Thus, social work has a unique perspective on the residents' situation and on their need for support. The information gathered from the resident's perspective enables the design of original, genuine and creative answers to his or her situation. Since the answers respond directly to people's needs, they are also efficient.

"Tsunami Project:" A Case of a Collaborative Project Between Two Universities

Mojca Urek | Bogdan Lešnik

The paper is a report on the findings of a research camp held in a village on the southern coast of Sri Lanka eight months after the Indian Ocean tsunami. The camp was part of a wider project of collaboration between the University of Colombo and the University of Ljubljana, and its participants were students from both universities working together as a group. The report is mainly focused on the views and experiences of humanitarian aid as expressed by the people of this village. They keenly observed the distribution of aid and saw irregularities and abuses that only increased their distress. Among other issues, they questioned the methodology that caused less visible and socially excluded members of the community to be excluded once again from the distribution of aid, and they particularly resented being forced into submission. The project that started as a summer camp in this tsunami-affected village led to the signing of a Memorandum of Understanding between University of Colombo and University of Ljubljana for academic collaboration in the field of social work. This was followed by introducing social work as a stream within the special degree program in sociology at University of Colombo and by a fruitful exchange of knowledge, students and teachers between both universities.

Seismic Isolation for Asymmetric Building Structures

David Koren | Vojko Kilar

The paper presents the summary of the main results of research work within the framework of the doctoral thesis of the first author performed in the past two years at the Faculty of Architecture, University of Ljubljana. The paper examines architectural-structural particularities of asymmetric buildings in earthquake-prone areas and the possibilities for the implementation of advanced technologies to increase earthquake resistance of such structures. In doing so, it examines new dimensions offered by the use of one such advanced technology (*i.e.*, various devices of seismic isolation such as bearings, dampers, systems for displacement reduction) and their influence on architectural building design in earthquake-prone areas. Conventional design of structures, which is based on ensuring sufficient stiffness, strength and ductility, does not completely prevent the structure from damage. Contrarily, seismic isolation as a modern alternative in earthquake-resistant design offers a possibility of much higher damage protection, yet with much bigger

financial input, which could be justified only for especially important buildings.
In the first part of the paper, the architectural-urban reasons leading to the design of irregular buildings in architecture are determined, and explanations for its unfavorable seismic behavior from a structural point of view are given. Furthermore, the promising results of parametric study on the seismic behavior of structures with different levels of structural asymmetry isolated with lead rubber bearings are presented. The nonlinear dynamic analyses have been performed, and the results obtained have shown that the behavior of base-isolated structures is much affected by the distribution of isolators. It was observed that some distributions favored by common building codes are best only for accommodating the torsional effects in the base isolation system. A significantly different conclusion was found observing the nonlinear behavior of the superstructure, where such distributions might cause more damage in the flexible side of the structure.
In the second part of the paper, a simplified nonlinear method is applied for analysis of base-isolated structures. For this purpose, a new bilinear idealization of the capacity curve for a base-isolated structure is proposed. In this way, the new method is capable of detecting the first damage (yielding point) of the superstructure as well as of estimating the behavior of the superstructure further in the nonlinear range. The results are presented in terms of top and base displacements as well as damage patterns of the superstructure. Comparisons of the results of the simplified method with the 'exact' results of nonlinear dynamic analyses have shown a very good agreement. It has been shown that the presented simplified approach might be a valuable tool for design, analysis and verification of the behavior of seismically isolated structures.
It has been shown in the paper that the correct use of seismic isolation can contribute to freer design of architecture, which is in the interest of both structure and architecture designers. Moreover, the topic discussed is rather interdisciplinary and tries to improve the level of cooperation between architects and other experts. In doing so, it would also make it possible to shift certain interesting architectural concepts from earthquake-safe areas to earthquake-prone ones. In this way, more advanced, more daring and at the same time sufficiently earthquake-resistant architectural designs would be possible to build.

Socio-Economics and a New Scientific Paradigm

Rogers J. Hollingsworth | Karl H. Müller | Ellen J. Hollingsworth | David M. Gear

This paper argues that a new scientific paradigm [Science II] is slowly emerging and is rivaling the Descartes-Newtonian paradigm [Science I], which has been dominant during the past several hundred years. The Science II paradigm places a great deal of emphasis on evolution, dynamism, randomness, chance, and/or pattern identification. As a cause and effect of the new paradigm, scholars in the physical, biological and social sciences are increasingly addressing common problems. Several of these are discussed. In their research, these scholars are using common models, methods, and metaphors. The paper focuses much of its attention on the field of socio-economics as an example of how the newly emerging paradigm [Science II] offers considerable potential for a hybrid field of social science to become more engaged with colleagues in the natural sciences. The convergence of interests across scientific fields has enormous implications for the appropriateness of reshaping the structure of existing universities that encourages high fragmentation, specialization and differentiation, but poor communication across academic disciplines.

Turning Science Transdisciplinary: Is it Possible for the New Concept of Cross-Disciplinary Cooperations to Enter Slovenian Science and Policy?

Franc Mali

In the paper, some theoretical and empirical aspects of scientific trans-disciplinarity are presented. The development of recent post-academic science is characterized by a strong orientation to trans-disciplinarity in science. For example, the whole 'philosophy' underlying the European Research and Innovation Area places a strong emphasis on cross-, inter- and trans-disciplinarity in science. Discussed in more detail in the contribution, the concept of converging technologies represents a new phase in the development of trans-disciplinarity in science. In the paper, the main attention is given to the explanation of some barriers that hinder the realization of the new trans-disciplinarity in science and policy discourse in Slovenia. Here, the new role of the centers of excellence as new intermediary science organizations is highlighted. Namely, the centers of excellence could play an important role in shifting science and policy discourse from disciplinarity to trans-disciplinarity.

Approaches to Interdisciplinary Collaborative Research

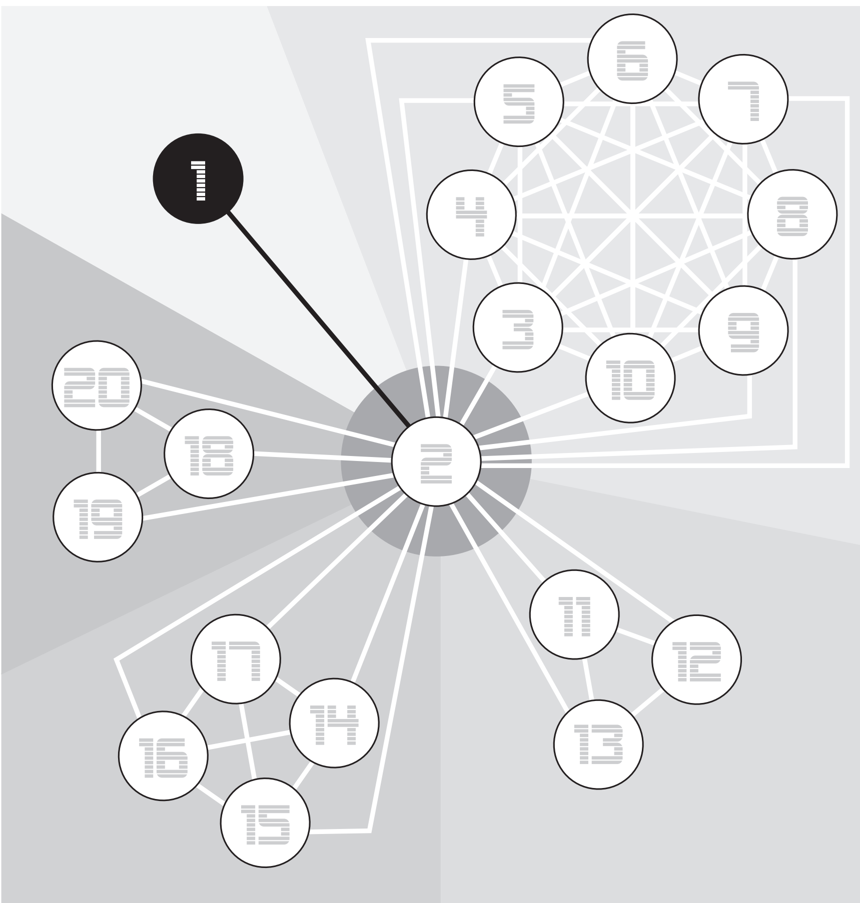
Simona Tancig | Urban Kordeš

The aim of this article is to identify some of the main issues related to inter- (trans-, cross-, multi) disciplinary work on complex problems. The focus is on concepts, theoretical frameworks, practical considerations and challenges, and possibilities of collaborative learning and problem solving.

1

The RISC-Program: An Experiment in Trans-Disciplinary Knowledge Production at the University of Ljubljana

Karl H. Müller | Ivan Svetlik | Niko Toš



The last fifty years of the 20th century as well as the first decade of the new millennium have experienced a rapid and profound re-configuration of the science system as a whole. After a brief summary of these secular changes and phase transitions the article will present an overview of the organization and the outputs of a small research program at the University of Ljubljana which, from 2007 to 2009, ran under the name of RISC (Rare Incidents, Strong Consequences). The rationale for the focus on rare events was that, on the one hand, these rare events constitute a very important problem cluster for contemporary societies and that, on the other hand, rare events, due to their widespread occurrences in societal and natural systems, can serve as a paradigmatic example for a new type of trans-disciplinary knowledge production. Moreover, rare events belong to the class of complex scientific problems which share a number of characteristic features.[1] For instance, rare events with big societal impacts are in most instances difficult or impossible to predict in terms of the time of their appearance as well as of their magnitude. They appear suddenly as a consequence of much longer term development processes. Additionally, these rare events question the conventional wisdom on the close linkages between explanation, prediction and control.[2] Although nearly impossible to predict and very difficult to explain even *ex post*,[3] these rare events can be controlled, nevertheless, in ways beyond traditional scientific explanations or predictions.

1.1 Secular Phase Transitions in Science

Before entering into a detailed description of rare events a general background topic is to be discussed which became an important reference point in the organization of the RISC-program, namely a significant change in the overall science landscape.

At the outset two major phase transition in the overall scientific landscapes will be laid out, albeit in a very brief manner. Currently, the cognitive and organizational landscapes of science are experiencing a secular shift which can be characterized in its epistemological, ontological, theoretical and organizational

1 On complex problems and their characteristic features, see, *e.g.*, Anderson, Arrow and Pines', 1988, Stein, 1989, Casti, 1994, Coveney and Highfield, 1995, Cowan, Pines and Meltzer, 1999, Holland, 1995, Kauffman, 1995 or Rescher, 1998.

2 On the conventional wisdom of the strong ties between prediction, control and explanation, see, for example, Casti, 1989, Popper, 1965 and 1972 or Suppe, 1977.

3 See, for example, the very revealing article on ex post explanations of financial crises by Peter Strukelj in this volume.

dimensions as a transition from Science I to Science II[4] and in its knowledge organization as a change from Mode I to Mode II.[5]

Science I corresponds to the organization of science from its initial modern phase in the 16th century to the 1940s and 1950s approximately. Science I is the long-term period of majestic clockworks, culminating at an early stage with the "Principia Mathematica" of Sir Isaac Newton in 1687. In contrast, Science II operates with blind watchmakers [Richard Dawkins] or, to use another metaphor from Karl R. Popper, works in a configuration of clouds.[6]

The transition from Science I to Science II should not be seen as replacements or substitutions of old homogeneous forms with new ones, but as a transition in terms of hegemony. The first phase from the long 16th century up to the period between 1900 and 1950 is characterized by the dominance of Science I and contained only a few elements of Science II, whereas the second phase from the 1950s onwards can be described as the peaceful co-existence between a dominant area of Science II and a substantial cluster, which remains structured and organized in Science I.

Table 1.1 highlights some of the major shifts from Science I to Science II, which, once again, should be understood as an exchange between center and periphery. Following Table 1.1 more specifically, the following distinctions can be introduced between Science I and Science II.[7]

With respect to theory construction, general and universal laws, while at the core of Science I, move to the periphery of Science II, while pattern formation or pattern recognition, formerly marginally embedded in the domains of Science I, move to center stage of Science II. The leading discipline for Science I is theoretical physics whereas the core areas of Science II are the life sciences, broadly conceived. Science II addresses a large number of common problems, common metaphors, common methods as well as common models and mechanisms which can be identified across a wide variety of disciplines in the natural and in the social sciences. This common domain comprises issues like evolutionary dynamics, structural changes, multi-level organization or morphological issues. George Cowan identified a large set of problems which, contrary to the age of Science I, require the co-operative efforts of scientists across the Great Divides

---

4 See especially Hollingsworth and Müller, 2008, Hollingsworth, Müller and Hollingsworth, 2008 or Hollingsworth, Müller, Hollingsworth and Gear, 2008 and in this volume.

5 On the transition from Mode I to Mode II, see especially Gibbons *et al.* 1994 or Nowotny, Scott and Gibbons, 2001, and Nowotny, 2005.

6 One could make the point that Science I and Science II correspond, at least partially, to the two epistemic cultures, identified by Knorr-Cetina, 1999, namely the closed culture of high-energy particle physics [Science I] and the open trial and error type of micro-biology [Science II].

7 For more background materials, see also Price, 1963 or Rescher, 1982.

of natural, technical and medical sciences on the one hand and of the social sciences and humanities on the other hand.

TABLE 1.1 **Basic Differences between Science I and Science II**

Dimensions	Science I	Science II
Leading Fields of Science	Classical Physics	Evolutionary Biology and the Sciences of Complexity
Theoretical Goals	General, Universal Laws	Pattern Formation and Pattern Recognition
Theory Structures	Axiomatic, Reductionistic	Nested, in Multiple Levels Simultaneously
Research-Programs	Closed Deductive	Open, Recombinative
Heuristic Rules	Induction	Critical Phenomena, Qualitative Change
Units of Method	Causal Relations	Generative Relations
Forecasting Capacities	High	Low
Levels of Complexity	Low	High
Ontology	Dualism	Monism
Epistemology	Observer-Exclusion(“Objectivity”)	Observer-Inclusion
Re-Entries (Self-Reference)	Re-Entries Excluded	Re-Entries Possible
Dynamics	Linear Dynamics, Equilibrium	Non-linear, far from Equilibrium
Types of Distribution	Normal Distributions, Mild Distributions	Power-Law Distributions, Wild Distributions
Potential for Interdisciplinary Research	Low	High
Cognitive Distances between Natural and Social Sciences	High	Low
Leading Metaphors	Clocks	Clouds

Theoretical neurophysics; the modeling of evolution, including the evolution of behavior; strategies to troublesome states of minds and associated higher brain functions; nonlinear systems dynamics, pattern recognition and human thought; fundamental physics, astronomy, and mathematics; archaeology, archaeometry, and forces leading to extinction of flourishing cultures; an integrated approach to information science; (or) the heterogeneity of genetic inventories of individuals [Cowan, 1988:236].

It is interesting to note that the Austrian cybernetician and pioneer in the cognitive sciences, Heinz von Foerster, addressed the issue of the declining hegemony of Science I already in the 1970s and 1980 which, in his assessment, was about to crumble and fade away.[8] For Heinz von Foerster, the classical scientific method was characterized by three general rules which can be found in Table 1.1, too. First, Science I adhered to the rule of objectivity— "the properties of the observer shall not enter the description of his observations" [Foerster, 2003:285]. This rule effectively eliminated selfish designs from the landscapes of Science I. The second rule was described as the rule of induction or of conservation of rules— "rules observed in the past shall apply to the future" [Foerster, 2003:203] and led to the general inability and insensitivity for structural or qualitative changes. Finally, the third general rule was classified as the rule of causality or, alternatively, of necessary and sufficient causes and was characterized by Heinz von Foerster with a sufficiently necessary amount of romantic irony: "Almost everything in the universe shall be irrelevant" [*Ibid.*]. Resting on these three pillars, Heinz von Foerster concluded that the traditional scientific method is "counter-productive in contemplating any evolutionary process, be it the growing up of an individual, or a society in transition" [*Ibid*:204].
Aside from the cognitive phase transition in the theoretical science landscapes, profound changes are occurring simultaneously in the domain of knowledge organization. Here, a phase transition is under way which leads from the traditional modes of knowledge organization along disciplinary boundaries, labeled as Mode I, to a new and trans-disciplinary form of organization under the name of Mode II.[9] It must be stressed that the phases of Mode I and Mode II do not coincide with the two periods for Science I and Science II since Mode II emerges only in the course of the 1980s and 1990s and Mode I does not start prior to the massive "disciplinification" of the sciences during the second half of the 19th century. Nevertheless, both phase transitions should be viewed as complementary,[10] the first one in the cognitive domains of theory structures and leading epistemologies, the second one in the arena of scientific organizations and forms of intra-scientific or science-society co-operations. Table 1.2 highlights the major differences for both forms of knowledge organization.
According to Table 1.2, a substantial shift in knowledge organization is breaking its way. One of the changes, which is common to both phase transitions is the significant increase in inter- and transdisciplinary co-operations [Mode II] and

8 For more details, see Müller, 2007 and 2008 or Müller and Müller, 2007.
9 On these secular shifts, see Gibbons *et al.*, 1994, Nowotny *et al.*, 2000, Nowotny, 1999 and 2005.
10 On the important notion of complementarity, see especially French and Kennedy, 1985, Rozental, 1967 or Söderqvist, 2003.

a significantly increased number of theory—as well as mechanism-, methods- and model-linkages across scientific fields and disciplines [Science II].

TABLE 1.2 **Two Types of Organizing Knowledge Production**

Dimensions	Mode I	Mode II
Knowledge Organization	Separation between context of discovery and application	Basic discoveries in the context of applications
	Separation of basic- science and applied science	Entanglement between applied and basic science
	Focus on disciplinary matrices	Focus on trans-disciplinary problems, patterns, metaphors
Organizational Units	Homogeneous research-teams in stable spatial locations	Heterogeneous Research-teams; Distributed across space
	Long-term orientation	Limited periods, temporary configurations
Quality Control	Peer review, Internal	Wider set of criteria, including extra-scientific elements like societal acceptance, etc.
Extra-Scientific-Domains	Irrelevant	Societal responsibilities and the need for societal consensus formation

> The capacity to cooperate with experts from other fields, to come to see the world and its problems in a complementary way and to emphasize with different presuppositions, involves the capacity to assume multiple cognitive and societal identities ... Biologists working in environmental science, computer scientists in the analysis of gene sequences and mathematicians in ecological modeling can equally gain reputation on both their native and new grounds [Gibbons *et al.* 1994:149].

As can be seen in Table 1.1, one of the main distinctions between Science I and Science II lies in the two dimensions of potential for inter-disciplinary co-operation on the one hand and the distances between the natural and the social sciences on the other hand. Both dimensions change substantially between Science I and Science II. In short, Science II becomes a period with a high potential of inter-disciplinary co-operation and a phase with relatively small distances between the natural and the social sciences, due to a growing stock of common models, methods, mechanisms and metaphors which can be used across various disciplinary fields and due to the change in leading fields from theoretical physics to the life sciences.

1.2 The RISC-Program as an Experiment within Science II and Mode II

The RISC-program at the University of Ljubljana was characterized by a common focus on processes which exhibit a characteristic distribution between a small number of very big events with major effects and repercussions and a very large number of events with very small or marginal effects only. Therefore, the acronym RISC—Rare Incidents, Strong Consequences—has been chosen which, additionally, has the advantage of sounding strikingly similar to the concept of risk. Furthermore, well-established compounds like risk-society, risk-assessments, risk-insurances, etc. can be complemented with the corresponding RISC-notions. RISC-processes can be found in many fields of research and clearly transcend the boundaries of academic disciplines or the big divide between the natural and the social sciences. But it was not only the ubiquity of RISC-processes in geology, finance, migration research or linguistic which was so fascinating to study. The long-term aims of the research program on RISC-processes were

- to find common models, methods and mechanism across the various RISC-applications and, in doing this, establish a strong trans-disciplinary line of co-operations at the University of Ljubljana
- to search for a common framework of societal evolution which would be able to integrate the various disciplinary and trans-disciplinary RISC-work
- to provide the infrastructure for bringing together a number of international experts having experiences in dealing with RISC-processes and enable a reflection and exchange of experiences
- to become an internationally recognized focus for policy making activities in the RISC-arena by identifying major policy issues to be dealt with, possible future research on RISC-related hazards and disasters and new policy approaches.

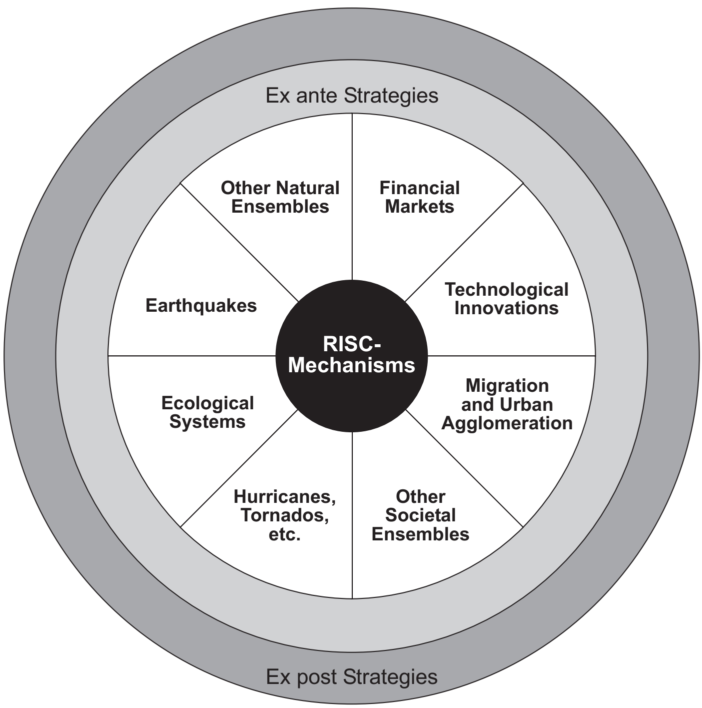
As can be seen from the long-term goals and perspectives, the research program wanted to give, on the one hand, new impulses for trans-disciplinary studies in the social, physical, biological and technical sciences at the University of Ljubljana and, on the other hand, to work on a common theory framework for the evolution of modern societies, past, present and future.[11]

11 For more background materials on the comparative advantages of this type of transdisciplinary organization, see especially Hollingsworth and Hollingsworth, 2000 or Hollingsworth, 2004.

1.3 The Profile of the RISC-Program

Following an international workshop at the University of Ljubljana on May 25 and 26, 2007 with an overview of RISC-processes the research program for the period from 2007 to 2009 was concentrated on institutionalizing a RISC-based agenda that was capable of advancing the state of global RISC-research.
The work areas of a new co-ordinating unit or hub have been laid out already in a programmatic paper, underlying the Ljubljana Workshop[12] and are to be recapitulated briefly. All the activities of the new hub fell into three broad cognitive domains [see Figure 1.1].

FIGURE 1.1 **The Overall RISC-Research Program**



With respect to the theoretical core, it was already noted in the Mission Statement[13] of the new research program that models, methods and mechanisms which generate or account for RISC-processes and a general evolutionary

12 See Hollingsworth/Müller/Svetlik and Toš, 2007.
13 See Hollingsworth/Müller/Svetlik/Toš, 2007, especially page 5.

framework which is able to integrate the various RISC-processes, lie at the core of the RISC-program.[14]

Different applications across different academic fields and disciplines constituted the second group of cognitive tasks. Since RISC-processes can be found in the natural as well as in the social sciences they can be studied in diverse academic fields like economics, sociology, historiography, information sciences, medical research, earth sciences, biology or the environmental sciences.

Finally, the third area in Figure 1.1 covered the overall implications of RISC-processes for the sustainability of contemporary societies. Within the research program policies and plans were developed to cope with large scale disasters or negative effects before they occur, in an effort to prepare societies (ex ante policies). Moreover, attention was given to efforts to sustain a high level of quality of life even in the face of disasters and, consequently, plans and policy suggestions to safeguard societies from disasters (ex post policies).

With respect to the organization of the hub it was envisioned that the overall number of personnel should be very small and limited to the following group of persons.

- First, a high-ranking hub coordinator from the University of Ljubljana was chosen who was well embedded in the communication processes between the different faculties of the University of Ljubljana. This person was responsible to guarantee the annual budget through contributions from the faculties. Professor Ivan Svetlik as vice rector of the University of Ljubljana stepped in to take over this central position. After his move to become Minister of Labour, Family and Social Affairs on November 21, 2008, Professor Lučka Kajfež Bogataj became his successor.
- Second, an external scientific advisor was needed as scientific hub coordinator, who should enable contacts to international networks dealing with RISC-issues. Working part-time, the advisor was expected to focus his activities on the development of the RISC-program. Here, Karl H. Müller from WISDOM in Vienna was invited to take this coordinating position.
- A group of experts at the University of Ljubljana have been selected who acted as a Faculty Advisory Board and who had the important task of disseminating the RISC-program to their faculties.
- Another group of local researchers were to be mobilized who should become the key actors for RISC-research. Ideally, these persons were assumed to be

14 For relevant literature of the RISC-core see, for example, Bak, 1996, Ball, 2004, Barabási, 2002, Beinhocker, 2006, Haken, 1982 and 1983, Jackson, 2006, Jantsch, 1972, Jensen, 1998, Mandelbrot, 2004, Newman, Barabási and Watts, 2006, Sornette, 2002 and 2006, Thom, 1989, Watts, 2003. For the general background, see especially Zipf, 1949.

teachers and researchers from the University of Ljubljana, who already dealt with various aspects of RISC-issues or who might have interest to do so in the future. Their immediate interest should be focused on bringing their students into the emerging RISC-activities and on the development of new research and teaching programs. They were considered as essential for the mobilisation of internal financial resources at the University of Ljubljana.

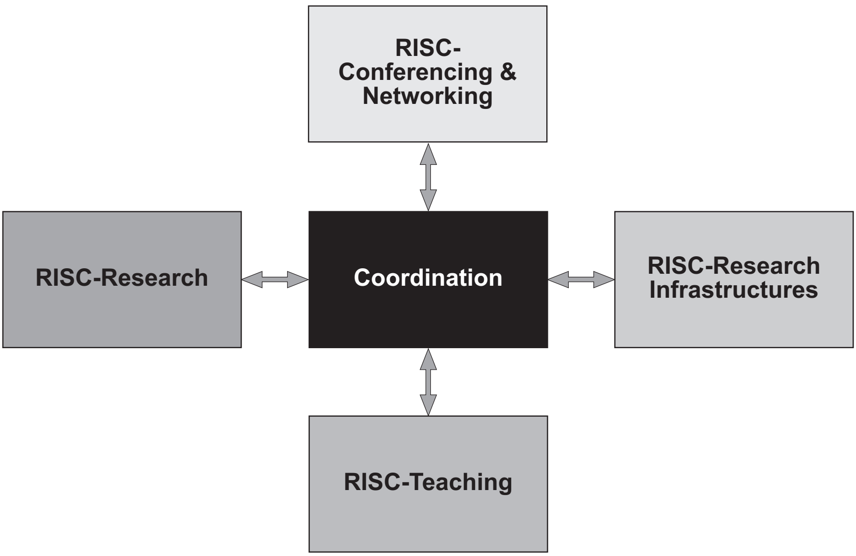
– An administrative and technical support was provided for the two coordinators. This included a part time employee, office, and infrastructure for meetings, workshops and conferences on RISC-processes, other services etc. From October 2007 onwards, Anja Polajnar helped to coordinate all the planned activities, to prepare materials, to manage the web site, to makes travelling and accommodation arrangements, to handle reimbursements etc. From October 2008 until summer 2009, Manca Poglajen fulfilled this role.
– An International Scientific Advisory Committee was set up, composed of several highly regarded foreign and Slovenian experts. The committee should monitor and advice the RISC-program. It assisted in implementing the vision for the new research program, energized the local participants and advised about sources of funding. The members were encouraged also to contribute to the program through lectures or individual advice. The international members from abroad were Professor Didier Sornette from the ETH Zürich, Professor Robert Boyer (Ecole des Hautes Etudes en Sciences Sociales and Centre Pour la Recherche Economique et ses Applications, Paris), Professor Henry Abarbanel (Professor of Physics and Research Physicist (Scripps Institution of Oceanography), University of California San Diego, Director of the Institute for Nonlinear Science at the University of California) and Professor J. Rogers Hollingsworth, from the University of Wisconsin, Madison as speaker of the board. From the University of Ljubljana, Professor Lučka Kajfež Bogataj and Professor Anuska Ferligoj participated in the Scientific Advisory Board.
– The RISC-program was placed in the framework of integrated activities of the University of Ljubljana. Organizationally it was situated in IRI (Institute for Innovation and Development).

This concludes the presentation of the organizational format of the RISC-program.

1.4 Main Groups of RISC-Activities

As already indicated, the RISC-unit was operating in a large number of areas like organizing talks, lectures, small workshops, or preparing a summer school, applying for research projects or counselling political bodies both nationally and internationally on appropriate policies for RISC-processes. As an overview the RISC-program wanted to operate, aside from the coordination activities, in four broad areas which can also be seen in Figure 1.2.

FIGURE 1.2 **The Organization of the RISC-Program 2007–2009**

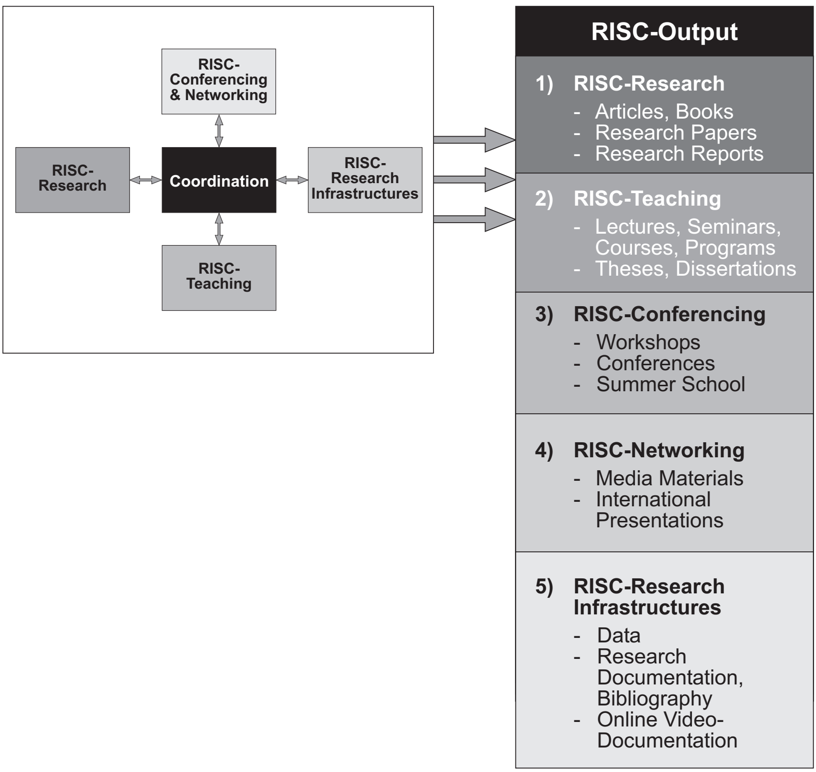


In terms of outputs of the RISC-program, one expected to obtain substantial results in five groups of RISC-activities during the period from 2007 to 2009 which can also be found in Figure 1.3.

RISC-Research and Publications

One of the core tasks of the RISC-program was the building of research communities at the University of Ljubljana across the social, physical, biological and technical sciences. These RISC-research communities were to conduct RISC-research and enhance the local expertise in this field. Leaders of faculties, research groups or centres and existing post graduate study programs were invited to take part in the initiative. The expected effect was to increase the horizontal and trans- disciplinary integration of the University of Ljubljana. Applying for grants on RISC-research at the national and the international level as well as conducting research projects was to become the most prominent type of activity.[15] Moreover, it was expected that a well structured research profile should emerge as a result of the two years activities.

FIGURE 1.3 **The Main Tasks of the RISC-Program**



Thus, by the end of the first period there should be a small number of research reports, resulting from national or internationally organized RISC-projects. Additionally, the RISC-program coordinators were to produce a number of articles and towards the end of 2009 also a book on RISC-processes. Aside from that, the RISC-program invited members of the University of Ljubljana

15 A total of seven research applications have been made to national and international funding bodies (ARSS, ESF, Norwegian Foundation) in the course of the two years. However, the outcome was only marginal and no important research project was approved.

to publish relevant articles or overviews under the new RISC-umbrella. For this purpose, a new series, entitled RISC-Research Series, was founded in January 2008.[16]

Risk-Teaching

The RISC-coordinators organized a series of lectures, seminars and courses by national and international experts as well as small workshops on different aspects of RISC-research on a regular basis. This main purpose of these activities was to explore the possibilities for further research and teaching activities and to mobilize national and international RISC-research experts.
By far the most important activity during the two year period was a regular series of talks and workshops that were organized in intervals of approximately four weeks. Speakers in this series included Henry Abarbanel, Patrick Doreian, Günter Haag, J. Rogers Hollingsworth, Lučka Kajfež Bogataj, Adrian Lucas and Didier Sornette. These mainly international experts on RISC-processes were expected to interact with different faculty members or students for a short period of three to four days. The intended format was a lecture to the interested students and staff, one or more informal discussion-rounds and workshops in different institutes as well as informal meetings with students and faculty members.
A second type of event consisted of small workshops for one or two days. For these workshops, several additional RISC-experts outside the University of Ljubljana were invited as well. The main emphasis of these workshops was concentrated on one of the following topics:

- on modeling and model-related problems of RISC-processes
- on a specific RISC-application domain like financial crises, environmental hazards, etc.
- on RISC-relevant research on hazards, disasters and policy-implications.

Additionally, the hub was working on establishing a summer school on RISC-research. It was envisioned to create this summer school in a two stage process, the first stage as part of an already existing summer school and the second and final stage as an independent annual summer school on different aspects of RISC-research.[17]
Moreover, the RISC-program attempted to mobilize local resources at the University of Ljubljana to support RISC-research by theses and dissertations

16 Currently, nine research reports have been produced in the RISC-series.
17 As a role model one can refer to the Santa Fe Summer Schools in the late eighties and nineties. See, for example, Stein 1989.

across various disciplines and faculties. Graduate and post-graduate students were invited to take part in a RISC-award and three students with relevant RISC-topics have been selected.

Finally, the RISC-unit produced two general outlines towards a graduate and a postgraduate RISC-program as joint degree study programs in cooperation between the University of Ljubljana and other institutions. The postgraduate RISC-program was conceptualized for persons already engaged in research professionally who want to add a special qualification and who want to become RISC-specialists. Both programs were designed to provide special competencies in:

- models and generative mechanisms for RISC-processes across a wide variety of areas
- applying models, methods and data for RISC-analyses
- hazards and disaster prevention
- conducting transdisciplinary RISC-projects.

Finally, one was also contemplating the idea of involving third countries' universities in order to apply to the Erasmus Mundus scheme.

Risk-Networking and Conferencing

One of the important targets of the RISC-program was the organization of knowledge-transfers on RISC-processes to other universities in Europe on the one hand and to the media on the other hand.

With respect to the networking within the university domain, the major target was the diffusion of the RISC-program as a role model for trans-disciplinary research within an university and for a new type of social science or, alternatively, for a new form of addressing serious societal problems. For this purpose, several meetings have been arranged with the European University Association and the design of the RISC-program was presented in several international conferences like the World University Forum.

In the area of media mobilization, the aim was to use national and international media as a carrier to inform the wider public on RISC-issues and on strategies and policies to minimize the impact of rare events. Additionally, counselling local, national or international journalists on appropriate policy measures for taming RISC-related consequences became an integral task of the RISC-media activities.

RISC-Research-Infrastructures

Following Figure 1.3, research infrastructures were the fifth and final group of RISC-relevant outputs. Several of the RISC-research applications were focused on the issue of data and data management for RISC-research. Unfortunately, none of these applications turned out to be successful. As a consequence, the RISC-related research infrastructures were only marginally developed in the course of the two years.

In terms of infrastructure, in January 2008 a web-page on the RISC-program became available which included also the TRASD-homepage, set up for the kick-off meeting in May 2007. The RISC-homepage provided an in-depth documentation of on-going activities and served at least two main important tasks, aside from being a vital communication tool both inside and outside the University of Ljubljana.

- First, all the lectures and seminars were recorded and could be accessed through the RISC-homepage.
- Second, the homepage offered the research papers of the RISC-series for downloads and provided essential information on relevant literature on RISC-processes.

At this point, this short summary of five different types of activities under the RISC-umbrella has come to its end.

1.5 Shortcomings

As it turned out, the RISC-program did not succeed to pass a critical threshold and, to use a terminology from Walt W. Rostow, to launch a "take off" which would have moved it into a stage of "self-sustained growth." A final project application as a nationally funded center of excellence did not succeed.

In our view, three main reasons, the first one cognitive in nature, the second and the third one organizational, can be identified for the failure of the program.

Probably the most important reason for the failure of the program was the inability to mobilize RISC-related research capacities at the University of Ljubljana. On various occasions a general interest was expressed with respect to risk-related issues, but no or marginal interests could be recorded for RISC-issues. One can offer several empirical instances for the claim that no manifest RISC-related research interests emerged in the course of the last two years.

- All in all, there was a total of seven international lectures by specialists in RISC-modeling, most of them physicists, but the overall impact of these lectures in terms of contacts, networking or projects was close to zero.
- The 1st University Workshop showed an interesting risk-related program with presentations on risk-perceptions, floods, droughts, etc. Nevertheless, with the exception of a single presentation from the Jožef Stefan-Institute, not a single RISC-related lecture was presented during the workshop.

- The RISC-award produced a number of interesting risk-related submissions. However, the only RISC-centered submission on co-citation networks was given a low evaluation by the members of the Faculty Board whereas risk-related topics were very favorably assessed.
- The current RISC-volume has very valuable contributions from the University of Ljubljana but all these contributions are situated either in the area of risk-prevention, damage-control or in the area of the methodology of inter- and transdisciplinary research.
- Additionally, not a single long-term research program at the University of Ljubljana has added RISC-related topics into its menu of research goals. In essence, the long-term research programs remained essentially within their discipline-specific boundaries and RISC-issues were not part of any of these programs.
- Finally, the RISC-series was mainly produced by external persons outside the University of Ljubljana. Out of a total of nine papers so far one finds only two Ljubljana papers in the series, one by Lučka Kajfež Bogataj on climate change and one by Peter Strukelj on the weaknesses of economic explanations of the current crisis. Both contributions are very interesting on risk-related or methodological grounds, but do not belong to the core field of RISC-modeling or empirical RISC-research.

In a crucial sense, the RISC-program maintained itself on the semantic ambiguity between RISC as a study of rare events and risk as an inter-disciplinary research field associated with disasters, hazards or accidents. Due to the large research capacities of the University of Ljubljana in the fields of risk-research, the RISC-program was apparently conceived as a subset or as a pure variation of a risk-related program.

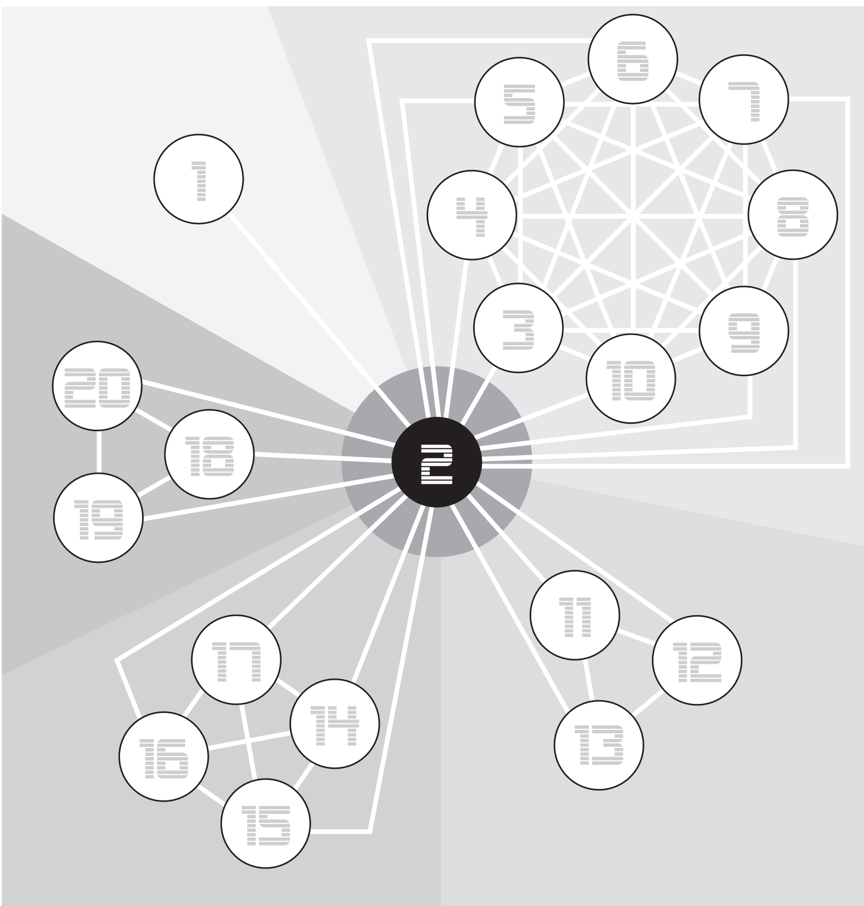
A second decisive element of weakness came about when the RISC-program was initialized. In the beginning, the first programmatic RISC-papers were focused on establishing a RISC-research institute at the University of Ljubljana. Due to funding difficulties, Ivan Svetlik made a very interesting move and the RISC-program became an internally generated activity where several faculties of the University of Ljubljana were to provide a seed money for a period of two years. What remained relatively vague, at this point, were medium and long-term targets and success criteria. With Ivan Svetlik and his strong position as vice-rector these pending issues could be kept implicit or vaguely defined. There was a general understanding that the RISC-program should have, on the one hand, international lectures, workshops or publications, and should generate, on the other hand, new inter-disciplinary research projects for the University of Ljubljana. Aside from this general understanding, no explicit targets have been

fixed and, especially important, no procedures have been discussed for the case that these general goals cannot be reached through the available instruments of lectures, workshops, publications.
The third component for the failure of the RISC-program emerged after the transition from Ivan Svetlik to the Slovenian Ministry of Labour, Family, and Social Affairs. At this point, the targets of the RISC-program as well as the function and the task distribution of all relevant actors should have been made explicit to and for all relevant participants. This should have included the role of and the financial incentives for the new RISC-coordinator of the University of Ljubljana, the role and the requirements of the Faculty Board and, finally, the role of the external scientific advisor. As a consequence, the weak governance structure became even weaker and the overall goals of the program became even less clear and diverse.

1.6 Future Outlooks

The present volume offers a first overview not only on the potential of RISC-research, but also on the potential of RISC-research as a new form for the study of contemporary societies. The subsequent article on the dimensions and the long-term evolution of global RISC-societies can serve as an evaluation instance whether the scope of the RISC-program was intrinsically too small and theoretically too restricted or whether the analysis of RISC-societies could and should become a new recombinant societal science to address important societal issues in a broader, more inter- and trans-disciplinary and, equally important, more interventionist manner.

Part I — An Overview on RISC-Research



Introduction to Part I: RISC 101 or a Primer on the New RISC-Framework for Societal Evolution

The introduction to Part I will deviate from the usual form of introductions in this volume which will be focused almost exclusively on the content of the articles included in the various parts. Within the present introduction however, a short summary will be given of the new framework for the study of societal evolution which runs under the name of RISC-framework.

The initial article has already indicated that the RISC-program was a two year effort at the University of Ljubljana to increase the inter- and trans-disciplinary communication across the widely distributed faculties across Ljubljana. The common topic consisted in the study of rare events across a wide variety of fields and academic disciplines and RISC (rare incidents, strong consequences) was the intentionally ambiguous name for this endeavor.

On the basis of the various workshops, lectures and publications during these two years, a new theoretical framework gradually emerged, which should shed fresh light on processes of societal evolution in the long run. Subsequently, a summary of important building blocks of the RISC-framework will be laid out which constitute this new research program or, more adequately, this novel research tradition.

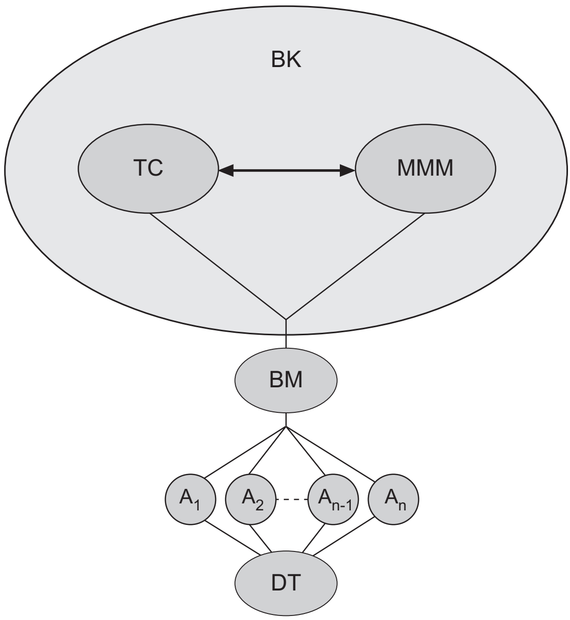
The RISC-Framework as a Comprehensive Research Tradition

Before going into the different RISC-building blocks in more detail it is useful to describe the requirements or ingredients of empirical research programs on the one hand and of larger research traditions on the other hand. Figure I.1 shows the typical modules or building blocks for empirical research programs like a theoretical core (TC), a set of methods, models and mechanisms (MMM), linked to the theoretical core, the embeddedness of TC and MMM within a wider background-knowledge BK, the bridge-modules BM which link the theoretical domain with applications, a class of paradigmatic examples A_1 to A_n, *i.e.*, applications of TC, MMM and BM on observable or actually observed processes as well as an underlying class of observations, data and measurements (DT).[1] In Figure I.1, no arrows have been used in order to stress the duality of top-down and bottom up flows. Theoretical concepts, generative mechanisms

1 As a relevant selection from the philosophy of science literature, see Balzer/Moulines/Sneed, 1987, Curd/Cover, 1998, Bunge, 1998, 2002, 2003, Donovan/Laudan/Laudan, 1988, Ludwig, 1990, Schurz/Weingartner, 1998, Salmon, 1998, Sneed, 1991 or Stegmüller, 1981.

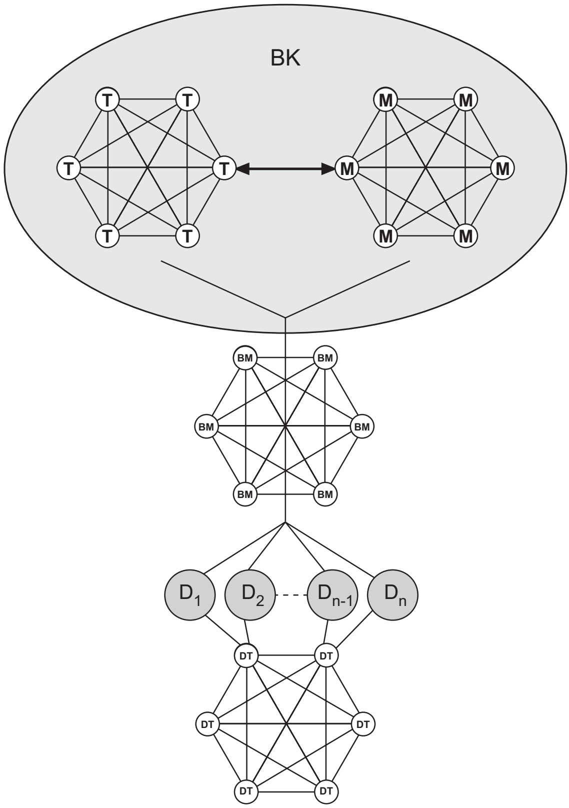
or transfer-modules are as much shaped by the DT-segment as observations, methods and data are determined by the theoretical core, the MMM-segment or the BM-domain.

FIGURE I.1 **Mapping Empirical Research Programs**



Research traditions can be described as a network of research programs and can be visualized in the way of Figure I.2. Here one can see networks of theoretical cores T, of methods, mechanisms and models, of bridge modules M on the one hand and a rich network of different classes of observations, methods and data (DT) and a network of wider application domains (D) on the other hand. The application area changes into larger application domains D_1 to D_n where each domain captures a set of paradigmatic examples. The RISC-framework, due to its large set of application domains and to its heterogeneous composition of theories, generative mechanisms or models, can best be characterized as an emerging trans-disciplinary research tradition. The application domains D_1 cover unusually wide areas, ranging, as the introductory article already indicated, from earthquakes, forest fires or sun-flares to income distributions, financial markets, migrations and settlements or the evolution of languages.

FIGURE I.2 **Mapping Empirical Research Traditions as Networks of Research Programs**



At this point the various components of the RISC-research tradition will be summarized briefly, using the format of a RISC-introductory course or a RISC-primer with a small number of basic propositions for each relevant RISC-segment.

The TC-Networks of the RISC-Framework

1) The RISC-approach relies on four main theory groups, namely on a general theory of networks, a general theory of systems, a general theory of self-organization with a special emphasis on critical phenomena or structural changes and, finally, on a theory cluster from the cognitive sciences with a special focus on situated or embedded cognition.[2]

2 See, for example, Adams/Aizawa, 2010, Augoustinos/Walker, 2001, Clark, 1998, 2001 and 2008, Fiske/Taylor, 1991, Noe, 2006, Pfeifer/Bongard, 2007 or Robbins/Aydede, 2008.

1.1) The emphasis on general theories of networks, systems, of self-organization and of situated or embedded cognition becomes necessary since these four theory groups comprise a set of different special theories which vary in their theoretical core or in their MMM-domains. For example, the general theory of networks includes different potential network formations like flow networks and relational networks or random networks and scale-free networks.

1.2) The relations between a general theory of networks and of systems should be understood in the following way. Both theory groups are considered as strictly equivalent and irreducible to each other. Both theory groups are powerful description devices for the societal and natural worlds and should be used according to criteria like adequacy, epistemic utility or cognitive viability. Systemic approaches are primarily required wherever boundaries, boundary conditions, closures and environmental interactions become of central importance. Likewise, network approaches are to be preferred when boundary issues are mostly irrelevant and when the main emphasis lies on the interactive micro-dynamics of a specific configuration.[3]

1.3) Each of the TC's of special theories of networks, systems, self-organization and situated cognition constitutes a node in the TC-network. Figure I.2 indicates already that the theoretical core of the RISC-framework should be viewed as a network of TCs from network, systems, self-organization and cognitive science theories.

1.4) In general, the general theories of networks and of systems can be seen as the most general description devices within the RISC-framework, whereas the theories of self-organization become relevant for the specification of the structures of networks or systems.[4] The theories of embedded cognition serve as the necessary micro-foundations for societal RISC-mechanisms and processes and for the subjective side of RISC-perceptions, expectations and actions.

1.5) The background-knowledge (BK) of the RISC-framework lies, therefore, in more general theories of space and time, of sub-atomic, atomic or molecular composition and dynamics or of general theories of evolution and of self-organization.

3 Of course, it would be possible to classify systems and networks in a different way, for example by characterizing networks as the more general configuration and systems as subsets of networks. This would imply, for example, that elementary systems like input-output systems would have to be classified as strongly reduced networks with basically one node only. Since systemic descriptions are well established across scientific disciplines, such a sub-set relation would violate the well-embedded usages of systemic concepts and apply network formations in domains where basically all ingredients for networks are missing.

4 For a very useful summary of the core concepts of a general theory of systems, see, for example, Bunge 1978, 1979 and for a systemic epistemological outline 1983a and 1983b.

1.6) In general, the RISC-framework places special emphasis on non-trivial theory compositions and recombinations. This means that only those components from the general theory of embedded cognition should be included which are based on (self)-reflective or state-determined practices and routines.[5]
1.7) The stock of available theories of societal differentiations and of the long-term historical dynamics becomes partially and selectively integrated into the network of bridge modules (BM) of the RISC-framework.

The Network of Mechanisms, Methods and Models within the RISC-Framework

2) With respect to mechanisms,[6] methods and models, the main focus in the RISC-framework lies in the specification of generative mechanisms and its corresponding models. Generative mechanisms must fulfill the following basic requirement. They must be able to specify how the interaction between micro-units produces or generates a specific macro-process which in the case of the RISC-framework must be a process with a power-law distribution. Generative mechanisms are to be understood as generic and qualitative explanation sketches. The RISC-framework provides a comprehensive set of generative mechanisms both within societies and in the environment of societies. The former are to be classified as internal RISC-mechanisms, the latter as external RISC-mechanisms.
2.1) Within the internal or the societal side of RISC-mechanisms, a special emphasis is placed on two generative mechanisms, one in the sphere of economic production and one in the field of knowledge production.
2.1.1) For the side of economic production, the RISC-framework provides the specification for a capitalist network formation with a large number of micro-units, with average profits as long-term reproduction requirement, and with innovations, very broadly understood, as central internal disturbance components.
2.1.2) For knowledge production, the science network can be characterized in its composition by a large number of micro-units, by a multiplicity of research programs and research traditions, by an average problem-solution capacity as long-term reproduction requirement for research programs and research

5 For more information on state-determined schemes of embedded cognition, see especially the article by Günter Haag, Karl H. Müller and Stuart A. Umpleby "Toward Self-Reflexive Forms of RISC-Modeling" in this volume.
6 On the seemingly contradictory notions of social or societal mechanisms, see, for example, Hedström/Swedberg, 1995, Schmid, 2006 or Schmidt/Florian/Hillebrandt, 2006.

traditions, and by scientific innovations, widely understood, as the central internal disturbance elements.
2.1.3) These two RISC-mechanisms, the one for economic production and the one for knowledge production, should be specified as coupled or linked. They operate, thus, in a coevolutionary fashion and are situated at the core of societal RISC-processes and their long-term coevolution.
2.2) Aside from the two generative RISC-mechanisms for economic and knowledge production, societies are characterized by a multiplicity of additional RISC-mechanisms in areas like migrations and settlements or in the cultural and artistic spheres.
2.3) For the external or the environmental side of RISC-processes, one finds a large number of independent RISC-mechanisms like tectonic plates and their dynamics or ecological systems and their long-term development patterns.
2.4) Furthermore, RISC-mechanisms can be specified across the five layers of the Earth's atmosphere, namely in the troposphere, the stratosphere, the mesosphere, the thermosphere and the exosphere.
2.5) Relevant RISC-mechanisms are distributed outside the Earth's atmosphere as well and processes like the permanent inflow of cosmic material, including large-sized meteorites, should be seen as the paradigmatic example for an external RISC-process outside the Earth's atmosphere which has produced and still can cause a massive impact for regional societies and the global environment.
2.6) Each of these internal or external RISC-mechanisms can be characterized by a variety of RISC-models and each RISC-model, iin turn, can be used for a variety of RISC-mechanisms. For example, model groups like self-organized criticality (SOC), complex networks (CN) or master equation networks (ME)[7] can be used for the modeling of a variety of internal and external RISC-mechanisms.
2.7) With respect to common methods, the statistical theory of extreme events constitutes the central component within the RISC-framework.[8]

Bridge Modules (BM) for the Study of Modern RISC-Societies

3) Due to wide diversity of application domains, bridge modules play an important triple role in the formation of the RISC-framework. These bridge modules serve three main purposes. First, they provide the guidelines for the

7 See, for example, the article by Günter Haag "New Models for Generating Power Law Distributions" in this volume.
8 As a relevant reference, see for example, Embrechts/Klüppelberg/Mikosch, 1996 or Resnick, 2007.

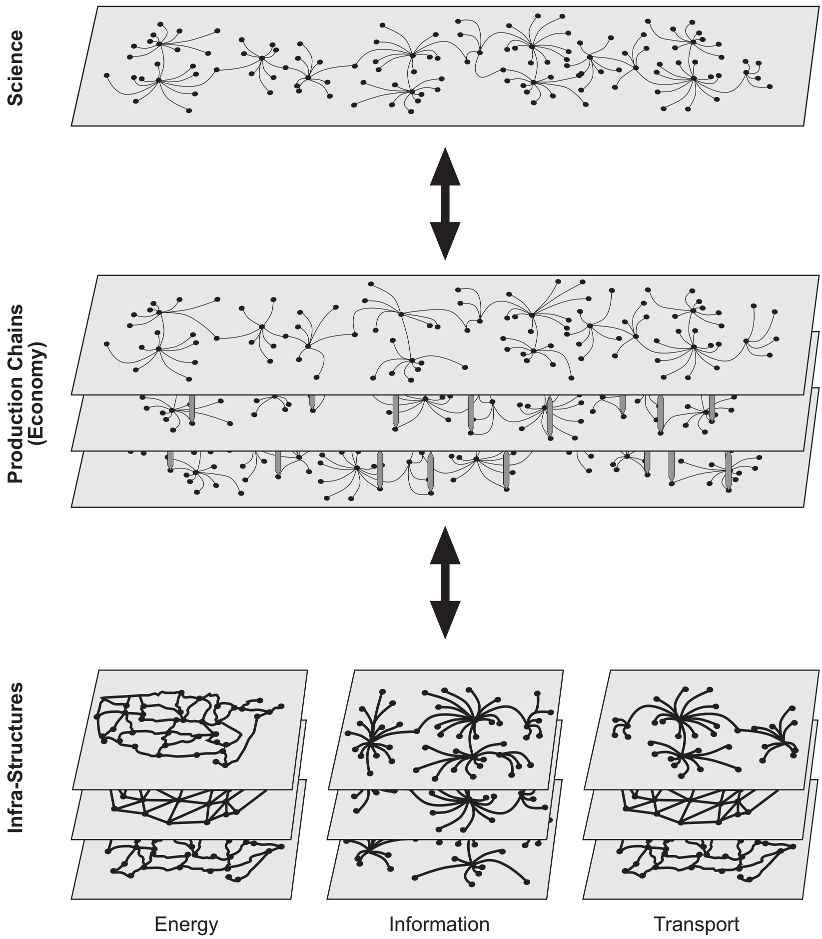
specification of a new architecture for contemporary societies. Here, these bridge modules must identify the constituent elements, the structures and, especially important, the inter-linkages and the coevolution between these constituent components. Second, along the vertical axis of Figure I.2, these bridge modules must establish the necessary theoretically mediated descriptive and historical accounts for a RISC-application domain D. Third, along the horizontal axis of Figure I.2, the bridge modules provide the necessary horizontal connections between various RISC-application domains as well.

While in traditional approaches the specification of bridge modules for internal and for external RISC-processes is undertaken independently from each other, the RISC-framework puts heavy emphasis on the coevolution of internal and external RISC-processes which should be reflected in the construction of bridge modules as well. Thus, the horizontal components of bridge modules become of special importance since they specify the inter-linkages between the societal domains on the one hand and various groups of external RISC-networks or systems on the other hand. Within the RISC-framework, a relatively large number of modules is needed which, in conjunction, forms the network or RISC-relevant bridge modules.

3.1) The most important bridge modules for the RISC-framework lie in the specifications for a new societal architecture which can be classified, inter alia, as the infrastructural constitution of societies [see also Figure I.3]. Modern RISC-societies should not be specified, as in traditional perspectives, as a composition of functional systems or networks for economic production and distribution, for the political sphere, for the science field, for cultural fields, the life world domains, etc. Rather, the internal domains of modern RISC-societies should be conceptualized as a tripartite configuration, composed of (1) a variable number of functional systems or networks for economic production, for knowledge production, culture and arts, media, household (re)production, etc., (2) by infrastructural networks or systems in the three domains of energy, information and transport and (3) by RISC-protection networks or systems, understood in an unusually wide fashion.

3.2) A first bridge module is needed for the class of production or functional networks or systems with a large number of internal RISC-processes. These functional or production networks or systems lie in the sphere of economic production and distribution, educational production, knowledge production, household (re)production, news and entertainment production, arts and cultural production, health production and the like. Aside from the domains just mentioned, modern RISC-societies can be described by any re-combination of these ensembles, too. With respect to the bridge module for the economic sphere, a special emphasis should be laid on the level differentiation in the economic sphere and on the phenomenon of vertical or horizontal production chains where economic production and distribution processes are organized at three levels, ranging from agriculture and raw material extraction (primary level) to industrial production (secondary level) and services (tertiary level).[9]

FIGURE I.3 **The Infrastructural Constitution of RISC-Societies**



3.3) A second bridge module must be focused on ensembles in the three infrastructural spheres of energy, information and transport. These infrastructural networks or systems are organized in an accumulative mode where a new infrastructural network or system operates in conjunction with already existing

9 See, for example, Fischer/Reiner/Staritz, 2010, Froebel/Heinrichs/Kreye, 1977 or 1986.

ones. In general, infrastructural networks or systems are not crowding out or substituting previous ones. As an important element in the specification of the infrastructural bridge modules, a special emphasis must be devoted on the co-evolution of these three ensemble groups and on the bottlenecks and shortages in a specific infrastructural segment, due to large-scale innovations in another infrastructural segment.

3.4) The third bridge module is devoted to the area of RISC-protection networks or systems which cover a wide class of ensembles which, in the spirit of Karl Polanyi,[10] can be seen as the societal protective belt which limit and contain the detrimental consequences of RISC-mechanisms in the production networks or systems. Following Karl Polanyi, the political system or network, NGOs or the civil society in general belong to the RISC-protection networks or systems. An important class of RISC-protection networks or systems consists in those ensembles that deal with the catastrophic consequences of rare events of external RISC-mechanisms and processes like droughts, floods or earthquakes. It seems very useful to treat the available societal support-capacities as an important sub-segment of the RISC-protection networks under the name of RISC-support networks or systems.

3.5) The fourth bridge module is concentrated on the overall structures, forms or designs of these three large societal ensembles. Here, the following guiding principles become relevant.

3.5.1) First, the infrastructural networks or systems in the three domains of energy, information and transport enable and constrain the unfolding of societal networks in their energy, information and transport potentials and capacities.

3.5.2) Second, functional systems and networks of production on the one hand and RISC-protection systems on the other hand should be specified according to a homeostat[11] model where the RISC-protection networks assume the role of an under-critical regulator R^{PROT}.

3.6) The fifth bridge module covers the subjective or the human side of networks and ensembles. Contrary to Jürgen Habermas' separation between systems and life worlds, the RISC-approach stresses a variety of specification possibilities for networks and systems and points to the possibility for exclusive, trivial and highly inclusive non-trivial network or systems specifications. In short, the four bridge modules can be based on trivial mechanical models without any subjective or life world-components to them, on models with trivial action schemes like rational action or bounded rationally and, thus, of restricted or stylized life

10 See, for example, Polanyi, 1978. And for the Polanyi-configuration of networks or systems of production and for protection, see, for example, Müller, 1995.

11 On the model of the homeostat, see especially Ashby, 1957.

world-elements or, finally, on models with non-trivial action schemes which are based on the stock of theories on situated cognition. The last group, while highly complex, is able to account for life world components in their fullest form.
3.7) Additional bridge modules are required, obviously, for the empirical domains of external RISC-mechanisms and processes as well. For each of the larger application domains from Table 2.1 in the subsequent article on "RISC-Processes and Societal Coevolution" like earth quakes, epidemics, environmental systems or forest fires, but also for atmospheric RISC-processes in the form of tsunamis, floods or droughts specific bridge modules are needed which provide the general specification guidelines for RISC-applications.

Observations, Measurements and Data (DT) for the RISC-Framework

4) The RISC-approach is focused on the totality of processes with a power law distribution and the network of observations, measurements and relevant RISC-data (DT) cover, thus, three very heterogeneous functional classes of information.
4.1) In general, the overall data network DT comprises both quantitative and qualitative data and includes different media like official macro-data, panels and surveys, documents, observation reports, diaries, pictures, films, etc. These different and heterogeneous sets can be qualified as DT-components of the RISC-DT-network.
4.2) The first functional data class comprises all DT-components which are needed for the statistical and for the model analysis of internal and external RISC-processes.
4.3) Aside from data sets for power law distributions as the constitutive empirical units of the RISC-framework, one must add a second functional class of relevant DT-components on the long-term coevolution of the three societal segments, namely functional production networks and systems, the three infrastructural networks or systems on energy, information and transport and the RISC-protection networks or systems, including the special segment of RISC-support networks or systems.
4.4) A third relevant functional class of DT-components is needed for the inner and the outer environments of modern RISC-societies and their long-term development or coevolution.
4.5) The RISC-framework, due to its heterogeneous DT components and due to its reliance on three functional sets of relevant DT-components, poses new challenges for data integration and data management which have to be solved along the unfolding of the RISC-framework as a trans-disciplinary research tradition. However, the problems of DT-integration are generic ones and apply to all trans-disciplinary research traditions with heterogeneous DT-networks.

Paradigmatic Applications for the RISC-Framework

5) The application domains of the RISC-framework can be summarized in two alternative ways, namely according to the different domains of RISC-mechanisms and processes or according to two very broad problem domains, namely with respect (1) to a very comprehensive notion of sustainability on the one hand and (2) to a RISC-based concept of viability on the other hand.
5.1) The separation according to the domains of RISC-mechanisms and processes can be conceptualized in the format of an additive list and Table 2.1 in the subsequent article provides such an overview of RISC-application domains.
5.2) Along the second perspective of RISC-applications, two very broad and general problem domains stand in the center of RISC-applications, namely sustainability and viability. Both domains must be separated into several principal dimensions each. Moreover, these sustainability and viability dimensions cover core problems with respect to the medium and long term maintenance and survival of contemporary RISC-societies.
5.3) Viability and sustainability of modern RISC-societies and their principal dimensions should be viewed as strictly independent from each other since RISC-societies may be RISC-sustainable and not RISC-viable—and *vice versa*.
5.4) The problem of sustainability of modern RISC-societies is dependent on three principal dimensions, namely on sustainability (1) with respect to the globalization of currently advanced production systems, (2) with respect to future generations and (3) with respect to RISC-robustness. Each of these dimensions is strictly independent from each other and the space of sustainability dimensions covers almost any recombination of specific sustainability states in each dimension. The central research problem with respect to the sustainability of modern RISC-societies addresses the feasibility of trajectories or of drifts towards high sustainability levels across all three sustainability dimensions.

TABLE I.1 **A Typology of Modern RISC-Societies**

		Viability	
		Low	High
Sustainability	Low	Type I	Type II
	High	Type III	Type IV

5.5) Turning to the problem of the viability of modern RISC-societies the main emphasis lies on two principal dimensions, namely (1) on the subjective evaluations and assessments in core areas like overall life-satisfaction, happiness or quality of life and (2) on institutions of basic or fundamental rights and their actual performance levels. Thus, the central research problem with respect to the viability of modern RISC-societies is focused on the feasibility of trajectories or of drifts towards high viability levels across the two viability dimensions.

5.6) Aside from these two general core problems and applications, RISC-applications should provide at least partial answers to the two core problems of sustainability and viability. For example, studies of financial crashes or floods should be discussed alongside their sustainability and viability impacts.

5.7) The RISC-framework can be seen, thus, as an emerging research tradition which opens new perspectives and produces new solutions with respect to the sustainability and to the viability of contemporary societies which recombines large segments of scientific fields in the natural and in the social sciences which, so far, treat their domains of investigation in splendid isolation from each other.

The Long-Term RISC- Perspectives on Societal Evolution

6) So far, the coevolution of RISC-societies can be described in three long-term stages where each stage is characterized by a unique distribution of RISC-mechanisms and processes.

6.1) The first stage of RISC-societies was characterized by the absence of RISC-mechanisms in the sphere of economic or knowledge production and by strong impacts of external RISC-processes. The dominant societal systems or networks were situated in the political sphere. Moreover, the world was separated into a configuration with a number of societal islands surrounded by a natural RISC-environment whose impact for economic production in agriculture was strong and direct. The first stage comprised RISC-societies of varying degrees of complexities, including world empires of limited regional scope and covers the entire period of human history prior to a critical transition phase in the 14^{th} and 15^{th} century.

6.2) The second stage in the evolution of RISC-societies starts with the long 16^{th} century and brings the implantation of two societal mechanisms which, in combination, generate a variety of societal RISC-processes. Thus, the second stage sees the irreversible diffusion of the capitalist mode of network and system formations in the domain of economic production and of the science mode of network and system formations in the area of knowledge production. The second stage comes to an end approximately in the decades between 1900 to 1950 when the global diffusion of these two RISC-mechanisms has reached its regional limits.

6.3) The third stage of RISC-societies starts around 1945 and is characterized by new features like global economic micro-units in the form of transnational enterprises and of global actors in the RISC-protection systems or networks like the United Nations, the World Bank or the International Monetary Fund (IMF). The three most relevant new elements, however, come from the domain of RISC-mechanisms and processes.
6.3.1) First, a rare event in technological innovations is focused, for the first time, on the infrastructural networks and systems for information and brings about an enormous increase in network densities both at global and at local scales.
6.3.2) Second, internal and external RISC-mechanisms become linked and coupled in unprecedented ways and the internal RISC-engines exert their impacts on the external RISC-dynamics and vice versa. The most striking example of coupled RISC-processes runs under the heading of climate change where the outputs of the capitalist RISC-engine and its related societal production networks or systems change the composition of the atmosphere in a critical manner and alter, thus, the distributions for atmospheric RISC-processes like floods, droughts, tsunamis, hurricanes, tornados, etc.
6.3.3) Third, these new external RISC-distributions, in turn, have a direct impact on internal RISC-processes, most notably on the capitalist RISC-engines in areas like finance, insurance, but also in agricultural production and across the different levels of the production chains.
6.3.4) Thus, the third stage of RISC-societies can be described with attributes like high levels of complexity, unpredictability, emergent phenomena or a growing number of un-intentional effects.

Central Theoretical Propositions of the RISC-Framework

7) The dynamics, the sustainability and the viability of modern RISC-societies results from the interplay of external and internal RISC-mechanisms and, correspondingly, from the distribution of internal and external RISC-processes and from the capacities of RISC-protection networks or systems.
7.1) Internal RISC-mechanisms are embedded in three main network groups or systems, namely, first, in the multi-level economic production and distribution networks or systems, in the knowledge production networks or systems and in other functional societal production ensembles, second, in the infrastructural networks or systems for energy, information and transport and, third, in the group of RISC-protection networks, including the RISC-support networks for prevention and damage control. During the second and the third stage of RISC-societies, both the inter-linkages between these three large-scale societal segments and between internal and external RISC-processes have increased significantly and continue to increase.

7.1.1) With respect to internal RISC-mechanisms, very large-scale innovations in the field of economic or knowledge production should not be seen in the usual way as long swings or cycles, but as rare events and as the outcomes of a RISC-mechanisms in the sphere of economic or knowledge production.
7.1.2) Consequently, very large scale technological innovations happen, due to their very high diffusion potentials, in one of the three infrastructural networks or systems for energy, information and transport. Moreover, large scale innovations, medium innovations and small-scale innovations should be specified in a generative mode where large scale innovations provide the basis for medium or small-scale innovations and small or medium scale innovations give rise to large-scale innovations. Similarly, rare events or large-scale scientific innovations should be specified in a generative network of small-, medium- and large-scale innovations.
7.1.3) The substitution potential of the global configuration of RISC-societies, due to higher network densities or systemic links, is growing substantially. In terms of network densities or systemic links, the global RISC-ensemble achieves, thus, higher level of S-robustness where S stands for substitution.
7.1.4) Conversely, the accumulation of scale-free networks in the infrastructural domains of transport and information leads to lower levels of RISC-NC-robustness where N stands for network nodes and C for systemic components. Phrased in network terms, the collapse of only a few central nodes, due to the high linkage densities across the infrastructural and societal domains, could lead to extremely serious effects for the maintenance of modern RISC-societies as a whole.
7.2) Due to the coupling of internal and external atmospheric RISC-processes both contemporary RISC-societies and their environments are entering a period of increasing stress.[12]
7.2.1) The increasing societal stress results from the fact that societal systems or networks operate on average events and smaller or larger deviations from relatively constant average events, and not on shifting averages. These shifting averages, however, are the necessary by-product of the new stage of coupled internal and external atmospheric RISC-processes.
7.2.2) Likewise, the growing environmental stress is due to the fact that the boundary conditions for environmental actors are changing more rapidly and, in many instances, cross critical survival and reproduction values for environmental actors.

12 For an interesting background on integrated societal-environmental couplings, see Holling, 1978, Gunderson/Holling, 2002, Gunderson/Allen/Holling, 2010 or Perrings/Mäler/Folke/Holling/Jansson, 1995. In this context, stress has been introduced as a "general term … for effect of human use" Scheffer/Westley/Brock/Holmgren, 2002:197.

7.3) Due to the couplings of internal and external RISC-mechanisms and processes and due to the strongly interlinked connection patterns of contemporary RISC-societies, rare events in the environment of RISC-societies acquire an increasing potential for large-scale detrimental effects in two general directions, namely, first, along the functional direction across internal societal production networks and systems, the infrastructural networks or systems and the protection networks and systems and, second, along the spatial direction, following a path towards globalization.[13] In other words, the E-robustness of RISC-societies with respect to external or environmental RISC-processes decreases.
7.4) Internal RISC-processes, due to their complex and self-organized dynamics, cannot be effectively controlled by the RISC-protection networks or systems. Even worse, the control capacities of RISC-processes in the third stage of RISC-societies diminish significantly due to a growing asymmetry between global actors in the sphere of economic production and distribution and the absence of strong global actors in RISC-protection networks and systems. For the decades ahead one will observe a governance gap between the global actors of the economic RISC-engine and the national and weakly supra-national or very weakly global actors of the RISC-protection networks. Moreover, RISC-protection networks, due to their under-critical control capacities, create a growing number of unintentional effects.
7.4.1) Rare events with highly negative societal impacts are usually accompanied by upward changes in the control- and steering capacities of the RISC-protection networks or systems.
7.4.2) The protection networks or systems are characterized by a time lag of one period since the increase in control or steering capacities is directed towards the control or the prevention of the last rare event and not towards the next one.
7.5) The RISC-support networks or systems for disasters operate usually in an under-critical stage, because they are based on the assumptions of small deviations from average events and not on large scale-deviations in the form of rare events. Rare events in the case of external RISC-processes are usually situated beyond the rescue and relief-capacities of the available support networks or systems.

13 Think, for example, of the eruption of the volcano underneath Iceland's Eyjafjallajokul around the year 1600, at the beginning of the second stage of RISC-societies. At this point of time, the eruption would have been unnoticed outside Iceland. By 1800, the eruption would have been recorded with long time-delays in areas outside Iceland, but no detrimental effects on economic production would have occurred. Around 1900, the same result would have been recorded. Even in 1940, the overall societal effects would have been small. In April 2010, the eruption was linked primarily with the infrastructural transport networks (air traffic) and secondarily with economic production networks and other functional networks and systems as well. Moreover, these negative effects, while concentrated on Europe, were spread across the entire world.

7.6) In instances of actual disasters, the logic of situated cognition and the subjective side of RISC-perceptions, of fear or of risk-expectations must be viewed as an essential element which should not be eliminated by trivial action models or by idealized schemes of local needs and a corresponding outside support. In general, RISC-support networks or systems do not operate in a blank slate and clashes between the local population, affected by a disaster, and support from outside are to be viewed as the necessary results of such a configuration. Usually, one can observe a striking incongruence between the perceptions and expectations on the part of the affected population and the perceptions and expectations of the outside support moving into a disaster region.

7.7) The growing couplings and interdependencies between societal and natural RISC-mechanisms and processes and the organization and structures of contemporary RISC-societies as hyper-complex adaptive networks or systems have multiple consequences for the sustainability and for the viability of the global network or system of contemporary RISC-societies.

7.7.1) Due to the architecture and the self-organizing nature of the dynamics of contemporary RISC-societies simultaneous increases across all five dimensions of sustainability and viability are clearly beyond the control-capacities of the RISC-protection networks or systems.

7.7.2) While the coevolution of RISC-societies during the second and the third stage exhibits an arrow of complexity in terms of composition and linkage densities, no arrow of sustainability and viability can be identified. Rather, the dynamics with respect to the sustainability and viability of contemporary RISC-societies depends on the self-organizing coevolution of the overall RISC-ensembles and on local or global drifts. With respect to sustainability and viability, the hyper-complex configuration of the overall RISC-ensembles operates far from equilibrium in a mutually adaptive or coevolutionary mode in both upwards and downwards directions of the five-dimensional sustainability and viability space.

7.7.3) While the coevolution of the economic RISC-mechanisms and processes operates on a global drift toward higher levels of globalization, differentiations and inequalities,[14] no long-term natural drifts can be observed with respect to sustainability and viability. On the contrary, due to the couplings of external and internal RISC-mechanisms and processes one can assume, for the decades ahead, a negative correlation between the coevolution of the economic RISC-ensembles and the sustainability and viability dimensions.

---

14 According to an estimate by the economic historian Paul Bairoch, 1995, the levels of GDP *p.c.* between today's First and Third World were roughly equivalent at roughly 180 US$ as late as 1750.

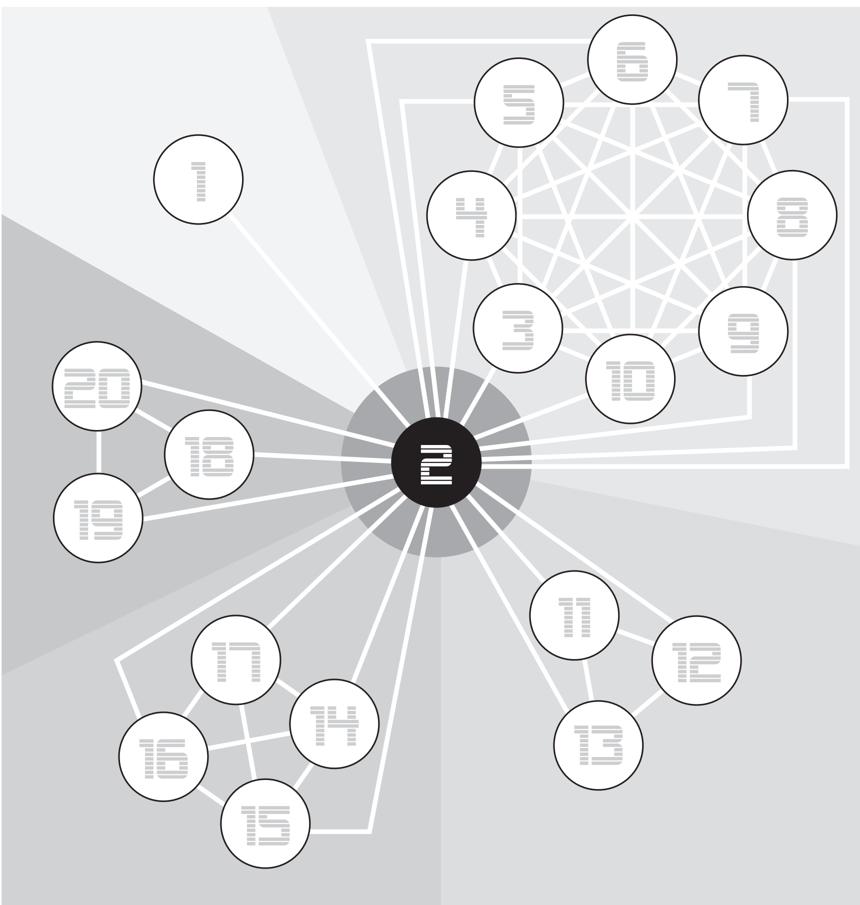
7.7.4) Within the five-dimensional sustainability and viability space, trade-offs between sustainability and viability should be expected as normal or reference cases, and correspondences or complementarities between sustainability and viability as rare events. Increasing the degree of robustness (sustainability$_3$) for example, does not lead to increases in the viability dimensions and vice versa.
7.7.5) Similarly, with respect to the sustainability dimensions alone, trade-offs between the three sustainability dimensions should be seen as the normal outcome and simultaneous increases across all three sustainability dimensions as improbable events. The same situation applies to the two viability dimensions where trade-offs are to be expected as the regular outcomes.
7.7.6) Moreover, the five-dimensional space of sustainability and viability is characterized by lock-ins and path dependencies where the coevolution of the overall RISC-ensembles has no effects on a particular sustainability or viability dimension and where a given sustainability or viability level can only be changed by rare internal or external RISC-events themselves.
7.7.7) From a global perspective the biggest challenge for contemporary RISC-societies lies in the construction of functional boundaries which are capable to contain the negative or disastrous effects of rare events. Such an emphasis on spatial separations should become of special relevance in the new designs for the emerging new cluster of converging technologies.[15]

15 On converging technologies, see the article by Toni Pustovrh in this volume.

2

RISC-Processes and Societal Coevolution: Towards a Common Framework

Karl H. Müller



One of the persistently puzzling issues for contemporary theories of societal evolution or coevolution[1] concerns the engines or, alternatively, the (f)actors for societal changes. To be sure, the literature is full of potential candidates for generative mechanisms[2] of societal coevolution like, to mention a few, functional differentiations into specific societal sub-domains or systems,[3] knowledge as a new wealth generating factor of production,[4] configurational and structuration dynamics,[5] great ideas,[6] the Schumpeterian entrepreneurs pursuing their recombinations of factors of production or innovations for short,[7] forces of production, revolutionizing both economic sub-structures and societal super-structures,[8] a technologically driven transition from low and medium risk production to high risk production processes with substantial ramification for individual life-courses,[9] urbanization,[10] a small set of crucial variables relevant for long-term sustainability[11] or a permanent interplay between systemic differentiations and life world developments.[12] So

1 Societal evolution at the regional, national or global levels is almost by necessity coevolutionary in nature. Societies at the regional or national levels are horizontally embedded in an environment of coevolving regional or national societies and the societies at the global levels interact with their global environments in a coevolutionary manner, too. Thus, in the context of this article, the terms societal evolution and societal coevolution are used in a strictly equivalent fashion. See also Durham, 1991, Lewontin/Oyama, 2000, Oyama, 2000 or Thompson, 1994.

2 Subsequently, the concepts of generative mechanisms or, alternatively, of generative engines will be used for the following minimal configuration, namely for a process P as a sequence of events and for an ensemble EN which can be attributed with the production of this sequence of events P. The ensemble EN could be a system, a network or any other complex configuration like a system of systems, a network of networks, a system of systems and networks, etc. Typically, generative mechanisms or engines involve a dual level configuration between a set of micro-actors A^{MI} who are dynamically inter-linked with one another and who through their aggregated micro-dynamics produce or generate the macro-process P^{MA}.

3 See, *e.g.*, Parsons, 1951, 1964 and 1994 or Luhmann, 1984 and 1997.

4 Along the knowledge line, see Bell, 1979a and 1979b, Drucker, 1993, Nelson, 1996 or Thurow, 1996, 1999 and 2005.

5 See especially Giddens, 1984, 1991, 2000 and 2009.

6 As a recent example, see Ogle, 2008.

7 On the Schumpeter system, see, for example, Arthur, 2009, Schumpeter, 1934, 1952, 1961, 1975, 1991, or Weidlich/Haag, 1983.

8 Under this category fall all Marxist approaches that use the distinction between an economic production ensemble and a collection of societal systems which are strongly influenced by the economic production ensemble and which, in turn, have a limited capacity to influence or control this production ensemble.

9 See, for example, Beck, 1986, 1997, 1998a, 1998b, 2000, 2002 or 2007.

10 On urbanization see, for example, Florida, 2002 or 2005.

11 See, especially, Diamond, 2005, with his five driving forces of environmental damages, climate changes, hostile neighbors, loss of trading partners, inappropriate reactions to change.

12 Of course, Jürgen Habermas is the most relevant source of reference in this area as can be seen from Habermas, 1968, 1981 or 1984.

far, the problem of rare events remained outside the mainstream discussions on the driving (f)actors for societal development, growth or coevolution.[13]
Thus, the next steps will introduce the notion of RISC-processes (Rare Incidents, Strong Consequences) within an evolutionary theory landscape and build up a set of crucial components for an evolutionary RISC-based approach to societal unfoldings, differentiations and complexifications.

2.1 RISC-Processes as the Missing Links in the Theories of Societal Coevolution

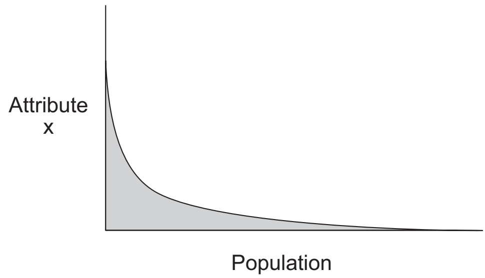
Formally, a RISC-process is characterized by a specific distribution and an underlying distribution function where a very large number of minor or marginal events is accompanied by a very small number of very large-scale events. RISC-processes occur within societies as well as in their environment. Societal or internal RISC-processes comprise areas like the global finance system with rare occurrences of severe global crises in 1893, 1929, 1987 and 2008 or the current global information and communication networks with a very large number of marginal and local network defects and rare incidents of major failures with widespread and disastrous consequences. Natural RISC-processes in the environment of societies can be found, for example, in earthquakes with very rare instances of earthquakes with deep impact and catastrophic consequences and a very large number of very weak quakes.
In the words of Didier Sornette, RISC-processes exhibit a wild distribution and can be qualified, thus, as wild processes. In contrast, the bell shaped normal distribution can be described as a mild distribution and the underlying processes, consequently, as mild ones.

> What is the probability that someone has twice your height? Essentially zero! The height, weight and many other variables are distributed with 'mild' probability distribution functions with a well-defined typical value and relatively small variations around it. What is the probability that someone has twice your wealth? The answer of course depends somewhat on your wealth but in general there is a non-vanishing fraction of the population twice, ten times, or even one hundred times wealthier as you are. [Sornette, 2006:104]

13 On the current scope of disaster research, see, *e.g.*, Felgentreff/Glade, 2008, Quarantelli, 1998 or Rodriguez/Quarantelli/Dynes, 2007.

FIGURE 2.1 **Two Distributions of a RISC-Process**

1a Linear Scale



1b Dual Logarithmic Scales

Table 2.1 offers a short overview on the ubiquity of RISC-processes with respect to natural or social domains and with respect to different scientific disciplines involved.

TABLE 2.1 **RISC-Processes Across Different Scientific Disciplines**

RISC-Process/ Scientific Discipline	**Distribution-Characteristics**	
	Rare Incidents, Strong Consequences	**Very Frequent Incidents, Weak Consequences**
	Natural Science Domains	
Sandpiles/ Physics	very small number of very big avalanches	very large number of very small avalanches
Earthquakes/ Earth sciences	very small number of earthquakes with very strong effects	very large number of earthquakes with very small effects
Solar flares/ Astronomy	very small number of very strong outbursts	very large number of small outbursts

CONTINUING TABLE 2.1

Tornados, hurricanes, taifuns, etc. Meteorology	very small number of very devastating tornados, hurricanes, taifuns, etc.	very large number of atmospheric turbulences
Forest fires/ Environmental sciences	very small number of fires with very large scale consequences	very large number of fires with very local effects
Viruses and epidemics/ Medical Research	very small number of new viruses with very large- scale effects	very large number of new viruses with no or marginal effects
Ecological systems/ Environmental sciences	very small number of breakdowns with very large-scale effects	very large number of vanished species with no or marginal effects
The brain/ Neuro-cognitive sciences	very small number of neurons with a very high number of links	very large number of neurons with a very low number of connections
	Social Science Fields	
Language/ Linguistics	very small number of words with a very large number of occurrences (in books, plays, etc.)	very large number of words with a very small number of occurrences (in books, plays, etc.)
Scientific quotations/ Science studies	very small number of articles, quoted with very high frequency or very high impact	large number of articles with no quotations or zero-impact
Scientific breakthroughs/ Science studies	very small number of institutes with a very large number of scientific breakthroughs	very large number of institutes with no scientific breakthroughs
Innovations/ Science-technology-society	very small number of innovations with far- reaching effects and very strong repercussions	very large number of innovations with near-zero effects or re-percussions
Financial markets/ Finance	very small number of crashes with very strong effects	very large number of fluctuations with very small consequences
Wealth and income/ Economics	very small number of very high income or wealth	very large number of persons or households with small or medium income
Power grid/ Energy sciences	very small number of accidents/failures with very widespread consequences	very large number of minor accidents/failures with no or marginal effects
Migration and settlement/ Sociology, demography	very small number of very large cities within a nation	very large number of small settlements

Another interesting aspect of the overall RISC-framework lies in the micro-operators or actors and in their relevant operations which constitute or produce a RISC-process. As can be seen from Table 2.2, operators and operations comprise very heterogeneous sets, ranging from simple operators like a grain of sand to complex ones like firms, organizations or scientific institutes and from simple operations like dropping/falling down to very complex ones like doing research work, publishing or quoting articles. It is important to note that the focus on operators and operations does not assume a reference model of behaviour/action or a set of maximization or minimization rules. Operators and operations can be specified freely and can include trivial and non-trivial operation schemes.[14]

TABLE 2.2 **Selected Examples for Micro-Operators, Micro-Operations and Mechanisms in the Production of RISC-Processes**

	RISC-Building Blocks		
	RISC-Micro-Operators	RISC-Micro-Operations	RISC-Mechanism
	Natural Science Domains		
Sandpiles	a single grain of sand	dropping down (on a specific spot)	a non-random growth mechanism
Earthquakes	a tectonic plate	movements and inter-Actions	dynamic plate mechanism
Forest Fires	a tree, bush, etc.	inflaming, interactions with neighbouring trees or bushes, etc.	local diffusion mechanism
Viruses and epidemics	a single virus	replication, movement, interactions, mutation	epidemiological diffusion mechanism
Ecological systems	a species	reproduction, inter-actions, mutations	eco-network-mechanism
Cognitive systems	a neuron	signaling	neural propagation mechanism
	Social Science Fields		
Language	a competent language user	bindings of language elements	societal network mechanism
Scientific quotations	a single scientist	quoting articles	science network mechanism
Scientific breakthroughs	a scientific institute	solving new research problems	science network mechanism

14 On situated or embedded cognition, see, for example, Adams/Aizawa, 2010, Augoustinos/Walker, 2001, Fiske/Taylor, 1991, Noe, 2006 or Pfeifer/Bongard, 2007.

CONTINUING TABLE 2.2

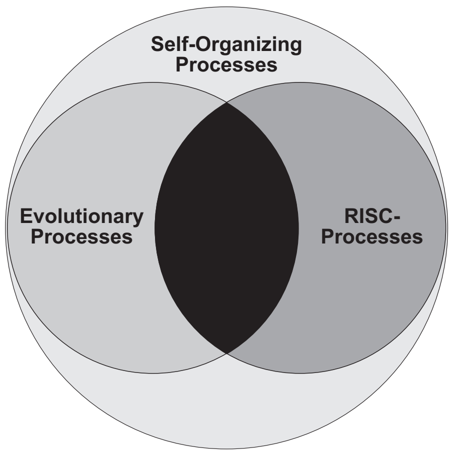
Innovations	a firm or an organization	changing the production processes	economic network mechanism
Financial markets	a single trader	selling and buying, innovating products or processes	economic network mechanism
Income and wealth	a single individual or household	income from employment or self-employment	economic network mechanism
Migration and settlement	a single individual or household	moving to a new place, spatial attractivity differences	societal network mechanism

From Tables 2.1 and 2.2 it becomes clear that RISC-processes can be characterized as self-organizing since all the examples in Tables 2.1 or 2.2 have no units for effective steering and control. No malevolent or benevolent controller or demon is in sight for arranging, following Table 2.2, the succession of sand avalanches, the order of magnitude of earthquakes, the severity of forest fires, the power of hurricanes or tornados, the diffusion degree of epidemics, the severity in the breakdown of ecological systems, the ordering of neural waves, the frequency order of words, the frequency distribution of scientific quotations, the orchestration of scientific breakthroughs across institutes, the rank-size distribution of firms or, finally, the severity of financial crises.

In other words, RISC-processes are mostly generated through the characteristic micro-operations of their micro-operators although one can identify control units in many of the examples in Table 2.2 where these control units remain well embedded and couched in an overall self-organization ensemble.

Furthermore, while all RISC-processes can be classified as self-organizing, the relations between RISC-processes, self-organization and evolution are complex and can be captured with the help of Figure 2.2. While all evolutionary processes can be characterized as self-organizing, the converse relation does not hold since not all self-organization processes should be qualified, at the same time, as evolutionary ones. As an example, take the case of the dynamics of tectonic plates and the issue of earthquakes which, for obvious reasons, is to be qualified as a non-evolutionary self-organizing process. Similarly, all RISC-processes turn out to be self-organizing ones, but the reverse side does not hold either since not all self-organization processes are distributed in a RISC-like fashion. As an empirical example, take the size distribution in a species which is normally and, thus, mildly distributed. Finally, not all RISC-processes are to be qualified as evolutionary ones and not all evolutionary processes exhibit a RISC-distribution. Thus, Figure 2.2 summarizes the intricate relations between RISC-processes, evolution and self-organization. Additionally, RISC-processes are produced by generative mechanisms which can be divided into two broad clusters, namely into non-evolutionary and evolutionary mechanisms. In terms of demarcation criteria, an evolutionary mechanism requires an endogenous proliferation of novelty as well as a dualism in the micro-constitution of evolutionary actors. In biology, this dualism has a well-defined meaning,[15] since the observable properties, structures and processes of an organism as micro-actor belong to its phenotype and the sequence of nucleotides, forming the DNA of an organism are qualified as its genotype.[16]

FIGURE 2.2 **The Relations between RISC-Processes, Evolutionary Processes and Self-Organization Processes**



Moreover, the evolution of evolution in general exhibits a very illuminating RISC-characteristic as well because innovations or mutations in the history of life exhibit only a very small number of very profound changes and transitions and a very large number of marginal or minimal changes. The following table, compiled by John Maynard Smith and Eörs Szathmáry [1996:5], offers an overview on the very small number of big evolutionary jumps.

Moreover, it must be added that these innovative jumps and transitions were accompanied by a widening of the evolutionary landscape and not by a complete substitution, something which can be captured in Figure 2.3.

---

15 On this point, see, for example, Feldman 1988:43 and Maynard-Smith, 1974, 1982b or 1989.

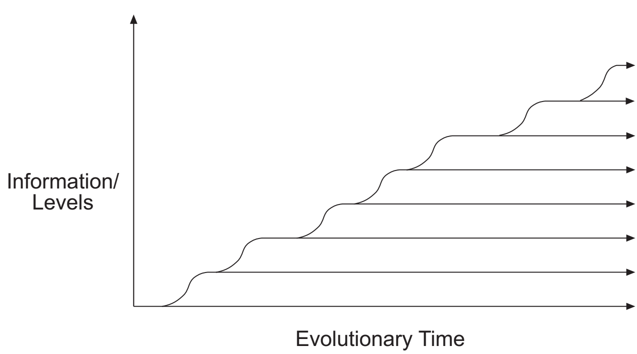
16 Due to this separation of domains, an interesting point could be made that any evolutionary theory from its very outset is coevolutionary in nature. On this point, see especially Margulis, 1981, 1993 or 1998.

Focusing on the generative mechanisms and models of RISC-processes, the relations between RISC-processes and generative mechanisms are intricate and can best be described as a dual one:many-relationship. For each RISC-process one usually finds a non-empty set of generative mechanisms and models which can be used for empirical analysis. Likewise, each generative mechanism or model can be utilized in several different contexts and, thus, for a variety of different RISC-processes.

TABLE 2.3 **Very Large Scale Transitions in Evolutionary Time**

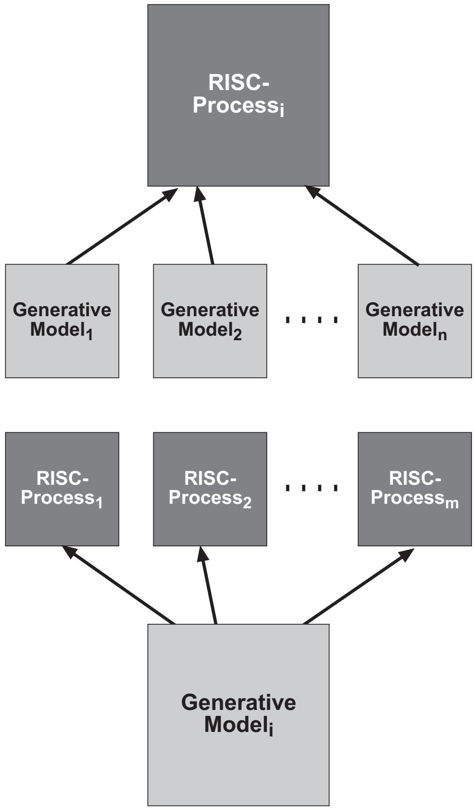
Previous State Transition	Phase	New State
Replicating molecules	→	populations of molecules in compartments
Unlinked replicators	→	chromosomes
RNA as gene and enzyme	→	DNA and protein (genetic code)
Prokaryotes	→	eukaryotes
Asexual clones	→	sexual populations
Protists	→	animals, plants and fungi (cell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

FIGURE 2.3 **The Pattern of Evolutionary Unfoldings**



At the current point it must be posed as an open question whether the different generative mechanisms and models will converge to one or a small number of second-order mechanisms and models generating mechanisms and models. Thus, Figure 2.5 leaves it open whether the model cluster at the deep-structure will consist of one, two or several independent clusters of generating mechanisms of generating mechanisms.

FIGURE 2.4 **The One-Many Relationships between RISC-Processes and Generative Mechanisms**



At this point it could be interesting to continue with a short discussion on the differences and similarities between the concept of RISC-processes and the focus on rare events with large-scale societal consequences on the one hand with the meanwhile well-recognized notion of risk-societies[17] on the other hand.

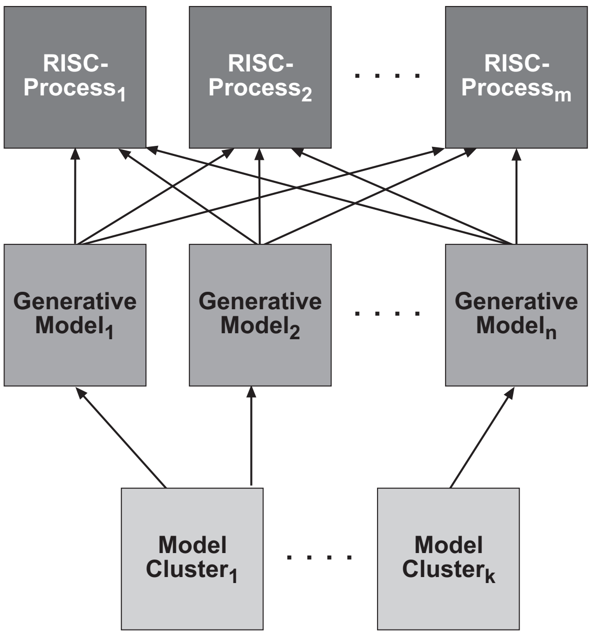
At the outset, RISC-societies, *i.e.*, societies with an ensemble of internal and external RISC-mechanisms and processes, differ from post-modern risk-societies in a fundamental manner, since risk-societies, following Ulrich Beck and others,[18] emerged as the latest phase of capitalist development only whereas

17 As *locus classicus*, see Beck, 1986.

18 On risks and risk-research, aside from Ulrich Beck's risk-society, see also Adams, 1995, Banse, 1996, Bernstein 1996, Bonß, 1995, Caplan, 2000, Dembo and Freeman, 1998, Douglas, 1992, Dowd, 2005, Fischhoff et al., 1981, Gardner, 2008, Graham and Wiener, 1995, Pidgeron,

RISC-societies and their evolution can be traced throughout the entire history of human societies. Figure 2.6 and Table 2.4 offer some guidelines on the special relations between contemporary risk-societies and RISC-societies.

FIGURE 2.5 **The Convergence Towards Small Clusters of RISC-Mechanisms**



Due to the profound dissimilarities between RISC-societies and their risky counterparts it seems worthwhile to continue this article with a long-term historical perspective which should shed new light on the intricate relations between rare events and societal evolution.

Kasperson and Paul Slovic, 2003, Reason, 1994, Slovic, 2000 or Wisner et al. 1994.

FIGURE 2.6 **The Relations between Risk-Societies and RISC-Processes**

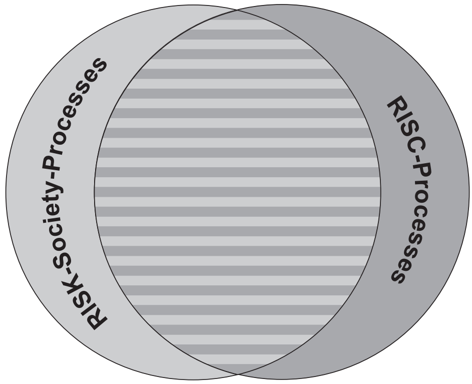


TABLE 2.4 **Shared Domains and Differences between Risk-Societies and RISC-Processes**

Shared Domains	RISC-Processes Independent of Risk-Societies	Aspects of Risk-Societies without RISC-Processes
Production processes and large-scale Innovations; Relations between production processes and the environment; Size distribution of firms; Income and wealth distribution; Financial markets; Migration and settlements, etc.	solar flares sandpiles tectonic formations brain mechanisms word-frequency distributions; scientific quotations complex networks (preferential attachments), etc.	processes of the individualization of life Courses; drifts towards scientific self-reflexivity, etc. indisvidualization of risks from Systemic domains to private households, individuals, etc.

2.2 The Three Very Long-Term Stages in the Evolution of RISC-Societies

As stated already, rare events with far-reaching societal consequences have been part and parcel of the evolution of modern societies from its earliest stages onwards. So far, the history of rare events has been considered as exogenous and as residing outside the driving (f)actors or the generative mechanisms for societal complexifications and differentiations. Earthquakes, like forest fires, floods, droughts, famines or epidemics were seen as short and catastrophic episodes beyond the scope of endogenous socio-economic development and growth patterns. In sharp contrast, it is suggested here that rare events play a genuinely endogenous role. Moreover, the history of RISC-societies can be separated into three distinct stages where Stage I comprises, by and large, all human societies prior to the irreversible capitalist expansion in the 16th century, Stage II consists of the evolution of a package of societal RISC-mechanisms and processes and their global diffusion in the half millennium between the 1450s to the 1950s and Stage III is breaking its way from the 1950s onward as new forms of couplings and interplays between societal and natural RISC-processes emerge. Table 2.5 presents an overview of the three stages of RISC-societies.

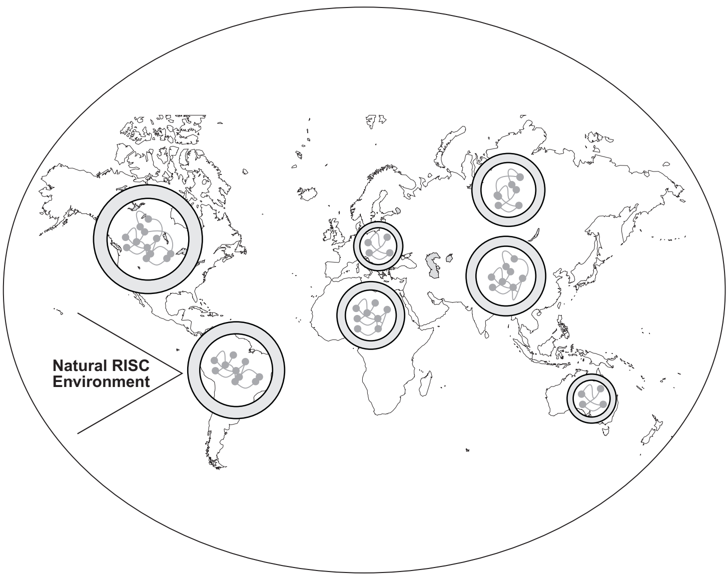
TABLE 2.5 **Three Historical Stages in the Diffusion of RISC-Processes**

Time	Distribution of RISC-Processes
Stage I	
[prior to 1450] Societies under the dominance of natural RISC-processes	A large class of RISC-processes in the environment of societies
	A relatively small class of RISC-processes in the sphere of economic production and knowledge generation
Stage II	
[1450–1950] Societies under the dominance of societal RISC-processes	Aside from the RISC-ensembles already in operation during the periods prior to 1450:
	1) A collection of RISC-processes in the spheres of economic production
	(2) A set of RISC-processes in the domain of knowledge generation
	(3) Secondary, tertiary, n-ary RISC-processes as a consequence of (1) and (2)
	(4) The self-organization of the interlinked RISC-ensembles from and across (1) to (3)
Stage III	
[after 1950] Societies under the dominance of couplings between natural (external) and societal (internal) RISC-processes	The growing interdependencies and interconnections between natural and societal RISC-processes

The RISC-World before 1450

The RISC-worlds prior to 1450 were relatively small, with a world population of approximately 50 million persons around 1000 B.C. to roughly 400 million people around 1450. For centuries, the world population remained stable, with the exception of the period from 600 to 300 B.C. and around the decades of the year 1000. One of the most striking features prior to the long 16th century lies in the near absence of RISC-mechanisms inside the economic or knowledge production spheres of societies.

FIGURE 2.7 **Globally Distributed Societal Ensembles Prior to 1450**



According to the stylized Figure 2.7, the socio-economic worlds prior to 1450 were composed of a large number of societal islands, separated by no man's land or the seas between them and embedded in natural environments which were self-organized in a large class of external RISC-processes. In essence, during the very long first RISC-stage, the regionally separated states, empires or other societal ensembles of varying degrees of organizational complexity and embedded in different natural settings were affected and threatened by natural RISC-processes in the form of earthquakes, fires, famines, droughts, floods, epidemics, etc. Societal RISC-processes played a dominant role in the field of languages, and were possibly involved in migration patterns within empires, in selected cases of societal wealth distribution, etc. Inventions, innovations and new technologies, although deeply engrained into the societal fabric, were not organized in a permanent and continuous way and remained largely outside the scope of societal RISC-processes.

Following Karl Polanyi [1978, 1979], these different isolated and globally distributed societal ensembles can be classified as reciprocal or as re-distributive. Re-distributive formations exhibit a higher degree of organizational complexity, are clearly dominated by the political system and are, therefore, regionally confined up to the level of empires. These more complex re-distributive societal formations are characterized by the dominance of agricultural production and by a small and limited number of trades, by a rigid stratification system where the economic production processes mainly in agriculture reflect this stratification system. Capitalist engines, as they will be introduced in the next section, were only present to a sub-critical degree. This state of independent reciprocal and re-distributive worlds has been captured, aside from Figure 2.7, also by Table 2.6 which exhibit a small number of empires and societal ensembles, all embedded in a natural environment and subject to the influence of natural RISC-processes.

The second noteworthy feature in the first RISC-stage lies in the absence of RISC-processes in the domain of knowledge production. Analogous to Polanyi's scheme, societal knowledge-bases prior to 1450 can be characterized either as distributed or as centralized. Centralized knowledge bases were dominated by special knowledge preserving groups usually also associated with a dominant religion and empirical knowledge remained, using a term from Michael Polanyi, largely implicit. [See also Table 2.7]

TABLE 2.6 **Societal Ensembles Prior to 1450**

Societal Ensembles	
Reciprocal Formations	**Redistributive Formations**
Societies under the dominance of personal exchanges	Societies under the dominance of the political System

Quite obviously, rare events like strong earthquakes, catastrophic eruptions of volcanoes, long-enduring famines, wide-spread epidemics left a deep imprint in the collective memory of societies and it would be a fascinating research task, to link these rare events prior to 1450 to traditional knowledge systems, especially to religious and magic practices which should safeguard these societal ensembles from the occurrence of these rare events.

TABLE 2.7 **Knowledge Production Systems prior to 1450**

Varieties of Knowledge Productions	
Distributed Knowledge Bases	**Centralized Knowledge Bases**
Knowledge bases shared among the members of a societal ensemble	Knowledge bases under the dominance of a knowledge preserving group

Two Great RISC-Transformations and Their Global Diffusion 1450–1950

At a surface-level it is widely recognized, following Immanuel Wallerstein,[19] Fernand Braudel,[20] and others,[21] that the five centuries between 1450 and 1950 experienced a gradual integration of reciprocal as well as re-distributive societal formations into a relatively small global production system which was composed, initially, of a core region in the north-western parts of Europe (France, England,. The Netherlands), of semiperipheral areas (Spain, Portugal, Eastern Europe, the Italian peninsula, etc.) and of small bands of peripheral regions along the coasts of Africa, of Latin America or the East Indies. This global production system was fueled by a capitalist engine and was bound or linked together during its first centuries by a more and more differentiated system of trade relations. This global production system had placed itself outside the realm of effective political controls through regional political systems in Europe like the one in Spain, in France, in the Netherlands or in England. Subsequently specific development patterns emerged in each of the three global regions, reaching from differences in world trade-relations to significantly different roles and control capacities of national governments or to different compositions with respect to socio-economic groups or classes.

19 On Immanuel Wallerstein's world systems perspective, see especially Wallerstein, 1974, 1979, 1980, 1984 or 1989.

20 With respect to Fernand Braudel, see especially his three volume compilation on *Civilization and Capitalism* with a time span from the 15th to the 18th century in Braudel, 1979, 1982 and 1986.

21 From Karl Marx, 1964 to Max Weber, 1949, 1951 or 1978 one finds a wide-spread consensus on the uniqueness of the capitalist transformation. Relatively seldom, however, one finds an emphasis of a dual movement in economy and science. [Müller, 1999] To view both production processes within the economic sphere and within science under a homogeneous RISC-perspective constitutes a novel feature of the present approach.

- Core regions were characterized by an advanced economic production system and by a powerful state apparatus which shielded, supported and stimulated the national system of production both internally and externally.
- Semiperipheral areas occupied an intermediary position both in the sphere of production and, especially important, in trade relations.
- Peripheral domains were specializing in the role of agricultural producers and providers of raw materials. The state apparatus was comparatively weak and acted in a core-oriented manner. Likewise, trade relations with the center were highly asymmetrical.

Over the centuries, one can observe the gradual emergence of global instruments like the gold-standard for coordinating and balancing the evolving world economic system. By 1930, towards the end of Stage II, weak global institutions and organizations like the League of Nations emerged which attempted to fulfill essential co-ordinating functions, too.

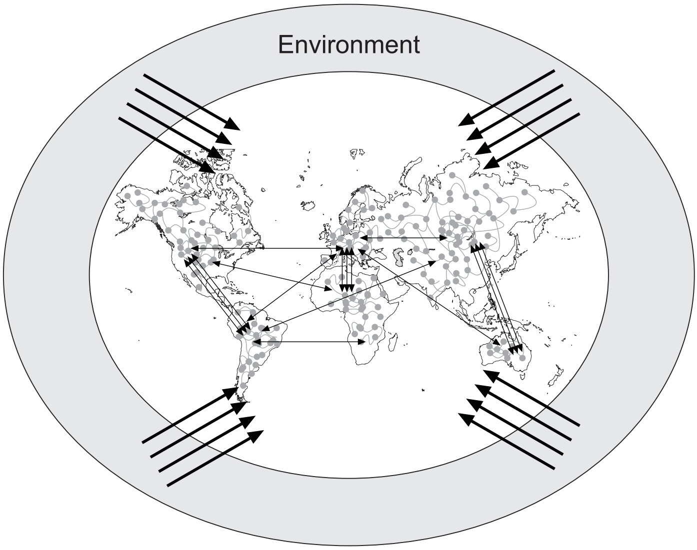
Thus, the First Great Transformation can be characterized as the world-historic turn towards an economic RISC-mechanism as network of networks of self-organizing and globally distributed markets. Following Karl Polanyi, the societal consequences were twofold. On the one hand, "the economy is no longer embedded in social relations, but the social relations are embedded into the economic system" [Polanyi 1978:88].[22] On the other hand, during the half millennium between 1450 and 1950 all hitherto external societal formations were gradually integrated into this expanding network of networks which had conquered every continent and every country within the five continents. As a consequence, reciprocal and redistributive societal formations became market or, alternatively, capitalist formations. [See also Table 2.8]

TABLE 2.8 **The Great Transformation I: Local Reciprocal or Redistributive Formations Become Integrated in a Single Global RISC-Mechanism**

The First Great Transformation: Economic RISC-Production			
Reciprocal Formations	**Redistributive Formations**	→ →	**Capitalist Formations**
Societies under dominance of personal exchanges	Societies under dominance of the political system	→ → → →	Societies under dominance of markets

22 Translation by Karl H. Müller from Polanyi, 1978.

FIGURE 2.8 **The Irreversible Expansion of the Capitalist Engine**



The second Great Transformation is much less recognized and occurred in the domain of knowledge production. The half millennium between 1450 and 1950 saw a gradual integration of traditional forms of knowledge production and of societal knowledge bases which could be characterized either as distributed or as centralized knowledge bases. Thus, between 1450 and 1950 a globally distributed science-driven knowledge base emerged [See also Table 2.9]. Between 1450 and 1950, a global differentiation can be observed which brought about a separation into three distinct regional types of knowledge bases with respect to the (re) production and to the accessibilities of knowledge: central, semi-peripheral and peripheral knowledge-bases, all of them, of course, science-driven.

- Core knowledge bases turn out to be 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 knowledge base is diffusion driven, exhibiting a global diffusion potential but being highly selective, in turn, with respect to knowledge bases and contributions 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 articles from core knowledge producing regions quote mainly other core region publications while, in turn, they are being quoted throughout the semiperipheral or peripheral knowledge bases.

- For semiperipheral knowledge bases, a genuine mixture between core features and peripheral features 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 knowledge bases are mainly reception driven, exemplifying a high reception potential but being only marginally reproduced and recombined in other regions. Once again seen from an intellectual 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 regions of the world.

TABLE 2.9 **The Great Transformation II: Distributed or Centralized Knowledge Bases Become Integrated in a Single Global Knowledge Base**

The Second Great Transformation: Knowledge Production			
Distributed Knowledge Bases	**Centralized Knowledge Bases**	→	**Science-Centered Knowledge Bases**
Knowledge bases shared among the members of a societal ensemble	Knowledge bases under the dominance of a knowledge preserving group	→	Knowledge bases under the dominance of an open mode of knowledge production (modern science)

The most surprising feature of Table 2.9 lies in the fact that the essential spatio-temporal differentiations for the evolving economic RISC-mechanism can be applied to the evolving RISC-mechanism for knowledge production as well. Although some important differences prevail, the deep similarity in the evolutionary development patterns of knowledge bases and economic production formations remains unaffected. Thus, it is not only possible and heuristically fruitful, to differentiate between core, semiperipheral and peripheral knowledge bases, but it is also rewarding from a cognitive point of view, to study the coevolution of economic and knowledge production throughout the five centuries of Stage II.

The scientific production, like the evolving capitalist mechanism, have always carried with them a strong tendency toward globalization, although globalization is to be understood in the spatio-temporal contexts of the evolving world-economy only.[23] 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, have not only been excluded, but also de-qualified and mis-understood in a very profound manner.[24]

The Third Stage of RISC-Societies after 1950

The decades between 1900 and 1950 have seen the emergence of three major shifts which justify to categorize the period after 1950 as the third stage in the very long-term evolution of RISC-societies. These three new components will be outlined in greater detail in the fifth section of this article. At this point, the three basic stages of RISC-societies as well as the two Great Transformations in economic and in knowledge production have been introduced. In the next section both transformations will be discussed in greater detail from a RISC-point of view.

2.3 The Two Great Transformations as Complex Network Mechanisms

The present section deals with the incorporation of RISC-processes into the metabolisms of economic production and into the forms of global knowledge production of the 17th, 18th, 19th or 20th century. Within this section, four strong claims will be developed and supported with historical evidence.

First, it will be argued that both for the sphere of economic production as well as for the domain of knowledge proliferation two self-organizing mechanisms or, alternatively, two self-similar network structures and dynamics can be specified which account for the spectacular growth in the area of economic and knowledge production.

Second, the embedding of a capitalist and a science RISC-mechanism and their self-organized evolution has led to a swarm of interlinked RISC-processes in the economic and scientific spheres as well as in societal arenas.

As a third thesis, the capitalist RISC-mechanism in its long-term unfoldings has generated and continues to generate a series of infra-structural networks which,

23 On this point, see especially Merton, 1985.

24 See, for example, Raynal and Diderot, 1988, Hegel, 1956.

over the last decades, became organized more and more as complex networks. Finally, from the 18th century onward, the capitalist and the science mechanism started to operate in a synchronous and, thus, coevolutionary manner.
At the outset, Table 2.10 summarizes basic operations for the capitalist RISC-mechanism and the swarm of RISC-processes, associated with this capitalist engine. Of course, the term RISC-mechanism does not stand here for a hidden mechanical construct in the centre of production processes, but for a basic set of network structures and a for a growth dynamics of this network.[25]

TABLE 2.10 **The Great Capitalist Transformation and the Emergence of Socio-Economic RISC-Processes**

Operations of the Capitalist Engine	RISC-Processes
Average profits as basic requirement for long-term reproduction	Firm size distribution Distribution of income and wealth
Growth processes for micro-units horizontally and vertically (production chains)	Distribution of the frequencies of changes in jobs
Search for extra-profits	Distribution of innovations
New technology as a constant source of extra profits	Distribution of technological accidents Rank-size distribution of
Birth-processes for new micro-units (firms) in a non-random manner	spatial ensembles for economic production and distribution (cities, villages, etc.)
Death-processes for established micro-units in a non-random manner	

Turning to the nodes of the capitalist RISC-mechanism, the micro-units of the capitalist engine are composed of firms, farms, associations and the like, capable of economic production or service provision and embedded in a monetary system of purchases and sales. The basic reproduction requirement for these micro-units is to reach an average profit-rate in the medium and in the long-run. Furthermore, these micro-units are capable of expanding horizontally, *i.e.*, regionally, or vertically, *i.e.*, by integrating pre- or a after production processes. The capitalist engine is energized by the search for extra-profits which can be accomplished in a variety of ways. Following Schumpeter, extra profits can be earned *via*

> technological change in the production of commodities already in use, the opening up of new markets or of new sources of supply, Taylorization of work, improved handling of material, the setting up of new business organizations such as department

25 On this point, see especially White, 2002.

> stores—in short, any 'doing things differently' in the realm of economic life—these are instances of what we shall refer to as by the term innovation.[26]

Thus, innovations in their broadest possible variety constitute the incentives and attractors inherent in a global capitalist network. Again from a dynamic network perspective, the second basic feature of a capitalist network, aside from the search for extra profits or gainful innovations for short, lies in the creation of new actors with strong preferential attachments. New actors come into play preferably in those network domains or niches which are characterized by extra profits like in the case of the integration of new territories or in very large-scale technological innovations like in the diffusion of railroads or automobiles. Finally, network actors, failing the survival condition in the medium or in the long run, vanish from the network, although, in the long run, the birth rate of new micro-actors surpasses the death rate of outgoing micro-units to a significant degree.

From the right hand side of Table 2.10 it becomes clear that the economic RISC-mechanism for the first Great Transformation is accompanied by a large number of socio-economic RISC-processes which became part and parcel of societal reproduction processes.

Out of the total number of new societal RISC-processes a special emphasis will be devoted to Schumpeterian innovation processes since a permanent flow of innovations, due to their creative destruction and building capacities, turn out to be the most important single feature of the capitalist RISC-mechanism. As one of the new elements of the RISC-framework, Schumpeterian innovations are assumed to follow a power-law distribution and, thus, to fall under the class of RISC-processes. At first sight, this point may be surprising to economists, historians or sociologists of innovation processes. So far, socio-economic historians of innovations were rather convinced that the Industrial Revolution marked the first of a series of long-term cycles or long waves.[27]

Table 2.11 provides a customary overview of the succession of long innovation cycles from the 18th century onward.[28]

These long innovation waves usually exerted significant effects on the overall economy. Table 2.12, for example, enables one to understand that before and after the railroad revolution the levels of societal transport, production and maintenance levels differed significantly. Around 1873, the world had become clearly different with regard to the transport dimensions than it had been thirty years earlier. Even

---

26 Formally, Schumpeter defines innovations as any change that does not alter the quantities of production factors of a production function, but that leads to a variation in the production function itself.

27 On long waves, see only Devezas, 2006, Kondratieff, 1928 or Schumpeter, 1961.

28 Table 2.11 is strikingly similar to the one found in Ayres, 2006.

though the question as to the proper dimensions and the adequacy of the historical data generally meets with great difficulties, the example of Germany between 1850 and 1873, around the time of the founding of the German Empire, provides substantial evidence that a big technological innovation wave must have taken place both in the overall performance dimensions of the transportation network and in its various other and more specific dimensions as well.

TABLE 2.11 **Long Innovation Waves as Rare Events of a RISC-Process**

Rare Innovations With Strong Consequences	**Long-Term Diffusion Peak**		
Steam engines/ Textile industry	1788	1814	1848
Railway	1848	1873	1896
Electrical industry	1896	1914	1945
Automobile	1945	1973	1996
ICT/Internet	1996	?	?

TABLE 2.12 **The Very Strong Effects of the New Railroad Transportation System in Germany, 1850–1873**

	Beginning of the 2nd Industrial Revolution	**End of the 2nd Industrial Revolution*)**
Network Dimensions		
Persons employed in transport	132.000	349.000
Value added railroads (mil. Mark)	17 bill. M.	274 mill. M.
Value added transport (total) (mil. Mark)	53 bill. M.	387 bill. M.
Freight traffic (in bill. Ton kilometers)	0,23 mill. TKM	9,9 bill. TKM
Capital stock of the railroads (in bill. Mark)	1,15 bill. M.	6,74 bill. M.
Dimension for the Economy as a whole		
Capital stock in trade (in bill. Mark)	7,16 bill. M.	13,70 bill. M.

*) Following Joseph A. Schumpter, each of the long cycles can be qualified as an industrial revolution

Source: Hoffmann 1965

The repercussions of the railway construction can be quickly described in quantitative terms, using data for Germany. For iron and steel production, the strength of the linkages was assumed to be 40% to 50% of the output, which, in turn, induced additional effects in iron ore and coal mining. Moreover, iron ore and coal were also linked directly to the railroad cluster between 5% and 10%. "The significance of railway construction as driving force in the process of industrialization ... with a strong inducive effect cannot be called into question." [Spree, 1977:288] It can also be shown from the perspective of capital mobilization that the railroads changed the financial world, figuring both as an obscure object of speculation and desired object of financing.

> If one takes into account the typical way capital was raised for railroads, mainly by way of the stock emissions as well as by way of the issuance bonds—as in the case of government financing—... the dominant role of railroads in the capital market becomes particularly evident in the 1840s to the 1860s. [Spree, 1977:266][29]

This brief description shows that the construction and expansion of the railway system resulted in a fundament shift in the traditional means of transportation and actually had revolutionary effects for both the economy and society. These radical changes to the previous production and distribution modes as a result of rapidly growing transport capacities were achieved by a cluster of enterprises in the domains of private railroad companies proper, of machine construction, iron industry, coal production but also in the realm of banks and insurance companies. This core segment in the second industrial revolution succeeded within only a few decades—almost from nothing—in increasing the distribution capacities of the productive sectors within and, above all, between regional or national economies to significantly higher levels. In broad terms, one can agree with Walt W. Rostow, who emphasized that the construction of railroads

> lowered transport costs; brought new areas and supplies into national and international markets: helped in some areas to generate new export earnings which permitted the whole process of development to move ahead at a higher rate; stimulated expansion in output and the accelerated adoption of new technologies in the coal, iron and engineering industries; set up pressures (via the need for more durable rails) which helped give birth to the modern steel industry; altered and modernized the institutions of capital formation; and accelerated the pace of urbanization, with all its dynamic feedback effects on economic as well as social and political development.[30] [Rostow, 1978:153]

By substituting a RISC-perspective for the usual cyclical view, one is led, invariably, to assume that these long innovation waves constitute the peak in a distribution of innovations where a very large number of innovations has small and marginal impacts only. Table 2.13 provides a typology for four basic innovation types which

29 Translation by K.H. Müller.

30 Rostow 1978:153.

separates innovations into different diffusion potentials (low/high), different outputs (product/process) and, thus, into different innovation classes.

TABLE 2.13 **Types of Innovations**

		Type of Innovation	
		Product	**Process**
	High	Type I	Type II
Diffusion		(long waves)	
Potential			
	Low	Type III	Type IV

Thus, the emphasis of long waves research should shift from the few rare events to a spectrum of innovation types and their overall distributions. Here, the expanded typology for innovations in general places the Kondratieff technology waves or the Schumpeterian industrial revolutions in the broader context of four possible innovation types. If one differentiates—as in Table 2.13—between innovations according to their output in product and process innovations, as well as differentiating by high and low diffusion potential in innovations, then one reaches a configuration with a total of four different types of innovation, of which only a single group, *i.e.* the one at the interface of product innovation/high diffusion potential, corresponds to the Kondratieff or Schumpeter waves. Thus, large-scale innovations are not primarily arranged as long waves, reserved for a very few industrial revolutions, but innovations are arranged in a power law distribution, composed of a very large number of marginal or incremental innovations, of a limited number of medium-sized innovations and of a very small number of innovations with a very high diffusion level. These very few very large-scale innovations constitute the rare events or incidents with strong economic and societal consequences. Figure 2.9A reproduces fluctuations in a typical sequence of small, medium-sized and large innovations, which, at first glance, appear as three large innovation waves. Figure 2.9B, by contrast, shows that there is a highly structured power distribution behind or underlying the three long cycles from 2.9A. Power-law distributions, as shown in Figure 2.9B, can be either very steep or rather flat, depending on the exponential coefficient in equation (1). For instance, for g = 1, the slope consists of a 45° gradient.

$$P(k) \sim k^{-\gamma} \qquad (1)$$

In the context of Figure 2.9B, the long waves or the seemingly cyclical patterns of big surges in technological development and in large-scale innovations are transformed into a highly structured configuration with a very small number of innovations with very large-scale effects—the classical long waves—and a very large number of small changes with marginal or small effects. According to the distribution in Figure 2.9B, the cycles from 2.9A only depict those rare peaks that are embedded in an immense number of small changes.

FIGURE 2.9A **Long Waves at First Sight**

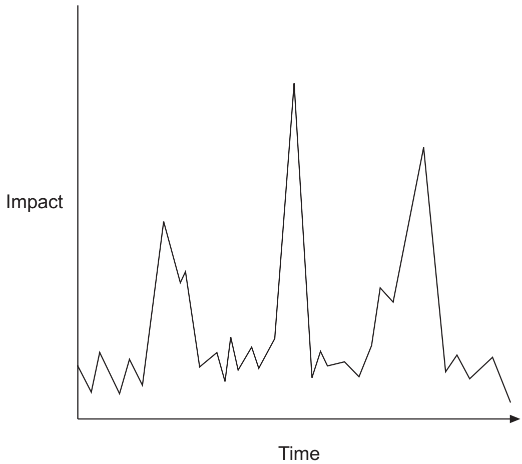
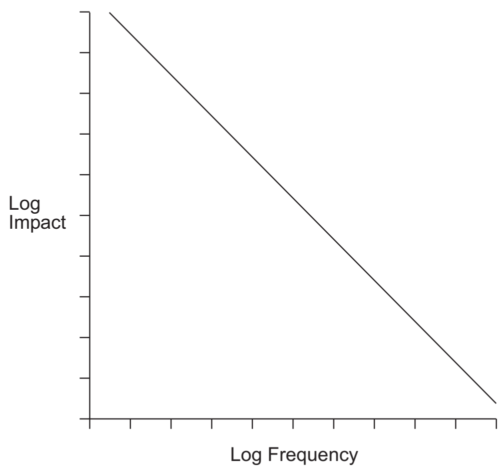


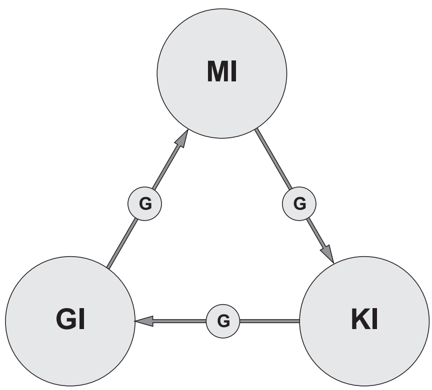
FIGURE 2.9B **A Power Law Distribution at Second Glance**



Yet Figure 2.9B does not only indicate a special distribution of innovations. These innovations, of different sizes and with different numbers, turn out to be generative with respect to their internal linkages. A very large-scale innovation enables, as is indicated by Figure 2.10, a number of medium-sized as well as smaller innovations across economic domains. Many small innovations, in turn, lead to bottlenecks and shortages in other areas of the economy and in the infrastructural domains which increases the propensity for a new large-scale innovation and so on. Figure 2.10 illustrates this generative and productive pattern between the many small, the less frequent medium-sized and the rare large-scale innovations.

In this way, an important substitute and a considerably richer empirical basis can be provided for the traditional view of long waves, which does not focus solely on the large-scale innovations *alias* long waves, but on the overall context of many small innovations, a smaller number of medium-sized innovations and a few large-scale innovations. It is in this sense that the substitution of the traditional cyclical paradigm in favor of fluctuations or, more generally, a RISC-framework is to be understood.

FIGURE 2.10 **The Generative Relation between Small, Medium-Sized and Large-Scale Innovations**



GI. Large innovations MI: medium-sized innovations KI: small innovations

An important aspect of substitution has to do with the question why and how such power law distributions occur, why innovations are distributed in such an asymmetric way and what general mechanism not only produces, but also reproduces this special configuration.

Here, it is important to point out that networks with power law distributions are not only found in the economy but are distributed ubiquitously across society and nature, and range from economic domains like firm sizes or income and wealth, to other societal spheres such as migration and agglomeration processes, to the evolution of languages and their word distributions or to ecological systems with their forest fires or ecological disasters to geological formations—

earthquakes—and to many other phenomena of the natural world. In general, these processes are characterized by a high level of compositional complexity, by both global and local interactions, a relatively slow global dynamic and by critical thresholds and phase transitions.[31]

Turning to the engine for the second Great Transformation, Table 2.14 presents an overview of the basic operations for the science-based engine and the cluster of RISC-processes, linked with this knowledge-producing engine. Once again, the concept of an engine refers to a basic network structure and to a growth dynamics of this science-based network.[32]

TABLE 2.14 **The Great Knowledge Transformation and the Emergence of Science-Based RISC-Processes**

Operations of the Science-Based Engine	RISC-Processes
Average problem solving capacities	Innovations in science
as requirement for long-term reproduction	Locations of radical breakthroughs
Growth processes for micro-units	in science
horizontally and vertically (program chains)	Quotations of scientific articles
Search for extra-cognitive gains	Co-operation networks between
New research programs as a constant	scientists in a given field (Erdös
source of extra cognitive gains	number, etc.)
Birth-processes for new	Reputation distribution across
micro-units (institutes) in a non-random	scientific domains
manner	
Death-processes for established	
micro-units in a non-random manner	

With respect to the nodes of the science-based network, the micro-units of the science engine consist of research units in the form of labs, institutes, research centers, scientific schools or even individual scientists, capable of scientific production or service provision and embedded in a global system of scientific co-operations and publications. The basic reproduction requirement for these micro-units is to reach an average co-operation and publication rate in the medium and in the long-run. Furthermore, these micro-units are capable of expanding

31 Regarding individual types of models see also Bak, 1996, Barenblatt, 2003, Jensen, 1996, Laughlin, 2005, McComb, 2004 or Ong and Bhatt, 2001.

32 On this point, see especially White, 2002.

horizontally, *i.e.*, regionally, or across disciplinary boundaries, *i.e.*, by stretching out to other scientific disciplines. The science-based engine is energized by the search for radical breakthroughs in particular and for scientific innovations in general which can be accomplished in a variety of ways. These radical breakthroughs or scientific innovations can be accomplished, in a paraphrase to Joseph A. Schumpeter, *via*

> significant improvements in the available scientific research programs already in use, the opening up of new domains in the scientific landscape or of new sources of research infrastructures, advances in general or special methodologies, the setting up of new research organizations such as small trans-disciplinary research institutes—in short, any 'doing things differently' in the realm of scientific life—these are instances of what we shall refer to as by the term scientific innovation.[33]

Thus, scientific innovations in their broadest possible variety constitute the incentives and attractions inherent in the global science network. Again from a dynamic network perspective, the second basic dynamic feature of a science-based network, aside from the search for radical breakthroughs or, more generally, for gainful scientific innovations, lies in the creation of new actors with strong preferential attachments. New actors come into play preferably in those network domains or scientific niches which are characterized by a high innovation potential like in the case of the integration of new scientific domains of inquiry or in very large-scale scientific breakthroughs like the rapid diffusion of molecular biology in the 1950s or 1960s. Finally, scientific network actors, failing the survival condition in the medium or in the long run tend to vanish from the science network, although, in the long run, the birth rate of new micro-actors surpasses the death rate of outgoing micro-units significantly.

From the right hand side of Table 2.14 one can see that the science-based engine for the second Great Transformation is accompanied by a large number of socio-cognitive RISC-processes, too, which, by now, belong to the normal scientific reproduction processes. As an empirical corollary, the extensive studies of Rogers and Ellen Jane Hollingsworth on the locations of radical breakthroughs point to a clear power law distribution where a very small number of institutes is responsible for a very large number of these radical breakthroughs whereas most institutes are characterized by no radical breakthroughs at all.[34]

---

33 Formally, Schumpeter defines innovations as any change that does not alter the quantities of production factors of a production function, but that leads to a variation in the production function itself.

34 See, for example, Hollingsworth and Hollingsworth, 2000a and 2000b.

2.4 The Infrastructural Constitution of Modern Societies

The discussion on the long-term evolution of societal RISC-processes offers a new perspective on the constitution of modern societies which places a special focus on their infrastructural domains and dimensions. Upon closer inspection, the rare events in technological innovations with a very large impact for societies occurred in special segments of the economic sphere which can be qualified as the infrastructural domain. These infrastructures, while part of the evolving economic production networks, occupy a special place since they offer and limit vital inputs and outputs for economic micro-units in three major areas, namely in the domain of energy, information and transport.[35] Table 2.15 offers an interesting overview which connects the discussion on long waves with the three infrastructural segments of energy, information and transport.

TABLE 2.15 **Rare Innovation Events and Their Infrastructural Domains and Their Generating Capacities**

Rare Innovations with Strong Consequences	Long-Term Diffusion Peak			Infrastructural Segment	Infrastructural Networks
Steam engines/ Textile industry	1788	1814	1848	Energy	No Networks
Railway	1848	1873	1896	Transport	Railroad network
Electrical industry	1896	1914	1945	Energy	Power grid
Automobiles	1945	1973	1996	Transport	Road network
ICT/Internet	1996	?	?	Information	Information net-Works (Internet, etc.)

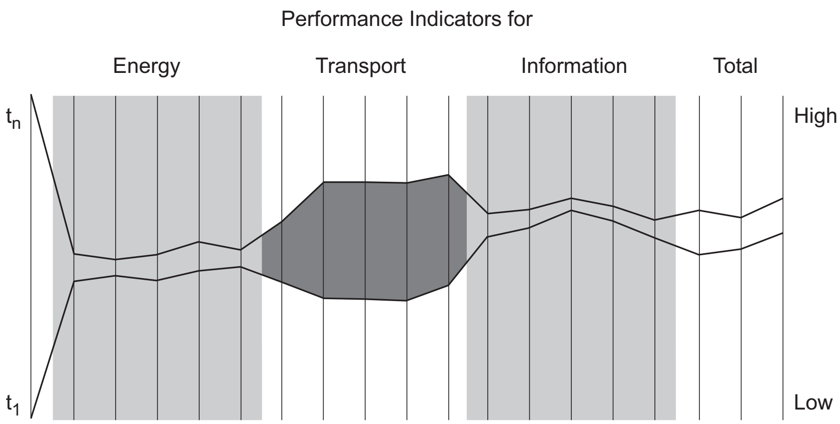
A rare innovation event with a very large impact across several dimensions of infrastructural capacities can also be visualized diagrammatically. Sticking to the second industrial railroad revolution, Figure 2.11[36] creates a multi-dimensional space in the form of five performance dimensions for the three infrastructural domains of energy, information and transport as well as for the development of

35 One should add that infrastructures can be extended to other domains as well like water supplies or sewage systems. The focus on energy, information and transport has been made primarily because these three infrastructural areas are directly linked with the succession of industrial revolutions, discussed so far.

36 Figure 2.11 is based on Parallel Coordinates where each dimension is visualized by a single vertical line and the different time-trajectories from t0 to tn move horizontally through the different dimensions. On Parallel Coordinates, see especially Inselberg, 2009.

economy and society as a whole. The general dimensions can be measured by overall societal performance indicators such as gross national product per capita or by the capital stock in trade for the economic system. For the infrastructural transport segment the dimensions could include, for example, the transport of goods as a whole, the number of employees in the transportation network, the value added in railroads, the total freight traffic and the capital stock in railroads. Figure 2.11, which is vaguely based on the German data from Table 2.12, illustrates in general terms how between 1850 and 1873 in large parts of Europe as well as in the United States a very rare technological innovation with very large effects must have taken place within the infrastructural transportation domain. As can be seen from Figure 2.11, changes in the infrastructural transport domain lead to significant shifts both in the overall economic system and in societal spheres as well.

FIGURE 2.11 **The Scheme of a Rare Innovation with Very Large-Scale Consequences in the Infrastructural Transport Domain**



Over a period of two decades only, these changes led to a transformation of the overall societal production regime.[37]

With the descriptions so far and with the help of Figure 2.11 it becomes possible to summarize the different effects, generated by a rare innovation event. Rare innovation events in a single infrastructural network create a large number of primary and secondary effects and, equally importantly, also second-order

37 For instance, the dimension of network density must have also increased on *a priori* considerations, namely, through the increased number of actors (new companies), through a rising network density in railroads, through the linkages of the financial sector with the railroad system, the linkages of domestic markets and finally through the new connections in the export sector.

effects. More specifically, an industrial revolution within a single infrastructural network like the rapid diffusion of railroads induces effects

- first, by revolutionizing an existing infrastructural domain itself (primary effects)
- second, by inducing a bundle of changes in other infrastructural areas (secondary effects for the infrastructure domain)
- third, by creating new nodes, linkages and linkage patterns for various economic arenas (secondary economic effects)
- fourth, by the changes in domains outside the economic sphere, like the state, households, the science system, etc. (secondary societal effects)
- fifth, by the changes within the induced changes of the infrastructural arena (second-order infrastructural effects)
- sixth, by the changes of these induced infrastructural changes in the economic sphere both for the immediately effected areas and for other segments of the economic system (second-order economic effects)
- seventh, by the influence of these induced impacts on societal arenas, etc. (second-order societal effects).

To sum up, very rare technological innovation events from the 18th century onward can be described as a number of simultaneous, substantial and mutually reinforcing changes[38] within performance dimensions and specific dimensions in one of the three infrastructural domains of energy, information and transport. More specifically, such a rare innovation event occurs

- within the diffusion period[39] of a new infrastructural regime either in energy, information or transport, which brings about
- significant and strong shifts in performance dimensions of the particular domain
- with strong repercussions or resonances [Niklas Luhmann] in other infrastructural arenas and in the economy and society as a whole.

This concludes the infrastructural dimensions of rare innovation events with very large-scale economic and societal effects.

Another striking feature becomes apparent in Table 2.15, however, as well. With the exception of the first industrial revolution which produced a significant rise in the energy sector for important parts of the economy, most notably for the cotton and textile industry, these rare innovation events with very large-scale consequences were accompanied by the emergence of new economic networks. Table 2.16 introduces—following the dimensions of Table 2.13 on innovation

38 See on this also point the account of Solomou, 1990.

39 Traditionally, one would write about the upswing phase of a so-called long innovation wave.

types—various network types, which are separated, on the one hand, according to the number of network actors into small-scale and large-scale networks and, on the other hand, according to their form of connections, into flow networks and into relational networks.

- Flow networks have, as their *differentia specifica*, physical connections between their network actors or nodes and manifest themselves, *inter alia*, as railroad networks, power grids, water networks, road networks, the Internet, high-frequency networks for mobile telephony, etc.
- Relational networks comprise attributes or operations of network actors or nodes and do not involve physical connection lines. Relational networks can be based on kinship, on friendship, on acquaintance, on cooperation, etc. What is absent in all these instances is a direct physical link between actors like in the case of a railroad-network, the power grid or a telephone network.

Furthermore, it becomes interesting to focus on the topology of these infrastructural flow networks.[40] As for the topology, networks—flow networks as well as relational networks—can be differentiated into two different architectures, namely, into so-called random or egalitarian networks and into complex networks, scale-free or aristocratic networks.

- Random networks, as depicted in Figure 2.12, evolve in a configuration in which the emergence of new nodes or links is not dependent on the pre-history of the overall topology. To put it differently, one does not find traces of memory effects. A typical random network, like the street connections of a region, links all relevant nodes. Here, the central goal is to reach all other nodes from one specific node with as little loss of distance as possible.
- Scale-free networks, as shown in Figure 2.13, emerge where the creation of new connections does not take place randomly, but are formed based on a non-random rule, giving higher probability to nodes with a high number of links already. Global air traffic—but also the Internet—exhibit such a complex architecture in which new connections tend to orient themselves to the strongest, *i.e.*, most connected nodes.

From a constitutional perspective, the new focus on infrastructure networks in the domain of energy, information and transport is so fascinating because these three areas—transport (or more generally: transport of material), energy and information—are, at the same time, the three basic ingredients in the constitution of the natural and the social world. What cannot be linked

40 For an overview see Barabási, 2000, Buchanan, 2002, Newman, 2005, Newman/Barabási/Watts, 2006, Sornette, 2003, 2006, Watts, 1999, 2003 and 2004.

to matter, energy or information[41] can hardly be imagined as being part of a natural or social ensemble. More importantly, energy, transport and information constitute a substructure that enables and maintains other societal domains as superstructures.[42] Because of their central importance, these three infrastructural domains define and restrict the societal developmental capacities not only with respect to transport, energy and information, but also with respect to other capacities, like production, distribution or communication.

FIGURE 2.12 **A Scheme for a Random Network**

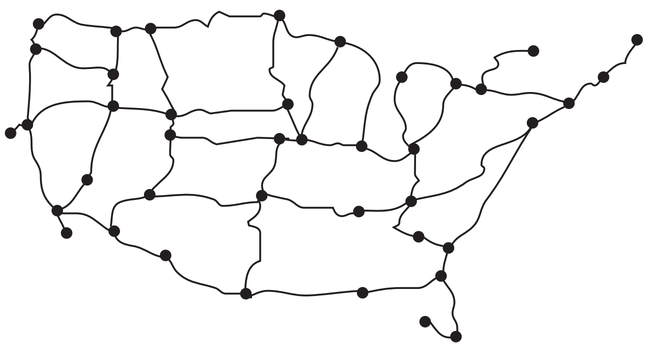
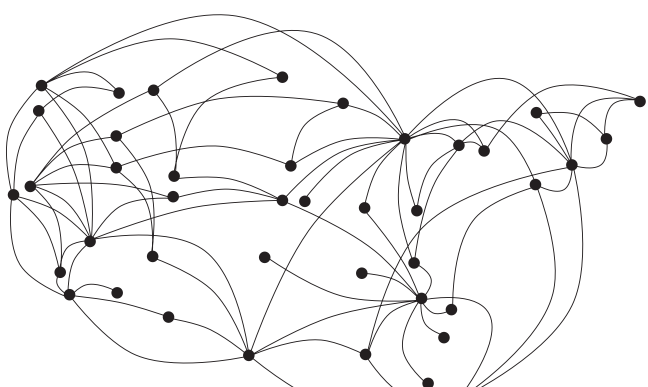


FIGURE 2.13 **A Scale-Free Network**



41 See, for instance, Norbert Wiener's dictum that information is information, not matter and not energy, or Horst Völz's definition of information as everything that is not matter or energy. [Völz, 1994].

42 One might add water and air as necessary ingredients for societal infrastructures and metabolisms. But while air has been and still remains a free and public good, in the long run, water infrastructures, while being modernized continuously, have not had the potential for large-scale societal innovations during the last three centuries.

Several characteristics can be associated with each of these three infrastructural networks and their long-term developments.

First, these three infrastructural networks, in the course of their evolution, have become organized as globally distributed networks across the territories and regions of contemporary societies. In this sense, one can speak today of a global societal transportation system, a global information system or a global energy system, all of which extend to every relevant place in a particular nation, region or settlement.

Second, these three infrastructural networks have become intrinsic components of the economic world system and of practically all major societal configurations outside the economic arena, like the national systems of education, of the national systems of health or of the political-administrative systems. Thus, an economic system becomes embedded in infrastructural networks and other societal systems turn out to be embedded in precisely these three infrastructural networks as well.

Third, each of the three infrastructural networks can be observed by means of one or several performance indicators, which measure the overall capacity levels in the domains of information, energy or transport and by means of a large number of ensemble-specific indicators, which record particular levels or flows of an infrastructural ensemble. Performance indicators, such as the per capita-consumption of energy, capacities for information flows or transport capacities, serve as overall parameters for these three infrastructural ensembles. Generally, one can assume that each of the three infrastructural networks can be measured with at least one, but usually several performance indicators and a comparatively large number of network-specific indicators. In sum, each of these indicators constitutes one dimension of a given infrastructural network, be it transport, energy or information.

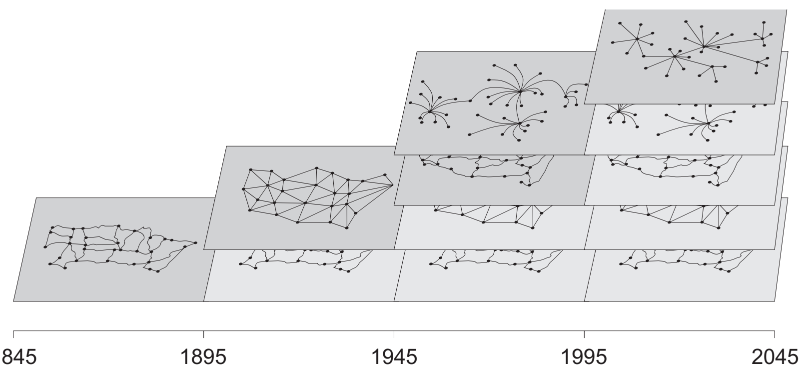
Fourth, the observations and measurements at the level of performance dimensions for these three infrastructural networks can be assumed to be evolutionarily stable. No matter how societies in the distant past, in recent history, in the present or in the future evolve, they can continue to be observed and compared on the basis of these performance dimensions. Evolutionarily stable dimensions have the advantage that they can be applied to almost any interval of societal time scale or time horizon. Over very long stretches of time, the distribution of values may change within these performance dimensions, but the dimensions themselves do not change.

Fifth, these three infrastructural networks also constrain the societal potential for self-organization and become, thus, critical parameters for dimensions such as degrees of societal complexity, of order or other structural configurations. For example, societal self-organization depends on the amount of transferable information and transport speed. A small message that needs several weeks to be transported restricts the domain of feasible forms of self-organization in the same way as a globally distributed instant access to very large quantities of information generates entire clusters of new forms of societal self-organization.

Sixth, these different dimensions constitute, naturally and formally, specific spaces. Since the observations or measurements of infrastructural networks can be carried out in these multi-dimensional spaces across time, the three infrastructural networks can be characterized by specific dynamics as well. Thus, regions, cities or nations change within these multi-dimensional spaces at different speeds, depending on the underlying capacities and dynamics of their infrastructural networks.

Seventh, in the long run, these infrastructural networks turn out to be accumulative. Figure 2.14 shows that from the mid-19th century to the present day several such large-scale flow-networks have evolved cumulatively, and at present can be found in an accumulation of co-existing and interactively linked large-scale infrastructural networks.[43]

FIGURE 2.14 **The Accumulative Evolution of Five Infrastructural Networks—Railroads, Electrification, Roads, Airports and the Internet between 1845 and 2045**



What is interesting here is not just the cumulative character—at present all large-scale flow-networks are operating simultaneously. The reciprocal linkages, too, between these infrastructural networks in the three domains of energy, information and transport deserve special notice. In a certain sense,

43 For clarification I would like to point out again that in the last two centuries several medium-sized and smaller flow-networks have also emerged, *e.g.*, networks for water, telegraphy or urban trolleys, which have played an important role in the third infrastructural revolution, which Joseph A. Schumpeter described as the "electric revolution."

these networks mutually generate and stabilize each other. For their operation, railroads require a functioning power network, which in turn is based on a novel information network, which, in turn, requires a power network and so on.

The accumulation of infrastructural networks in the course of modernity puts a new flavor to Manuel Castell's notion of the "rise of the network society"[44] although these infrastructural networks, aside from the current ICT-revolution, play a very minor role Castell's oeuvre.

Eighth, these infrastructural networks—irrespective of whether they are random networks or scale-free networks—exhibit an interesting life cycle dynamic because, at an early stage, these networks are to be found practically nowhere. Railroads were a typical non-issue around 1760 as much as electric power in 1830 or automobiles and airplanes in 1875. These networks start as marginal forms in a new energy, information or transport niche, increase considerably in compositional or functional complexity[45] and reach their full diffusion potential in the context of one of the three infrastructural domains at a later period, only to lose their dominant position within a few decades.

Ninth, another interesting point lies in the sequence of these infrastructural revolutions. A specific rare innovation event in one of the three infrastructural networks of energy, information or transport leads to an asymmetry with respect to the two other networks. Historically, it becomes relevant that the sequence of such infrastructural revolutions changes the probability for subsequent rare innovation events. Relations (2) and (3) demonstrate that a rare innovation event RIE does not take place sequentially within the same infrastructural domain $(IN_{i,t})$ & $(IN_{i,t'})$ at two consecutive points in time. Rather, a rare innovation event in one infrastructural network results, almost by necessity, in a subsequent, new rare innovation event in another infrastructural ensemble $(IN_{j,t'})$.

$$RIE\ (IN_{i,t}) : < P(IN_{i,t'}) \quad (2)$$
$$RIE\ (IN_{i,t}) : > P\ (IN_{j,t'}) \quad (3)$$

After this intensive discussion of infrastructure domains, of flow, random or scale-free networks and of rare innovation events which are concentrated exclusively in these infrastructure domains, it becomes possible to develop a new architecture for modern societies. Figure 2.15 exhibits a macro-pattern of vertical and horizontal linkages that run counter to the conventional wisdom of the constitution of modern societies, especially in the modernization or

44 See, for example, Castells, 1996, 1997, 1998 or 2000.

45 Compositional complexity refers—according to Rescher 1998—either to the number of modules or elements in a configuration or to the number of different types of such modules or elements. Functional complexity refers to the variety of modes of operation.

neo-modernization tradition. In Figure 2.15, the economic ensembles as well as various societal systems all are horizontally linked with one another and vertically connected to a societal sub-structure which comprises infrastructural networks for energy, information and transport.

FIGURE 2.15 **The Infrastructural Macro-Constitution of Modern Societies**

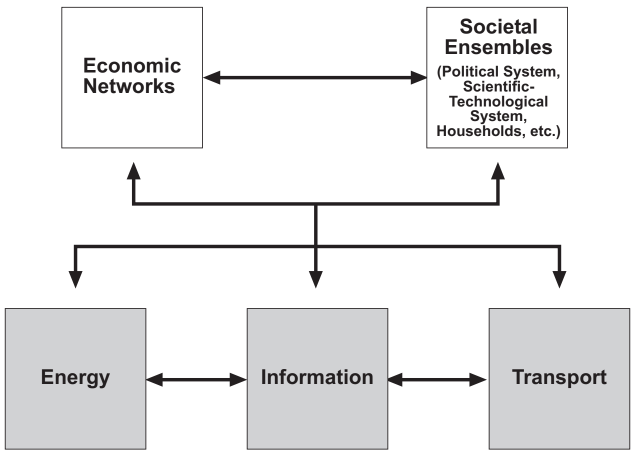
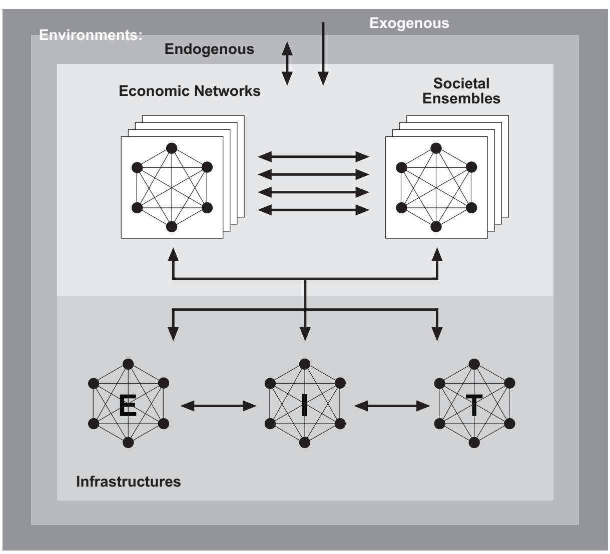
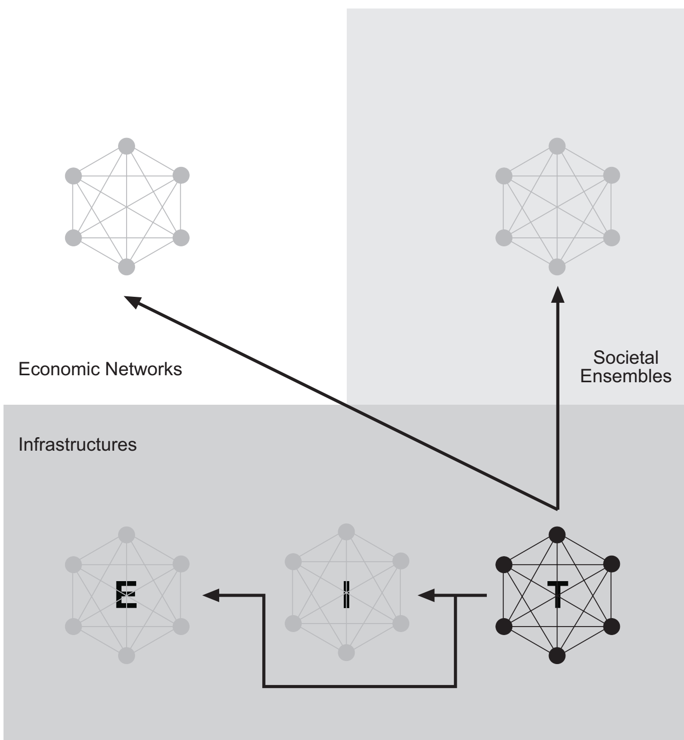


FIGURE 2.16 **The Infrastructural Network Micro-Constitution of Modern Societies**



In this sense, Figure 2.15 shifts the emphasis from the economic sphere to infrastructural network as the core of societal sub-structures.
Figure 2.16 exhibits the micro-infrastructural constitution of modern societies which in its overall structures reproduces the macro-ensemble of Figure 2.15 and which contains infrastructural networks for energy, information and transport as its basic sub-structure.
Figures 2.17 and 2.18 summarize the different effects of the rare innovation events in infrastructural networks. Figure 2.17 presents these primary and secondary effects and Figure 2.18 exhibits the second-order effects and adaptations, induced by these primary and secondary changes. In sum, rare innovation events in infrastructural networks imply four large groups or clusters of restructurings or reconfigurations.

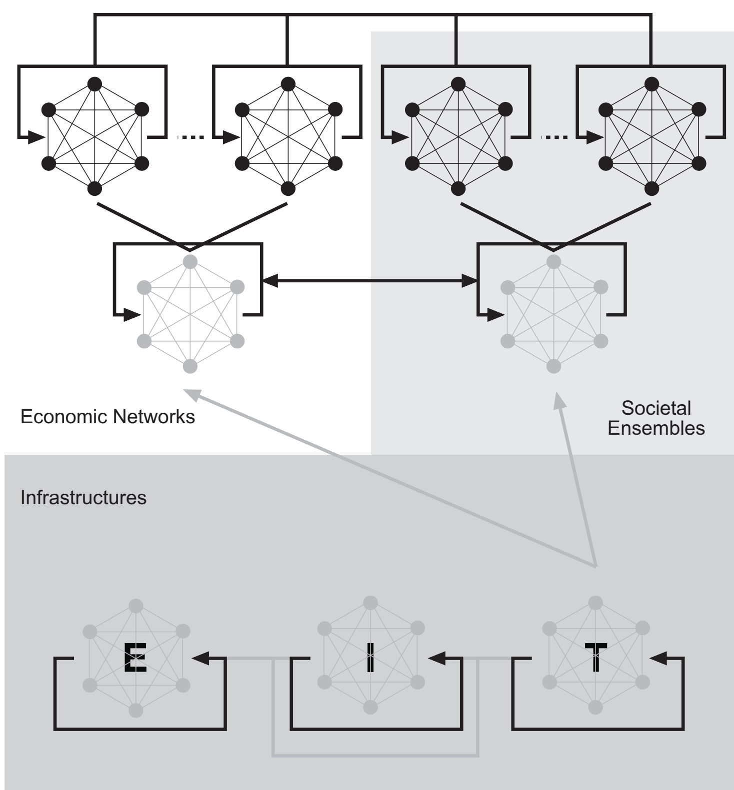
FIGURE 2.17 **Primary and Secondary Effects of a Rare Innovation Event in a Single Infrastructural Network (Transport)**



First, the primary effects usually manifest themselves as a big jump both in relevant performance dimensions as well as in specific network dimensions.

Second, a rare innovation within a specific infrastructural network opens up new horizons for innovations and can stimulate innumerable search processes for inventions, which can result in medium-sized or smaller innovations in other infrastructural networks, too. For instance, the expanding railroad network led to an end of the previous means of transport means for mails within the infrastructural information segment. In 1878 the last stagecoach closed its service in Germany and a series of innovations was needed to adapt the postal delivery system to railroads. By the same token, the packaging and delivery forms changed for many companies in response to the operations and requirements of railroad transport.

FIGURE 2.18 **Second-Order Effect of a Rare Innovation Event in a Single Infrastructural Network (Transport)**



Third, a big fluctuation in a specific infrastructure domain like transport leads to second-order changes that result from the ongoing diffusion of such an infrastructural revolution and its continued proliferation of primary and secondary changes. For instance, a European railway network also means that the transportation potential for commodities within and between countries can be significantly expanded in the long run. More export and import diversifications, in turn, open up new directions of specialization, comparative advantages and economies of scale, which are then reflected as second-order effects on small business or on the local production.[46]
Fourth, a significant element of diversity comes into play because a rare innovation event does not reproduce itself identically and does not occur at a uniform speed. From a global perspective, different types or families of development trajectories become possible, depending on the time-frame of a rare innovation event. Despite regional variations, however, a rare innovation event—for instance, the one that took place during the rapid expansion of the European or North American railroad networks—proves sufficiently homogenous throughout various regions, cities or nations that the same general directions prevail within the various dimensions of the infrastructural transport network. With reference to the revolution in railroads one will look in vain for regions in which the transport capacities have declined during the course of the building up of the railroad network.

2.5 The Third Stage in the Coevolution of RISC-Societies: The Recombinations between Societal and Natural RISC-Processes

After the presentation of a new infrastructural perspective on the constitution of modern RISC-societies the present chapter will be concentrated on the current phase of RISC-societies and on the new configuration of natural and societal RISC-processes across regional, national or global levels.

The Recombinations between Societal and Natural RISC-Processes

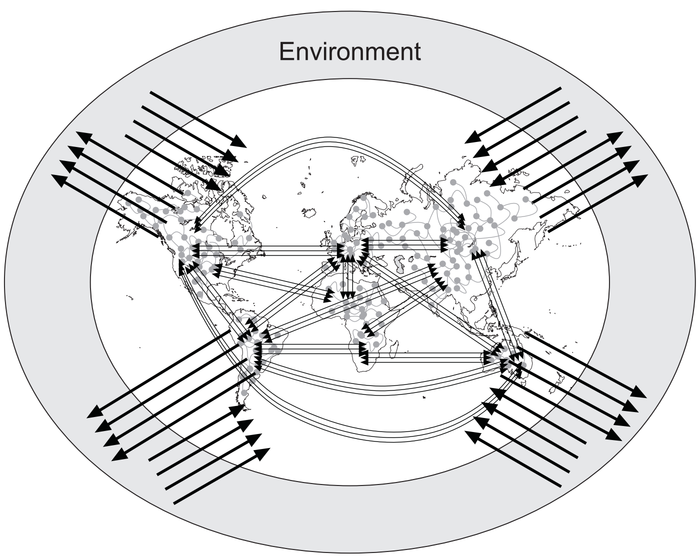
Figure 2.19 presents, once again, the state of RISC-societies around 1950 which marks the end of the second stage and the beginning of the third stage. Due

46 On both the positive and the negative effects of railroad construction on processes such as the development of cities, of national companies and the destruction of local production *cf.* the classical studies by Allan R. Pred 1966, 1973 and 1980.

to the two Great Transformations and the two RISC-network mechanisms for economic and knowledge production, the RISC-societies worldwide have become a densely interlinked ensemble with a large quantity of societal RISC-processes and, initially in strict independence, a relatively stable amount of natural RISC-processes. Prior to the third stage in the evolution of RISC-societies rare events with a high damaging societal impact shared the following three characteristics.

- First, these rare events, despite their usually strong effects, were local and affected relatively small parts of the world and left other regions virtually unaffected.
- Second, rare events were strictly independent from each other. Earthquakes and technological accidents, for example, were in no way related to each other and occurred for strictly independent reasons and within different generative mechanisms.
- Third, rare events, due to their local and strictly independent form of production, had rather weak effects for the continued development of entire nations or for the global survival in general.

FIGURE 2.19 **The Global Configuration at the End of Stage II**



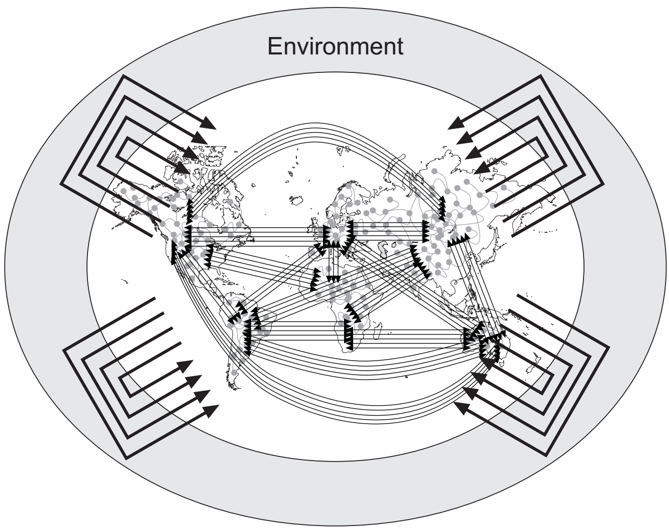
Within a few decades, however, the third stage in the evolution of RISC-societies has led to an entirely new configuration and to a recombination of natural and societal RISC-processes. Currently, all three characteristic features, associated with rare events during the second stage, have changed dramatically. In recent decades, these rare events have been undergoing a triple transformation process which, as will be shown below, has spectacular consequences for current and future problems of regional, national or global stability or sustainability, for that matter.

The first novel feature lies in a new phase of globalization which differs significantly from the global diffusion processes of the economic and of the knowledge engine of the second stage. The decades after 1950 produced a broad range of new globalization processes through the emergence of transnational enterprises and global institutions like the World Bank, the IMF and the United Nations, and, more importantly, through new global infrastructural networks for transport, *i.e.*, the global airline network, and, especially important, through new ICT-based networks. In terms of RISC-processes, globalization has lifted societal RISC-processes to global dimensions as well.

- The global air-traffic-system has been organized as a global scale-free network with a small number of central nodes, *i.e.*, airports with large a number of global destinations, and a very large number of small nodes, *i.e.* airports with connecting flights to the large nodes. Complex networks possess a special vulnerability pattern since the elimination of two or three central nodes can lead to the collapse of the entire air traffic-network.
- The world-wide web is organized as a global scale-free network in a number of ways. Most notably, the global information network itself is characterized by a distribution of a small number of central nodes, a large number of small connectivity nodes and the same vulnerability pattern as for the global air traffic-network applies.
- Computer viruses, due to the architecture of the world wide web, have the potential of affecting a huge number of businesses, state-administrations and private households practically simultaneously.
- The combination of global information and communication technologies and financial markets has produced a global financial system which, so far, has been growing exponentially and outside the control of global, supra-national or national RISC-protection networks or systems. Moreover, due to the ICT-support financial markets have advanced to a stage of automatic trading where the number of actors are considerably enlarged through automatic algorithmic traders with a vastly increased operation speed. Currently, this new financial system experiences the rare event of a global crash which spreads throughout the global economic sphere and which affects national conomies, regions or communities around the world in an unprecedented scale within the time-frame of the third stage of RISC-societies.

Aside from the globalization of economic, scientific or societal RISC-processes, one is confronted with a second fairly recent development which, however, becomes characteristic for the third stage in the evolution of RISC-societies as well. Economic development processes in goods and services, housing, transportation, energy, etc. in Asia, Latin America and Africa have passed, in conjunction with on-going processes of post-industrial growth in the highly developed regions, a critical level in greenhouse gas emissions, most notably in CO_2. Figure 2.20 points to the fact that global societal development processes have become critically related to the world climate and, as a consequence, to global climate change in the form of global warming.[47]

FIGURE 2.20 **The Re-Combination of Societal RISC-Processes**



The third stage in the evolution of RISC-societies experiences, thus, a double movement of RISC-processes.

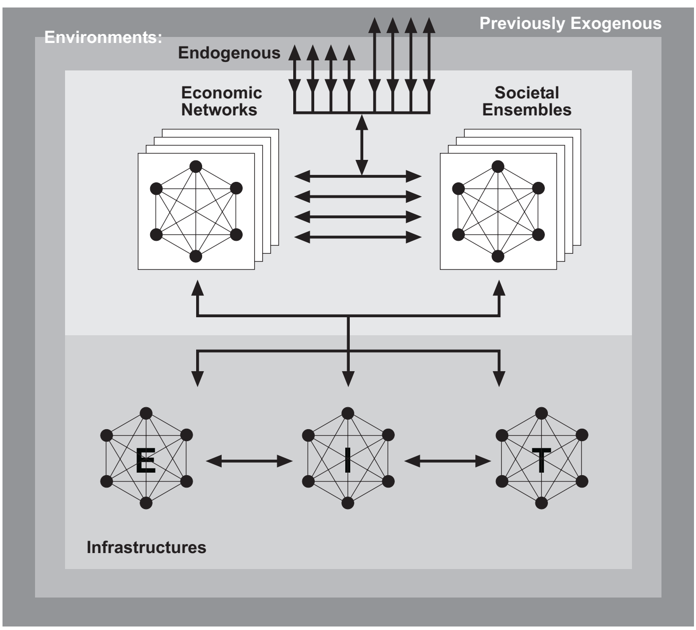
- On the one hand, societal RISC-processes become rapidly global in scale. ICT-technologies, air-traffic systems, financial markets, but also wealth, income distributions or urban agglomerations have left their national or local boundaries and enter a new phase of global distributions.
- On the other hand, the capitalist RISC-mechanism with its associated RISC-processes becomes critically linked with a bundle of natural RISC-mechanisms for the global climate.

47 For summaries, see, for example, Dessler and Parson, 2010 or Giddens, 2009.

While a steadily increasing amount of CO_2 emissions is not a RISC-process by itself, climate change has direct effects on the distribution of a large number of atmospheric and natural RISC-processes like floods, droughts, hurricanes, tornados, forest fires, and the like.

This, in turn, leads to the third new critical feature of the current stage in the evolution of RISC-societies. The third critical feature stresses the fact that societal and natural RISC-processes begin to interact and become entwined and entangled in unprecedented and unintended ways. Climate change with its new distributions for RISC-processes can affect infrastructural networks like the power grid which, as a direct consequence, can lead to energy shortages and, as an obvious secondary effect, to the inability to sustain the internet-economy in an undisrupted and continuous manner. Figure 2.21 summarizes the new challenges for the infrastructural architecture of contemporary societies through the three new features of the third stage of societal RISC-evolution.

FIGURE 2.21 **The Constitution of Contemporary RISC-Societies**



The Growing Risk-Potentials of Contemporary RISC-Societies

The three new features of the third stage in the evolution of RISC-societies, *i.e.*, a new phase in globalization, critical links between the capitalist RISC-engine and societal RISC-mechanisms on the one hand and global atmospheric RISC-mechanism on the other hand and, finally, new couplings and recombinations between natural and societal RISC-processes, have far-reaching implications for the future of RISC-societies at regional, national or global levels. Due to the three-fold transformation of natural and societal RISC-processes contemporary societies across the world are faced with an entirely new pattern of threats to societal maintenance, sustainability or viability.[48] As a catchphrase, contemporary RISC-societies are at risk in an unprecedented manner. At the global level, the following mismatches and maladaptations can be observed, namely

- a diffusion mismatch because more and more societal or natural RISC-processes can have non-local or even global effects
- a governance mismatch because economic globalization, despite a fast growing segment of global NGOs, has not been accompanied by the build-up of global institutions[49]
- a mismatch in the protection networks or systems because of changing distribution patterns of atmospheric RISC-processes due to climate changes and global warming and unchanging RISC-protection and RISC-support networks or systems, operating on constant average conditions with smaller or larger deviations.

For the national levels, new risk-potentials in the field of national security emerge which clearly transcend the usual profiles of military or terrorist attacks. Here, national security is understood in a comprehensive manner which includes military or terrorist issues alongside with economic, social, political, cultural or environmental dimensions. In this comprehensive context, national security is not simply synonymous with an absence of military or terrorist conflicts and violence, but depends on the well-functioning of the entire spectrum of societal and environmental networks and systems and their interactions in the face of the three new features of the third stage In the evolution of RISC-societies.

Thus, countries like Slovenia are confronted with a challenging new configuration which, *inter alia*, includes the following characteristics:

- an increased domestic vulnerability, due to a changing pattern of natural RISC-processes in Slovenia which are coupled with the economic RISC-mechanism in the form of global warming and climate change
- an increased vulnerability from outside, due to internal or external rare events in areas outside Slovenia, but with a high impact for Slovenia as well
- new requirements for regulation and prevention-policies not only in

48 On the differences between sustainability and viability, see the introductory article to Part I.

49 See the paper by Stark, 2009 which has been published as RISC-Research Paper Nr. 5.

traditional areas like building and construction, but also in financial markets, in the three infrastructural networks, in web-based technologies and in those environmental domains affected significantly from climate changes and from a different distribution of natural RISC-processes

- new capacities for damage control and for support networks which in the case of rare events are capable to operate with strongly improved soft skills and with locally adequate and accepted interventions.

In a separate article[50] different types of control challenges for contemporary RISC-societies will be outlined in greater detail.

2.6 Re-Dimensioning Sustainability: RISC-Robustness as a Third Dimension of Sustainability

The discussion so far on the evolution of RISC-societies opens up new perspectives for the concept of sustainability as well. The overall challenges ahead can be captured by Figure 2.22 which exhibits a new and third sustainability dimension alongside the two previously known ones. So far, sustainability has been discussed broadly in the following two dimensions:

- first, sustainability along a spatial dimension, *i.e.* the globalization of today's high socio-economic development levels to the entire globe and
- second, sustainability along a temporal dimension, *i.e.* the inclusion of future generations at today's high socio-economic development levels.

But sustainability has to be enlarged with a third RISC-dimension, namely

- third, sustainability along the RISC-dimension, *i.e.*, robust, or, alternatively, resilient[51] designs for the entire set of RISC-ensembles and for their environments across regional, national or global levels.

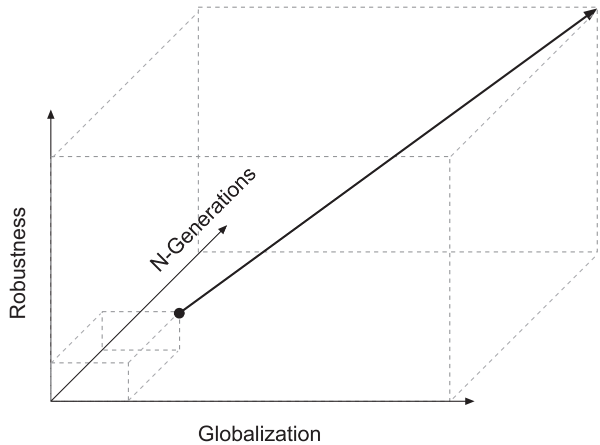
Figure 2.22 points to the new three-dimensional space for sustainability where the arrow indicates a drift towards higher levels in each of the three dimensions simultaneously. Currently, very little is known whether an arrow as depicted in Figure 2.22 is feasible at all or whether substantial increases of sustainability along all three main sustainability dimensions simultaneously cannot be accomplished under the given constraints, barriers and empirically observable distributions and reconfigurations of societal and natural RISC-processes at present.

50 See Karl H. Müller "RISC-Processes and Their Control Potentials" in this volume.

51 On the two equivalent notions of robustness or resilience, see Gunderson/Holling, 2002 or Gunderson/Allen/Holling, 2010.

In this way, a new and richer perspective on sustainability can be gained which moves sustainability problems into a vastly unexplored three-dimensional configuration of time, space and RISC-robustness.

FIGURE 2.22 **The Three Principal Components of Sustainability**



2.7 Three Big Challenges for Future RISC-Research

Due to the globalization and the partial recombinations of natural and societal RISC-processes it should become obvious why RISC-research should provide the missing links for a theory of societal evolution. The building blocks and the theories for a dynamic and evolutionary perspective of societal evolution, so far, lacked three crucial elements.

- The first missing component was a comprehensive and structured arrangement of both internal and external RISC-mechanisms and their production of RISC-processes. Past or contemporary societies are not experiencing rare events as a random sequence, but as a highly complex and coupled arrangement of RISC-mechanisms inside and outside of society.
- The second missing link consisted of appropriate accounts of actions or operations at the micro-levels which so far were dominated by schemes like Rational Choice or weaker variants like bounded rationality. Here, the RISC-framework operates with non-trivial models of embedded cognition which rely and require a rich observation basis of actions observed, of the internal stances of actors of themselves as well as assessments by others.

– The third missing building block is a result from the consequences of the previous two missing components. Societal learning processes as a consequence of rare events can be described and analyzed in a far more comprehensive and more trans-disciplinary manner since these societal learning processes take place simultaneously across a wide variety of societal domains.

The present overview of RISC-processes and their generative mechanisms can be concluded with a short summary of necessary steps and research tasks for the immediate or medium-term future. Quite obviously, the discussion so far on the long-term evolution of RISC-societies has led to a long list of extremely demanding research challenges and to a wide variety of potential RISC-applications. Towards the end of this article three of these major survival-critical research challenges and their appropriate RISC-applications will be outlined briefly.

– First, there is a highly demanding challenge for coupled RISC-modeling. The new stage in the evolution of RISC-societies around the globe requires intensive explorations of model groups with positive mutual feedbacks and the general format of:

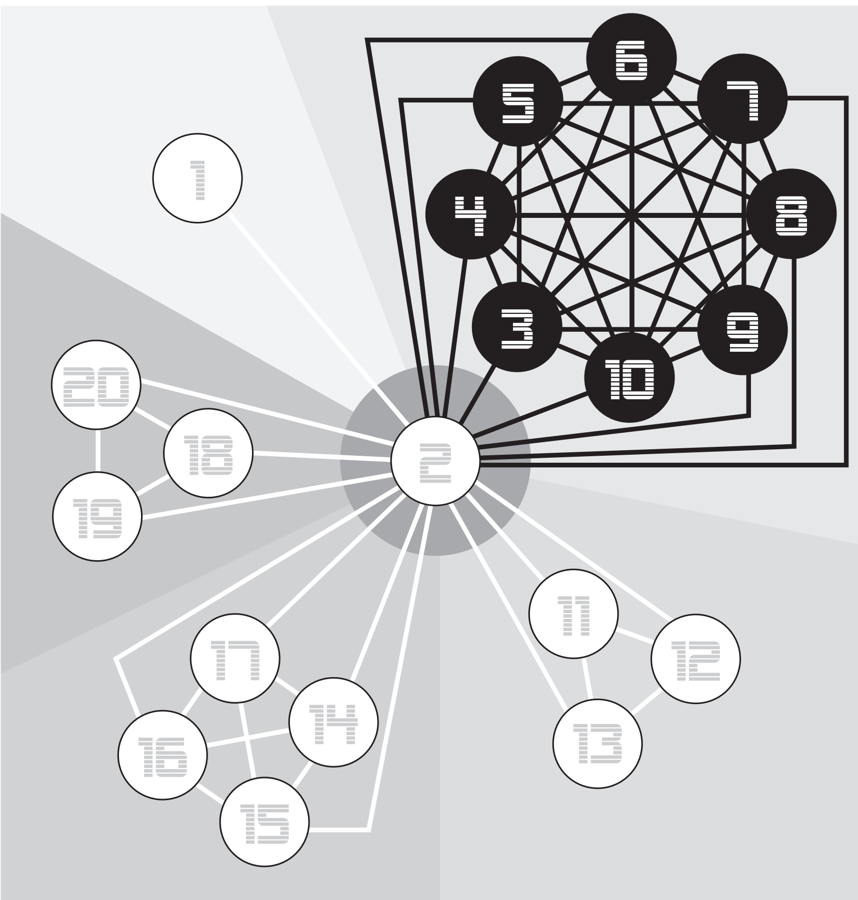
  $$M_1 = F(M_2, M_1)$$
  $$M_2 = F(M_1, M_2)$$

  These coupled RISC-models should be capable to specify the potential impacts for societal and environmental domains in a more comprehensive way than isolated and independent models.
– The second research challenge has to do with governance issues and new forms of institution building. The two most relevant governance challenges are directly linked with the ongoing globalization processes.
  The first very big problem has been mentioned already and lies in the asymmetry between the increasing set of global actors in the economic RISC-mechanism, the lack of actors of similar strength and scope at the global level within the RTISC-protection networks or systems and the need for a rapid catching up-process of global actors in the RISC-protection networks or systems.
  The second very large-scale problem lies in the opposite direction of globalizing actors, namely in a de-globalization of the impacts of rare events. In this respect the construction of institutional firewalls and institutional barriers becomes of utmost importance in order to contain rare events in relatively small areas only and to prevent a rapid diffusion to global levels. Such an institutional containment of rare events is urgently needed in areas like computer viruses, the power grids or financial bubbles, to name only a few prominent instances.
– Finally, the third research challenge lies in the utilization of transactional or electronic data in the study, in the prevention or in the rescue operations

of RISC-processes. The diffusion patterns of epidemics can be reproduced by studying Google-search operations, the contagious attractors inherent in financial markets become more transparent by the micro-data for selling and buying, or informal support networks can be created or activated in the case of disasters through recent Web 2-tools like twitter, facebook and the like. In this area, new observation devices and tools become available which must be integrated and utilized within the RISC-research tradition.

This small list of very big research challenges completes, in combination with the introductory RISC-primer, the overview on the potentials and the application domains for RISC-research, present and future.

Part II — RISC Modeling and RISC Theory



Introduction to Part II

Part II summarizes contributions which are aimed at a better understanding of the theoretical and modeling backgrounds of RISC-processes across contemporary societies. Part II can be subdivided into three rather homogeneous segments.

The first section comprises the two articles by Heinz von Foerster and by Monika Gisler and Didier Sornette. They provide a general qualitative discussion for an in-depth understanding of RISC-processes and their generative mechanisms. Heinz von Foerster discusses Zipf's law in the context of the 9th Macy Conference and he stresses the importance of self-similar or scale-invariant distributions. Gisler and Sornette advance the social bubble hypothesis as a general generative mechanism for societal RISC-processes. The social bubble hypothesis stresses network configurations with positive feedbacks unhampered by countervailing factors as the decisive element for the emergence of rare events across science, technology, financial markets, and one could add, politics, fashions, etc.

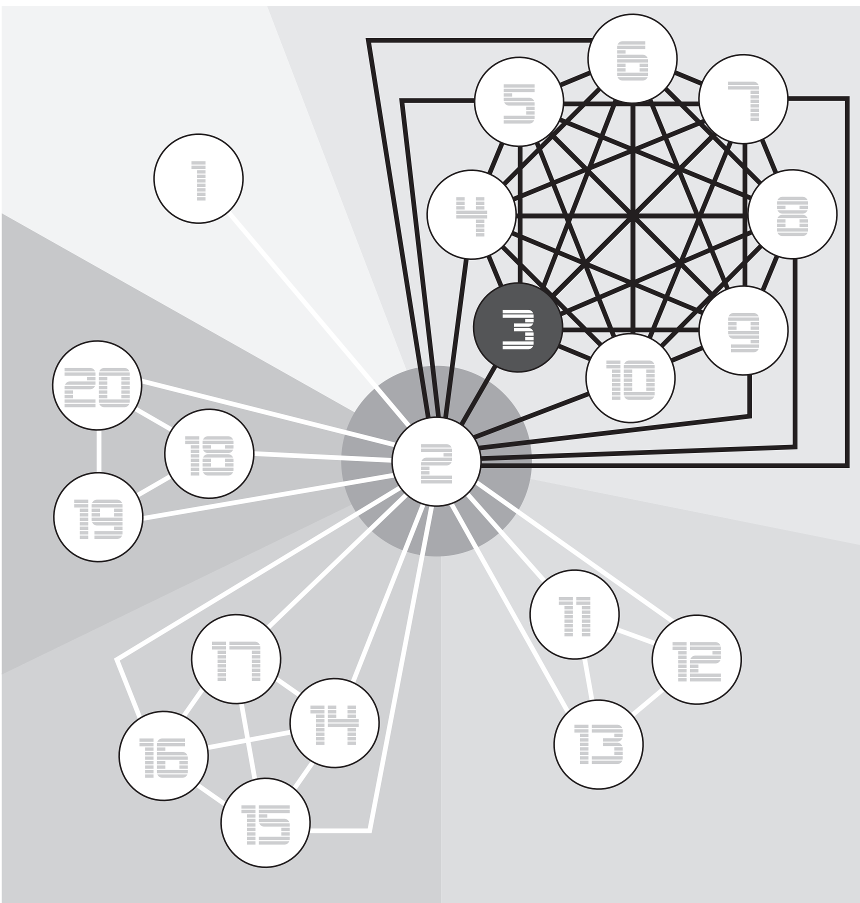
Turning to the second section four articles have been compiled on the modeling aspects of RISC-processes. Günter Haag proposes new models for generating power law distributions and suggests new micro-macro relations in this respect. Karl H. Müller discusses the wider issue of controlling RISC-processes by pointing, on the one hand, to a typology of RISC-control configurations and to a special theorem on the vulnerability of the emerging RISC-societies of the 21st century. Michael Schreiber, after giving an overview of labor markets as self-organizing systems, finds a new RISC-process in the field of labor market transitions. Finally, Günter Haag, Karl H. Müller and Stuart A. Umpleby offer a new type of self-reflexive RISC-model which draws considerably on the work by George Soros.

Finally, the third section offers two interesting perspectives which should be seen as complementary to the previous two sections. Adrian Lucas points to a potentially relevant framework for RISC-mechanisms in financial markets which is heavily based on the work of Richard Buckminster Fuller. And Peter Štrukelj reminds us that our state of knowledge on RISC-processes in financial markets is not only very restricted with respect to forecasting and quantitative modeling capacities, but also with respect to *ex-post* qualitative explanations. Investigating current studies on the financial crisis by renowned economists in closer details, he comes to the conclusion that these accounts do not even qualify as explanation sketches and simply qualify as an expression of relative blindness even *ex post*.

3

A Discussion on Zipf's Law

Heinz von Foerster *et al.*



Heinz von Foerster *et al.*: A Discussion on Zipf's Law[1]
[Titlepage 1]
Zipf's Law.
Macy Meeting 1952

[Titlepage 2]
Ninth Conference on Cybernetics
Josiah Macy, Jr. Foundation

March 20–21, 1952
Hotel Beekman
New York, N.Y.

[Transcript]
VON FOERSTER: I will try to make Zipf's law as short as possible. About two years ago, a professor in Harvard, Professor Zipf, published a book which was called *Human Learning and the Principle of Least Effort.* This book was an extensive survey of statistics which dealt with the frequency of occurrence of elements of various kinds which belonged to a particular class. I will give you immediately a concrete example.

For instance, classes of things which were dealt with were words in a book or beetles in a backyard or occupations in the country, and the question was, how often did a particular occupation, for instance, occur in the country; for instance, how many barber shops can be found in the United States, or how many beauty parlors can be found in the United States, and so on and so forth; so that occupation would be a class, and then the kind of barbers or beauty shops, and so on and so forth. In the case of the words, I would say it would be the different words.

He found the following situation: In counting, for instance, all the different words in a book, he found that there is one word which occurs most frequently. Let's say in English it would be "the." As a particular example, in James Joyce's *Ulysses*, you have about twenty thousand "the's." This word is a word with a rank, No. 1, and we give it the first prize in the occurrence of words. The word with rank No. 2 will be another word—and I will put down here [on blackboard] the rank and here I will put down the frequency. The second word—I have forgotten it, unfortunately, but it might be "a," the general article. He found it had a

1 Slightly edited text following an unpublished typescript kept in the Heinz von Foerster archive at the Department of Contemporary History, University of Vienna, Sign. DO 968, 4–8–1. Words and signs in brackets indicate corrections or additions to the transcript.

frequency of 10,000, which is precisely half of the most frequent word. The word which ranked No. 3 as the third most frequent word would have a frequency of about 6,666, which would be a third of the maximum frequency. If you call the maximum frequency F, he found that the frequency of a word with the particular rank could be written down in a formula which is F/r. This does not hold only for words, but it holds also, for instance, in counting the number of different kinds of beetles in the backyard. It is also valid for counting the different occupations in the country. One can find out, for instance, that the most frequent occupation in the United States is actually the barber shop, the second frequent one is the beauty parlor, and the third frequent one is the laundry, and, also, they follow precisely this kind of statistics. This is certainly very peculiar, and lots of people have thought about how such statistics actually occur.

Now, the usual way of plotting the results of this kind, of making statistics, is plotting rank logarithmically and the frequency in units, so that in this direction, the logarithm of frequency is plotted, and in this direction, the logarithm of rank is plotted, and as a result of the original equation I put on the blackboard, F/r, as a constant in this time, the maximum frequency F, you have a straight line in that logarithmic representation. This straight line cuts the frequency, so that 1 is about here, and it goes through the axis of the rank just at a point which indicates the total number of different kinds. With respect to words, it would be the total number of different words used in a book, or the total number of different species found in the backyard, or the total number of different occupations existing in the country.

It can easily be found, for instance, if you put the frequency, F, equal to 1, then certainly r becomes equal to F, and since the highest rank must automatically, by the way in which we count the rank, be identical with the number of different kinds, that means that n, the number of different kinds, equals then the number of or the frequency of the most frequent word. That means that if you actually want to know how many different words are used in a book, the only thing you have to do is to count the number of times the word, "the," occurs in that particular book and then you know immediately quite well how many different words occur in that book. That is certainly very startling and very peculiar.

There is a possibility of making an indication why that counts, and it is as follows: If we make statistics at all of such a sample of the different kinds that can occur, where every kind is represented by lots of individuals, then what you have to look for is certainly a function which I would call, rather, generally, P, which should be a function of the different kinds, which I would call n, and the possible rank. I would say this is just the thing that I select out of the whole thing. Our particular example, for instance, for actual type distribution is n/r, because n is identical with the maximum frequency and r gives the number of ranks.

Now, let us forget for the moment what actually is found out, and let us consider a very general picture. Let us assume that I have here a universe in which lots of different kinds are floating, by representing a lot of different individuals within that kind. Let us make several triangles that would represent, for instance, "the's" or barber shops or beauty parlors in the country and all those things, another kind, and so forth. Let us assume that such a universe exists. To know what actually occurs in that universe, we have to make a sample universe. Making a sample means collecting a particular region out of those things. Immediately, we can make statistics. For instance, in this particular sample, with three plus signs, one circle and one triangle, our rank frequency diagram would certainly rank 1 for the crosses, it would be frequency 3; rank 2 for the circles would also be frequency 1; and rank 3 for the triangles would also be frequency 1. Now, in this particular example, you can see that the definition of what we call a rank becomes a little bit arbitrary in the moment where several different kinds have the same frequency. But I will show you a little bit later that it is possible to avoid this arbitrariness and it is also possible to establish for any particular kind a real rank, a value.

Now, I asked for this kind of universe the following things—and this is a particular assumption which is made, and I would like to call this particular assumption for lack of a better word, the generalization of the cosmological postulate, and what I mean by a cosmological postulate—which was the famous idea pointed out by Eddington, Millikan, Jennings, and so forth—is that if we look at the world, the world should, from all points in the universe, look alike; that is, wherever you put an observer in the universe he should see the same kind of a universe, the same distribution of stars or nebulae. Let us ask precisely the same thing for this kind of a universe; that is, that every observer should see precisely the same kind of distribution. Then we must ask for such a distribution free play, which actually does that job. In doing that, it means the following thing: Whether I go in my backyard or whether you go in your backyard or whether somebody else goes in his backyard, he should find a similar distribution. On the other hand, it should also be the case that if you increase your sample, if you make it a little bit larger, you should also see a similar distribution. Now, I have to state precisely what I mean by a similar distribution.

By a similar distribution, I mean that the rank-frequency diagram should actually give the same kind of a function. For instance, we have a rank-frequency diagram of any particular form; we should expect, if we increase the sample, to find a similar form. That would be a generalization of the rank-frequency function. Now, increasing the sample could also refer to two different ways of doing it; namely, increasing the sample could mean going forward until I find the next element, and these elements could be two different things: either it could be an element which I already have in my sample, or it could be a new element with a new species. Now, I define a proper increase of my sample until I reach a new species, and this for the very simple reason that if I increase my sample and I have a particular rank-frequency diagram already established, [of] any kind, let's say—let's make it general—then it would mean only that I am going to disturb this kind of a rank-frequency diagram, which I would call a fluctuation, a particular fluctuation of that diagram. A proper increase means only if I go further and catch a new sample.

In establishing this as a proper increase of a particular sample—and it should give exactly the same function of a rank because of the distribution—I have to say the following thing: The change of Φ in respect to n, with the number of different samples, should be a mere function of r, the rank alone. That means it should be independent of the number of different kinds I actually observe in that sample. Making this very specific definition, it can be integrated immediately and I get an integral which gives [the result]: Φ must be n times the functional r, plus, I would say, an integration constant which would be a function of r. These can be shown to be zero, because if I have no sample at all, I certainly must have a frequency function of zero. Φ must be zero; therefore, [c] turns out to be zero. The next thing we can establish immediately is the following—

BIGELOW: Those two functions of r aren't the same thing, are they?

PITTS: Those two Fs are the same, are they? Yes, they obviously are, as a matter of fact.

VON BONIN: You mean this F?

PITTS: He is just integrating directly.

VON FOERSTER: This is a partial derivative of Φ in respect to n.

BIGELOW: F is a constant, then, with respect to n?

VON FOERSTER: Yes, with respect to n. Now, I can immediately ask what will happen if I put r to n; that is if I make my rank the highest rank which exists. Then, certainly, by the definition that I would go and increase my sample so long until I catch a new sample or a new species, then this new kind can occur only once. That means a function of n, n, whether r is equal to n, must equal 1, because when this sample occurs just one time in the whole sample, by putting r to n, I get an equation of n to n must equal 1. That means that our function of F to n must equal 1 over n, for all n's, and this is precisely the thing which has been proven; namely, that there is a general function which shows always 1 over r as a distribution function which I actually get in the sampling of those things. This is always the case, then, only if I am operating in a universe where the things are so distributed that wherever I start in that universe, and how large I make the sample, I get the same distribution.

You see the restriction of this law immediately, because it is restricted at that point by already touching the limits of the universe, because then I really know I am on the edge. That is information, and it means that the whole rank and distribution would be completely changed. It would not be possible, therefore, by knowing the total number of beetles, kind of beetles, which we have on the earth, to infer about these numbers directly to the number of actual beetles living in the world, because then we have already touched the limits of the universe and we can't make any such statement. In the ease of our mental patients, let's say, they are living somewhat at the edge of the universe and therefore, in the universe language, they do not have those words more available and therefore you have distortions of the straight line occurring. Now, I must confess that I do not recall precisely.

BIGELOW: Hold it a minute, will you? Within that first sample box, you contain a certain sample; right? A certain sample is contained there?

VON FOERSTER: I collect a sample there.

BIGELOW: The sample is finite?

VON FOERSTER: Absolutely finite, yes.

BIGELOW: Then there are some, by the law, which are not in the sample, because if the sample contains a finite number, if you keep finding those species which are rarer, you will finally find a species which is so rare that not one of them will be in this sample. However, if you expand the size of the sample, you will get this new species.

VON FOERSTER: That is right. I get this new species and I say, by proper increase of the sample, it is only that increase which gives me that new very rare species.

McCULLOCH: Let's put it this way.

BIGELOW: This thing implies that there are an infinite variety of species.

VON FOERSTER: Right, and that is the ease with your sample in comparison to all possible species.

McCULLOCH: Zipf' s law would not hold for the chemical atoms.

BIGELOW: How can it hold for language?

WIESNER: Does this mean, then, a man uses only a small portion of his total vocabulary?

VON FOERSTER: That is right.

McCULLOCH: Unless you deal with a lobotomized individual; then the peculiarity is that the lobotomized patient runs out of words for rare cases, Zipf's law curve comes down and is chopped off at the bottom. He has run out of kinds.

VON FOERSTER: Precisely. It assumes that the universe is infinitely larger than compared to that which you are actually able to observe. That means you are sampling only a small section of the potentially available universe.

BIGELOW: How do we get this third out of this?
VON FOERSTER: This third?
BIGELOW: Yes. You were bringing them down, and you indicated that n was a certain constant. The rate at which they fall off, the most common number, is a definite constant in the first case you put on—your 20,000, 10,000, and 6,666.
VON FOERSTER: Oh, yes. I mean the function, F/r, should be a function of the form 1/r. That means, if I have n different kinds which I actually observe, then my function must look equal to n/r; that is, if I am collecting a thousand samples or a thousand kinds, rather, of things, then my rank-frequency diagram must look like the following thing: rank 1, 1000. This is the maximum frequency. Second rank, 500. Third rank, 1000 over 3, 333, and so on.
PITTS: I must say that since you have increased the size of the sample to the degree necessary to find one more species, which may be a very large degree, replacing those finite differences by derivatives leaves me with some doubts.
VON FOERSTER: That is true, that is perfectly [loss of text].
... start from a point, you take a square and take everything in that square, and make a list of all the dots belonging to each class. Naturally, if you allow that square to end at a limit, there will be the mean density of spots or dots of each particular type in the universe, and that forms an arbitrary set of numbers that can vary, I think, somewhere between zero and 1, all independently.
PITTS: Now, what you are saying is that no matter what that set of population density is, for smaller samples at any rate, you will always get Zipf's distribution, with respect to the numbers inside any given square. Is that right?
VON FOERSTER: No, I am not saying that.
PITTS: Well, this is certainly a case where it is homogeneous from the point of view.
VON FOERSTER: In that case, you don't get Zipf's distribution. There is a particular complication in assuming the following thing: In my work, I had to assume an infinite number of kinds, that each kind should represent an infinite number of elements. Now, in the case of, let's say, a [Poisson] distribution off a plane.
PITTS: Well, a collection of objects, each distributed with a [Poisson] distribution, and there will be an infinite sequence of densities which we suppose converge to an infinite number of objects.
VON FOERSTER: You get a peculiar result, a result which is much more probable; that with the next increase of your sample, you get always a new kind into the whole thing. Let's say we can treat the whole thing the following way: Assume you have a tremendously large urn and in this urn are a lot of different marbles with an infinite number of colors. You are drawing marbles and you always make a note of what kind of marble you get. The highest probability you ever get is a new color with every draw. That is the highest probability. Actually,

to get—and this would be a distinguishable case because if you are going on and drawing marbles, you get a certain series of red, blue and green, for instance. I collect those marbles also and I get violet, pink and orange, or something like that, out of the urn. That means we would both draw different samples. Therefore, our urn must have such a kind of statistics that we cannot distinguish whether you are going to draw samples or I am going to draw samples, or anybody is going to draw any kind of large samples; that we get precisely the same kind of samples out, it must have an internal distribution at this point of 1/r, so we get a like result.

PITTS: But the crux of the process that distinguishes it from the ordinary sample is that you take the size of your sequence of samples, determined by the number of kinds in the content.

VON FOERSTER: Yes. This I must say, to make a generalization of the function, F/r, because if I am increasing r my sample and I get something which I have already counted, then it would just perturb a little bit my rank-frequency curve, because then I have a particular unit to a certain frequency level for a particular rank. That means it would just be counted as a fluctuation, so I have to increase the sample until I get a new kind.

BATESON: I am in some doubt about the definition of the classes that you are doing this with. Suppose you were doing it with beetles, and you extend the area at which you count beetles and find that you have included barber shops. Could this statistical method be made to discriminate between barber shops and beetles or is that left to you?

VON FOERSTER: That is a very peculiar thing, and I confess I don't know what are classes of elements, say, whether elements are in a certain structural relationship to each other. Talking about beetles, we know that we mean beetles, and beetles are not barber shops. But I must confess that I don't know where to make the distinction, because you can invent some rather close questions, where it is rather arbitrary which is which. I must purposely exclude the barber shops.

BIGELOW: What happens when you carry your sampling out to three dimensions?

McCULLOCH: Oh, that doesn't matter.

VON FOERSTER: That is exactly the same.

WIESNER: I didn't understand the answer to Pitts' question, which I think is rather important.

PITTS: What apparently is the case is this: that apparently he so increases his size of samples, according to a curious sequence, depending upon the actual number of kinds visible in the content, in such a way that it converges to a different limit.

BIGELOW: I don't get that.

PITTS: I don't see any reason for supposing that this curious sampling process actually acts in the accumulation of data to which Zipf's law applies.
GERARD: Let's go back to a single book. You say that the most common word is going to be twice as common as the next common and three times as common as the third most common one. Then you say, in English, the most common word is going to be "the." If we go to German and that one word breaks up–.
McCULLOCH: It holds.
GERARD: –into three others, why does that still hold?
McCULLOCH: Well, it wouldn't be "the."
GERARD: Then it won't be "the."
McCULLOCH: It would be "ein" or something else like that.
WIESNER: There is a fundamental of the sampling process which I don't quite understand.
McCULLOCH: Let's take a few of the things for which Zipf's law won't hold.
PITTS: What reason has he got for supposing the sampling process is actually carried out in that way in cases that give Zipf's law?
McCULLOCH: Let's wait one moment and let's see the things for which Zipf's law doesn't hold. It will not hold for chemical elements, or atoms. It will not hold for simple inorganic molecules. It may hold for protein molecules. We are not in any reasonable sample going to exhaust the richness of our universe. Wherever you exhaust the richness of your universe, you are going to come down.
WIESNER: I want to bore a little further into the answer to Walter's question. Are you saying that if I have a universe in which the populations are equally likely, I can get this kind of sample?
PITTS; He is saying that it doesn't depend on what the potentials of the population are.
WIESNER: But if he says he doesn't care, it implies that you can use the one you want to use.
PITTS: Then you wouldn't get Zipf's law.
BIGELOW: This means that in each case, the increment he takes is a function of what he gets in the increment. He doesn't really know that, however.
PITTS: Well, he could. He could keep adding elements.
BIGELOW: This is not the sampling process.
PITTS: Not in the ordinary sense—well, yes, it is, really, because he doesn't determine which element he picks. He keeps picking elements at random, but he stops as soon as he finds a new kind that isn't already in the sample. He just determines where he stops adding to his sample and then looks at it.
BIGELOW: But a random sample is one in which you don't do this, in the ordinary sense.

PITTS: Well, this is random in the sense that any particular sample is composed of elements, each one of which has been randomly selected.
BIGELOW: But if you play a statistical game in which you are allowed to terminate the game when the variables have certain properties, you can always affect the answer.
PITTS: Well, of course, but I mean, the individual choices are independent.
WIESNER: May I ask what is the probability of getting this result? It must be very small. If you allow me to start, as you said you would, with an equally likely distribution of all the elements in the population.
PITTS: Incidentally, if that is so, of course, an argument of this kind will not proof it.
BOWMAN: I would be inclined to put the statement more or less the other way round, and regard this as an observation rather than a proof of anything.
VON FOERSTER: Right.
BOWMAN: That there are a large number of classes of natural things for which the cosmological postulate holds, and let us just accept as a strange empirical fact.
KLÜVER: It is not so difficult to think of this in connection with lobotomy. What I find surprising is that in a population of any city in the United States, five million, ten million, or so, you have the same distribution. I am surprised at this strange observation, the facts here, if this is so. All the other laws of history, then, do not seem to count for very much. What actually is underlying such a strange equation?
MEAD: How many languages were used?
KLÜVER: I would first like to know what is the fact.
McCULLOCH: Three—Latin, English and Old German.
BIGELOW: How close does it fit in these cases?
McCULLOCH: Oh, surprisingly well.
PITTS: He has samples of 10.000 or 20.000 at least and taken from all sorts of books, picked at random, at least so I would suppose. It impressed me.
McCULLOCH: And it doesn't matter whether you take English, modern English, or anything else, you get Zipf's law. There is one language that is deviant. Let me tell you, there is another thing that is rather interesting here. There is one language that is deviant, and that is Old Gothic.
MEAD: Well, are there any non-European Languages in this?
McCULLOCH: I don't know of any that have been studied. I heard that somebody was studying Chinese. Now, here is one more point I would like to draw in here, if I may. If you study musical intervals, you find a corresponding law for Zipf's law holding for musical intervals. The Zipf's law breaks immediately. That has been studied from Haydn up to modern times, and it breaks immediately.
BIGELOW: By whom, sir? Who carried out this study?
McCULLOCH: One of Zipf's students.

PITTS: He has a whole project of people counting things. He did it for many years.
McCULLOCH: It holds beautifully for musical intervals until you hit a man who set himself to write music in the following way: that he would use no interval twice until he had used all others once [laughter], and, of course, Zipf's law doesn't hold. It is a perfectly flat horizontal line.
VON FOERSTER: That was Schoenberg because he introduces very artificial means of creating music.
McCULLOCH: Schoenberg was the first deviant from it.
PITTS: The cosmological postulate is quite irrelevant. That is generally the assumption that is made in ordinary sampling theory, that if you take one additional element, the probability of getting a given value for it will not depend upon the ones you have selected, and they will be essentially the same and independent of the ones you have already taken, which is what you usually assume. This is the assumption of ordinary sampling theory. The way in which you get it, of course, is this very special method of sampling, and that is the assumption that really underlies it, not the assumption of the uniformity of probability, which certainly by itself would not do it.
Now, what strikes me as strange is the supposition that the data are so gathered, according to the special sampling rule which alone would lead to Zipf's law. Can one suppose that all the people who have collected data on words have constructed a sequence of samples according to these rules?
VON FOERSTER: I don't know.
PITTS: Or collected moths in a moth trap according to this rule?
BIGELOW: One might, in fact, find such a trick in their data-gathering system.
McCULLOCH: No, the whole of the book was counted. All of Joyce's *Ulysses* and the whole of Homer's *Ulysses* were counted, and Zipf's law holds for both.
BIGELOW: There is one comment, that it is extremely difficult to find general empirical laws which hold like this in the history of science. There have been a number, all of which have been proven to be false alarms. This one may be true, but take the question of the Gaussian distribution, which is one of the things statisticians and scientists really believe in. You can produce situations where the Gaussian distribution does not hold in nature, where it should be thought to hold. A typical example is if you go out and measure the distribution of trees in a forest. If you measure the distribution as the function of diameter, the function of area, the law of the distribution of size of trees can't be Gaussian and be this, too.
VON FOERSTER: Yes, but I think the difference in the two kinds of statistics is that here we are dealing with a number of different kinds, whereas in the other case in the Gaussian situation, for instance,—we are dealing with one kind only.
BIGELOW: But there can be many weasels where you identify a kind, you see. I don't think that is the ease in this situation, but I merely say one should be

cynical of rules which purport to extend over a very wide class of phenomena, and also; the statistics have to be examined extremely carefully, as well as the method by which they were gathered.

PITTS: If this were true, of course, it would imply in a case subject to Zipf's law that the sampling data were of absolutely no value, and Zipf's law was completely an artifact and told you absolutely nothing about the actual population frequencies, say, of words, in actual English speech. But, really, it can have a very large random sample, and it is purely an accidental sampling.

McCULLOCH: In essence, that is right; that is, if you had a large enough sampling of English so that you ran out of all the words in English, your Zipf's law from that time on cannot possibly hold. All you can do is shove this segment up. You can get more of those than you already have.

PITTS: I think you have to be extremely careful about your sampling procedures to yield a result like this.

ASHBY: Is it true to say that the old method of sampling is merely a device to get to the form of [P]. It is just a device for constructing the method for the argument. It doesn't necessarily assume that that method is usually in practice.

PITTS: It was that method that is used in practice. I would say that what you do in forming the statistics is actually the following thing: You go through the book, count the number of different words, and afterwards you order them in the rank-frequency diagram. That means you do certain things to that kind of a diagram. Therefore, you can already expect a certain kind of restriction of possible results because you are already doing something to the sampling. I would say certainly it doesn't give any kind of an explanation to the whole thing. It just suggests the following thing, that if we have such a kind of universe, we would get a Zipf distribution. That is the only thing. I would say there is no explanation for the whole process. The next question which can immediately be thrown up is, why do we have this kind of universe? I can't answer that.

YOUNG: If you deal with letters, what would be the relation?

PITTS: I don't know. With letters, we are, unfortunately, very much restricted because we have only 24 letters. Therefore, the sample should always be smaller than 24, and then I would say that the whole thing is certainly far away from any possibility of getting Zipf results, because you have to assume an infinite number of kinds here, which is certainly not the ease in the language. But if you get a smaller sample, where not all words in that language are actually occurring, then you can fairly say you have not yet touched the limits of the universe but you have made a large enough sample that you can't say it is too small.

MEAD: But is your assumption of occupations in a country that you have an infinite number of kinds?

VON FOERSTER: Well, at least the number of kinds must be related to the large number of kinds you actually collect.
BATESON: Is this the same law that was running around in the twenties~ that came out from a botanist in Cambridge? 1t was called "aged area." He argued, and had some very pretty curves, that if you got the number of seeds in a genus, you would find a very large number of genera, with only one species.
McCULLOCH: The botanists have run into it, the biologists have run into it, and many others.
BOWMAN: Will somebody define a genus for me?
VON FOERSTER: No, nobody will.
BATESON: The genus has to be set up by somebody who knows this law.
YOUNG: Who knows something about the nature of genera of this sort, that all these rather arbitrarily defined genera–
MEAD: Isn't it a function of the method of definition, conceivably? Genera, after all, is a man-made definition of the universe. This may be merely a statement about a properly functioning Western mind. The two cases where it doesn't work nicely are the schizophrenic and the lobotomized. All of these classifications are man-made; they are all made by Western science.
KLÜVER: The population of Chicago and New York are not by definition.
MEAD: Well, the conception of population is.
BOWMAN: Where do we put the city limits?
MEAD: And are dogs part of the population or not? Are unborn babies part of the population, or are potentially conceived babies part of the population, or are mice part of the population? You see, you have to work that all out.
VON FOERSTER: But there is another conclusion which you can get from the etymological consideration. For instance, it shows that the barber shop is the leading profession in the United States. It shows that this would be the ideal, approximating a straight line. On the other hand, funeral homes are a very high frequency occupation. But it turned out to be that the barbers are a little bit off the curve, too low. This immediately suggests to me to become a barber [laughter], because then I would have a chance in that distribution and I would make an efficient barber.
PITTS: Incidentally, I might say something about what Zipf did. Since he is now dead, it can't redound to his harm. He got himself into some trouble about this. He took the size distribution of cities and countries such as the United States and Germany and so forth, and found that on the whole, they obeyed Zipf's law. Then he discovered that before the Nazis came into Germany, the distribution of population sizes by ranks was quite different from Zipf's law. It exhibited systematic deviations. Sometime after the Nazis came in, it was much closer to Zipf's law. He concluded from this that the Nazi government

had been beneficial to Germany because it had corrected the distribution of the population in frequency. [Laughter]

QUASTLER: That was because of the Anschluss, Germany plus Austria.

PITTS: No, he took account of that, but the changes in population were in that direction. I think this is a very useful example of what a scientist can do if he is not careful.

QUASTLER: I don't want to darken the memory of the late Dr. Zipf, but why call this law by his name? He did not discover it. He wrote a big book about it in which he gave a very bad explanation. Incidentally, he stated that frequency and rank distribution in most of the objects you look at fall into one of three classifications, which is not generally the case. The distribution in words was discovered a long time before, by some Frenchman.

McCULLOCH: Oh, it has been discovered in lots of fields, separately. The first man who gathered it all together, so to speak, was Zipf. That is the only reason, I think, for attaching his name to it.

PITTS: He had a whole institute of graduate students who did nothing but count curious objects of one kind or another; that is, count members of the classes in classes of classes.

WIESNER: Did he publish a book of those things?

PITTS: I don't know.

McCULLOCH: In collections of coins, large collections of coins, you get Zipf's law again. It turned out that way.

BIGELOW: It is fantastic.

BATESON: If I have a multifaceted penny, say, of a hundred facets, with equal chances of throwing any one of those facets, and I experimentally start to throw and I chop off any sample according to von Foerster's resume–

VON FOERSTER: No, no!

McCULLOCH: Will you tell him the comminutorial story?

VON FOERSTER: I would say this is precisely the situation. The following thing does not work. Assume for instance, the urn, with an infinite number of kinds, where each kind is represented by an infinite number of samples. For each, there is the probability, P, an equal P. Then the most probable distribution curve you can get is the distribution curve of each sample occurring for each kind occurs once in your sampling. You can do it also in a different kind of way; for instance, if you have n different words, you ask what would be the book which would give the maximum amount of information.

With [these] n different words, it would be a book in which each word would occur just once, or if you are writing a book which is much larger than the number of different words, then each word should occur with the same frequency. The result would be a curve like this [indicating on board]. This is the most probable curve. This, on the other hand, is the curve with the highest amount of information.

There is another thing which Warren and I were thinking about for a long time. It was the following situation: Assume you have a box with lots of equal white marbles in it. Now, you take one of those marbles out and you take a second marble out and you glue them together so that you get an element of a higher complexity. Afterwards, you throw that into the box. You again take out two things. It might be, by some chance, the already glued-together marble, or a marble which is not yet glued together. Then you glue those two elements together again. And so you proceed, setting up entities from higher complexity. Now assuming that the marbles would stick together, that the glue would be excellent, then after a certain number of processes, you would have one big ball with the complexity of n, where n is the initial number of marbles. But to get different kinds of the whole thing, where the kind now means complexity, namely, consisting of small and different marbles, you have to assume a particular half-life of any of these complex structures. You come immediately into the tremendous mess in the making of a particular theory, because you can assume the following thing: This complex element can break up in a situation where only one marble drops off or where two marbles drop off at the same time or where three marbles drop off at the same time or something like that. That means the problem of assuming a particular breakdown situation for this complex entity leads you to so many different possibilities that you can with ease establish a particular theory which would very nicely fit almost any kind of statistics. That means, finally, that it doesn't mean a thing. That means we would just have to assume that the marbles are breaking up in that fashion, to furnish the kind of distribution in the box.

PITTS: Have you seen Kolmogoroff's paper about the distribution of sizes of stones in a river bed, where he supposes that smaller ones have been derived by breaking up the larger ones? In a rather general condition, he shows that the logarithms of the sizes are Gaussian.

VON FOERSTER: No, I have not seen that. I would say, as a probability, this does not work. I would say it does not work, to assume this principle. The information content idea, that it maximizes the information, is also important, because it is absolutely the same story as the probability. I tried another thing which was extremely complicated. I was asking myself, how many different kinds of those rank-frequency diagrams is it ever possible to draw? That is, if I plot here n different kinds, and I distribute them with a proper rank-frequency diagram, I can make, with a certain amount of things, a lot of different distributions which would look so and so. This problem, for instance, breaks up into what is known in mathematics as a partition problem, namely breaking up a particular number of things into components; that is, for instance, if I have a total number of words, let us assume it is 10, then I can assume the following: 10 can be established in having just one word occurring 10 times, or I can have two words, one occurring nine times and the other occurring one time, or eight times the one word and two times the other word, or seven times the one word and three times the other word, and so on. That means the maximum rank is equal to 1 or the maximum rank is equal to 2 in the first rank. I can go further and further, increasing the rank. I can ask myself, finally, what is the highest probability for having such a distribution? There is establishable a certain law, because this is breaking up the particular number, M, into a smaller number, m, and this is a particular number and you can maximize it with respect to n. Unfortunately, it doesn't turn out that this is connected directly with that, which establishes what can cause an equal probability situation in this case. I would say there are lots of particular possibilities in which you can look into the whole thing, but for most of these things, it does not work so far as I can find out.

PITTS: Speaking for myself at least, and probably also for Bigelow, I think it would be very good if you would insert even at somewhat greater length, the convincing mathematical derivation of your result in the transactions, because we don't consider that this argument even makes it probable at all. It has so many holes in it.

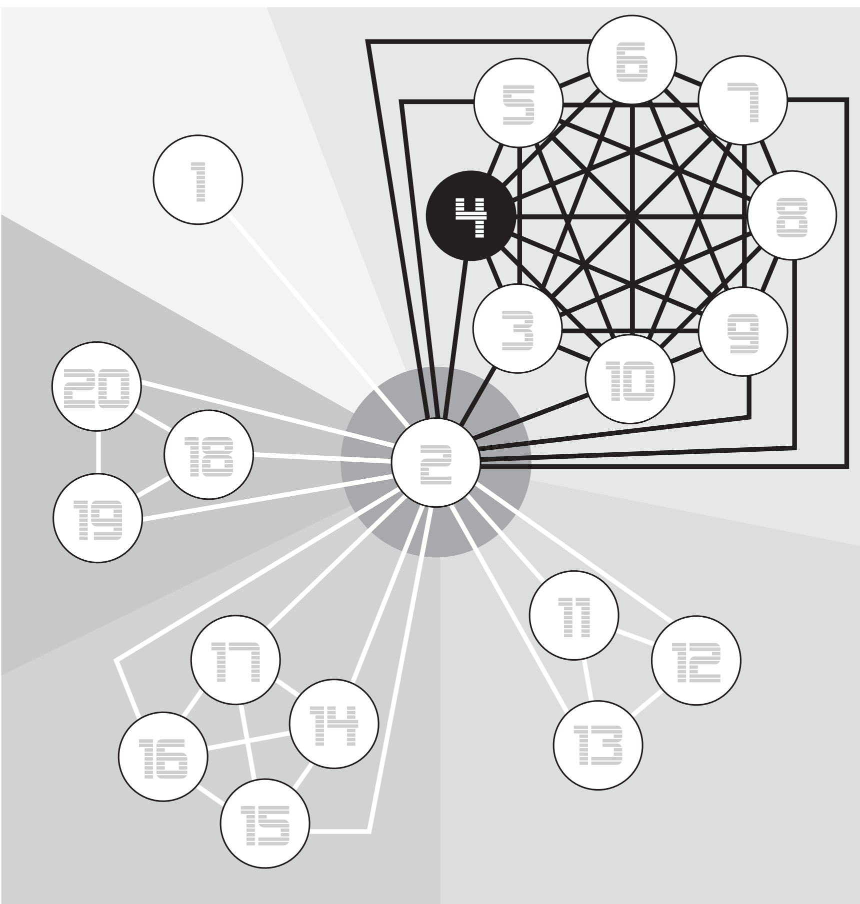
VON FOERSTER: Yes. Perhaps in a different discussion, we can talk about the whole thing.

PITTS: You can easily insert it in two pages in the transactions.

McCULLOCH: There are two more things. I know that Ralph Gerard has to catch a train in the not too distant future. It is about twenty minutes after four. I would like very much if we might deviate from the program I outlined and ask Walter Pitts to say a word or two, but to keep it pretty brief, about the investigations under way on synaptic transmission. That would tie back into the thing I know we want. Will you do it?

4 Bubbles Everywhere in Human Affairs

Monika Gisler | Didier Sornette



4.1 Introduction

Casual observations of the development of large scale entrepreneurial projects, reinforced by two detailed case studies, the Apollo program [Gisler and Sornette, 2009] and the Human Genome Project [Gisler *et al.*, 2010], has shaped our hypothesis that bubbles constitute an essential element in societal processes and in the dynamics of society at large. We believe that bubbles are ubiquitous in human affairs, providing fundamental driving forces for the societal courses of action. In that, they provide an important positive contribution to society. This view is a somewhat paradoxical statement because bubbles are usually understood as being bad.

Our intention here is to outline our concept of 'social bubbles.' The roots of this concept grew out of Sornette's research on the triggering mechanisms for market failures. In contrast to the view that the triggering mechanisms occur only hours, days, or weeks before the collapse, Sornette and collaborators have proposed that the underlying cause of market failure can be sought months and even years before the abrupt, catastrophic event [Sornette, 2003a; 2003b; 2005; 2008; Kaizoji and Sornette, 2009; Sornette *et al.*, 2004; 2009]. Furthermore, Sornette [2003b] has presented a general framework to characterize, quantify, model and predict financial bubbles and their aftermath. The main concepts explained and illustrated in details are imitation, herding, self-organized cooperation and positive feedback, leading to the development of endogenous instabilities. By probing major historical precedents, from the Dutch tulip mania that wilted suddenly in 1637, to the South Sea Bubble that ended with the first huge market crash in England in 1720, to the Great Crash of October 1929, and Black Monday in 1987, the conclusion was that most explanations other than cooperative self-organization failed to account for the subtle bubbles by which the markets lay the groundwork for a subsequent crash. According to this theory, the fundamental causes of the burst of bubbles lie in the maturation towards instability, due to positive feedbacks. As a speculative bubble develops, it becomes more and more unstable and very susceptible to any disturbance. If it has not been the raise of interest rate, it would have been something else that was the triggering factor for the crash.

With the concept of social bubbles, we intend to open up this initial focus on financial bubbles and dig into the spheres of politics and social thinking, by investigating the investment in major innovations. Innovations are framed by interactions and novel relationships among science and technology, business and industry, economy, and politics [Freeman, 1974; Rosenberg, 1974; Dosi, 1982; Mansfield, 1995; Nelson, 2005]. Because change is so vital for long-run economic growth, it is of fundamental importance to understand how creative individuals and firms obtain the resources needed to undertake their investments in innovation and invention. It is also important to understand how the availability of such resources, including the manner in which they are accessed as well as the amounts that can be raised, influences the rate, direction, and organization of maturity.

It is well known that investing in an innovation is not a clear cut choice. On the private side, it is imperative that the entrepreneurs decide, if, where, and how much to invest. In the case of public innovations, the situation is much more complicated. Increased government spending is often seen as critical to ongoing technological progress. On the other hand, the decision to invest in a specific project means to back out from other potentially socially worthy projects.

In addition, commitment of public funding comes at the cost of taxation and/or increased debt for future generations, which may crowd out private investments and their associated initiatives. Several actors, decision makers, politicians, the public, the future generation, are involved. Personal involvements, the interest of the outcome, the incentives in general, are completely different among these different participants. A somewhat complex social network is at the heart of innovation processes.

We believe that the social bubble concept provides a good tool for analyzing such processes. To do so, however, we first have to make sure how to understand what a social bubble essentially is. For this essay, we thus constrain ourselves to the discussion of the concept of social bubbles. Its concrete implementation will be a topic for further studies.

Since our concept of social bubbles stems originally from the financial field, in a first chapter [2], we discuss the topic of financial bubbles in the literature. We do so mainly to show that the topic is not as clear cut even in finance as one would wish it to be. In chapter [3] we provide an analysis of the modern literature of an episode that is believed to be the first known bubble in history, the so-called tulip mania of 1634–37 in the Netherlands. It is quite interesting that the same historical episode evoked very different interpretations from different scholars (economists, historian of economics, social historians): whereas some bluntly refer to it as a bubble, others reject the idea entirely. This is a good example after all to enlighten the difficulties when it comes to define an economic episode in history as a bubble. The following chapter [4] gives an example of one of our own understanding of a social bubble, the Apollo Space Program. The factors combined in this endeavor wove a network of positive feedback that led to widespread enthusiasm and extraordinary commitment by those involved. Social bubbles are thus on the horizon when several arrangements, such as technological, economics, and political, become intertwined into a self-reinforcing spiral. The generic set-up will be the subject matter of our last chapter [5].

4.2 Bubbles in the Literature

Economic Bubbles (sometimes referred to as speculative bubbles, market bubbles, price bubbles, financial bubbles or speculative mania) form in economies, securities, stock markets and business sectors because of a change in the way players conduct business. This can be a paradigm shift, with the invention of new technologies [Perez, 2002], or a change of regulation, *e.g.* a (partial) deregulation of finance institutions. During the boom, people buy assets (stocks, real estates, etc.) at high prices, believing they can sell them at even higher prices, until confidence is lost and a large market correction, or crash, occurs [Kindleberger, 2005]. At the end, resources built during a bubble seem to be lost, causing prices to deflate.

From this vantage point, most research on bubbles has proceeded by assuming it to be a 'truism'. However, not all behavior of asset prices is necessarily a bubble, it is in fact difficult to determine whether and when an asset price is a bubble [Bhattacharya and Yu, 2008a], and more so, why the bubble crashes.

The concept of the 'new economy,' a term used during the 1920s (the utility bubble), the 1960s (the 'tronic' boom) and the 1990s (the internet and communication technology bubble), captures vividly this mindset held by a majority of investors and firm managers at times of bubbles: there is widespread belief that times have changed irreversibly and for the better, and that a new epoch, a new economy, a new prosperity without business cycles and recessions is the novel emergent rule with the expectation of endless profits. Then, the 'new economy' bubble crashes, which is taken by the majority as a diagnostic that the bubble has been a waste of resources.

There is a rich literature in economics and finance on the topic of bubbles, concerned with defining what is a bubble and developing a suitable theoretical framework [White and Rappoport, 1995; White, 1996; Galbraith, 1997; Shefrin, 2000; Shiller, 2000; Shleifer, 2000; Sornette, 2003b; 2005; Kindleberger, 2005, Bhattacharya and Yu, 2008b]. Not all of the writers were equally attentive to the fact that the definition of bubbles is far from being unambiguous. O'Hara [2008] has recently provided her own review and offers a somewhat disenchanting conclusion: "Are there bubbles? Are markets really irrational? I am not sure. I do know that markets are very hard to predict and thus can seem 'irrational.' But I prefer a more neutral view." [p. 16]

Charles Kindleberger, in his book *Manias, Crashes, and Panics* [2005, 5th edition], was quite determined in identifying the financial processes at the origin of bubbles. He proposes that a bubble is an increase in asset prices in the mania of the cycle, in that asset prices today are not consistent with asset prices at distant future dates. Unsustainable patterns of financial behavior are thus at the origin of a bubble [p. 13]. Brunnermeier's [2007] description that 'bubbles are typically associated with dramatic asset price increases, followed by a collapse' goes in a similar direction.

The concept of a bubble implies the interplay between an underlying mechanism, excess elements and necessary burst. The upswing usually starts with an opportunity ('displacement')—new markets, new technologies or some dramatic political change, and investors looking for good returns. Robert Shiller in *Irrational Exuberance* [2000]—published at the height of the dot-com bubble—proposed twelve factors that 'propelled the market bubble,' among them cultural and political changes favoring business success, challenging the role of specific judgment biases in finance. Similar characteristic scenarios have been described by Galbraith [1997], Kindleberger [2005], Sornette [2003b] and Sornette and Woodard [2009], corresponding to five steps:

i) displacement
ii) credit creation
iii) euphoria
iv) critical stage/financial distress
v) revulsion.

The scenario proceeds through the euphoria of rising prices, particularly of assets, while an expansion of credit inflates the bubble. In the manic euphoric phase, investors scramble to get out of money and into illiquid things such as stocks, commodities, real estate or tulip bulbs: a larger and larger group of people seeks to become rich without a real understanding of the processes involved. Ultimately, the markets stop rising and people who have borrowed heavily find themselves overstretched. This is distress, which generates unexpected failures, followed by revulsion or discredit. The final phase is a self-feeding panic, where the bubble bursts. People of wealth and credit scramble to unload whatever they have bought at greater and greater losses. The sudden fall, first in the price of the primary object of speculation, then in most or all assets, is associated with a reverse rush for liquidity. Bankruptcies increase. Liquidation speeds up, sometimes degenerating into panic. The value of collateral (credit and money) sharply contracts. Then, debt deflation ends as productive assets move from financially weak owners (often speculators or the original entrepreneurs) to financially strong owners (well capitalized financiers). This provides the foundation for another cycle, assuming that all the required factors (displacement, monetary expansion, appetite for speculation) are present [Sornette and Woodard, 2009].

Since bubbles occurring in an economic context are seen as optimistic predictions about the future that prove wrong, they are considered to be bad. Their ominous character is amplified by the uncertainty stemming from the lack of a consensus on their causes, which make them a major challenge to economic theory. Only rarely and in passing has the question been brought up whether bubbles could also increase social welfare. Bhattacharya and Yu [2008a] asked whether it is possible that nascent, emerging industries need 'animal spirits' and overinvestment for innovation. They argue that it is likely that bubbles serve mainly to change the wealth dynamics of society, and through this mechanism affect the investment process. Only little research has been carried out in this concern.

The social economist Carlota Perez believes that bubbles inevitably precede each of the 'techno-economic paradigm shifts' by which society advances. In her seminal book *Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages* [2002], she uses the term bubbles to describe the financial processes characterized by the installation of a new paradigm (or 'revolution') and its concentration of investment in the respective new (scientific) enterprise (infrastructure, human resources, etc.). Her analysis suggests that the working of markets cannot by itself explain the recurrence of major crashes and depressions. Instead, the emergence of these phenomena need to be explained by the analysis of the tensions, resistance, obstacles and misalignments that arise from within the wider social and institutional scene. Perez moreover criticizes the majority of Neo-Schumpeterians to have neglected Schumpeter's legacy in that the accent was almost invariably on the entrepreneur, and has neglected the financial agent, no matter how obviously indispensable this agent may be to innovation. ("In Schumpeter's basic definition of capitalism as 'that form of private property economy in which innovations are carried out by means of borrowed money' [...] we find his characteristic separation of borrower and lender, entrepreneur and banker, as the two faces of the innovation coin.") This view is even more relevant in the diffusion of radical innovation, which is inevitably a question of investment. She develops further her argument by emphasizing the role of the sources of capital that funded the deployment of new technologies. The establishment of the major infrastructures associated with dominant techno-economic paradigms in this view has to be linked to major technological investments, entailing the euphoric and reckless build-up of overcapacities of various kinds. Nevertheless, the lack of attention paid to the sources of capital that funded the deployment of new technologies, diagnosed in 2007 by William Janeway, has not been overcome. More research in this concern is considered necessary.

The journalist Daniel Gross, in his 2007 book on *Why Bubbles Are Great For The Economy*, takes a counterintuitive look at economic bubbles. Common thinking states that excessive investment in fixed assets is bad for investors, for the employees of the bubble companies, and for the economy as such. On the contrary, he argues that during bubbles, investors' money is used to build infrastructure that can't possibly repay its upfront costs, but ends up being beneficial for companies and consumers in the long run. To take a recent case, most investors in the 'dot-com' episode lost, but their money built the software and infrastructure that runs today's Internet.

In fact, what is likely to be seen as a catastrophe from one point of view, others, such as Perez [2002; 2009] and Gross [2007], see as a collective social gain stemming from bubble behavior (major investments with low short-term returns) in the long run. Innovation processes and the creation of new technology seem inherently associated with bubbles. These authors suggest that crashes/crises/bursts are unavoidable epochs covering about 10% of the time but, on the other hand, they provide benefit for the remaining 90% of the time. Our own research extends and makes more precise these considerations.

The difficulties associated with the characterization of an episode as a bubble have been stressed by Peter Garber in his book *Famous First Bubbles* [2000], in which he revisited the three bubble episodes, the Dutch tulip mania of 1634–37, and the Mississippi and South Sea bubbles of 1719–1720. He herein argued that a bubble is "a fuzzy word filled with import but lacking a solid operational definition" [p. 4]. In line with standard financial economic theory, he defined a bubble as an "asset price movement that is unexplainable based on what we call fundamentals" [*ibid.*]. Under this view, bubbles could be positive or negative. Garber is so cautious about defining a bubble that he suggests to see explanations of market anomalous behaviors in terms of bubble as a 'last resort,' because they do not explain events thoroughly; they are merely a name attached to a financial phenomenon that has not been sufficiently understood [p. 124]. Accordingly, calling a sharp financial expansion that collapses a 'mania' or 'bubble' is too superficial and should be corrected by a deeper insight. In the three examples he studied, he finds evidence that rational behavior can explain the observed price dynamics.

The conclusions of Garber's study have been questioned, among others by Kindleberger [2005] and Chancellor [2000; on an earlier of Garber's articles]. The problem of defining what is a bubble is fundamentally influenced by the underlying economic model, which provides the reference point to judge what is 'normal'. For instance, assuming that markets ought to always be rational and efficient poses a fundamental problem of measuring something that is deemed impossible by construction. The next chapter highlights these difficulties with the example of the tulip mania.

4.3 The Tulip Mania

Often cited as a quintessential example of a bubble, the 'tulip mania' arose in Holland in the years 1634–1637. Its essential is that rare bulbs were hard to produce but, once obtained, they were relatively easy to propagate. During this period, tulip bulb prices rose dramatically, with prized specimens allegedly selling for the equivalent of more than what corresponds to the purchasing power of $30,000 in present days. Otherwise sensible merchants, nobles, and artisans supposedly spent all they had (and even borrowed heavily) on tulip bulbs. Starting in 1637, however, prices collapsed, ending the first well-known great bubble episode.

Whether or not a tulip bubble was present has ever since played at a central stage of heated debates. The disagreement stems from the clash between those who believe that markets are always rational and efficient and those who call attention to the ubiquity of financial crises. A particularly interesting divergence in the discussions is whether or not the traders and likewise the markets have behaved rationally or irrationally.

Garber [2000] argues against the generally accepted view that this was a bubble. He points out that the fact, that rare varieties of tulip bulbs could fetch high prices among professional traders, was not necessarily irrational behavior. On the contrary, the tulips could be used to grow many more valuable hybrids and often earned their purchasers far more than they invested. One of his arguments against a bubble interpretation of the Tulip episode is that no economic distress followed the end of the craze as might have been expected if it was a bubble. This is confirmed by the insights of a recent study of historian Anne Goldgar [2007], who claims that while it is certain that some people lost a lot of money, there is no archival evidence suggesting that any of the involved merchants went bankrupt. The claim that the crisis caused a disruption of the Dutch economy rests solely on some contemporary pamphlets that are highly critical of the trade and use it as a warning against greed, materialism, financial speculation and subsequent social disorder.[1]

1 Anne Goldgar highlighted a problem that none of the other authors writing on the Tulip mania have ever been concerned with: that the data on which the tales about the Tulip mania are based are more than weak.
The most often cited references [Charles Mackay's 1841 Extraordinary Popular Delusions and the Madness of Crowds as well as the several contributions by the Dutch Historian of Economics Nicolaas W. Posthumus, published in the 1920s] are not contemporary and are thus unreliable. Goldgar stresses that Posthumus' texts are full of incorrect transcriptions and misprints, which caused a lot of wrong data. Mackay on the other hand took most of his accounts from a contemporary, Johann Beckman, and did not check the sources. The accounts

Kindleberger [2005] has energetically discarded this view, pointing out that the Dutch economy slowed in the 1640s before putting on a tremendous spurt again after 1650 (there are no price data immediately after the crash). The decline in the prices of tulip, Kindleberger assures, led to a decline in economic activity.

Garber's second and more relevant argument is that the market for bulbs was not out of line, even though traders were pursuing potentially irrational strategies. The Netherlands, he argues, was a sophisticated trading center, with well-developed commodity markets. The investors were bidding up the price of shares, financed by a captive bank, in the hope that supply would expand later to justify the higher prices.

The role of the bubonic plague of 1634–36, decimating Europe at that time, played a crucial role, adds Garber. He shows that the individuals involved in the trade were merely seeking entertainment, after the disastrous bubonic plague, confident that any substantial losses would be written down by the state. He further argues that: "The wonderful tales from the tulipmania are catnip irresistible to those with a taste for crying bubble, even when the stories are so obviously untrue. So perfect are they for didactic use that financial moralizers will always find a ready market for them in a world filled with investors ever fearful of a financial Armageddon" [p. 83].

Kindleberger [2000] in a review of Garber's book, sees it to be of interest to analysts with a strong commitment to rationality and market efficiency, because it provides a re-examination of the question of whether the use of the term bubble is appropriate or not. A rational investor is one who seeks to optimize his wealth by offsetting risk with reward and using all publicly available information. Were the traders of bulbs behaving rationally? Kindleberger's answer is no. Nor does Kindleberger believe in efficient markets. Many investors, he claims, do poorly in the market because they chase the latest fashion. This is herd behavior. Only if one is assured that all of us and our actions/reactions are always rational, he concludes, one could explain bubbles just from the speculation of rational investors. Hence, "complexity permits one to say that markets are mostly reliable but occasionally get caught up in untoward activities."

Ross [2005] argues against Kindleberger by stating that modern finance never said, nor required, that individual investors be rational and thus a bubble is necessarily defined by deviations from rationality. What matters, Ross asserts, is that there are a few sharks, or arbitrageurs, who wait for opportunities and then pounce. This makes markets behave 'rationally' even if individual participants may be irrational.

---

delivered therein are simply not true. The argument of the Tulip mania being a legend or myth is fueled by such misinterpretations.

Chancellor [2000] devotes a paragraph to the interpretation of the tulip mania episode provided by one of Garber's early articles [Garber, 1989]. He rejects Garber's hypothesis as an act of 'historical revisionism' performed with the goal of supporting the efficient market school of economic thought according to which bubbles or mania cannot exist since market prices always reflect their intrinsic value. The high prices for tulip bulbs could never have reflected the rational expectation of investors, he holds, since it was not known until the twentieth century that the variegate tulip petals were the result of a virus which attacked the bulb. He sees Garber's assumption as a somewhat wrongful (if not to say ideological) rewriting of what is known already.

In our work on financial bubbles, we have found that bubbles are not necessarily followed by crashes. Instead, bubbles are non-sustainable transient regimes that end at a tipping point, beyond which a new regime is established. The new phase can be a crash followed by revulsion, or simply a plateau or slow decrease of the market [Sornette, 2003b]. Therefore, Garber's first argument that the absence of bankruptcies and of an economic recession following the Tulip mania bursts is a testimony of the absence of a bubble becomes pointless. On the other hand, the argument that markets are always rational, efficient and collate all available information is difficult and perhaps impossible to debunk since any behavior could in principle be attributed to some rational speculative strategies. This raises the issue of falsification of the rational expectation and efficient market hypothesis, which remains unsettled. Indeed, the problem of testing the efficient market hypothesis (EMH) or the rationality assumption is that there are not strict tests for them only. Any test comes as a joint test of the hypothesis and of a specific mathematical formulation. This is referred to as the 'joint hypothesis' problem in financial economics. The joint hypothesis problem means that market efficiency as such can never be rejected, because any test of the EMH is a joint test of an equilibrium returns model and rational expectation. To make the EMH operational, one must specify additional structure, such as investors' preferences, the amount of available information and how it is accessible to investors, and so on. But then a test of market efficiency becomes a test of several additional hypotheses as well. The rejection of such a joint hypothesis does not provide any clues on which aspect of the joint hypothesis is inconsistent with the data. In order to make progress, other approaches may be considered. For instance, Sornette *et al.* [2007, 2008] have developed a working methodology to validate/falsify a given model and/or hypothesis, based on testing the degree to which predictions of the model are born out by crucial empirical tests, and thus increase/decrease our trust in the model.

4.4 The Apollo Space Program[2]

The Apollo program was one of the most ambitious and costly single project ever undertaken by the United States in peacetime. With the first men landing on the Moon in 1969, it was the general belief at the time that thirty years later at the transition to the third Millennium, mankind would have established permanent stations on the Moon and on Mars, with space travel expected to become almost routine and open to commercial exploitation for the public. Today, we know better. In our study of the Apollo program [Gisler and Sornette, 2009], we stressed that this (too) optimistic view exemplifies the bubble spirit that is typical rather than exceptional.

Enthusiasm was always present to push for the endeavor, risk always a topic but never an issue. Major risks have been accepted by individuals, first of all by some of the pioneers (engineers, astronauts). They did not shy away from taking all possible types of risks, even at the costs of their own life or health. The cold war and the space race were indeed important factors in the formation of the Apollo program; however, we argue that there were other equally important and perhaps even more important factors at play. Support for this hypothesis can be found in the fact that the Cold War did not end with the termination of the Apollo project; neither did collaboration between the US and the USSR start after the collapse of the latter in 1989, on the contrary, the SOJUS project started as early as 1967. Our interest hence focused on the internal perspectives that played a role in the development of the Apollo program. It is important to note that the program enjoyed high visibility and strong interest from a large fraction of the population, including its financial and technical components. We argue that the Apollo program developed as a bubble, first mounted up by a special interest group, later inflating to a very large size, through general positive feedback mechanisms. Indeed, the Apollo program enjoyed a tremendous support, financially as well as societal.

The Apollo program was originally conceived early in 1960, during the Eisenhower administration, as a follow-up to America's Mercury program. The goal was to develop the basic technology for manned spaceflight and investigate human's ability to survive and perform in space. At its peak, the Apollo program employed 400'000 people, and required the support of hundreds of universities and 20'000 distinct industrial companies. Enthusiasm was high in terms of funding as well as in terms of human effort. Its objective was twofold and its expectation was soaring: the immediate goal, as proclaimed by President John F. Kennedy before Congress in 1961, was to land men on the Moon. A second and

2 This section derives from our paper on the Apollo program; see Gisler and Sornette, 2009.

far broader objective was to make the United States preeminent in space, taking a leading role in space achievement and ensuring to prove the nation's ability to explore the riches of the solar system and beyond.

Kennedy did not immediately come to a decision on the status of the Apollo program once he became president. He knew little about the technical details of the space program, and, what's more, he was put off by the massive financial commitment required by a manned Moon landing. Despite public support, Kennedy had expressed concerns about the program and the funds that it absorbed. His plans were abruptly changed by two unexpected events in mid April 1961: The first man in Earth orbit by the soviets [Yuri Gagarin] and the CIA-backed Cuban exiles invasion failure at the Bay of Pigs. Kennedy, as a result, seized on Apollo as the ideal focus for American efforts in space. He ensured continuing funding, shielding space spending from the 1963 tax cut and diverting money from other NASA projects.

Even though Kennedy did not say it directly, he had significant concerns with respect to the risks associated with putting humans into space and the corresponding public consequences of possible failures. The reward for the United States when people were willing to take risks and to explore through manned space flight was obvious to Kennedy; it was the public he had to convince and make sure that it understands it. After Johnson became president in 1963, his continuing support of the program allowed it to succeed in 1969.

The U.S. commitment to space progressively captured the American imagination and attracted overwhelming support. No high official at the time seemed deeply concerned about either the difficulties or the expenses. This was essentially to the credit of Johnson's effectiveness in building a nation's consensus for a space program. Observing some of the most powerful people endorsing the idea of a space program made it easier for the rest to follow. Johnson increased NASA's spending from 150 million to over 4 billion USD, to develop the required technology and the science needed to build a human presence in space. Johnson argued that the space program as expensive as it was could be "justified as a solid investment which will give ample returns in security, prestige, knowledge, and material benefits." [L. B. Johnson cited by Dallek 1997:73]. It was of little use that economists argued against it. Polls carried out in 1964 showed that he had made his point to the public, who overwhelmingly supported him. The fact, that the rational cost-benefit analysis put forward by economists was ignored, provides a vivid illustration of the bubble spirit mentioned previously in our introduction.

Financial support was not a given thing, though, but had to be negotiated on a yearly basis during the entire project [fiscal years 1961–1969]. The Apollo share of the total NASA Budget increased over the years from 10% [1962] to 70% in 1966, when it reached its peak [Ertel and Morse, 1969–1978]. In 1963, the final fiscal budget for Apollo was still 0.62 billion USD or 17% of the entire NASA budget. In 1964, it increased to 2.27 billion USD or 57% of the overall NASA budget, even though the aim of putting men on the Moon was still far beyond reach. Public complains about the costs in 1963 did not put an end to the support by Congress; it merely led to a momentary halt of the budget increase. In 1965, the total sum of 4.27 billion USD went to NASA, and thereof 2.61 billion USD to the Apollo program. The funding reached its zenith in 1966 with an overall NASA budget of 4.51 billion USD, of which 2.97 billion USD or 67% went to the Apollo program.

After the initial rise of efforts embodied in the Apollo program, space exploration reached equilibrium, accompanied by drastic budget reductions; the fiscal budget in 1971 was 0.91 billion USD for Apollo or 36% of the overall NASA budget, and in 1973 it was down to a minuscule 3% fraction only. The last Apollo mission landing astronauts on the Moon was in 1972, when *Apollo 17* concluded the Apollo mission. Thereafter, the United States did not undertake any other Moon flights.

Enthusiasm for the program was usually high, even though not necessarily uncritical. Launches from Cape Canaveral drew hundreds of thousands of excited spectators. In 1962, the volume of sales of space toys and kits in department stores after each launch was proof of the public attraction to anything related to space. As early as 1963, however, criticism was beginning to grow in the press. Whereas in 1962, the editors used superlatives when talking of space exploration, in 1963, fervor was somewhat low. The lavish amount of money being poured into NASA was being questioned, should it go up continuously. A number of writers criticized the program as a cynical mix of public relations and profit-seeking, a massive drain of tax funds away from serious domestic ills of the decade, a technological high card in international tensions during the cold war era. All the same, the pendulum again swung towards the space program. After this temporary drop of enthusiasm in 1963, polls in the spring and fall of 1964 showed 64–69 percent of the public were favorably disposed to landing an American on the Moon, with 78 percent saying the Apollo program should be maintained at its current pace or speed up. Financial support was not a given thing, though, but had to be negotiated on a yearly basis.

Polls performed in summer 1965 showed another slight decrease of enthusiasm, as a third of the nation now favored cutting the space budget, while only 16 percent wanted to increase it. Over the next three and a half years, support for cutting space spending went up to 40 percent, with those preferring an increase dropping to 14 percent. At the end of 1967, *The New York Times* reported that a poll conducted in six American cities showed that five other public issues held priority over efforts on outer space. The following year *Newsweek* echoed the

Time's findings, stating that the United States space program was in decline. At the same time, Congress was strongly leaning towards a reduction of NASA's budget. A White House survey of congressional leaders at the end of 1966 revealed pronounced sentiment for keeping Apollo on track but, simultaneously, for cutting NASA spending by skimping on post-Apollo outlays.

The efforts of 1966/67 paid their tributes: When *Apollo 11* made it to the Moon on July 19, 1969, an estimated 600 million people—one fifth of the world's population—witnessed it on television and radio. Some observers designated the day as a turning point in history. After *Apollo 11* had landed on the Moon, lunar scientists as well as astronauts became highly optimistic about the outcome of scientific research associated with orbiting flights and exploration of the Moon. Astronauts had demonstrated that men were able to function as explorers in the lunar environment. They were viewed by the advocates for manned space flight as ample justification for the enormous investment they required. Hopes of the scientists for resolving major questions about the origin and evolution of the Moon reached a peak of optimism at the beginning of 1970.

With astonishing rapidity, however, the *raison d'être* of the Apollo program was undergoing a metamorphosis. By the spring of 1970, it was obvious that the intellectual rationale for Apollo could not justify the full program in the absence of enthusiastic public support, and that was waning. In November 1969, *Apollo 12* astronauts achieved a second lunar landing and made two Moonwalks. Once again, there were live pictures, but the reactions lacked of enthusiasm, the public was progressively more disenchanted with the space program. The voice of Apollo's critics began to swell. The national polls in the summer of 1969 found that 53 percent of the country was opposed to a manned mission to Mars. And a poll taken in 1973 showed that only foreign aid had less support than space exploration. In the short run, project Apollo was an American triumph. In the long run, the costs, close to 25 billion USD in total in 1960s dollars, were large and might have made a difference in other programs.

In the context of bubbles associated with innovation ventures and the creation of new technology, the Apollo project demonstrates the large risks that have been undertaken individually, politically and financially, leading to a collective (individual, public and political) over-enthusiasm, which played a very significant role in the development and completion of the process as such. The qualifier 'over' emphasizes that the enthusiasm did not out-live by much the first Moon landing, and a general positive sentiment in favor of the Moon exploration started to fade shortly after the first step on the Moon. The evidence gathered here supports the view that the Apollo program was a genuine bubble, with little long-term fundamental support from society. It led to innumerable technological innovations, and scientific advances, but many of them at a cost

documented to be disproportionate compared with the returns. These returns may turn out to be positive in the long run as many of its fruits remain to be fully appreciated and exploited. Enthusiasm was constantly, even though not univocally present to push for the endeavor, risk always a topic but never an issue. The program was first nucleated by a special interest group, which inflated to a very large size only through the general positive feedback mechanisms. As a result, the Apollo program enjoyed a tremendous support, financially as well as societal. At the same time, Congress approved funding until its peak in 1966. The 'upheaval' by the public in 1963 had no direct manifestation, at the time Congress was strongly willing to increase NASA's budget. After 1966 though, support by Congress slowly decreased until it was cut off almost entirely under Nixon, terminating it in 1972.
We have called the Apollo program one of the most exceptional and costly project ever undertaken by the United States at peacetime. However, just as Apollo had come out of nowhere, and held center stage for a decade, it vanished from the public consciousness, as if it had never happened. It thus was an exceptional niche, not having been revisited to any significant degree ever since.

4.5 Outcome

The example of the Apollo Space Program has revealed that, in situations where new technology or scientific options are on the horizon, *i.e.* when a new horizon opens up, and individual or groups believe to be ready for it, then they do it, whatever the risks and the consequences are. The factors combined in this endeavor then weave a network of reinforcing feedbacks that lead to widespread over-enthusiasm and extraordinary commitment by those involved in the project. Our concept of social bubbles tries to grasp such episodes. When several arrangements, such as technological, economics, and political, become intertwined into a self-reinforcing spiral, *i.e.* when social networks and their financial and societal dynamics are at stake, such situation is adequately refereed to as a social bubble. The central factors can be decomposed into:

i) idea (scientific/technological)
ii) credit creation via public/private investment
iii) enthusiasm
iv) saturation of the idea (exploration comes to an end)/open critic
v) program termination.

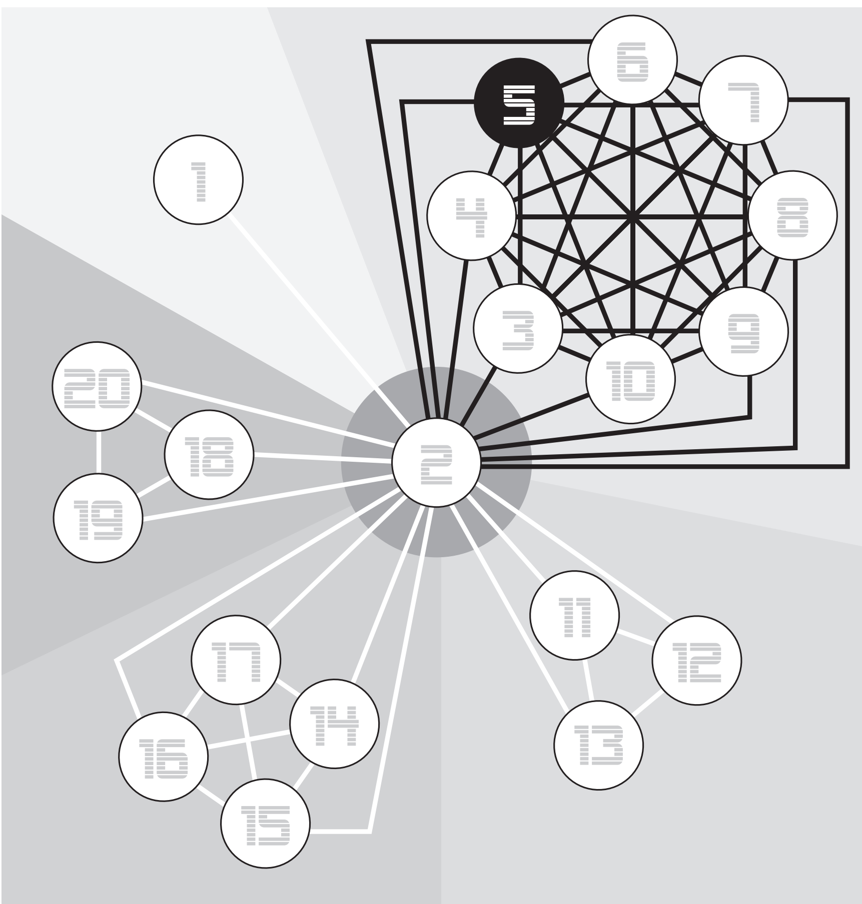
The appearance of a new idea is followed by upward engagement (financially, man power, time load), connected to high expectations and utopian goals that push a project for an extended period. Collective over-enthusiasm, as well as unreasonable investments and efforts derived through excessive expectations of positive outcomes, lie at the bottom of such processes. People want to get the maximum, but have no such opportunity most of the time. Only during these times do they dare explore new opportunities, many of them unreasonable and hopeless in a non-bubble context, with rare emergences of lucky achievements.

And even when investments flop with the crash of the bubble, businesses and consumers can find themselves with a usable commercial and industrial infrastructure at large, which they can progressively put to new uses. Resources created during bubbles do not disappear in the long run, when its investors go bust. It more often than not gets reused, by entrepreneurs with new business plans, lower cost bases, better capital structures [Gross, 2007]. Our overall goal is thus to explore and test the evidence that bubbles lead to a lot of destruction of value but also to the exploration and discovery of exceptional niches.

The investigation of other examples of major inventions should strengthen this point: the Human Genome project [Gisler, *et al.*, 2010], the cloning of mammals (Dolly, the sheep), the ITC bubble culminating in 2000 [Sornette, 2008], or the adventure of nanotechnology (impossibility to keep up with the pace initially announced very optimistically). One thing in common to all this topics is the presence of extremely high expectations towards the outcome of the proposed research and/or innovation project. The large enthusiasm at the inception of the project prompted the undertaking of very risky decisions, which opened the road towards tremendously high innovations. Some of them led to dynamic societal progress and structural changes, others captured the imagination of large societal groups and proceeded along a roller-coaster of rising expectations, steep growth and spectacular downturns, while their potential future benefits are still uncertain. They all constitute an essential element in the dynamics of important inventions or innovations, and are thus crucial for society.

5 New Models for Generating Power Law Distributions

Günter Haag



5.1 Introduction

The Pareto distribution is fascinating scientists since many years, not only because of its seemingly very simple mathematical structure but also because scaling laws are some particularly simple cases of more general relations. It should be emphasized that scaling never appears by accident [Barenblatt, 2003] but reveal an important property of the system under consideration, namely self-similarity. This means that the structure of the system reproduces itself on different scales. In physics many systems can be found which exhibit scaling behavior over many orders. In social sciences, *e.g.* for the city size distribution, a potential law can be found with acceptable accuracy only for a few rank-size-decades often within a population interval between about 1 Million to about 1000 inhabitants.

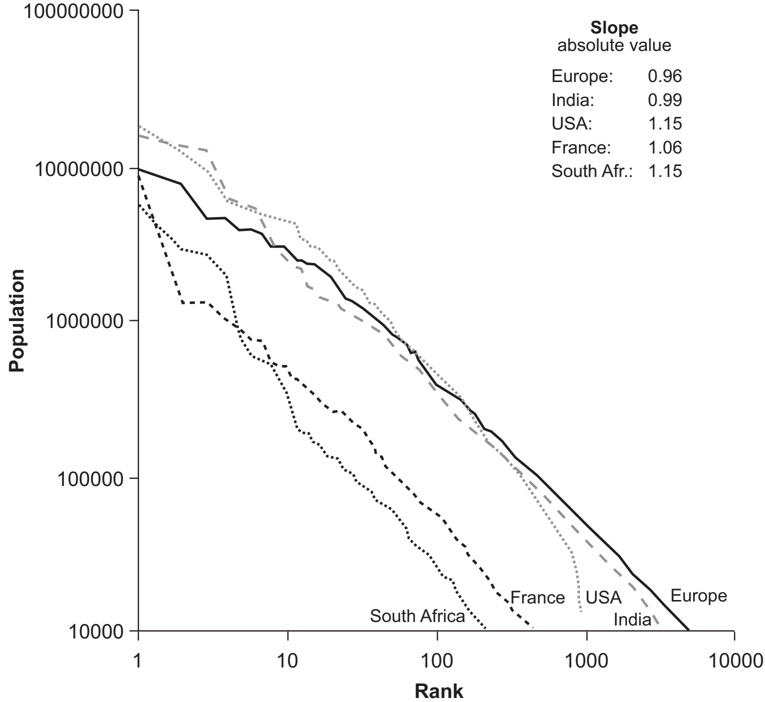
The mechanisms behind the urbanization process, namely the transformation of rural into urbanized landscape is of significant interest among researchers of different disciplines. Since Auerbach [1913], Gibrart [1931] and Zipf [1949] possible explanations of how the observed size distributions are generated are discussed. Different aspects of city growth have been treated on the basis of different frameworks [Beckmann, 1958; Roehner and Wiese, 1982; White, 1977; Wong and Fotheringham, 1990; Guerin-Pace, 1993; Curry, 1964, to mention a few].

However, since the rank-size distribution reflects just one dimension of a highly dimensional dynamic process of urban growth it is not surprising that all the different frameworks come out with size distributions more or less similar with the observed ones. The explanation is thus shifted from the size-distribution issue to the constraints which have to be defined to force the theory to conformity with the process [Pumain, 1982; Pumain, 2006].

A description of the size distribution by mathematical models which attempt to replicate data suffer from the fact that they are easily adjusted to the observations, because of the simple structure of the distribution. This problem was already encountered by Quant [1963] and Robson [1973] and is referred to as the "over-identification of models problem." This has the following consequence: The quest about an appropriate dynamic modeling of the urbanization process and its projection to the size-distribution can only be decided by a comparison of the complex underlying empirical and theoretical interaction processes and not via looking at the size-distribution. This means that we do not need a further theory for the explanation of the size-distribution but rather a good framework for the dynamic urbanization process of highly interacting units.

In the following some new modeling ideas are considered with respect to this issue.

FIGURE 5.1 **Hierarchical Differentiation in City Sizes**



Sources: Europe: Moriconi-Ebrard F., 1994, GEOPOLIS/India: Census of India 2001/USA: United States Census 2000/ France: INSEE, Recensement de la Population 1999/South Africa: Statistics South Africa, Census 2001, Base CVM.

The power-law distribution or more general the term scaling describes a very simple situation namely the existence of a relationship between

$$n_k = n_1 k^{-q} \tag{1}$$

the population n_k of a city and its rank k. The rank-size-coefficient q and n_1 the population of the biggest city are constants. Scaling laws reveal the phenomenon of self-similarity. This property requires that certain characteristics of the system reproduce itself on different scales.

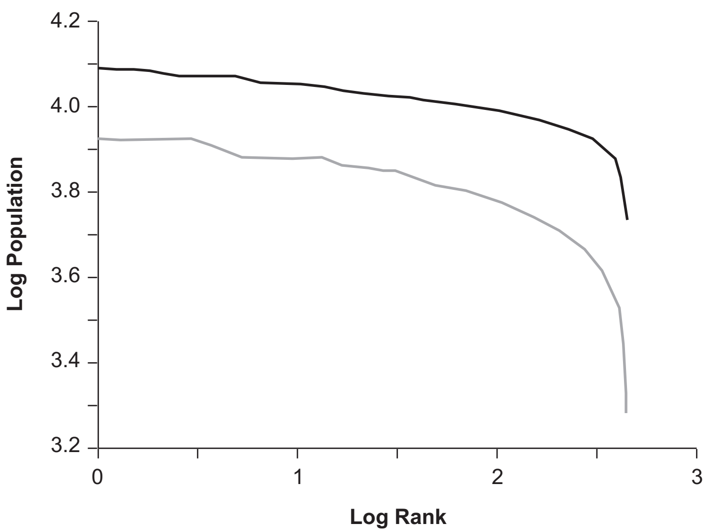
The stability of the rank size distribution of cities over the last century and the question of the general appearance of such distributions in most countries of the world are an important issue of research.

During the last twenty years many computer experiments have been performed to illustrate under what conditions power laws for city size distributions can be found [Pumain, 2006]. Batty [2006] demonstrated in a number of computer experiments that the distribution generated from the Gibrat process with diffusion are somewhat flat and as the level of diffusion is reduced, the hierarchical structure begins to disappear.

$$n_{it+1} = (1+\varepsilon_{it})\, n_{it} + \lambda \frac{\sum_{k\in\Omega} n_{kt}}{4} + \phi\, n_{it}^{1.08} \tag{2}$$

The underlying process assumed (2) describes the dynamics of a number of cities in a grid at place *I* at time *t* with size n_{it} and a randomly chosen growth rate ε_{it} according to Gibrat. In order to model the interaction between the cities some simple diffusion to adjacent cities is added via a fixed proportion λ of the population diffuses to its nearest cities. In case of the introduction of agglomeration economies into the model by adding a term $\emptyset = 0.2$ reflecting current city size the sharpening of the distribution of city sizes according Figure 5.2 comes better in line with real experiments.

FIGURE 5.2 **City Size Distribution for the Model (2) at *t* = 1000 and *t* = 10.000**



Source: Batty [2006]

To introduce a different form of hierarchy Batty introduced much more explicit networks of interaction. In each time period, for a city which is already linked to other cities a random link is added an the new population size n_{it+1} of city *I* is modeled via

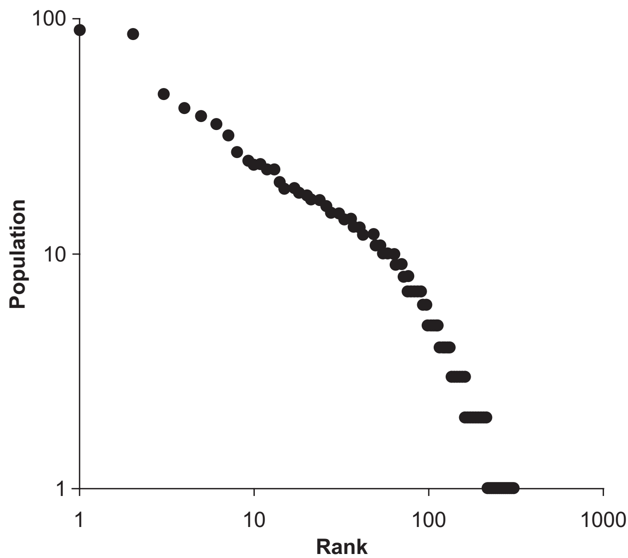
$$n_{it+1} = \sum_j n_{ijt} + \delta_{itk+1} \tag{3}$$

In (3) n_{ijt} is the total number of links from city *I* to *j* and the random addition of a link is described by δ_{ikt}. It is assumed that a link is added or not depends on the size of the city n_{ijt} and its distance d_{ij} to other cities via a gravitational function

$$\delta_{ijt+1} = 1, \quad if \quad rnd(\varepsilon_{ijt+1}) = Kn_{ijt} \exp(-\beta d_{ij}) \tag{4}$$

where the term $rnd(\varepsilon_{ijt+1})$ determines a random choice. The parameter β reflects the frictional effects of distance. However, this model (4) is related to a scale free network [Barabasi and Albert, 1999].

FIGURE 5.3 **Rank-Size distribution of the Nodal Network Distribution**



Source: Batty [2006]

Figure 5.3 shows the Zipf plot where in addition to (4) an algorithm is added for the birth of new nodes. This population distribution is close to the pure Zipf scaling. It confirms that this model of preferential attachment based on Gibrat does generate a distribution compared to the simpler non-network cases.
However, empirical data of migration flows, traffic flows or flows of commodities in a network of cities clearly demonstrate that the underlying assumptions concerning the spatial interaction of cities are quite different from the above discussed issues.

1) There are no diffusion terms λ in the population dynamics as introduced in (2). The exchange of population between cities is based on migration.

2) The nodes (cities) are not randomly linked. The flows are rather determined by economic reasons of transport, labor market conditions and general economic impacts.
3) Agglomeration effects as introduced in (2) lead to the amplification of the population growth with increasing population size. This leads in the long run to a steady increase of the slope of the rank-size distribution and not to an almost stable rank-size coefficient q.

A further critique on current modeling efforts is found in Pumain and Haag [1994] in the sense that the geographic specificity of a set of cities must be integrated in mathematical models. The above obstacles can largely circumvented by incorporating a stochastic approach. The master equation framework provides a flexible tool for passing from individual decisions of different agents (micro level) to a macroscopic consideration of a system of cities. Therefore, it seems to be advisable to start with an integrated dynamic urban model where all parameters and functions involved have a clear meaning and can be related to empirical observations. The simulation of this integrated urban macro model then should lead under certain conditions to the observed hierarchical organization characterized by the rank-size distribution. Of course, the self-organization process, and therefore the development of the skewness and complexity of the distribution, is related to the model parameters and the flows within the network of settlements (flows of people, materials, information, etc.). The interactions among the different elementary units of the system (the different settlements, agents, economic effects, etc.) depend in general on the spatial distribution pattern of the elementary units. Self-accelerating processes and saturation processes have to be considered. The elementary decision process of an individual to migrate depends on those impacts, as well as on psychological, social and economic conditions. The occurrence and temporal stability of the rank-size distribution is then obtained as the result of a dynamic self-organization process of the urban network [Haag, 1993]. Under these conditions, the rank-size distribution of settlements can be considered as a stable attractor in urban growth [Haag and Max, 1995].

5.2 The Dynamics of Urban Pattern Formation

The Rank-Size as a Self-Organization Process

The master equation is the starting point [Weidlich and Haag, 1983; Haag 1984; Weidlich, 1984] for the modeling of the urban system. Since settlements can not be considered as isolated systems, rather as elements of an urban network, flows between the urban elements (nodes) are of fundamental importance.

In addition the settlement/hinterland interaction and the emigration and immigration rates as well as birth/death events have to be considered in this stochastic framework.
Let the urban system be composed of L settlements and the hinterland. Then [Haag *et al.*, 1992] the most probable development of the city size can be described via

$$n_{it+1} = (1+\rho_{it})n_{it} + \sum_{j=1}^{L} \nu_0 f_{ijt} n_{jt} \exp[u_{it} - u_{jt}] - \sum_{j=1}^{L} \nu_0 f_{jit} n_{it} \exp[u_{jt} - u_{it}] + W_{ih} - W_{hi} \tag{5}$$

where n_{it} is the population size of city i at time t and ρ_{it} its natural growth rate. The two sums describe the in-migration and out-migration of population. The migration flow between the cities I, j is driven by differences of attractiveness $(u_{it} - u_{jt})$ of the different settlements I, j. The parameter v_0 is a measure of the mobility of the population and the barrier effects (distance deterrence function) are modeled via the symmetric matrix $f_{ijt}(d_{ij}) = f_{jit}(d_{ji})$. Emigration and immigration effects are modeled via W_{ih}, W_{hi}. Evidently (5) is a set of L coupled nonlinear first-order differential equations for the mean city sizes. The change in population size of city I is due to migration events between cities as well as to interactions with the hinterland and birth-death events. Specifications of this model were discussed in the case of interregional migrations [Weidlich and Haag, 1988].
A hierarchical ordering of the settlements is assumed such that n_{1t} is the largest city, and n_{it} is the population of the i-th ranked place. Now the nonlinear transformation

$$n_{kt} = n_{1t} k^{-q_k(t)} \tag{6}$$

is introduced, where $q_k(t)$ are denoted as rank-size coefficients. Insertion of (6) in (5) yields after some minor manipulations an equation of motion for the rank-size coefficients [for details see Haag 1994]:

$$\frac{dq_k(t)}{dt} = f(\vec{q}(t), f_{ijt}, \nu_0, \vec{u}_t, \ldots) \tag{7}$$

The rank-size distribution would be a stable attractor of the spatial system of settlements if

$$\lim_{t\to\infty} q_k(t) = q \quad for \ \forall_{k=2,\ldots,L} \tag{8}$$

However, this seems to be a rather restrictive condition.

Equation (5) or (7) becomes fully explicit by insertion of the analytical form (assumption A or B) of the attractiveness $u_k(n_k)$:

Assumption A

$$u_{kt} = \delta_{kt} + \kappa n_{kt} - \sigma n_{kt}^2 \qquad (9)$$

In assumption A the attractiveness $u_k(n_k)$ of city k in dependence of its population size n_k is represented as a truncated Taylor series up to second order. Positive agglomeration effects, $\varkappa n_{kt}$ increase its attractiveness with increasing size, negative externalities are represented by the term $\sigma\, n^2_{kt}$. This means it is assumed that an optimal city size exists, which maximizes the cities attractiveness. All other socio-economic influencing factors (not size dependent) merge into the term δ_{kt}.

Assumption B

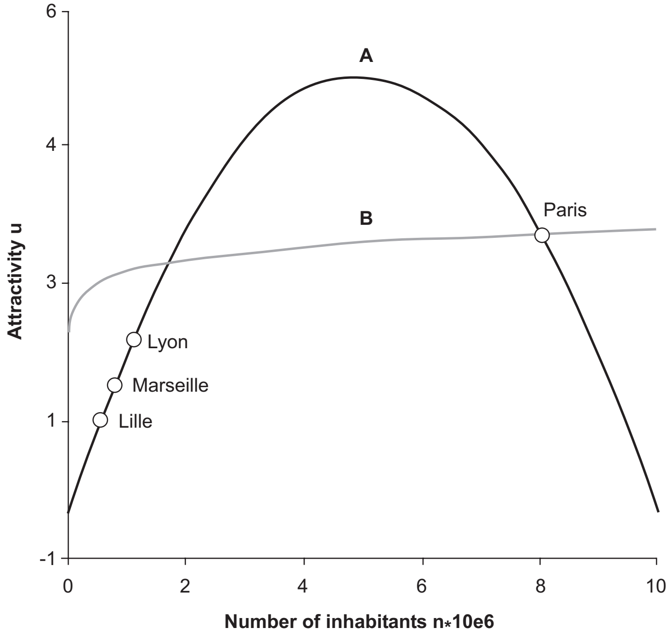
$$u_{kt} = \delta_{kt} + \kappa \log n_{kt} \qquad (10)$$

In assumption B, a convex decreasing marginal settlement attractiveness is assumed, approximated by the term $\kappa \log n_{kt}$. This assumption seems to be rather plausible, compared to assumption A. In Figure 5.4 the two assumptions A, B are shown for a subset of the French city system consisting of the 78 largest urban units. This contains all cities with more than 50.000 inhabitants in 1962. The parameters pertain to this urban system was obtained by means of a nonlinear estimation procedure.

As starting condition of the simulation of the urban process an almost homogeneous initial distribution (same city size for all cities) has been chosen. Furthermore, the system of settlements has been treated as closed; this means that emigration and immigration processes have been neglected. Therefore, the total population remains constant during this simulation, but a redistribution of population among the cities due to migration occurs.

In Figure 5.5 assumption A is used in the dynamic simulation of (5). Under those conditions the urban system remains close to the initially chosen homogeneous distribution for a prolonged time period (almost 300 time units). When the hierarchy starts to develop the evolution accelerates and within a short period of about 40 time units as an intermediate state a rank-size distribution appears which finally ends up in two clusters of cities, namely a small cluster of dominating cities (Paris, Lion, Marseille) of almost the same size and a big cluster of smaller cities. A reason for this agglomeratory phase transition is caused by the shape of the attractiveness function favouring an optimal city size.

FIGURE 5.4 **Size-Dependence of the Cities Attractiveness for the French Urban System in 1962**



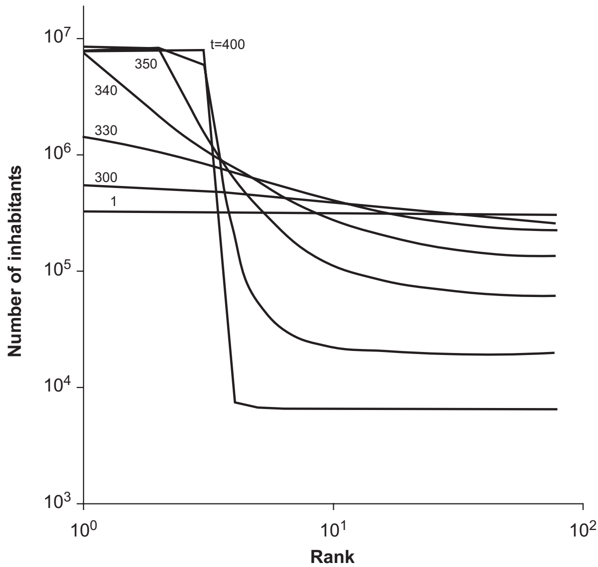
Source: Haag [1994]

In Figure 5.6 assumption B is used in the simulation. The hierarchical ordering process starts immediately and within a much shorter time interval of approximately 100 time units a Pareto distribution is approached. In this case, the rank-size distribution is the result of a dynamic self-organization process with the rank-size coefficient q as a stable attractor. In other words, the slope of the distribution is completely determined by the parameters of the settlement model (5) and therefore linked via the individual choice processes behind (5) to the micro level.
The slope of the rank size distribution according Figure 5.6 corresponds to the observed distribution [Figure 5.1], if the agglomeration parameter is closed to its critical value $\kappa_s \approx 1/2$. For $\kappa > \kappa_s = 0{,}5$ the homogeneous population distribution (the initial distribution) becomes unstable [Weidlich and Haag, 1987]. Therefore, the obtained distribution belongs to the case of SOC (self organized criticality).

Agent-Based Modeling and SOC

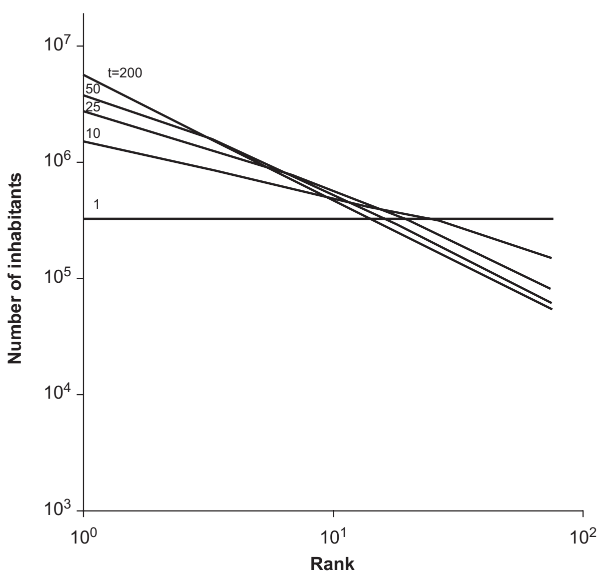
The model of the settlement system (5) can easily be improved by the introduction of subpopulations (*e.g.* age groups, sex, different other population groups).

FIGURE 5.5 **Simulation of an Urban System Using Assumption A**



κ=0.596; σ=0.188; ν=0.001; N=25.6*10^6; L=78

FIGURE 5.6 **Simulation of an Urban System Using Assumption B**



κ=0.596; σ=0.188; ν=0.001; N=25.6*10^6; L=78

The interaction between the subpopulations may lead to more complicated dynamic structures such as limit cycles or even chaos [Haag, 1989].
If we introduce as many subpopulations as agents in the spatial system, equations for the modeling of a agent-based spatial simulation model are obtained

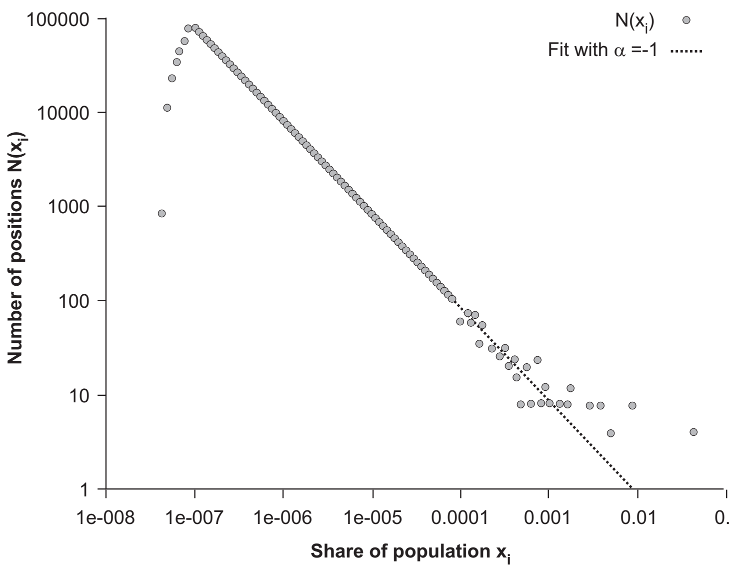
$$x^{\gamma}_{it+1} = (1+\rho^{\gamma}_{it})x^{\gamma}_{it} + \sum_{j=1}^{L} \nu_0^{\gamma} f^{\gamma}_{ijt} x^{\gamma}_{jt} \exp[u^{\gamma}_i(\vec{x}) - u^{\gamma}_j(\vec{x})] - \sum_{j=1}^{L} \nu_0^{\gamma} f^{\gamma}_{jit} x^{\gamma}_{it} \exp[u^{\gamma}_j(\vec{x}) - u^{\gamma}_i(\vec{x})] \quad (11)$$

Where the different individuals are denoted by γ and x^{γ}_{it} the probability that agent γ decides for alternative I (settlement i) at time t. The different agents are coupled together via their utility functions $u^{\gamma}_i(\vec{x}, \kappa^{\gamma})$, depending on the decisions of all other agents and a set of control parameters κ.

$$u^{\gamma}_i(\vec{x}) = C - \kappa \sum_k \ln(d^{\gamma}_{i|k=rank}) \quad (12)$$

If one assumes that the attractiveness (12) of a city depends on the distances $d^{\gamma}_{i|k=rank}$ to the hierarchically ordered centres κ (to be close to the centre is more attractive) again a Pareto distribution is obtained [Vogel, 2007] [Figure 5.7].

FIGURE 5.7 **Size-Distribution of Settlement Places for a 1000x1000 Grid, for κ= 1**



Deviations from the scale-free distribution for small values [see Figure 5.7] are related to the quadratic grid structure. However, only for a decreasing marginal attractiveness with distance (*e.g.* a logarithmic dependence) a scale free distribution was obtained. This finding corresponds to the results of subsection "*The rank-size as a self-organization process.*"

5.3 Conclusions and Summary

In Pumain [2006] a comprehensive overview of assumptions and models linked with the hierarchical differentiation of space are discussed. It is shown, as already mentioned that many different, partly not compatible assumptions may lead to systems exhibit rank-size behavior. Which of those many theories seems to be the most adequate one with respect to the many different aspects of urban systems and the behavior of its agents? Because of the dynamic spatial network structure of the urban system and the various organizational levels, nonlinear interactions, feedback effects, millions of involved agents, the social and political structure of the system we are dealing with, the urban system and its mathematical representation is certainly complex.

As described in the early book of Weidlich and Haag [1983] these urban phenomena belong to the field of socio-political decisions of individual agents on the micro level and the consequential collective, economic and abstract structures on the macro level of society. On the level of individual agents a complex mixture of fluctuating rational considerations, professional activities and emotional preferences and motivations finally merge into one of relatively few well demarcated resultant attitudes. The same fluctuating micro thoughts, emotions and experiences finally merging into an attitude may from time to time also lead to the transition from one attitude to another. The manifold of attitudes is an open one. Changes in the attitude space of an individual may lead to the decision to change the place of home or work, or both, or... Therefore, the dynamics of interacting populations on the macro level is linked via the nested decision behavior of its individuals to the micro level. Which one from the many different, in general not distinguishable attitudes may finally enforce the decision to move and how much of this decision is related to uncertainty and hazard?

The evolution of a socio-economic system such as a system of settlements is not an autonomous process, but the result of human decisions, occurring over time as a broad stream of concurrent, unrelated and interrelated, individual or corporate choices, embedded in a spatial environment which is shaped by the choice processes of the individuals and hence also changing over time. In quantitative sociology a probabilistic description of the motion of macro variables *e.g.* the population sizes of cities proves to be adequate even when the details of the micro fluctuations of the system are unknown. In Haag [1989] a general coherent and closed framework for the dynamic modeling of decision processes is presented, based on the master equation.

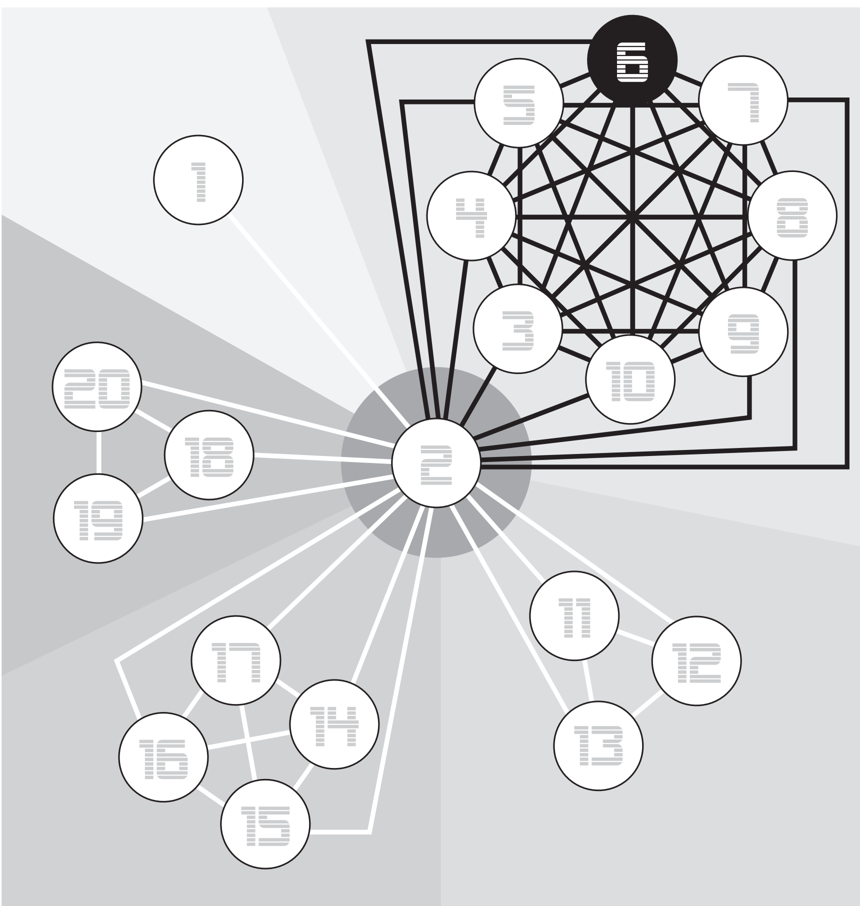
Therefore, the mathematical description, the master equation, leads to the development of a highly dimensional probability distribution namely that a certain population distribution is realized. The most probable distribution of settlement sizes provides the input to construct the rank-size distribution. In so far the comparison of the computed rank-size distribution of an urban settlement model of a spatial system with the empirical rank-size distribution of that particular system can be used as a necessary but not sufficient test for the underlying model assumptions. One finding of such a comparison of the distributions based on the outcome of the simulation models (5) and (11) supports the assumption B of decreasing marginal attractiveness of a settlement rather than of a quadratic dependence of the attractiveness on size.

The evolution of a network of settlements based on migration and the hypothesis of marginal decreasing attractiveness of settlements with size demonstrate that the rank-size distribution behaves as a stable attractor in urban growth. The distance (travel time) between the cities influence the spatial structure and the net growth effects beside the natural growth rates of the settlements. The mobility of the population is responsible for the speed of adjustment to any disequilibrium situation. The dynamic response of the rank-size coefficient is therefore influenced by the mobility. The steepness of the rank-size distribution, the rank-size coefficient in this self-aggrandizing urban model is finally determined by the spatial agglomeration parameter, namely the tendency of the population to cluster together in cities. For the existence of any rank-size distribution the homogeneous population distribution must become unstable. This requires that the agglomeration parameter is above a critical value and a phase transition appears.

6

RISC-Processes and Their Weak Societal Protection Networks

Karl H. Müller



This article provides an overview on the special relations between RISC-processes and their societal control potentials, be it at the national or at the global level. At the outset, the intricate relations between RISC-processes, controls or governance and forecasting will be discussed in greater detail and the classical equivalence of explanation control and prediction will be effectively abolished.[1] Finally, the second part of the article points to inherent vulnerabilities of globalized RISC-societies which lie clearly beyond any societal control. These concluding considerations point to the uneasy fact that the infrastructural constitution of RISC-societies which has been discussed at greater length in the second chapter of this book has an in-built Achilles heel or a necessary blind spot which makes today's globalized societal ensemble open to very large-scale breakdowns.

6.1 Towards a Typology of RISC-Processes and Control Potentials

In standard textbooks on Philosophy of Science or on scientific modeling one finds a statement that to explain a process P means also to be able to predict P and to control this particular phenomenon P under consideration:

$$Ex\,(P) \equiv Pr\,(P) \equiv C\,(P)$$

This classical equivalence is no longer valid in the case of RISC-processes. Table 6.1 has been constructed in a way as to demonstrate that one finds a variety of RISC-processes with varying degrees of control, of forecasting capabilities and of prevention and damage control.

In particular, one is confronted with RISC-processes which are perfectly predictable, although there is currently a lack of control and, consequently, an absence of prevention and damage control. A paradigmatic RISC-process in question are the distribution of incoming materials and meteorites from outer space where rare events can be predicted with high accuracy, although the controls on the underlying dynamics or prevention and damage controls are, at least at the present time, beyond societal capacities.

Similarly, one finds RISC-processes whose underlying dynamics cannot be controlled, they cannot be predicted accurately but, nevertheless, there is a large potential for societal prevention and damage control which minimizes the impact of rare events. Again, the paradigmatic instance here comes from earthquakes which are beyond control in their tectonic dynamics and beyond forecasting

1 On this equivalence, see, for example, Casti, 1989a and 1992.

capacities, except for probability mappings of sites with high, medium and low probabilities for earthquakes. However, regulations for buildings and construction materials can be implemented in a way as to guarantee a minimal impact even in the case of very strong earthquakes.

Table 6.1 introduces a wide variety of types of RISC-processes and their different recombinations of control dynamics, predictability and societal prevention and damage control.

TABLE 6.1 **RISC-Processes and Control Potentials**

	Prevention and Damage Control					
	Not Possible		**Limited Degree**		**High Degree**	
	P*	**NP***	**P***	**NP***	**P***	**NP***
No Control on the RISC-mechanism	Type I	Type II	Type III	Type IV	Type V	Type VI
Limited Control of the RISC-mechanism	Type VII	Type VIII	Type IX	Type X	Type XI	Type XII
Efficient Control of the RISC-mechanism	Type XIII	Type XIV	Type XV	Type XVI	Type XVII	Type XVIII

P*: Accurate predictions possible NP*: No accurate prediction possible

The most surprising fact about the eighteen types of Table 6.1 is that many of these types can be empirically observed. The types with the rarest occurrences are centered in the third line of Table 6.1 where it is assumed that an efficient control on the underlying dynamics has been established. Here, it can be argued that the types XIII to XVI are, most probably, empty because an efficient control of the underlying dynamics is incompatible with no or limited controls with respect top prevention or damages.

Another striking feature emerges from Table 6.1, however. RISC-processes can change from one type to another. The history of financial markets shows, for example, that one can observe in the long run an oscillation between type X and type XII, *i.e.*, between regimes of high degrees of prevention and damage controls like the period from 1945 to the 1970s and periods of limited and insufficient degrees of control like in the period of the super-bubble from the 1980s onwards, leading to the crash of 2007ff.

6.2 The Infrastructural Constitution of Contemporary Societies as MR-Ensembles (Metabolism-Repair)

To assess the potential impact of RISC-processes in a somewhat unconventional manner, a new multi-component framework for the Great Transformation I[2] will be utilized[3] where a multi-component ensemble is characterized by two main attributes, namely by metabolism and by repair. Not surprisingly, the resulting configuration can be described as MR-networks. The following main ingredients become necessary for an appropriate MR-specification.

Starting from a national or, more appropriate, from a global level, one can construct a self-organizing complex of five interacting market networks, consisting of agriculture (M_1), industry (M_2), firm-related services (M_3), household-related services (M_4) and a domain for waste-disposal and recycling (M_5). Each of these five network segments fulfills the following conditions.

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

It becomes quintessential, to characterize the concept of a market environment in a more precise manner. The first essential environmental complex for M consists in a repair-and maintenance segment which may be composed of five distinct components, namely of the three infrastructural networks for energy (R_1), information (R_2) and transport (R_3) as well as a household segment (R_4) and a sector for the education and training networks (R_5). It should be easy, even at first sight, to identify input-output relations between each of the market segments and the five repair and maintenance ensembles.[4] The second environmental domain consists, not quite unexpected, of natural resources, land or, more generally, of the ecological settings as well as of the waste production, emissions, etc. which are produced in the course of the basic market metabolism.

---

2 On the first Great Transformation, see the second chapter of this book.

3 See, for example, Rosen, 1991 or Casti, 1986, 1988, 1989a,b, and 1992.

4 One could think on the relations between monetary flows between (M_1 – M_5) → energy networks (R_1), information networks (R_2) or transport networks (R_3) or between financial contributions from (M_1 – M_5) → households or the national education and training systems (R_4, R_5).

Formally, the following three conditions must be fulfilled:

- $Condition_1$: 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.

In the case of the ten-component MR-network specified above which, one must add, corresponds to the infrastructural constitution of RISC-societies, introduced in the second chapter of this book, conditions 1 to 3 are fulfilled even in a highly trivial manner.

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 five 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 repair system must be conceptualized as well which has two essential functions. On the one hand, the 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

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

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

With respect to the five 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 internal manner—the exchanges between sectors 1 to 4 and sector 5 as well as in an external way—the exchanges between all five sectors and the natural environment proper. 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_i-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 state that input-output exchanges can be observed between all five market with each of the five repair segments.

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 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 this specific societal configuration in which each of the ten segments is linked to the remaining nine domains in a multiplicity of ways.

6.3 The Potential for Very Large-Scale Involutions of RISC-Societies

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 networks within contemporary RISC-societies.

Robustness-Theorem (RISC-Society 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 RISC-societies has the quality of an coevolutionary stable complex.

In light of the "Zero-Hypothesis," two theorems will be proposed which run counter to the vision of coevolutionary 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.

Both theorems offer a counter-intuitive picture on 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 network densities. Growing interdependencies and network connectivities are not a safeguard from catastrophic disruptions. In other words, a densely connected MR-configuration is, contrary to the modernization-based "Zero-Hypothesis," not coevolutionary 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.[5]

The second interesting implication has to do with the micro-constitution of the overall MR-configuration. Since each of the ten MR-components can be conceptualized, once again, as an MR-ensemble itself, consisting of smaller MR-units which, at the level of firms, are MR-systems themselves ...,[6] a growing awareness should set in that contemporary RISC-societies are inherently unstable. It might well be the case that relatively small MR-units acquire the capacity to disrupt the entire MR-ensemble in an all-encompassing manner especially because the MR-network connectivities have become so dense.

5 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 metabolism-repair 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.

6 Quite generally, M-R 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. Moreover, the core-domain for M-R ensembles lies in biological areas, namely in cells and cell-formations.

Consequently, the MR-theorems offer a radically alternative view on robustness and coevolutionary 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].

Thus, network formations of the MR-type have an involution potential which cannot be diminished—it just can be shifted from one network type of a large number of non-re-establishable and isolated components—for example the capitalist world system in the 18th century—to today's formations of a very large number of re-establishable components and a very small number of non-re-establishable, but central segments. Centered on any major global RISC-induced rare event, the following implications are very difficult to avoid.

First, contemporary configurations within the economic sphere exhibit a small number of non-re-establishable segments in infrastructural areas like electricity, gas, oil or water which have been labeled as the MR-infrastructure. These components alone or in conjunction qualify for obvious reasons as a central component since they act as necessary pre-requirement for a smooth metabolic exchange and transformation within the main economic sectors or clusters.

Second, RISC-induced problems become a very serious issue for the MR-infrastructure. There is clearly an above average amount of repair and adaptation work needed within the MR-infrastructure in order to avoid a partial or prolonged breakdown of the overall MR-ensemble. Why? Simply because the delivery chains within the MR-infrastructure have become highly sensitive to time and, thus, to failures in relation to time.

Third, the increasing network densities through new production regimes like just in time-proliferation or lean, non-degenerate organizations, 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 RISC-induced failures of large magnitudes 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 within an MR-ensemble would require, among other things, a complete revision of the organizational changes introduced over the last fifty years. Thus, successful 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.

6.4 ICT-Based Knowledge Pools as PM-Configurations (Program-Maintenance-Ensembles)

From a RISC-perspective, it becomes highly instructive, once again, to point to a specific domain of vulnerability which lies in the diffusion of today's complex information networks. The machine code basis of contemporary knowledge pools can be described and analyzed as a multi-component configuration, consisting, on the one hand, of program segments (P) and a maintenance part M which sets the common standards and measures like time, sizes. More specifically, M is responsible for a proper coordination and standardization of the program outputs.
The subsequent specifications are aimed at the new machine code-bases in the regional, national or global knowledge pools which can be labeled as pools of machine-based programs. In order to facilitate the subsequent definitions, this specific pool will be qualified as program pool, for short. In a trivial manner, the program pool can be separated into various segments. In the present case, the program pool will be divided into those ten segments that have been identified for contemporary RISC-societies already. Thus, the overall knowledge base consists of a program pool for each of the five market segments and for each of the five repair components.[7] For a single program pool component P_i, the following points become of relevance.

- First, inputs from other program domains like new program tools, new program languages, etc. will be transformed into new outputs within a specific program domain.
- Second, the output of P_i is reproduced at least in some degree by other program pools P_j as well.
- Third, a part of the output of P_i is connected with the M-segment.

M is a to be conceptualized as a very small segment of the program pool, organized and defined by all those program components necessary for the organization

7 To be more precise, the program pool is composed of ten program components and of ten practically identical PM-elements.

and synchronization of standards like time, space, lengths, weights, money etc. within the overall program pool.

In a formal way, the following three conditions must be fulfilled for the interactions between program pool components and the M-element.

- Condition$_1$: Each program segment must receive at least one input from the internal or external program environment.
- Condition$_2$: Each program segment P_i produces at least one output.
- Condition$_3$: Each program segment is linked at least with one of its outputs to the time maintenance segment M.

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

The basic formalism for the PM 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 an recognizable surface output. Formally, each of the ten program pools transforms external inputs Ω from the environment into an externally accessible program output Γ.

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

This program metabolism 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 this program metabolism from disturbances, a maintenance system must be in operation which has two essential functions. On the one hand, the 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 maintenance adaptation can be formalized as

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

To set the basic PM-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 ten program pool segments, the metabolic transformations can be analyzed in a straightforward way in terms of program reproductions and program connections. With respect to the relations between the maintenance domains and the program pools, the maintenance areas must be included within the two program transformations *g*: Ω → Ξ and *h*: Ξ → Γ. At this point it must be sufficient to state that the maintenance segment is included in a mission critical manner within the input-output transformations of the ten program pools.

Finally, the PM-segment turns out to be highly standardized and uniform, being composed of synchronized elements distributed in an identical fashion throughout the knowledge bases. The PM-part has a unique format for the global knowledge society. In other words, time has become embedded in an identical fashion throughout the global TM-bases.

6.5 The Potential for RISC-Induced Involutions in the Program Pools

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

Robustness-Theorem (ICT-networks): Due to dense linkages, high replication rates and a huge amount of redundancies, ICT-knowledge pools are highly robust to external and internal disturbances. Thus, the machine-layer of the knowledge pools can be qualified as coevolutionary stable.

Once again, two counter-intuitive theorems can be laid down which run opposite to this code-based stability vision.

- Theorem_1: A PM-complex in all of its possible connectivity patterns possesses a non-reproducible element.
- Theorem_2: If a PM-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 societal formations as a whole. Four special points are worth being emphasized.

The first one is self-similar to an argument, developed for the societal network side already. An intensification of code 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 PM-components aggravates and intensifies the resulting repair and coordination efforts.

Second, in all these instances of PM-transformations, changes in the societal 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 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.

Third, RISC-induced problems should be considered as the first and probably 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.

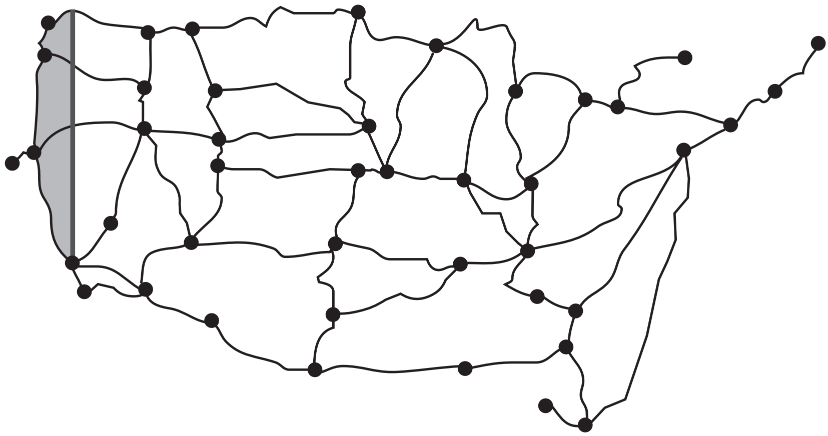
Fourth, these new coordination problems will lead to a radical re-definition and re-shaping of the notion of comparative regional or national advantages since flexibility and high adaptability in dealing with PM-transformations will become one of the major regional or national advantages within the RISC-societies of the future.

6.6 The Deceit of Reason

The introduction to Part I already indicated that the linkage densities during the third stage of RISC-societies have increased dramatically and that the current RISC-phase is characterized, more and more, by the emergence of scale free networks which become embedded in a cumulative mode in the already existing network formations both in the economic and in the infrastructural domains. In combination with the two theorems presented in this article, an interesting trade-off can be observed which justifiably can run under the heading of Hegel's deceit of reason.

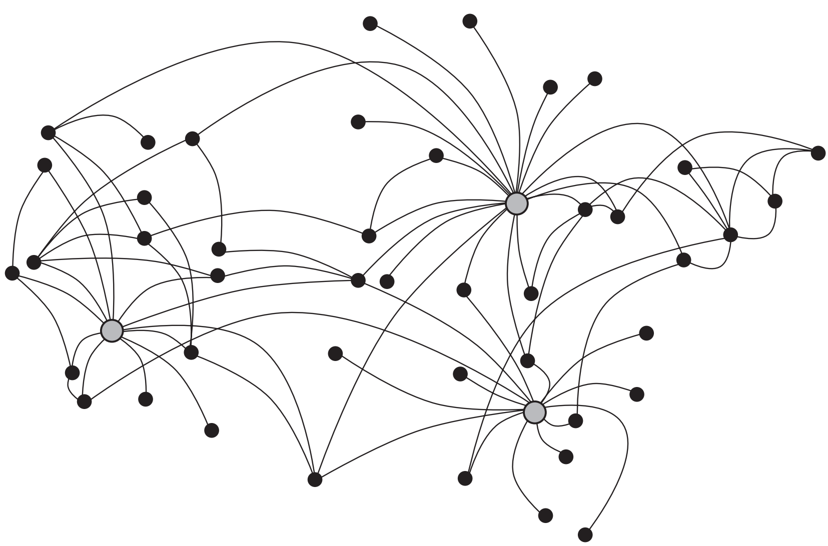
Figure 6.1 points to the disaster potential for RISC-societies during the second stage in which several random networks in transportation like railroads or in the automotive sector were built. Due to the overall network-structures, the effects of a rare event turned out to be local only. However, the local effects were usually heavy because the networks themselves had only a very limited substitution potential.

FIGURE 6.1 **Local Disasters in Random Networks**



Turning to the current stage of RISC-societies, scale-free networks are characterized by a high substitution potential so that a local network failure, due to the overall network structure, can be compensated internally. However, scale-free networks have, although at very low probability levels, a potential for global failures if, for example, two or more central nodes are affected simultaneously. Figure 6.2 points to the critical configuration of scale-free networks with three central nodes.

FIGURE 6.2 **The Potential for Global Disasters in Scale-free Networks**



Thus, seen from a long-term perspective, RISC-societies are drifting from a pattern of local disasters without substitution potentials during Stage II to a state with a considerable substitution potential at the local level and, at the same time, a non-negative probability for overall failures and global breakdowns.

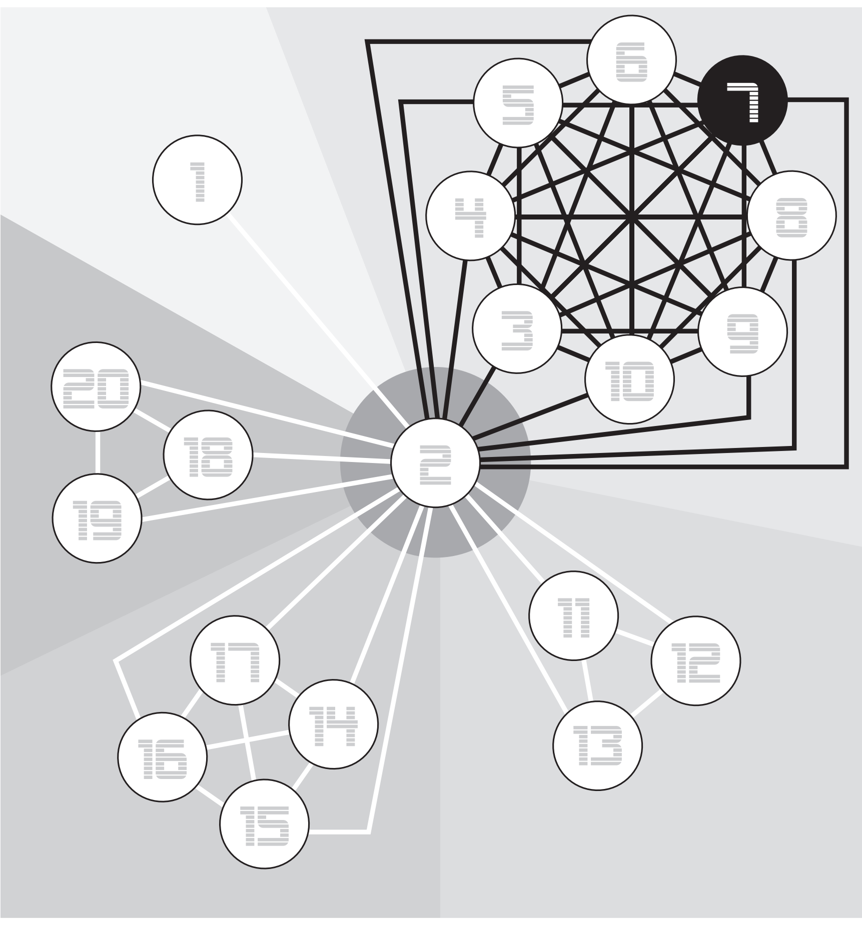
6.7 Further Outlooks

To conclude, both the network formations and the machine-code centered knowledge bases of contemporary RISC-societies are inherently unstable and vulnerable, due to their composition and due to the necessary existence of non-reproducible components within these networks or knowledge bases. Viewed in a global manner, intensifying the linkage densities of the regional, national or global RISC-configurations reproduces the potential for very large-scale failures and breakdowns, too.

7

Zipf's Law in Labor Status Transitions: New Insights from Austrian Labor Market Data

Michael Schreiber



Motivated by discussions about competitive strategies of Europe that expect member states to implement flexicurity for employers and employees we present recent findings of research into RISC-processes and labor markets. We studied the transitions in the employment status in Austria for a period of six months in 2009 by analyzing monthly data according to three divisions among target groups: age, gender and education. It turned out that frequencies of changes in employment status followed a power law during these six months. Apparently, labor markets can be characterized as complex, adaptive and self-organizing systems, too. Moreover, the complexity of the status change networks was shown to be reducible by cut-off values that enable schematic classifications of the different groupings.

7.1 RISC-Processes and Labor Markets

Rare incidents with strong consequences have been traditionally linked to financial markets or to the domain of income and wealth distribution. So far, labor markets have eschewed the attention of RISC-researchers. At first sight, labor markets stand in very close relations with labor market policies and with steering efforts by the state apparatus and by public labor market services which aim to push labor markets towards high levels of employment and, correspondingly, low levels of unemployment. Thus, labor markets seem to be situated very far from complex self-organizing systems and from an evolutionary perspective which are the usual arena for RISC-processes to emerge.

At second glance, however, labor markets share an impressive amount of characteristics of a complex self-organizing system and should exhibit, thus, a variety of RISC-processes as well. In a first move we want to provide a short list of attributes for labor markets or, alternatively, for employment systems which belong to the domain of complex and self-organizing systems.

Multiple decompositions: First, labor markets can be decomposed in a multiplicity of ways. Take, for example, a decomposition of labor markets into sectors. Then one can focus on the evolution of these employment sectors and describe this sectoral evolution as being headed in an irreversible movement to a complete marginalization of two traditional main sectors, namely of agriculture and industry, and to an all-encompassing service segment. Additionally, this sectoral evolution can be accompanied by a variety of different trends, ranging from a dualistic split between high-qualified and low-qualified activities to a more homogeneous rise of high quality activities especially in the services.

A second decomposition of labor markets can be undertaken in terms of employment clusters. Cluster arrangements are in the long run consistent with a multiplicity of professional shifts, ranging cross-nationally from a sharp rise of scientific-technical professions to a modest increase only, from a rapid expansion of state employees to an overall stagnation or even decline, from a severe downward movement in the number of skilled industrial workers to a slow decline.
Moreover, the evolution of economic sectors and of clusters share a clear relation of complementarity since changes in the cluster-composition can be accompanied cross-nationally both by increases or decreases in specific sectors. A shift from an iron and steel-cluster to a cluster of constructing iron and steel-plants industries may imply both a decrease or an increase in the corresponding economic sectors, depending entirely on the performance of the other sector-components outside the specific clusters.
Furthermore, even a single decomposition like the sectoral approach can be separated into a manifold of ways, from a three sector scheme or from the nine sector OECD-classification to the nineteen sectors of input/output-analysis or to the twenty-five economic sectors of the Austrian micro-census. In addition, two types of sectoral partitionings can be found. In the first instance, sectoral schemes follow a sub-class relation where, for example, the three sector classification can be subdivided in a way that the three sectoral building blocks of an employment system S^E (primary, secondary, tertiary sector) can be subdivided into more distinct sectors so that the tertiary sector can be divided into banking and insurance, retail trade, personal services and the like. In this case, the following subset-relation holds–

$$S^E_{i,k,l} \subset S^E_{i,k}$$

i.e., the building blocks$_k$ of the economic system E under the decomposition$_i$ can be separated into different sets of sub-units$_l$. In the case of non-subset-divisions, strict independence prevails. Take for example a sectoral division where a heavy emphasis is placed on natural resources and where a sector of natural resources and energy is defined by comprising mining and quarrying, crude petroleum and natural gas as well as, finally, electricity, gas and water, then the resulting new sector will have the following non-subset relation with the three sector scheme or the nine sectors of the OECD–

$$S^E_{i,k,l} \not\subset S^E_{i,k}$$

Since the sector of natural resources and energy comprises sector 2, parts of sector 3 and parts of sector 4 in the OECD-categorization, this particular building block can neither be reduced nor decomposed into the OECD scheme.

Thus, the building blocks for labor markets exhibit an astonishing openness and, above all, independence with respect to their basic constitutive elements. As a consequence, processes of structural adjustments, learning and adaptations occur in a multiplicity of ways for which, by necessity, a multitude of complementary and, thus, irreducible decompositions can be established.

Aside from the multiplicity of decompositions labor markets exhibit all sorts of other characteristics of complex and self-organizing systems. For example, labor markets can be described with the following concepts from complexity and self-organization theory.

- Multi-Component Systems: The overall direction of labor markets are determined by numerous interactions of many dispersed units acting in parallel.
- No central steering unit: Labor markets proceed without efficient controls on interactions—controls are maintained in an inefficient manner and incapable of reaching central target values like a minimal value of unemployment within a short or even medium time range.
- Multi-level-organization: Labor markets can be divided into many levels of organization and interactions, ranging from local, regional, national to global dimensions. Units at any given level typically serve as building blocks for constructing units at higher levels.
- Permanent adaptation: At *any* level, these building blocks of labor markets are recombined and revised continually, leading, thus, to a permanent adaptation process far from equilibrium.
- Coupled fitness landscapes: These adaptation processes are performed within coupled fitness landscapes, leading to an embedded process of feed-forward and feed-back between different levels of labor markets.
- Economic niches: At any level, the arena in which labor markets operate is structured by niches and, consequently, by entrance and exit barriers. Moreover, there are no universal super-competitive units that can fill all niches.
- Socio-technological systems as niche creator: Niches in labor markets are continually created by new socio-technological systems with new products and services and the very act of filling a niche provides new niches.
- Technologies as niche annihilator: In turn, long established niches in labor markets are continually closed by the introduction of new technologies, leading, thus, to permanent processes of creative destructions.
- Far from optimum: Labor markets operate, because of the permanent creation of new niches, far from an optimum or from a global attractor.
- Power of the Local: The spatial distribution patterns of labor markets are not homogeneous, but highly concentrated in comparatively few areas.

- Temporality: The permanent adaptation processes are characterized, finally, by time lags and an uneven temporal distribution in the duration of adaptation patterns.

In this manner, an evolutionary and self-organizing vision of labor markets and their trajectories has been formulated which serves as one of the background justifications for a deeper search for power laws and for Zipf-distributions in labor markets.

7.2 Probing Flexicurity

A second motivation to look into possible power law-distribution in labor markets comes from recent political discussions at the European level on flexicurity. Flexicurity replaces traditional employment strategies from protecting existing jobs that had been popular in Europe in recent decades but were perceived as part of the problem. "Institutional changes affecting Europe's labor markets over the last 25 years are a central reason for Europe's poor labor market performance."[1]
The flexicurity model started, first, in Denmark under a social democratic government, headed by Poul Nyrup Rasmussen during the 1990s. In its simplest form, it can be described as a recombination from flexible hiring and firing practices (flexibility for employers) with high benefits for the unemployed (security for the employees). In December 2007, the European Council adopted eight common principles of flexicurity in the following manner:

1) Flexicurity is designed to implement the main principles of the Lisbon Strategy.
2) Flexicurity, in addition to being committed to life-long learning, active labor market policies and a modern social welfare system, sees the need for flexible contractual arrangements.
3) Flexicurity needs to adapt to the different circumstances in each Member State.
4) Flexicurity needs to support open and inclusive labor markets which help to reintroduce inactive employees back into employment.
5) Flexicurity needs to involve the smooth transition between jobs by constantly up-grading employees' skills and providing the necessary social protection in transition periods.
6) Flexicurity should promote both gender equality as well as considering means to reconcile work|life balance issues.
7) Flexicurity needs the support of the social partners.

1 See Siebert [1997] p. 39.

8) Flexicurity needs to involve a cost-effective distribution of resources which public budgets can sustain.[2]

From the description of labor markets as self-organizing and from the European discussion on flexicurity as a target for employment systems in general it becomes a highly relevant empirical question whether labor markets like the Austrian labor market exhibit processes and distributions which are characteristic for complex and self-organizing ensembles.

7.3 Employment Status Transition Frequencies

The following sections present a particular heuristic interaction prototype developed to monitor frequencies of changes in employment status. In this article, we will outline the methods used and share some preliminary results. Our pilot study processed frequencies of employment status changes obtained from a database provided by the Austrian government for six month in 2009 [June, 2009, July, August, September, October, November, 2009]. We compared frequencies of employment status changes among groups segmented by sex, age and education. Three age groups were distinguished:

- → below 25 years
- → from 25 to 44 years
- → over 45 years

Segmentation according to education is problematic because of privacy concerns. We had to rely on synthetic data computed by official agencies which provide only a formal classification into seven levels of qualification in their database.

Table 7.1 presents the most important twenty transitions within the Austrian labor market.

2 These principles have been retrieved from http://www.eurofound.europa.eu/areas/industrialrelations/dictionary/definitions/FLEXICURITY.htm

TABLE 7.1 **Top Twenty Transitions**

Frequency	Link			Source	Target
572 067	XO	→	OL	other out of labor force	other out of labor force
332 952	UB	→	XO	employed	other out of labor force
325 254	XO	→	UB	other out of labor force	employed
201 005	NU	→	AL	non subsidized employed	unemployed
188 274	AL	→	NU	unemployed	non subsidized employed
185 424	XO	→	AL	other out of labor force	unemployed
147 074	AL	→	XO	unemployed	other out of labor force
131 273	ND	→	G*	changed employer	changed employer
109 284	AL	→	QU	unemployed	qualification
73 499	QU	→	AL	qualification	unemployed
47 548	GB	→	UB	marginal employment	employed
44 862	KG	→	OL	child benefits	other out of labor force
41 558	UB	→	UB	employed	employed
37 964	UB	→	GB	employed	marginal employment
31 299	UB	→	RE	employed	pension
29 748	UB	→	KG	employed	child benefits
28 872	RE	→	OL	pension	other out of labor force
25 421	KG	→	UB	child benefits	employed
19 647	QU	→	UB	qualification	employed
18 367	XO	→	QU	other out of labor force	qualification

These top transitions are positioned in the following adjacency matrix together with less frequent changes of employment status. The headings of rows give the initial employment status of transitions. The headings of columns indicate the final states of these changes.

TABLE 7.2 **Adjacency Matrix of Transition Frequencies**

	AL	GB	GU	KG	ND	NU
AL			14473	5699		188274
GB						
GU	4049					
KG	8961					
ND					131273	
NU	201005					
OL	185424			6296		
PZ	3863					
QU	73499					
RE	2318					
SB	6180					
UB		37964		29748		

	OL	PZ	QU	RE	SB	UB
AL	147074	2259	109284	6481	5892	
GB						47548
GU						
KG	44862					25421
ND						
NU						
OL	572067	13621	18367	10899	15764	325254
PZ	8909					12294
QU	16489				1964	19647
RE	28872					6941
SB	14938		40		972	16443
UB	332952	9811	1571	31299	16939	41558

We simplified this adjacency matrix and its corresponding graph below by modifications of identifiers. The label XO is replaced by OL as both indicate an other out of labor status. This replacement generates a self loop at node OL. The labels XB and B_ are replaced by SB because both are labels for self-employment. These replacements result in a self loop at node SB. Finally we replace "G*" by ND and obtain an isolated self loop at node ND which indicates a change of employer.

Sorting by net differences between the counts of source labels taken to be negative and counts of destination labels we condense the processed collection of transitions into the following table. The isolated self loop at the node ND reduces to a net value of 0. All other nodes have either positive or negative net counts. A marked decrease of non subsidized employment NU is partially covered by increases of subsidized employment GU. Self employment SB becomes more frequent which helps to compensate decreasing marginal employment GB and the counterintuitive difference between an increase in unemployment AL which is larger than the decrease in employment UB.

FIGURE 7.1 **Simplified Network of Transitions**

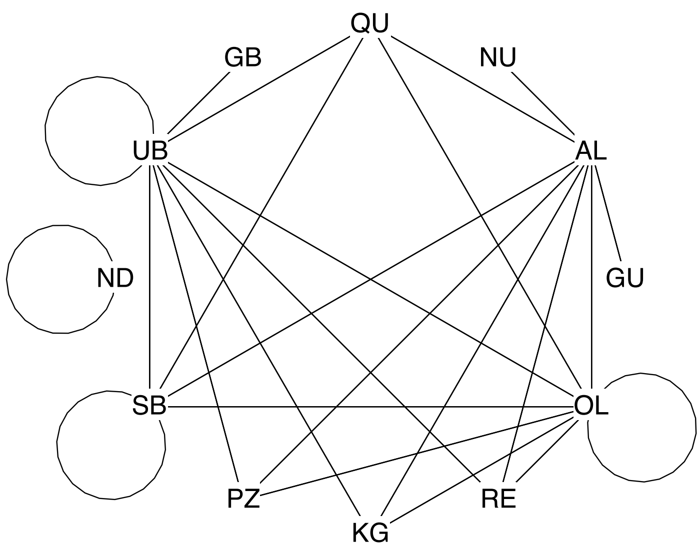


TABLE 7.3 **Net and Total Counts of Employment Labels**

Label	Translation	Net	Total
OL	other out of labor force	18471	2313855
QU	qualification	17663	240861
RE	pension	10548	86810
GU	subsidized employment	10424	18522
AL	unemployed	5863	964735
SB	self-employed	2958	80104
PZ	military service	625	50757
ND	changing employer	0	262546
UB	employed	-6736	996948
GB	marginal employment	-9584	85512
NU	non subsidized employment	-12731	389279
KG	child benefits	-37501	120987

Note that these net counts of status labels do not match the differences between status counts in June and November that are returned by a direct query for the 38 categories of employment status. The results of counting differences in unemployment by occurrences AL labels in transitions is 5863 for instance whereas the difference computed from direct queries is 29698. The following table groups differences consolidated according to three levels of classification. These nested classifications are given in the cells of the first column. The third level has been dropped unless it is different from the classification already specified at the second level of distinction. The individual labels encompassed by those nested classifications are given in the second column. The differences between the total of counts for June taken as negative and the total counts for November are computed in the final column.

The top and bottom ends of this sorted tabulation are dominated by other states escaping these records in particular data not available labeled by KD and the default status generated for intervals without social security coverage LL. The category encompassing labels for secured out of gainful employment includes military service and PZ but is dominated by receivers of pensions RE.

TABLE 7.4 **Differences Between Direct Status Counts for June and November**

Classification	Labels	June	November	Difference
other undetermined	TO, KD	321212	450712	129500
Labor Service Record unemployment	AL	239967	269665	29698
Labor Service Record qualification	D2, SC	60571	78861	18290
other secured out of employment	W1, W2, ED, EO, KG, KO, PZ, RE, LS, SG	2047333	2056291	8958
employment employed fragmented	FU	6281	7915	1634
other marginal employment	G1	142372	143632	1260
employment self employed	LW, S1	412513	413344	831
employment employed subsidized	FB, FL, FA, FF, FS	32924	25239	-7685
other pre unemployment record	AO	45388	37483	-7905
employment employed non subsidized	BE, LE, AA, FD, SO	3152503	3129130	-23373
other other out of employment	AU, MK, MP, MS, SV, LL	2413731	2243365	-170366

Some of these differences could be discussed in more detail by queries of the mon_erwerb_chg database but this would force us to omit or reconstruct the distinction between levels of education which depends on statistical reconstructions of fused anonymized records. We thus proceed by using heuristic frequency cutoffs instead to generate simplified views of this transition system according to our selected distinctions of focus: gender, age and education.

7.4 Zipf Compressed Views for Nested Audiences

Compressibility can be regarded as a proxy for entropy measures that indicate the amount of information in given sets of data elements. This idea can be applied to our data about employment status transitions by introducing a lossy compression according to relative frequency.

Relative frequency is defined as the number of occurrences of a particular label n(t) divided by the total count of all occurrences of all labels W.

$$f(t)=n(t)/W$$

The sum of relative frequencies S(f) can be required to match a desired constant of quality Q in the unit interval.

$$0<Q<S(f)<1$$

This results in a positive cut-off value C for ranked relative frequencies of transitions f(t) that are included in a compressed representation.

$$f(t)>C>0$$

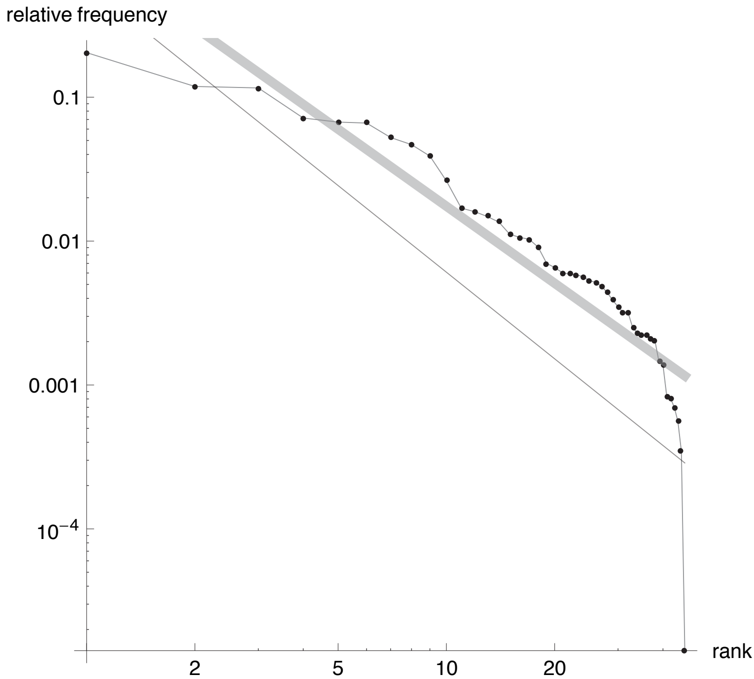
Conversely, a similar compression can be defined by setting a threshold value T for the number of different kinds of transitions that are to be considered in the compressed view.

$$f(1<t<T)$$

This alternative approach generates a variable measure of quality Q' that can be computed as the sum of the relative frequencies of the included transitions. We shall adopt the latter approach in an interactive prototype of a compressed graph browser presented after a preliminary analysis of the scaling properties found in our frequencies of employment status transitions.

A log log plot of the frequency values shows that their positions can be approximated by linear interpolation which is typical for values from a Zipf distribution. The logarithms of the ranks of the transition frequencies determine the position along the horizontal axis. The vertical positions are given by the logarithms of the relative frequencies of these transitions. The thin line interpolates between values from a Zipf distribution with shape parameter ρ equal to 1. The thick line approximates the preprocessed data about empirical frequencies of employment status transitions.

FIGURE 7.2 **Log Log Plot of Transition Frequencies**

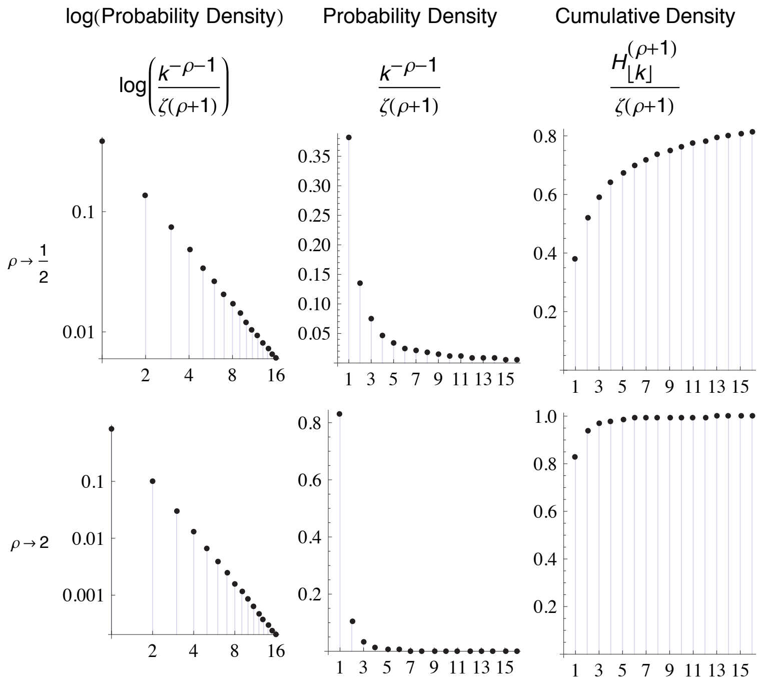


Heuristic compression by relative frequency is of course feasible for data following arbitrary distributions but distribution which—like the Zipf distributions—are following a power law will enable stronger compression ratios.

The following figures show log-log plots of probability density functions, ordinary plots of probability density functions and cumulative density functions of Zipf distributions with shape parameters 1/2 and 2. The plots of cumulative densities illustrate that compression ratios for given standards of quality or given thresholds of observed distinctions between labels are expected to rise with this shape parameter.

Returning from these methodological questions to the empirical distinctions observed with respect to frequencies of employment status transitions we will now present a screen shot generated by a prototype tool which draws customized compressions of transition networks. The customizations implemented by this prototype support the nested distinctions studied here, namely age, gender and education.

FIGURE 7.3 **Shape Parameter of Zipf Distributions**



The user interface permits specification of month, age, education level and cut-off thresholds of complexity in the shaded area. The output area has a white background and shows network graphs pruned by cut-off thresholds of complexity. These values are effectively specified as counts of distinct transition links that should be included in the compressed representation. The resulting sums of relative frequencies are given as absolute frequencies and as percentages of coverage achieved for male and female persons matching the nested distinctions of age and education in a given month. Absolute frequencies of included transitions are listed at the bottom of the output window.

Computing these qualities of compression for all combinations of age groups and education levels we arrive at tables that compare effects of these distinctions. Our prototype tool supports selection of month and cut-off threshold. It tabulates the corresponding compression qualities between plots rendering those percentages of coverage as shades of gray.

FIGURE 7.4 **Customized Heuristic Compression by Complexity Threshold**

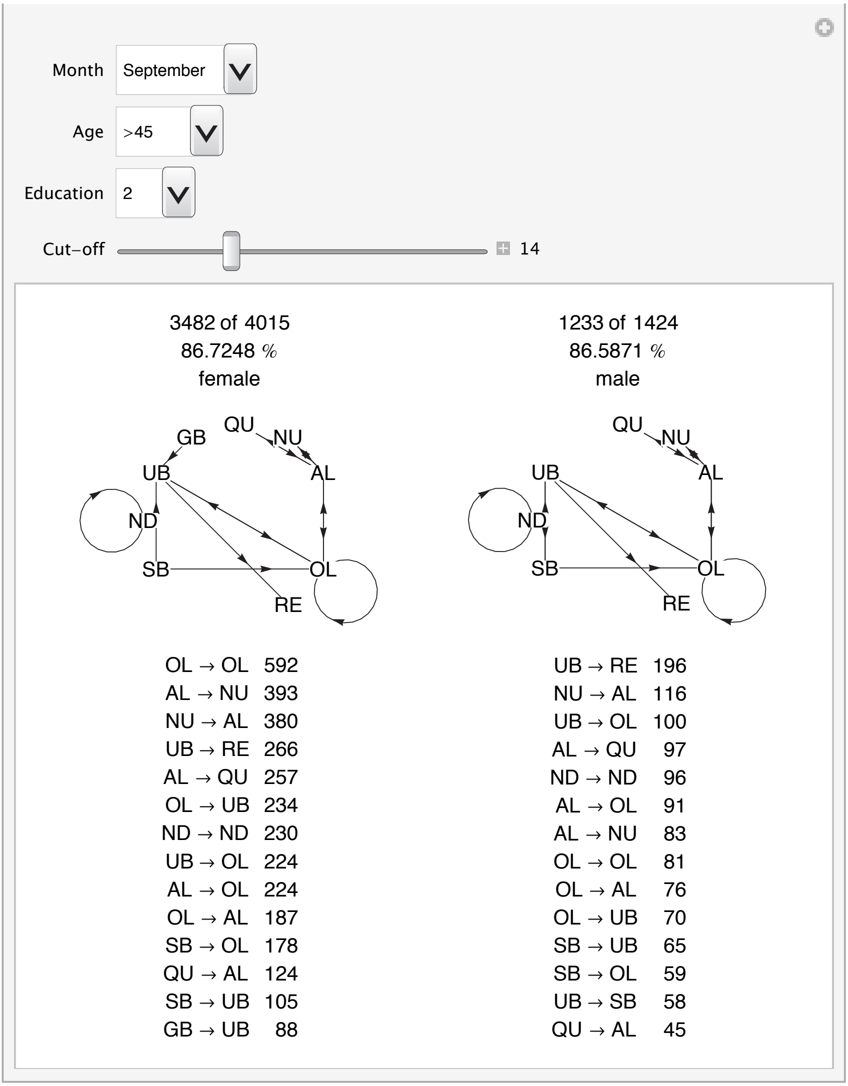
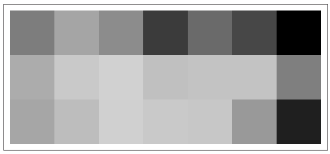


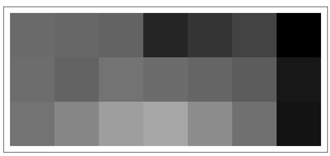
FIGURE 7.5 **Distinctions Affecting Quality of Compression**

Month September

Cut-off 6



	0	1	2	3	4	5	6	education
<25	73.9222	65.5631	71.0488	84.7704	77.4695	83.0645	92.6503	female
25–44	63.7699	55.3317	52.3791	58.3271	57.3174	57.1627	73.715	female
>45	65.2467	59.0533	52.8518	55.3293	56.0109	68.3814	88.6701	female
<25	64.9422	66.0091	67.2033	83.7718	79.7041	75.8621	93.1312	male
25–44	64.1998	67.018	62.487	64.5892	66.5675	68.9467	87.3723	male
>45	62.323	56.5621	48.8764	45.8941	54.6041	63.2207	88.4126	male



7.5 Perspectives for Research

Scaling parameters of transition frequencies are testable as hypothetical institutional variables expected to moderate differences between trends of employment in different industries, regions and nations.

Three results are possible:

1) correlations between scaling factors and trends of employment trends are not significant
2) scaling factors correlate negatively with trends of employment rates
3) scaling factors correlate positively with trends of employment trends.

It becomes clear, however, that correlations between scaling factors and trends of employment trends do not have to be significant for heuristic applications of frequency transition networks.

The preliminary results from our pilot project justify further studies of interactive tools that offer ways to achieve a compression of complexity by degree of frequency. While such tools might obviously be useful in acquisition processing and visualization they might also help to identify and manage the corresponding experiences of persons actually exposed to the real consequences of perceiving only a reduced network of alternative choices. Interactive simplification of transition systems offers a point of departure for discussions with target groups as well as staff and administrators of employment systems.

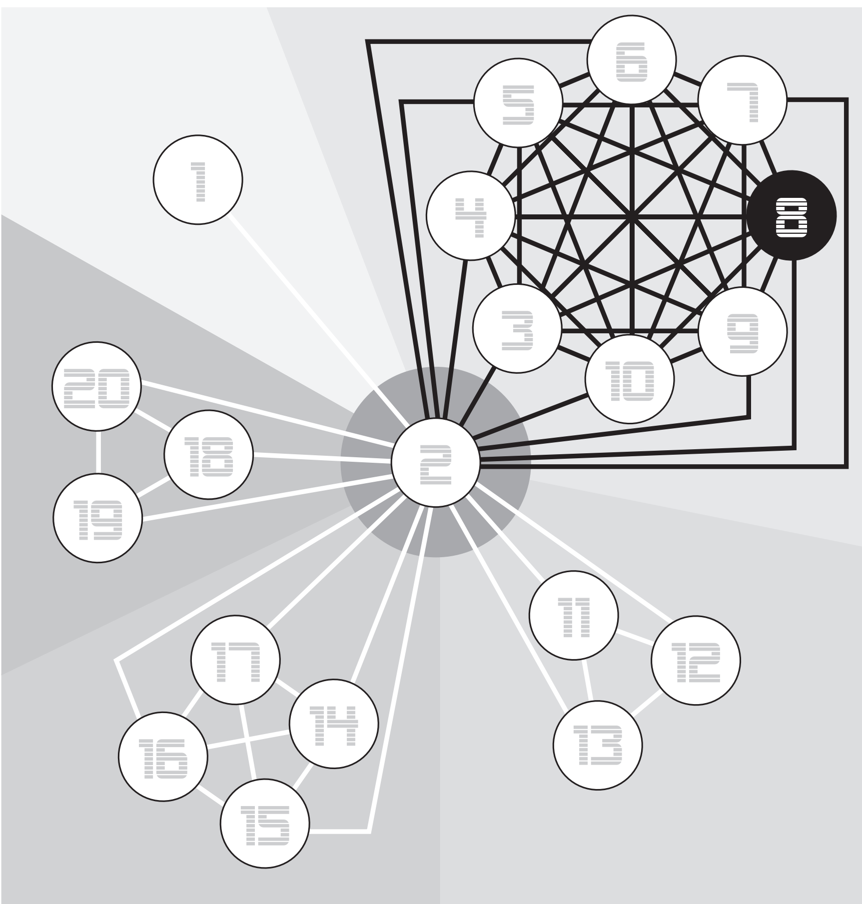
7.6 Conclusions

In anticipation of efforts to formulate new competitive—and hopefully more successful—strategies for sustainable employment we suggest further tests of the frequency approach presented for Austrian data for other members of the EU. We are confident that similar comparative analyses open the way for a much needed debate on flexibilities and rigidities in European labor markets. Moreover, it is hoped that the present analysis opens the way for a fruitful discussion on the nature of labor markets and their self-organizing capacities. Finally, the present study stimulates new forms of interaction and participation between different groups in the labor market and the institutions in charge of implementing labor market policies.

8

Self-Reflexive, Contagious, Attraction-Driven Networks (SCANs): Towards a New Transdisciplinary Framework for RISC-Modeling

Günter Haag | Karl H. Müller | Stuart A. Umpleby



This article extends the discussion of the modeling of RISC-processes to new clusters or families of network models which, so far, have not made their way to the core of socio-economic theory and model-constructions. These new network groups can be characterized as self-reflexive and contagiously attractive, *i.e.*, as driven by internal learning and by external imitation processes where contagious attractions become an intrinsic property of the network relations themselves and not an exogenous factor that can influence or disturb network actors. Usually, these networks exhibit multi-level structures and are normally marked by high degrees of observer-dependencies. Building blocks for these new network models have been put forward during the last decades by Heinz von Foerster,[1] L. Kauffman,[2] Vladimir Lefebrve,[3] George Soros[4] or Francisco J. Varela[5] in the domain of self-reflexivity, by Philip W. Anderson,[6] W. Brian Arthur,[7] Per Bak,[8] Albert-László Barabási,[9] John L. Casti,[10] Günter Haag,[11] Hermann Haken,[12] John H. Holland,[13] Stuart A. Kauffman,[14] Didier Sornette,[15] Wolfgang Weidlich[16] and many others in the area of multi-level and attraction-driven models as well as by Heinz von Foerster, Ranulph Glanville,[17] Humberto R. Maturana, Gordon Pask,[18] Stuart A. Umpleby or Francisco J. Varela in the field of observer-dependencies. In the course of this article, these various building blocks will be integrated into a more general class of models under the heading of self-reflexive, contagious, attraction-driven networks (SCANs) which can be

---

1 On Heinz von Foerster, see particularly von Foerster, 2003 and, as a short summary, von Foerster/Müller, 2003.

2 For Lou Kauffman's work, see especially Kauffman, 1987, 2005 or 2009.

3 On Lefebrve, see for example, 1982 or 2001or Umpleby, 1987b.

4 On George Soros and his approach, see especially Soros, 1994a,b, 1998, 2001, 2007, 2007 or 2010.

5 See especially Varela, 1975 and 1979.

6 For Philip W. Anderson, see only his classic paper on „More Is Different" [Anderson, 1972].

7 On W. Brian Arthur, see his latest compendium in Arthur, 2009.

8 See Bak, 1996 which contains a large collection of SOC- models (self-organized criticality) and their applications across very diversified domains.

9 On Albert-László Barabasi, see especially Barabasi, 2000 and 2010.

10 See especially Casti, 2010.

11 On Günter Haag see especially Haag, 1989 or Haag/Müller, 1992a,b

12 With respect to the research tradition of synergetics, see, for example, Haken, 1977, 1980, 1982 or 1983.

13 John H. Holland's explorations into evolutionary hill-climbing can be found, for example, in Holland, 1986, 1988, 1992, 1995 or 1998 and Holland *et al.* 1989.

14 With respect to Stuart A. Kauffman, see Kauffman, 1993 or 2000.

15 On Sornette, see aside from the article in this volume, also Sornette, 2003 or 2006.

16 For Wolfgang Weidlich, see Weidlich, 2000 and Weidlich/Haag, 1983 or 1988.

17 See especially Glanville,2009.

18 For an intrtoduction to Gordon Pask, see, for example, Glanville/Müller, 2007.

used for a wide variety of complex self-organizing RISC-processes across nature or society.

These self-reflexive contagious attraction network models become, due to their multiplicity of levels and their network topologies, of particular relevance for modern societies with continuous information loops from the macro-levels back to the micro-levels since today's knowledge-based societies possess well-developed information infrastructures with newspapers, radio, television or the world wide web that are capable of reaching very large groups of actors across various regions simultaneously. Although the new modeling framework can be applied to different societal arenas as well as to complex micro-domains like brain dynamics, the focus in this article will be on financial markets, past and present, because they exhibit a well-observed long-term history with recurrent periods of manias, panics, and crashes [Charles P. Kindleberger] and, moreover, they have moved gradually to the core of societal RISC-processes.[19]

In closer detail, the article will discuss several areas relevant for the construction of SCAN-models for financial markets.

- First, global financial markets can be viewed as self-organizing ensembles with limited and inefficient national or international controls and as a massive generator of a variety of RISC-processes like the boom-bust sequences on stock markets, the rank-size distribution of financial actors, etc.
- Second, from a logical point of view self-reflexivity can be characterized as a re-entry into a specific domain.[20] Basically, three different areas for re-entries will be distinguished, namely a re-entry of cognitive domains into cognitive domains, a re-entry of observers into their observations and, finally, a re-entry of observers and their cognitive domains into the cognitive domains under observations.[21] Out of these three different design paths, self-reflexive modeling within this article will be confined to the second way where self-reflexivity is achieved through self-adaptations and self-accommodations or, alternatively, through learning processes of participant observers.
- Third, the first groups of self-reflexive network models have been developed by Heinz von Foerster [1911–2002], a pioneer in advancing self-organization research and in promoting a new form of science of living systems by living systems for living systems. Already during the late 1950s and the late 1960s, Heinz von Foerster specified various network designs for non-trivial, *i.e.*, for state determined units and for the self-organization of brain mechanisms.

19 For a similar perspective on positive micro-macro and macro-micro feedback loops and their dynamics, see also Prechter, 1999, 2003 or 2009.

20 On this point see especially Spencer-Brown, 2004.

21 For more details, see Müller, 2010.

- Fourth, George Soros' modeling-sketch for boom bust sequences in financial markets will be introduced at greater length. Soros' modeling framework is composed of a network of non-trivial micro-actors and a permanent information loop from the financial macro-states to the learning micro-operators. George Soros' approach marks a significant progress in a deeper understanding of the micro-and macro-dynamics of financial markets and of societal evolution in general.
- Fifth, further advances in the area of formal self-reflexive modeling will be achieved by shifting to a synergetic framework. Here, a general model-sketch will be presented on how self-reflexive forms of modeling can generate, in principle, the dynamic behavioral histories of self-organizing systems like today's globalized financial markets.
- The sixth area to be discussed within this article stresses the high relevance of current network modeling in the domain of the brain sciences which, with high cognitive gains, can be transferred, adapted and generalized to societal domains like financial markets. Thus, this section will focus on an expansion of the frameworks discussed so far to a larger class of new RISC-models under the label of self-reflexive, contagious, attraction-driven networks (SCAN) where self-reflexivity, contagious attractions and observer-dependencies are entangled in a novel fashion. More specifically, self-reflexivity, contagious attractions and observer-dependencies become a necessary and sufficient condition for the possibility of RISC-processes to emerge.
- Finally, the seventh domain stresses the high potential and the fruitfulness of these new SCAN-modeling frameworks. In this spirit, the concluding part will end the entire article with an outlook on future modeling challenges and extensions in the area of self-reflexive modeling with contagious attractions and observer-dependencies.

As a starting point, the processes to be explained, the *explanandum*, will be introduced and several relevant concepts for the subsequent explanation sketches will be described in closer detail.

8.1 Contagious Attractions, Financial Markets and RISC-Mechanisms

Quite recently, Didier Sornette has used the term bubble to identify a largely hidden engine of societal evolution.[22] In a nutshell, bubbles are fed by positive feedback loops and are capable to move specific network regions or entire networks beyond critical states. Didier Sornette refers primarily to excessive periods of speculation in financial markets but also to periods of wild expectations and utopian goals in science like the human genome project or the Apollo space program in the 1960s and early 1970s. Some of these bubbles belong, quite obviously, to the driving forces of societal evolution since they are transforming a well-established regime and move into new areas of development and complexity. Other bubbles, while not leading to deep structural changes, capture the imagination of large societal groups and proceed along a roller-coaster of rising expectations, exponential growth and spectacular downturns. Nevertheless, the concept of a bubble implies implicitly a split between an underlying process on the one hand and illusionary excess elements and necessary bursts on the other hand. Bubbles outside financial markets are invariably associated with concepts like mass illusions or hypes. The main problem with expressions like bubbles or hypes is that they are accompanied by semantic necessity with elements of illusions, false expectations or even fake and deceit which restrict the classes of phenomena and processes to be analyzed considerably. In order to avoid these semantic connotations, the term contagious attraction will be proposed which, on the one hand, is sufficiently neutral and which, on the other hand, turns out to be more general because it can include the emergence of new technologies, migration processes, the evolution of settlements, new artistic styles, fashion trends or new political movements as well.[23]

From a very general perspective, contagious attractions are potentially at stake whenever large numbers of micro-units are linked in an overall network and operate, first, in a self-reflexive, learning or state-determined mode within a mutually observable domain and, second, within a realm of options or possibilities

22 See the article by Monika Gisler and Didier Sornette in this volume.

23 For example, it is rather misleading to talk of a National Socialist bubble from 1929 onwards whereas the contagious attraction of extreme right wing ideologies during the 1920s and 1930s can and, of course, has become a highly relevant field of historical studies. In contrast, expressions like the dot.com-bubble can be substituted by the phrase of a contagious attraction of new internet enterprises at the turn of the millennium. In short, contagious attractions can be applied to a larger set of domains and configurations whereas bubbles are restricted predominantly to financial markets and to periods of public mania or frenzy in societal spheres.

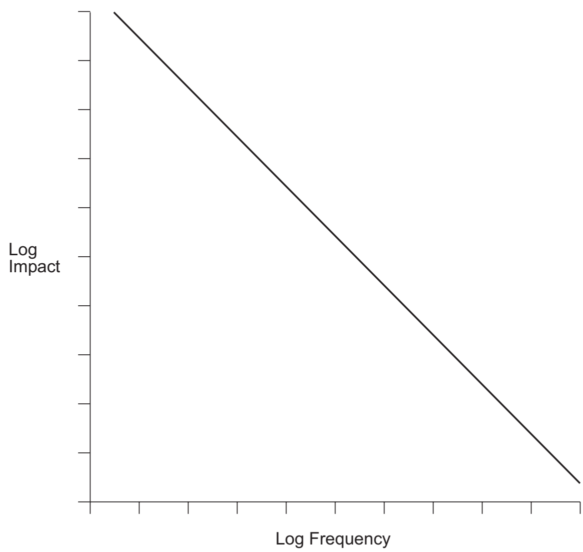
with various degrees of attractivities or, alternatively, of probabilities.[24] Under this overall configuration, specific network formations can be distinguished which will be labeled as self-reflexive, contagious, attraction driven networks (SCAN). Here, the network dynamics produces a sequence of processes with relatively stable events with small upwards or downwards fluctuations, interrupted by short periods of high and intense network activities and their subsequent collapse. In the field of technologies, contagious attractions can be identified in large-scale changes of the technological landscape like the introduction of new basic product technologies *via* railroads or digital information and communication technologies as well as in smaller episodes within the diffusion of such a basic technology. The Y2K-problem serves as an interesting example for such an intermediate contagious attraction, leading to an excesssive amount of new hardware and software equipment or program repairs worldwide and to a collapse of ICT-related purchases after January 1, 2000. In science fields, some of the emerging domains, due to their novelty and their potential impacts, become contagiously attractive of varying degrees. Thus, these SCAN-models become relevant whenever one can distinguish between normal network periods with relatively small changes and much shorter phases of bursts of network activities and their abrupt collapse.

Already in the introductory articles to this volume, financial markets and their boom-bust-cycles have been characterized as a paradigmatic example for a RISC-process and an underlying RISC-mechanism. This general observation can be supplemented with a more specific classification which views financial markets as a paradigmatic example for SCAN-models since the history of financial markets is characterized by a well-observed pattern of booms and busts that occur at irregular intervals and are of varying size. From the historical record it is well documented that most booms and busts are usually short-lived and mild whereas only few large-scale booms and corresponding busts can be identified like the long boom-period of the roaring 1920s and the deep bust phase between 1929 and 1933 or the accumulation of boom-periods and the super-bubble [George Soros] between 1988 and 2008 and the bust period from 2008 to probably 2009. These boom-bust-cycles in financial markets can be characterized as a global self-organization process with limited local or global controls which, due to Ashby's fundamental law of requisite variety [Ashby, 1970 and 1981], turn out far from being efficient. The asymmetrical periods of booms and busts are organized in a self-critical manner and are distributed

24 The notions of self-reflexivity, options and attractivity usually refer to human actors and human societies, the concepts of possibilities, learning and probabilities represent more general notions which can be applied to heterogeneous domains across nature and society.

in a power law fashion with $P(\tau) \approx \tau^{-\alpha}$ and $\alpha \approx 1$.[25] Figure 8.1 presents a typical distribution of the frequency and the impact of booms and busts where a very large number of marginal booms or busts is accompanied by a very small number of booms with very large-scale effects, followed by very deep busts.

FIGURE 8.1 **A Power Law Distribution of Financial Booms or Busts**



Thus, these boom-bust-sequences are organized as typical instance of a wide class of RISC-processes where one finds an underlying slow long-term growth process, a very large number of small upward and downward fluctuations and a small set of rare events with spectacular booms or busts.

Table 8.1 points to some of the most spectacular boom-bust sequences in the financial system of the United States during the 20th century and the first decade of the 21st century. Moreover, Table 8.1 can be supplemented with several general empirical observations on the nature of financial markets.

– First, one can observe an asymmetry between the network segments of private actors in financial markets and the public regulation domains simply because financial markets are characterized by a continuous stream of process and product innovations in the private network segments which tend to transcend the existing regulation regimes and their control capacities.

25 Empirically as well as historically these power law distributions exhibit cut-offs. On this point, see, for example, Vazquez, 2005.

- Second, the period from the 1980s up to the present crisis was characterized by a massive stream of large-scale product and technological innovations in financial markets and a significant weakening of the regulation capacities, thus increasing the asymmetry between financial and regulatory actors significantly. Even during the dot.com bubble a massive deregulation was undertaken by the Gramm-Leach-Biley Act which abolished the Glass-Steagall Act.
- Third, new regulation schemes come usually with delays of several years and usually lead to a new round of product and process innovations in financial markets which move them beyond the boundaries and the scope of existing regulation systems.
- Fourth, the longest period of relative stability in financial markets was the one between 1945 and the early 1970s where, as a matter of world-historic coincidence, the United States could operate as an actor of last resort in political-military, in scientific-technological and in economic-financial domains.[26]
- Fifth, the changing global configuration with a relative decline of the United States and the increasing asymmetries between private and public actors in financial markets from the 1970s onwards has moved the financial systems both nationally and globally into a period of high volatility and instability.

With Table 8.1, several of the observable processes in financial markets have been summarized for which the new SCAN-modelling approach and a novel explanation sketch will be constructed which is based on self-reflexivity and on the spontaneous emergence of contagious attractions on the one hand and which is characterized by multi-level configurations and by a high degree of observer-dependency on the other hand.

26 For the US-dominance in the science-technology field, see Hollingsworth/Müller/Hollingsworth, 2008.

TABLE 8.1 **Selected Examples for Boom-Bust-Cycles in US-Financial Markets**

Boom Period	Bust Period	Main Characteristics of a Bubble	New Regulations
1900–1907	1907	New institutional actors (trusts)	Federal Reserve Act [1913]
1919–1929	1929	Rapid diffusion of shareholders; long-term boom in the stock market	Securities Act [1933], Securities and Exchange Act [1934], Glass-Steagall Act [1932 and 1933]
1980–1987	1987	Globalization and securitization; removal of important regulations: (Depository Institutions Deregulation and Monetary Control Act 1980, Gam-St. Germain Depository Institutions Act 1982)	Modest refinements in regulations only; (circuit breakers that cut out trading programs, etc.); Insider Trading and Securities Fraud Enforcement Act [1988]
1995–2000	2000	Dot.com-bubble; increasing deregulation (Gramm-Leach-Biley Act in 1999, abolishing the Glass-Steagall Act)	Punitive actions by the Securities and Exchange Commission; Public Company Accounting Reform and Investor Protection Act
2003–2008	2008	Sub-prime mortgages and a housing bubble; new financial instruments (CDO, CDO2, CDO3, SIV, CLO, etc.)* technological innovations (global and algorithmic trading)	Dodd-Frank Wall Street Reform and Consumer Protection Act [2010]

*) The abbreviations stand for: Collateralized Debt Obligation (CDO), Collateralized Debt Obligation of a Collateralized Debt Obligation (CDO2), Collateralized Debt Obligation of a Collateralized Debt Obligation of a Collateralized Debt Obligation (CDO3), Structured Investment Vehicle (SIV), Collateralized Loan Obligation (CLO).

8.2 Re-Entries as Pre-Requirements for Self-Reflexivity

The next step will introduce the concept of self-reflexivity which can be applied to cognitive domains or to actors and their operations. Understanding understanding or the cybernetics of cybernetics are typical turns of a domain towards itself whereas the authors of this article could turn towards their current operations of writing this article by a description of their different research interests and their purposes in advancing self-reflexive models. Self-reflexivity, phrased very generally, is based on a characteristic feature which is absent in normal science models and methods and which becomes the *differentia specifica* for the four model groups to be introduced in the course of this article. While modeling can be conceptualized as a series of operations, leading from an initial or start configuration at time t_0 to the final model product(s) in t_n, self-reflexive modeling produces a characteristic twist in its operations towards its operations themselves. Thus, to use a notion from George Spencer Brown, self-reflexive modeling produces a re-entry into its operational domains O.[27] The general configuration for self-reflexive modeling can be captured in Figure 8.2 where one sees an operational domain O which re-enters into its own domain of operation.

FIGURE 8.2 **Self-Reflexivity as Re-Entry of an Operational Domain O into its Operational Domain**

More specifically, the domain of operation O can comprise three different areas and, consequently, this re-entry can be accomplished in three different forms, namely as a re-entry of

- a domain D into the domain D
- an operator OP into her or his operations OP
- an operator and a domain into the operator's domain OP(D).

These three different forms correspond to the three clusters of self-reflexive designs with three different directions, depending on the type(s) of re-entries. Turning to the new group of self-reflexive, contagious, attraction-driven networks (SCANs), re-entries into the domain of operation OP can be achieved in three different ways.

- In their weak forms self-reflexive, contagious, attraction-driven models provide a cognitive mechanism for learning and adaptation at the level of their micro-units, capable of performing re-entries into their operational domains.

---

27 On George Spencer-Brown's notion of re-entries, see Baraldi/Corsi/Eposito, 1997, Esposito, 1996, Glanville, 2009, Kauffman, 1987, 2005 or 2009, Luhmann, 1984, 1997, Spencer-Brown, 1969 or Varela, 1975.

- In their medium versions the I of the modeler becomes a trivial part of the societal segment which is being modeled.
- In their strong forms self-reflexive models introduce the I of the modeler as an integral and non-trivial part of the model itself.

The next steps will present four roads to modelling self-reflexive and contagious behaviours, starting with Heinz von Foerster's networks of self-reflexive or learning micro-units and their aggregation to a neuronal network, moving on to George Soros who develops the basic idea of a self-reflexive configuration which turns out to be a characteristic feature of financial markets and of modern societies in general, turning to a new formal synergetic framework for this self-reflexive configuration and concluding with an explanation sketch for a new class of network models under the name of self-reflexive, contagious, attraction-driven networks (SCANs).

8.3 Heinz von Foerster and the Design of Self-Organizing Neuronal Networks with Non-Trvial or Self-Reflexive Units

Already during the 1960s Heinz von Foerster[28] developed a network design for analyzing the micro-and macro-dynamics of brain processes. In these designs von Foerster specified adaptive and, thus, self-reflexive micro-units and their dense network formations. These micro-units could be considered as the minimal elements capable of performing cognitive operations like learning, making inferences, perceiving and the like. Of particular relevance are von Foerster's basic formalisms for the aggregation of these minimal self-reflexive units.[29] He proposed guidelines for the combination of these self-reflexive units, their horizontal and vertical forms of binding or aggregation as well as some hints on the dual closure of the overall network as a result of vertical and horizontal bindings.[30]

28 Heinz von Foerster was also involved in the Macy-Conferences where he presented an overview on George Zipf. See also the third chapter of the present book.

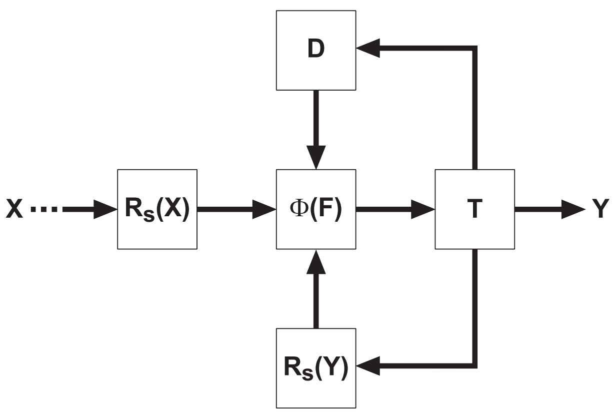
29 Heinz von Foerster categorized these micro-units also as cognitive tiles and their aggregations as tesselations.

30 It should be added that von Foerster developed also macro-models with circular positive feedbacks which were characterized by a catastrophic singularity. Of particular interest here is his doomsday model for population dynamics. See von Foerster, 1961 or Umpleby, 1987a.

Von Foerster's Minimal Model of a Self-Reflexive Actor-Network

Figure 8.3 is a graphical representation of the design for a minimal non-trivial unit or actor in the form of a block diagram. The entire configuration can be qualified as a self-reflexive actor whose various components can be quickly explained. X stands for the (external) sensory input, and Y for the output of the actor as seen by an outside observer. Hence, this elementary component is a through-put system. However, because of its self-reflexive organization, this micro-element is quite different from a simple stimulus-response mechanism with a fixed transfer function. The sensory information X is operated on to yield relations $R_s(X)$ between observed activities with respect to the self (note the subscript s), and is then used as input proper for the recursive function computer which may be operative at this moment with any of the functions F belonging to the range Φ. Its output is fed back over two channels, one being the recursive loop with delay D to allow F to assess the actor's earlier actions, the other carrying all the relational information of the actor's own actions R_s (Y) as they refer to self, and operates on Φ(F) in order to set the recursive function computer straight as to this actor's internal goals.

FIGURE 8.3 **A Minimal Scheme for a Self-Reflexive Actor**



This scheme for a non-trivial or self-reflexive actor incorporates all those faculties which can be considered as necessary components of cognitive processes like perceiving, remembering, inferring, learning, communicating or evaluating. However, in this scheme none of these faculties can be isolated functionally: it is the interaction of all the processes here involved that the information from the input signal and translate it into action meaningful for this particular actor.[31]

31 See especially von Foerster, 2003:101–131 and 133–167.

With respect to the interpretation of some of this self-reflexive actor's cognitive operations one could provide the following specifications:

- Perception is accomplished by the elements that establish self-reflexive relations in the spatio-temporal configurations of stimuli and responses.
- Memory is represented by the particular *modus operandi* of the central computing unit whose gross functional organization is determined and re-determined by evaluation of Eigen-states or relations.
- Inference in this scheme of a self-reflexive actor appears on three levels, depending on the type of function s, that are in range Φ and on the type of processes one wishes to focus on. Adductive inference is operative in the cumulative absorption of comparisons of past external and internal experiences that give rise to the functional organization of the central computing unit. Inductive or deductive inferences are computed by the central system concurrently with any new signal, the inferential mode being solely dependent on strings of earlier failures or successes and of some of this unit's internal dispositions to disregard false inductions.
- Learning is accomplished by any change in the *modus operandi* of a self-reflexive actor.
- Evaluation is performed through the channel $T \rightarrow R_s(Y)$
- For an external observer, communication and movements are related to different types of outputs Y.

After having introduced a general scheme for a self-reflexive actor, one is now capable to define her or his basic operations. In general, these operations are of two kinds and may be specified in a variety of ways.[32] The most popular procedure is first to define a driving function which determines the output state, given the input state and the internal state at each instant:

$$y = f_y(x, z) \tag{8.1}$$

Although the driving function f_y may be known and the time course of input states x may be controlled by an external environment, the output states y as time goes on are unpredictable as long as the values of z, the internal states of the unit, are not yet specified. A large variety of choices are open to specify the course of z as depending on x, on y, or on other newly to be defined internal or external variables. The most profitable specification for the purposes at hand is to define

32 It should be added that for reasons of simplicity the formalization of a self-reflexive actor has been undertaken in a somewhat reduced form compared to the constitution of cognitive tiles as depicted in Figure 8.3. However, the two mutually dependent functions—the driving function and the state function—do form the basis in all of Heinz von Foerster's writings on non-trivial machines.

z recursively as being dependent on previous states of affairs. Consequently, one can define the state function f_z of a micro-unit to be:

$$z = f_z\,(x^*, z^*) \tag{8.2a}$$

or, alternatively and equivalently

$$z' = f_z(x, z) \tag{8.2b}$$

that is, the present internal state of the self-reflexive actor is a function of her or his previous internal state and her or his previous input state; or alternatively and equivalently, the next internal machine state is a function of both her or his present internal and input states.[33]

At this point it is interesting to see how the two recursive functions specified so far give rise to an astonishing diversity of dynamic features, most notably to the emergence of Eigen-values.

- First, Eigen-values, because of their self-defining or self-generating nature, imply topological closure or, alternatively, circularity. This result, that there emerge Eigen-values, is the only thing one can rely on. It rests upon a theorem. Among the many variants and paraphrases of this astonishing theorem one could pick Francisco J. Varela and Joseph Goguen's version [1977]. "In every operationally closed system there arise Eigen-behaviors." (Closure Theorem)
- Second, these Eigen-values are discrete, even if the domain of the primary argument is continuous. In other words, Eigen-values represent equilibria, and depending upon the chosen domain of the primary argument, these equilibria may be fixed points, functional equilibria, operational equilibria, structural equilibria, etc.
- Eigen-values and their corresponding operators stand to each other in a complementary relationship, the one implying the other, and *vice versa*: where the behaviour of a self-reflexive actor represents the externally observable manifestations of the introspectively accessible cognitive operations.

Although one can indeed make the inference from given operations to their Eigen-behaviors, one cannot make the converse deduction from a stable or an Eigen-behavior to the corresponding generative operations. Therefore, the inference from the recursive Eigen-value "1" to the square root operation as the generator is not valid, because the fourth, the tenth, the hundredth root, recursively applied, yield the same Eigen-value "1".

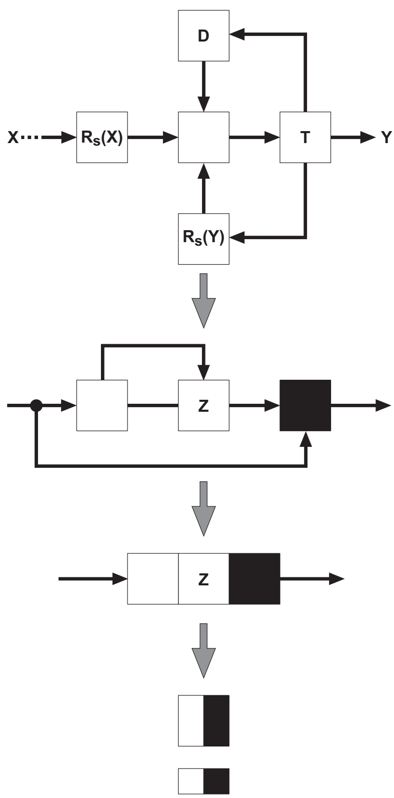
33 Readers familiar with chaos theory and with recursive functions will recognize at once that these are the fundamental equations of recursive function theory. Those are the conceptual mechanisms with which chaos research is conducted which gives rise to completely astonishing, unforeseen operational properties.

Von Foerster's Self-Reflexive Actor-Networks

As a next step, the aggregation process of the minimal self-reflexive actors to a network will be sketched briefly. Although the self-reflexive micro-actors consist of various components, the aggregation process will restrict the entire unit to a single square or rectangle: its input region denoted white, the output region black. [Figure 8.4a] For aggregational purposes this unit is treated as an elementary computer—a computational or, alternatively, a self-reflexive actor A_i—which, when combined with other units A_j, may form a mosaic of units—a densely packed computational or self-reflexive network. The operations performed by the i^{th} unit shall be those of a finite state machine, but different letters, rather than subscripts, will be used to distinguish the two characteristic functions. Subscripts shall refer to units.

FIGURE 8.4 **Network Aggregations of Self-Reflexive Actors**

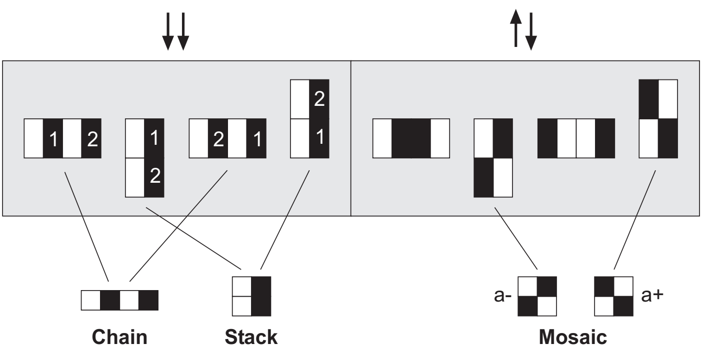
FIGURE 8.4A **A Schematic Reduction of a Cognitive Actor to an Input [White]-Output [Black] Unit in Three Stages**



$$y_i = f_i\,(x_i, z_i) \tag{8.3}$$
$$z_i = g_i\,(x_i, z_i) \tag{8.4}$$

Figure 8.4b sketches the eight possible ways (for each of the parallel and the antiparallel case) in which two units can be connected. This results in three classes of elementary aggregations whose structures are suggested in Figure 8.4b as well. Cases 1 and 3, and 2 and 4 are equivalent in the parallel case, and are represented in Class I ["chain"] and Class II ["stack"] respectively. In the antiparallel case the two configurations 5 and 7 are ineffective, for outputs cannot act on inputs, nor inputs on inputs; cases 6 and 8 constitute Class III, consisting of two autonomous aggregations AA = [a^+, a^-] distinct only by the sense of rotation in which the signals are processed. Interactions of the same concatenations result in tessellations with the following functional properties (for n iterations):

FIGURE 8.4B **Eight Elementary Forms of Aggregation for Two Cognitive Micro-Umits [1, 2]**



(I) Stack: nA: $y = \Sigma f_i(x_i, z_i)$

(II) Chain: A^n: $y = f_n\,(f_{n-1}(f_{n-2} \ldots (x(n)^*, z(n)^*) \ldots z^{**}{}_{n-2})z^*{}_{n-1})z_n$

(III) *Mosaic:* AA = [a^+, a^-] nAA^n [Stack] A^n [Chain]

[a^+, a^-], [a-, a+] = 0

[a^+, a^+], [a_-, a_-] ≠ 0

Introducing a fourth elementary tessellation by connecting horizontally A → AA → A, one obtains

(IV) A-AA-A n(A-AA^n-A) [Stack]

$(A\text{-}AA\text{-}A)^n$ [Chain]

Two features of these self-reflexive units permit them to mate with other units: one is its inconspicuous element T which translates into a universal internal language whatever the output-language may be; the other one is its essential character as a through-put element. Consequently, one may assemble these units into a dense network, each cross white or black, corresponding to a single unit, while each square in a cross represents the corresponding functional element. Information exchange between units can take place on all interfaces, however, under observance of transmission rules. For instance, one unit may incorporate into its own delay loop pre-processed information from an adjacent unit, but Eigen-state information of one unit cannot retroactively modify the operations of a left unit, although it can—*via* its own output—modify that of a right unit, and so on. When in operation, this system shifts kaleidoscopically from one particular configuration of cooperating sets of adjacent units to other configurations, in an ever changing dynamic mode, giving the impression of clouds of activity shifting, disappearing and reforming, as the tasks may demand.[34]

The network aggregation has been undertaken by Heinz von Foerster with a special focus on neuronal networks which, quite naturally, cannot be used for networks of financial markets directly. Thus, this section will conclude with only a brief report on some properties as they may be relevant to this topic of aggregates of such self-reflexive actors. John von Neumann [1964] was the first to realize the high computational potential of these structures in his studies of self-reproducing automata, and later Lars Löfgren [1961] applied similar principles to the problem of self-repair.

8.4 The Self-Reflexive Modeling-Framework for Financial Markets by George Soros

While Heinz von Foerster has provided a general minimal model of a self-reflexive actor, his main interests were concentrated on the issue of brain dynamics and not on financial markets or on societal evolution. Here, George Soros steps in who enlarges the von Foerster-actors with additional features and, above all, a fresh perspective on the micro-macro links which can be classified as the self-reflexive configuration (SRC). George Soros' approach can be characterized with the help of four basic building blocks.

As to the first building block, George Soros introduces, in a way very similar to Heinz von Foerster, a new type of self-reflexive actor who, unlike the *homo*

34 Heinz von Foerster's approach on the process of micro-aggregations is still highly intriguing. Among current versions, two programs become particularly relevant, namely William H. Calvin's hexagonal mosaics and Gerald M. Edelman's neural groups. On the former see especially Calvin, 1998, on the latter Edelman, 1987, 1988 1989, 1992, Edelman and Tononi, 2000 or Edelman and Changeux, 2001. On experimental evidence, see, for example, Rieke *et al*., 1999.

oeconomicus, is not selfish by nature or utility maximizing by necessity, but self-reflexive by design, *i.e.*, determined by her or his internal states. An actor within Soros' framework is described by two recursive functions, namely by a driving function for her or his operations and by a state function for her or his internal cognitive state. In his book "Alchemy of Finance" [Soros, 1994a], provides the following specification scheme for these two recursive functions.

The cognitive function captures the relation between the cognitive evaluations and perspectives y of a micro-actor and the macro-configuration x and its information set: $y = f(x)$. The macro-configuration x, in turn, is permanently produced and reproduced through the operations y of a large number of micro-actors, summarized as $x = \Phi(y)$. Thus, the two self-reflexive functions for the Soros' micro-macro-model become:

$$y = f[\Phi(y)] \tag{8.5}$$

$$x = \Phi[f(x)] \tag{8.6}$$

Soros uses additional assumptions which, even at second sight, could be supported empirically and which deviate markedly from the economic mainstream literature. Full information on part of the micro-actors cannot be taken for granted nor are these assessments grouped as normally distributed deviations from a "true" configuration.[35] Moreover, micro-actors may even increase their biases and cannot be corrected by the micro-actors involved.

The second feature in Soros' modelling framework lies in the specification of the macro-configuration x which is perpetually generated on the basis of the market biases of its micro-actors. For Soros, the relations between the cognitive assessments at the micro-level and the resulting information set on the macro-situation turn out to be complex and far from trivial. They are context-dependent and, due to the erroneous nature of micro-assumptions, likely to move far from equilibrium.[36] In fact, the implicit aggregation of the two recursive micro-functions can drift towards a multiplicity of, to use Heinz von Foerster's concept, Eigen-forms. One of the macro-trajectories could lead, in principle, along a long-term, but slow growth path, but the central aspect for Soros lies in the fact that the macro-trajectories exhibit a permanent sequence of boom-bust cycles.

The third building block can be summarized as the self-reflexive configuration (SRC) and is probably the most important new element within the Soros-framework. For Soros, the descriptions of the macro-configuration x as an aggregation of the micro-operations of individual biases become a genuine

35 Likewise, Soros emphasizes the determining role of biased expectations and their consequences on the course of events. "Markets can influence the events that they anticipate."

36 Soros replaces rational expectations or the efficient market hypothesis with an alternative assumptions: "Markets are always biased in one direction or the other". [Soros, 1994a:49]

factor of its own which changes the cognitive evaluations and, through changes in the cognitive function, changes the participative function as well. In other words, markets are moved by self-fulfilling cognitive micro-biases.

Thus, the self-reflexive configuration (SRC) comprises the state determined operations at the level of micro-actors on the one hand and simultaneous links between the various micro-operations and the information of their macro-outcomes on the other hand. In such a self-reflexive configuration (SRC) the emergence of contagious attractions both at the micro- and at the macro-levels and a continuous information stream about the macro-states of these contagious attractions to the levels of micro-units can and must give rise to a permanent sequence of spontaneous bursts and contractions.

The fourth building block of Soros' self-reflexive framework introduces the I of the investor, in this case George Soros himself. Assuming that a single investor cannot have a decisive influence on other micro-actors in the market or on the macro-configuration, the I of the investor can put her- or himself in juxtaposition to other market participants and to the self-reflexive configuration and is able to put forward a series of guesses or hypotheses on the trajectory of the macro-configuration which can be tested in a classical manner. In doing so, the I of the investor learns about her or his interactions with the interactions of the micro-actors and the macro-configurations.

In this way all four elements of George Soros' modelling framework have been introduced.

It should be stressed that self-reflexivity in the Soros-framework is present in its weak and in its strong form as they have been defined in section 8.2.

- In its weak form a micro-actor enters into his or her domains or operations and changes them in the context of a learning process. In the Soros-framework, micro-actors are immediately confronted with the consequences of their own operation together with the total effects of the operations of others.
- The strong form of self-reflexivity in the Soros-framework is accomplished through the inclusion of the modeler as an integral part of her or his model.

George Soros is very explicit that his overall model framework cannot predict the future in a way similar to forecasting within the contexts of majestic clockworks. Rather, Soros' approach

> can assert that a boom must eventually lead to a bust, but it cannot determine either the extent or the duration of a boom. [Soros, 2006:4]

Additionally, Soros' approach helps to find new ways for controlling the boom-bust cycles. While acknowledging the driving force of the developers and distributors of financial products, the building of new regulations and institutions can help to diminish the conditions for the possibility of bubbles or super bubbles to arise. Moreover, such a race between producers and regulators becomes typical for a generative, self-adaptive network where new regulations or new institutional arrangements intensify the search processes for product and process innovations capable transcending the boundaries of the current regulation regime, etc.

Thus, Soros' approach to financial markets can best be understood as a specification scheme for the self-reflexive configuration (SRC) in general or, more specificall, as a recombination of non-trivial agents at the micro-level, including the I of a self-reflexive actor or investor, of a macro-configuration in its own right and of generative linkage structures between the micro-actors, the I of the investor and the available information on the macro-configuration as well as an information stream from the macro-level to the micro-actors involved.[37]

8.5 Building a Synergetic Framework for the Self-Reflexive Configuration (SRG)

In this section a new perspective for the self-reflexive configuration (SRG) will be developed which, in general, is characterized by a large number of micro-actors, by a subdivision of these actors and their specific operations into several groups or populations, by a sequence of macro-events generated by the operations of the various groups of micro-actors and by an information stream from the macro-level to the different groups of micro-actors which, in turn, leads to a new round of operations and so on. More formally, this new self-reflexive and recursive perspective can be described in the following ways.

The macro state of the operations by micro-participants, agents or actors[38]

$$\vec{y} = \{ y_{\alpha i} \} = (y_{11}, \ldots, y_{P1}, \ldots, y_{\alpha i}, \ldots y_{PL})$$

is summarized by the participants-configuration, consisting of $C = PL$ integer elements $y_{\alpha i} \geq 0$. The number of subpopulations of micro-participants is described by α, ($\alpha = 1,2,\ldots,P$), the number of operations is indicated by i, ($i = 1,2\ldots, L$). Therefore the participants-configuration $\vec{y}$ describes the distribution of operations among the different participants in a societal segment (*e.g.*, a stock market, a national electorate, firms within a region, etc.).

37 Similarly, von Foerster's approach can be characterized in a sufficiently similar way, substituting the I of the investor in Soros' case, by the I of the observer.

38 As a note on the terminology, the concepts actors, agents or participants are used in an equivalent fashion. Moreover, actors, agents or participants can be applied to persons, organizations, animals or machines and are not confined to human agency alone or exclusively.

The ongoing participants' operations $\vec{y}$ generate or produce a dynamic and complex configuration (*e.g.*, the dynamics of the stock market, changes in published public opinion polls, drifts in regional innovations, etc.) where $\vec{y}$, in turn, is shaped and is under the influence of a given situation vector

$$\vec{x} = \{x_1, x_2, \ldots, x_S\}$$

and a set of cognitive-emotional parameters

$$\vec{\kappa} = \{\kappa_1, \kappa_2, \ldots, \kappa_T\}$$

describing the psychological constitution of the participants.

It can be shown (*e.g.*, using Boltzmann's H-theorem) that all distributions of the participants' operations—described, *e.g.*, by the master equation or the Fokker-Planck equation—end up in a stationary distribution $P_{st}(\vec{y})$, if the situation vector $\vec{x}$ and the cognitive-emotional parameters $\vec{\kappa}$ are constant. After the stationary distribution is reached, only stationary fluctuations around the probability peak of the stationary distribution may occur.

While this kind of motion may describe a static society of participants under stable psychological and situational conditions, it is not able to deal with societal processes where the overall configuration $\vec{y}$ is dependent on $\vec{x}$ and $\vec{\kappa}$ and where $\vec{x}$ and $\vec{\kappa}$, in turn, are dependent on the overall configuration $\vec{y}$.

The more general case consists of an interaction between the configuration of participants' operations $\vec{y}(t)$, the situation vector $\vec{x}(t)$ and the cognitive-emotional parameters $\vec{\kappa}(t)$, where the cognitive-emotional parameters describe the coupling strength between the participants' operations and the situation vector $\vec{x}(t)$. Here only some general remarks are possible on the structure of the equations of motion for the situation vector $\vec{x}(t)$ and $\vec{\kappa}(t)$, whose concrete form has to be specifically worked out for any specific societal segment.

The situation vector $\vec{x}(t)$ will be driven by the activities of the participants of differing cognitive-emotional constitution and with differing operation probabilities. Therefore, the time derivative of $\vec{x}(t)$ will be a superposition of partial rates due to these competing influences:

$$\frac{dx_i}{dt} = \left(\frac{\partial x_i}{\partial t}\right)_1 + \left(\frac{\partial x_i}{\partial t}\right)_2 + \ldots \left(\frac{\partial x_i}{\partial t}\right)_\Omega \qquad \text{for } (i = 1,2,\ldots,S) \tag{8.7}$$

Each term describes a certain partial influence and will in general depend, non-linearly on $\vec{y}(t)$, the participants-configuration and certain control parameters.

Similarly, the time derivative of the cognitive-emotional parameters $\vec{\kappa}(t)$ (which determine the explicit form of the transition probabilities of the participants to change their operations) describe the psychological reactions to the changing situation and will also consist of a superposition of competing influences expressed in partial rates:

$$\frac{d\kappa_l}{dt} = \left(\frac{\partial \kappa_l}{\partial t}\right)_1 + \left(\frac{\partial \kappa_l}{\partial t}\right)_2 + \ldots \left(\frac{\partial \kappa_l}{\partial t}\right)_\Gamma \qquad \text{for } (l = 1,2,\ldots,T) \tag{8.8}$$

For example, a partial rate can describe an opposing change in trend provoked by the situation $\vec{x}(t)$. This altered cognitive-emotional constitution will then lead to an alteration in the participants-configuration $\vec{y}(t)$, which in turn drives the situation $\vec{x}(t)$ into a new state, generating the next reaction, and so on. In so far terms with random forces have been neglected in (8.7), (8.8), which would transform these equations into Langevin equations and lead to a statistical description analogous to that for $\vec{y}\,(t)$. It is obvious that a multi-dimensional quasi-periodic or even chaotic motion for $\vec{y}(t), \vec{x}(t)$ and $\vec{\kappa}(t)$ is a reasonable type of solution for the coupled equations of the participants-configuration, the situation vector and the cognitive-emotional constitutions for the medium term time development. Indeed there exist systems of non-linear coupled differential equations with limit cycles or strange attractors whose solutions exhibit just this kind of quasi-periodic or chaotic behaviour.

The long-term development of the system, however, the superposition of a long-term irreversible motion can be expected to transform the quasi-periodic and quasi-closed path into a (multi-dimensional) non-closed semi-helical path winding through its configuration space. The irreversible motion may be due to the evolution of the genetic constitution, to the evolution of a "cultural memory" including the development of technologies or the exhaustion of natural resources, etc.

The mean value equations for the participants $\bar{y}_{\alpha i}$ can be derived directly from the master equation [Weidlich and Haag, 1983]. This leads to the approximate closed mean value equation. Omitting birth and death processes but taking into account individual transitions between operations and between subpopulations of the participants as described by the transition rates P^{y}_{ki} and $P^{y\alpha}_{i}$ the mean value equations are obtained:

$$\frac{d\bar{y}_{\gamma k}}{dt} = \left\{\sum_{i=1}^{L} \bar{y}_{\gamma i}\, p^{\gamma}_{ki}(\vec{y},\vec{x},\vec{\kappa}) - \sum_{i=1}^{L} \bar{y}_{\gamma k}\, p^{\gamma}_{ik}(\vec{y},\vec{x},\vec{\kappa})\right\} + \left\{\sum_{\alpha=1}^{P} \bar{y}_{\alpha k}\, p^{\gamma\alpha}_{k}(\vec{y},\vec{x},\vec{\kappa}) - \sum_{\alpha=1}^{P} \bar{y}_{\gamma k}\, p^{\alpha\gamma}_{k}(\vec{y},\vec{x},\vec{\kappa})\right\} \tag{8.9}$$

Here, the transition rates in general cannot only depend on the participants-configuration $\vec{y}$ and on the cognitive-emotional parameters $\vec{\kappa}$ but also on the situation vector $\vec{x}$.

Next an almost general form for the transition rates P^{y}_{ki} and $P^{y\alpha}_{i}$ will be assumed consisting of positive definite exponential expressions whose exponents are Taylor expansions in the variables $\vec{y}$ and $\vec{x}$ of which only the linear terms will be considered:

$$p_{ki}^{\gamma}(\vec{y},\vec{x},\vec{\kappa}) = \nu \exp\left[\delta\begin{pmatrix}\gamma\\ki\end{pmatrix} + \sum_{\beta,j}^{P,L}\kappa\begin{pmatrix}\gamma\\ki\end{pmatrix}\beta j\Bigg) y_{\beta j} + \sum_{m}^{S}\sigma\begin{pmatrix}\gamma\\ki\end{pmatrix} m\Bigg) x_m\right] \quad (8.10)$$

and

$$p_{i}^{\gamma\alpha}(\vec{y},\vec{x},\vec{\kappa}) = \mu \exp\left[\delta\begin{pmatrix}\gamma\alpha\\i\end{pmatrix} + \sum_{\beta,j}^{P,L}\kappa\begin{pmatrix}\gamma\alpha\\i\end{pmatrix}\beta j\Bigg) y_{\beta j} + \sum_{m}^{S}\sigma\begin{pmatrix}\gamma\alpha\\i\end{pmatrix} m\Bigg) x_m\right] \quad (8.11)$$

Here the coefficients v, μ describe the flexibility of the participants to change its subpopulation or their attitudes. The other trend parameters describe the coupling effects and will not be further specified. The expressions (8.10), (8.11) for the transition rates prove to be reasonable and sufficiently flexible even though they do not have a completely general form.
The approximate closed equations (8.9) with (8.10, 8.11) for the participants dynamics, together with the equations for the situation vector (8.7) and the trend parameters (8.8) still have a rather complicated structure, since only relatively general assumptions have been used. In special models, however, it may be possible to find alternative and simpler equations. The general framework, however, comprises the complexity of socio-economic systems with psychological effects and the impacts of an open environment (situation vector).

8.6 Towards New Network Models of Contagious Attractions

So far, a sequence of different SCAN-models have been sketched which started with Heinz von Foerster's neuronal network models, composed of learning, non-trivial or self-reflexive micro-units and organized via their horizontal or vertical integrations. Subsequently, George Soros' consequential notion of a self-reflexive configuration (SRC) has been introduced which can be seen as a characteristic feature of contemporary societies in general and of financial markets in particular, exhibiting a dual level organization of micro-operations, instantly distributed information streams of macro-states to all micro-actors and a functional specification for self-reflexive micro-actors strikingly similar to the von-Foerster model. Additionally, a formal and general modeling framework, based on master-equations and mean field theory, has been proposed for the formal structures of this self-reflexive configuration.
In the present section the two models of the self-reflexive configuration (SRG) and Foerster's neuronal model will become but two components of a new and large family of network models which are all based on self-reflexivity at least in its observer-dependent form of learning and self-adaptation and which have

been advanced over the last decades in different areas of RISC-applications,[39] but mostly not in an integrated or synthetic fashion.[40]

Upon closer inspection, the network models, so far, can be distinguished in two different groups where the self-reflexive configuration (SRC) serves as the main differentiation criterion. The von Foerster-network models, if fully developed, operate with different groups of excitatory and inhibitory neuronal groups and their self-organizing dynamics, but do not exhibit a SRC. The Soros network model, while providing an identical specification for its self-reflexive micro-units as von Foerster, requires a self-reflexive configuration and the synergetic network models turn out to be SRC-based, too. In the remaining part of the article the main focus will be devoted to SCAN-models that are organized in a self-reflexive configuration (SRC).

On Generative Relations and on Non-Trivial Observer-Dependencies

At the outset, several preliminary remarks will be made with respect to the self-reflexive configuration (SRC) and its characteristic relations. At the outset, it is fairly obvious that SRC is restricted to micro-actors capable of languaging [Humberto R. Maturana, 1985 or 1998] or of communicating in general, to instantly observable and measurable events at the macro-level which can be encoded and transformed into a language or communication system and to language or communication based relations between a permanent information stream on macro-events to all micro-actors involved. In principle, a self-reflexive configuration can be specified across different societal segments like financial markets, a regional economic network, a national election campaign, etc.

What has been left out so far is the exact relational form of this configuration. It is important to note that the micro-actors in the market and their operations $y_{\alpha i}$, the macro-configuration $\vec{y}$ and the I of the observing modeler are not linked in the traditional ways as an open network with causal relations, but are glued together by generative relations in a closed triadic form.[41] Figure 8.5 shows the self-reflexive configuration in greater detail as a triadic ensemble with generative relations G.[42]

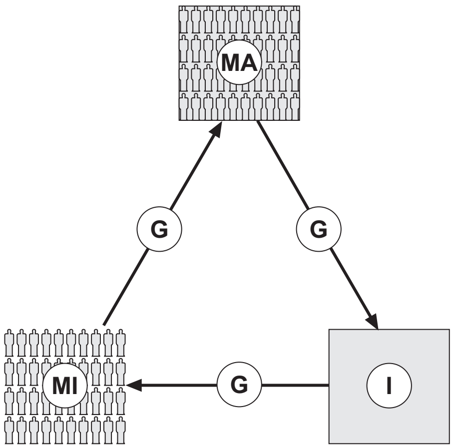
39 As an overview, see Rho/Sankar/Strafstrom, 2010, Schelter/Timmer/Schulze-Bonhage, 2008 or Soltez/Staley, 2008.

40 As a notable exception, see Sornette, 2010.

41 On the distinctions between causal and generative relations, see Müller, 2007 and 2008.

42 One should add that Figure 8.5 can also be viewed as the basic model for Heinz von Foerster and his view of interactions in biological systems. For Foerster, generative relations in a triadic network can be compared, perhaps, with the interrelationship between the chicken, and the egg, and the rooster. You cannot say who was first and you cannot say who was last. You need all three in order to have all three. [Foerster 2003:284]

FIGURE 8.5 **Self-Reflexive Configuration (SRC) with Generative Relations G**



MA: Macro-Configuration $\vec{y}$ I: modeller(s) MI: Micro-units and their operations

The first important additional ingredient lies in the closed organization of relations into which observing systems, the observing scientist(s) or I(We) included, can and should enter. In SRC, the new minimal configuration is not a single domain which is to be studied in itself like in the conventional scientific method, not a dual design of subjects and objects but is built in a triadic fashion, with the observing scientific unit(s) as one node, the micro-domains under observations as another node and with a third node for the macro-configuration which links and closes these two nodes to a triadic ensemble.[43] In short, SRC is to be built in its minimal form not with one, not with two but with three components.[44] In SRC, in contrast to the conventional scientific designs, the scientific observer in all her or his operations is inside and not outside of her

43 It should be added that Heinz von Foerster introduced human observing system in a triadic form, too, as a network between a human observing system, a specific language L, and a minimal societal context S. For him, an observed system changes into a triadic configuration of observers, language, and society. *"Let me repeat the three concepts that are in a triadic relation connected to each other. They are: first, the observers; second the language they use; and third, the society they form by the use of their language. This interrelationship can be compared, perhaps, with the interrelationship between the chicken, and the egg, and the rooster. You cannot say who was first and you cannot say who was last. You need all three in order to have all three."* [Foerster 2003:284]

44 See also the paper by Francisco J. Varela [1976a] where he starts from the usual dualistic suspects like observer/observed, subject/object, describer/described, operator/operand and the like and continues: *"It is very obvious, however, that these poles are not effectively opposed but rather moments of a larger whole which sits in a metalevel with respect to both terms."* [Varela 1976a:65]

or his investigation and becomes a necessary part of the analysis from the very beginning to the very end. Through this triadic configuration[45] self-referential descriptions can re-enter into the domain of admissible scientific statements without running the risk of anomalies or inconsistencies.

With triadic configurations a radical shift occurs also with respect to the types of relations because SRC is characterized by productive or generative relations, in contrast to the generalized causal relations of the traditional scientific approach. Table 8.2 offers some guidelines of how generative relations can be described and which types of outputs they produce.

TABLE 8.2 **Causal and Generative Relations**

Causal (A → B)	**Generative [(A, B), O. M]**
Asymmetrical in time	Symmetrical in time
Separation into cause and effect	No causes and effects
Cause is necessary, sufficient or both	Mutual dependence
Observers excluded	Observers included
Non-recursive	Recursive
Openness	Closure
Generalizations	Necessary Eigenforms

The most striking differences between the generative SRC-relations and the causal relations of normal science lie in their organization and in their dynamics. Due to their triadic closure, due to the recursive operations and due to the so-called Closure Theorem, generative relations, by necessity, lead to Eigenforms, broadly conceived, whereas causal relations lead to viable or, at times, spurious generalizations.

45 In his article "The Self and the Other. The Purpose of Distinction" Ranulph Glanville demonstrates the necessity for closed triadic relations by insisting *"that, in the first instance, self-distinction (A, A) implies the self distinction of an other (B, B), and thus that this implied the self-distinction of a third distinction (C, C) that allowed the appearance of the roles self and other (A, b), (B, a), which permits observation (communication) between these selves."* [Glanville 1990:4p.] Moreover, Ranulph Glanville goes on to account for the fact that and why the triadic configuration apparently collapses into a single operation of distinction. *"Yet, since all three are necessary to each other, and since there is already a reciprocity between the original self and other of the argument, and since there is no difference in level (all, equally, require each other), it is possible to think of them as all forming one distinction, within which they define their selves, and each other."* [*Ibid.*]

Thus, a triadic network of generative relations is characterized by attributes like closure, mutual dependencies, recursion or necessarily emerging Eigenforms. SRC can be found everywhere across contemporary societies and includes broad areas like markets, science and technology, the public sphere, media, private households, civil or society segments and can be seen, thus, as the *differentia specifica* of modern RISC-societies during their later phases of Stage II and, quite naturally, of Stage III.

On the Phenomenology of Contagious Attractions

Turning to the key concept of contagious attractions, the present section will provide a short sketch on their ubiquity and their different forms on the one hand and on their overall network organization on the other hand. It must be re-iterated that examples for contagious attractions are in no way confined to financial markets but extend to science, technology and to seemingly more remote areas like arts and culture, the political arena, fashion, leisure activities, household work or ordinary language use.

Turning to contagious attractions more specifically, one can separate each of them into two different segments, namely into a core-element which subsequently will be classified as the center or the core of an attraction and into a set of potential gains which are related to areas as different as future financial profits, strategic control or effective problem solutions for notorious and long-standing issues in the scientific knowledge base or in societal domains. These additional components outside the core can be summarized as the contagious belt of the core of an attraction.

The centers of attraction can be of quite different forms and nature. In the case of large-scale technological innovations the center is composed of a new basic process or product technology and its observable outputs and its observable diffusion-history. In science the core of a contagious attraction lies usually in a new theory framework which is capable of substituting a long established research tradition, a set of new tools and instruments or in new experimental findings with strong consequences and repercussions for established research traditions. In the case of single buzzwords that become fashionable seemingly out of the blue the center lies in their definitions and in their semantic relations.

The contagious belt around the centers of attractions is composed of quite different elements. In the case of technology, the contagious-belt consists of components like high profit margins, very large societal impact, a genuine revolution in an important societal domain like transport or communication or a unique cure-all all for long-standing societal problems. In science, the contagious-belt is constituted by elements like an entirely new world-view, a

Copernican revolution or inversion, a large-scale potential for new technologies, a magic bullet for highly relevant scientific problems, a universal remedy for persistent societal concerns, etc. And with respect to new fashionable concepts the contagious belt consists of elements like identity coding or their high diffusion potential.[46]

In retrospect, the contagious belts of contagious attractions usually turn out to be far-fetched, ill-founded, excessive, too ambitious and the like. Thus, the term irrational exuberance [Alan Greenspan] will be used for the second segment of contagious attractions and it comprises, following Sornette's dichotomy of mild and wild distributions, the wild and highly contagious components. These wild elements serve a basic function because they act as amplifiers and they increase the attractivity of the centers of attraction considerably. Analytically, it becomes usually very difficult if not outright impossible to separate the mixture of mild and wild components *ex ante* which makes contagious attractions practically immune to societal learning processes.

Furthermore, one of the interesting features of contagious attractions lies in the fact that their core components need not be entirely or mostly new. Science and technology abound with examples of dormant attractions which were part of the knowledge base for decades and which emerge suddenly to become wildly contagious.

Finally, contagious attractions with their mild and wild components are embedded in ongoing network relations and wild contagious attractions emerge within recurrent network interactions. In other words, mild or wild contagious attractions depend on the network interactions which make these attractions mildly or wildly contagious. This special point deserves special attention and will be analyzed in closer detail in the subsequent section.

Contagious Attractions and Network Topologies

After a brief phenomenology of contagious attractions the next step will introduce them into the context of network topology and network modeling more specifically. As an initial remark one can assume that these contagious attractions are distributed in a RISC-like fashion, too, where most of these contagious attractions remain just mildly contagious and only a small number of them turns out to be wildly contagious. These contagious attractions, in order to become effective, must be embedded in the operations of the network micro-units as well as in the linkages between these micro-units. Thus, contagious attractions are not to be treated as external events

46 It is important to note that ex post the centers of attraction may turn out to be without an adequate empirical foundation like in the case of cold fusion.

or processes that are capable of influencing network actors but as internal network relations which, due to special circumstances, change from a state with mild contagious attractions to a new functional state of wild contagious attractions.

Turning to the micro-units of the SRC, the necessary requirement lies in their self-reflexive or non-trivial organization and structure. This organizational condition is met with different structural arrangements, ranging, as has been shown through sections 8.4 to 8.5, from state-determined actors like in the Soros-networks to more the more complex actors of the synergetic network framework with their in-built learning mechanisms.

Turning to the network linkages of the SRC, one can distinguish, in principle, between three types of network linkages.

- The first form of network linkages is composed of contagious products which gets distributed throughout a network.
- The second type network relation is based on local interactions between neighboring network units and can be qualified, very generally, as contagious interaction or as herding. In SRC, local imitation processes or the changes from micro-actors without contagious attractions to micro-units with contagious attractions can produce a positive feedback process. In financial markets for example, imitative or herding behavior can become, under suitable conditions, self-sustaining.
- The third group of network relations in SRC is formed by the macro-micro links between the available macro-information of the specific or general network state to the micro-units of the network. This macro-micro-link provides a second source for positive feedback loops that become particularly strong, if supported by the positive micro-micro-relations of the second type.

Due to the network embeddedness of contagious attractions, the distributions of mild and wild contagious attractions become a general feature of the overall network dynamics which exhibits different network regimes.

- Small fluctuations and, thus, mild contagious attractions are characteristic for periods where contagious attractions in a specific area are compensated by countervailing attractions in other network areas so that, in essence, contagious attractions cancel each other out.
- Wild contagious attractions and, thus, large-scale booms or bursts emerge with functional changes in the overall network relations. Here, the functional changes refer to the two potentially positive feedback loops—micro-micro and macro-micro—which start to operate in a self-sustained manner.

Periods with wild contagious attractions within SCR can emerge, in principle, in two different ways.

- The first way can be labeled as the local path and is accomplished through a wild contagious attraction in a specific network region with a strictly limited diffusion potential for other network regions and through the two self-enforcing feedback loops from the macro-levels to the self-reflexive micro-units and back to the macro-levels within this confined network region on the one hand and through the imitative micro-micro loop of local imitations. In terms of self-reflexivity the local path operates on strong regional network learning and, due to the limited diffusion potential of the contagious attraction under consideration, on weak forms of global learning.
- The second way can be classified as the global trajectory and is successively implemented through a series of internally related contagious attractions across different network regions. The super-bubble [George Soros] from the 1980s to 2008 serves as a paradigmatic example which has been built up as a sequence of contagious attractions across different regions of the global network, operating in housing markets in the United States and through the securitization process in security-markets around the world. These globally contagious attractions are characterized by processes of strong global learning and strong local learning as well. It goes without saying that the global trajectories are particularly relevant for producing extreme events, *i.e.*, very large-scale bursts or booms initially and extreme collapses subsequently.

The considerations so far can be systematized and transformed into a general scheme with different phases of contagious attractions.

Different Phases in the Diffusion of Wild Contagious Attractions

The different stages of the boom-bust sequences in financial markets or, more generally, the cycles of bursts and collapses in other relevant domains like epileptogenesis have been laid out in Figure 8.6 which provides additional information on the cognitive aspects involved, *i.e.*, of SCAN-modeling and of SCAN-forecasting, and on the possibilities for prevention and *ex-post* intervention.

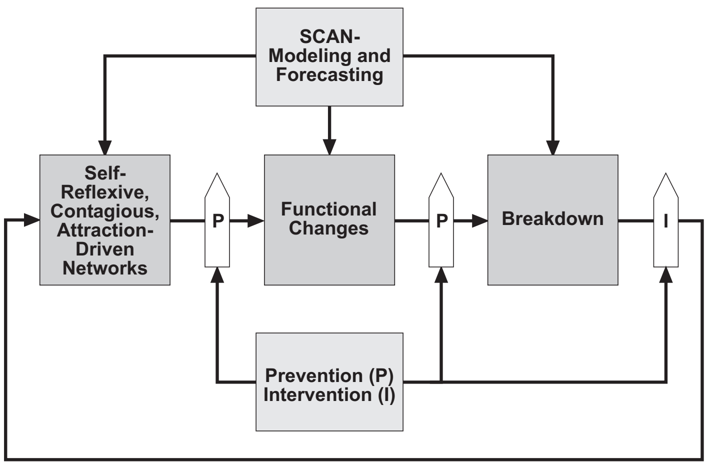
Following Figure 8.6 it becomes clear that one can distinguish between at least five stages in the diffusion of a wild contagious attraction, namely

- the initial phase (Phase I) which marks the birth of a contagious attraction within a specific network region plus the initial operations of two positive feedback loops (micro-micro, macro-micro) which become the generative mechanisms for the initial diffusion of a wild contagious attraction
- the transformation of a wild contagious attraction from its initial stages to a state of self-contained network diffusion (Phase II) where the two generative

mechanisms are able to operate largely unhampered and undisturbed by negative feedback loops, capable of setting off the effects of the two positive feedback loops

- a stage of exponential growth (Phase III) which, due to the absence of countervailing network mechanisms, spreads through a regional network area or across the entire network
- the tipping or turning point (Phase IV) is reached when the diffusion-process has exhausted its potential of micro-actors and self-generated negative feedback loops start operating
- finally, the subsequent strong collapse (Phase V) is marked by an irreversible change of the two positive feedback loops to negative feedback loops (micro-micro and macro-micro).

FIGURE 8.6 **A General Scheme for Self-Reflexive, Contagious, Attraction-Driven Networks (SCAN) and Their Forecasting, Prevention and ex post-Intervention Potentials**



From Figure 8.6 one can also see that prevention could and should operate in different ways, depending on the different phases, whereas intervention is, by definition, confined to the *ex-post phase* of a collapse only. Finally, SCAN-models are required which are capable of generating a model-dynamics for the different phases of a contagious attraction.

The Two Generative Mechanisms for Self-Reflexive, Contagious, Attraction-Driven Networks (SCANs)

The modeling sketches from 8.3 to 8.5 as well as the subsequent explorations on contagious attractions can be briefly synthesized in the following way. In general, SCAN-models can be based on two generative mechanisms.

- The first generative mechanism is based on the self-reflexive configuration (SRC) and on the emergence of two positive, mutually supportive feedback loops (micro-micro and macro-micro) that transform mild contagious attractions into wild ones. The generative mechanism can operate either regionally, *i.e.*, restricted to a specific network region, or globally, affecting a large number of different network areas. Soros modeling framework and the synergetic network model clearly fall under the first group of SCAN-models.
- The second generative mechanism is characterized by a division of different groups of inhibitory or excitatory network actors, capable of performing basic learning processes. Here, contagious attractions come into play implicitly through changes in network topologies and through the weakening of inhibitory micro-units. Historically, the network model by Heinz von Foerster serves as a paradigmatic example of the second group.[47]

The next and concluding step will lead to a few general remarks on the forecasting potentials of SCAN-models across different domains.

The Limits to Forecasting the Paths of Self-Reflexive, Contagious, Attraction-Driven Networks (SCANs)

It is instructive to give a short summary on the modelling and forecasting potentials in an area which in recent decades has produced a remarkable number of theoretical as well as empirical insights, namely the field of epileptogenesis. Two rather general points can be made that become, however, highly relevant for the overall field of SCAN-modeling.

- First, a small empirical survey has been conducted among researchers in the field of epileptogenesis [Velis, 2008:321p.] on the current as well as on the future status of forecasting possibilities especially for the critical phases II to IV. The interesting point was that forecasting was almost generally seen as neither possible in the future nor as particularly relevant.

47 It should be added that currently the most relevant models in the second cluster come, as indicated already, from the study of epilepsy. As an overview, see, for example, Rho/Sankar/Stafstrom, 2010, Schelter/Timmer/Schulze-Bonhage, 2008 or Soltesz/Staley, 2008

- Second, the field of epileptogenic research which qualifies as relatively soft when compared with the hard challenges of modelling the SRC in financial markets, provides very good reasons for assuming a very limited forecasting potential in the future. The reasons for a prevalently sceptical attitude towards specific spatio-temporal forecasts in the futire comprise components like
  - A multiplicity of configurations of epileptogenetic processes like partial and general seizures
  - a multiplicity of configurations of neuronal groups within a specific type of seizure
  - limitations in the observation processes
  - a multiplicity of SCAN-designs and conflicting forecasts, due to a high degree of observer-dependencies.

Turning to Figure 8.6 again, the possibilities of SCAN-forecasts especially for the critical stage of functional changes should be viewed, in general, as severely limited and the links between SCAN-forecasts and prevention measures should be seen as even more limited. However, prevention could operate even without appropriate forecasting-inputs from SCAN-models in inhibiting or blocking the conditions of the possibility for phases III and IV of SCAN-processes.

8.7 Further Outlooks

The sceptic conclusion on spatio-temporal forecasting of SCAN-processes for their different phases concludes the new outlook on SCAN-models which have been introduced in the course of this article as an important and probably central domain of RISC-modeling in general. However, the present article serves only as an initial impulse and as a potentially wild contagious attraction for further research. In our view, SCAN-modeling with a special focus on financial markets can and must be extended in several different directions.

- So far, the self-reflexive modelling framework was restricted to actors in financial markets. But financial markets are composed not only of traders, but also of regulators aiming to avoid excessive periods of boom or of bust. Thus, the inclusion of groups of inhibitory actors becomes a challenging research task especially the second cluster of SCAN-models.
- The second expansion should be undertaken with respect to the micro-units in financial markets themselves. In the synergetic framework, a distinction has been introduced already with respect to various groups or types of network-actors. Hyman Minsky,[48] for example, distinguishes between three groups

48 On Hyman Minsky and his „Financial Instability Hypothesis", see Minsky, 1982 or 2008.

of micro-actors, namely hedge-borrowers, speculative borrowers and Ponzo-borrowers with a different operation and vulnerability potential. These or similar differentiations like domestic or foreign micro-actors could advance SCAN-models for financial markets significantly.

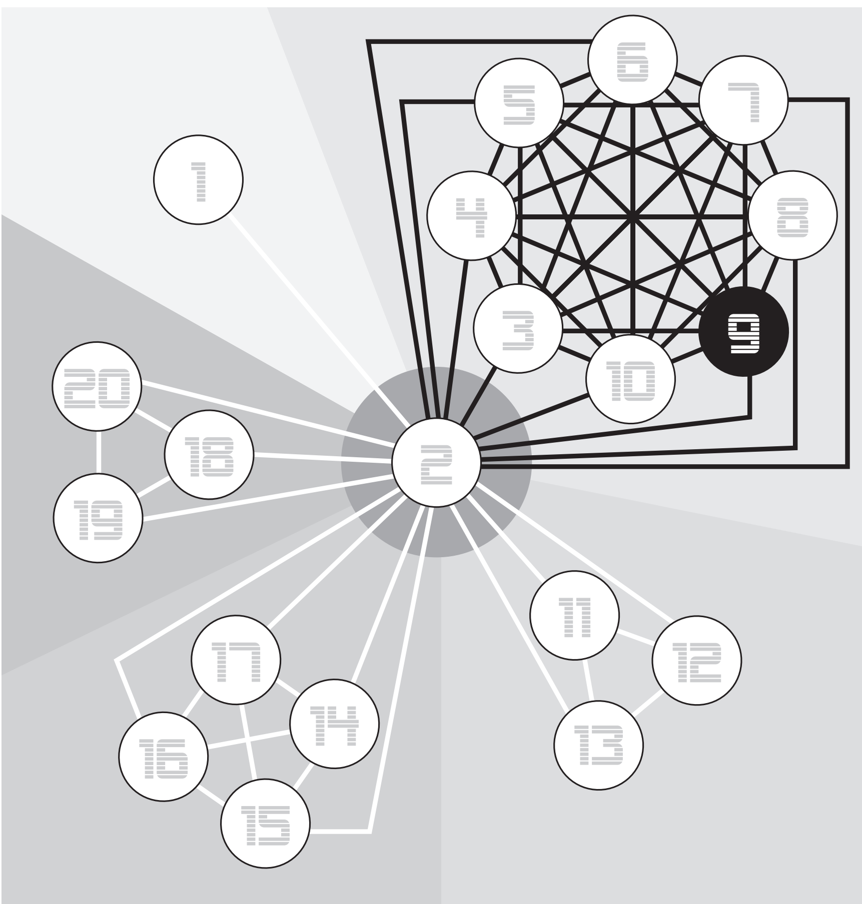
- A third extension could be made with respect to the underlying generative mechanisms. Here, the two generative mechanisms for SCAN-models should be placed into an even wider context which comprises generative mechanisms for burst-collapse sequences across RISC-domains like earth tectonics as well.

In this way, SRC and SCAN-models could become a particular instance in a wider domain of RISC-processes which are characterized by relatively long periods of small or minor fluctuations and short periods of bursts and their very rapid collapses that drive societal evolution in particular, biological evolution or, most generally, complex dynamic networks or systems.

9

The Organizing of Promises: Finance Capital as Tensegrity System

Adrian Lucas



Das ist komisch: jeder Glanz hat über sich noch einen höheren Glanz.
Irmgard Keun, *Das kunstseidene Mädchen*, Roman [1932].

P5: *The greatest affect of all, other things equal, is one toward a thing we imagine simply, and neither as necessary, nor as possible, nor as contingent.*
Dem.: An affect toward a thing we imagine to be free is greater than toward a thing we imagine to be necessary [by IIIP49], and consequently is still greater than that toward a thing we imagine as possible or contingent [by IVP11].
But imagining a thing as free can be nothing but simply imagining it while we are ignorant of the causes by which it has been determined to act (by what we have shown in IIP35S). Therefore, an affect toward a thing we imagine simply is, other things equal, greater than that toward a thing we imagine as necessary, possible, or contingent. Hence, it is the greatest of all, q.e.d.
Baruch Spinoza, 'Part V. Of the Power of the Intellect, or on Human Freedom', Ethics [1677].

9.1 Introduction

Le Corbusier [born Charles Édouard Jeanneret], together with his engineer cousin Pierre Jeanneret, was able to reconfigure architecture for the movements of modernity, by developing his five points of architecture, essentially 5 diagram-principles for reconfigurable architectures:

1) sparse array of freestanding support pillars (*pilotis*)
2) open floor plans independent from the supports
3) vertical façades free from the supports
4) long horizontal sliding windows, and
5) roof gardens.

The goal of this paper is to reconfigure our thinking on capitalism by introducing a graph of *finance capital as a reconfigurable tensegrity system*.

9.2 Power is an Effect of a Promise

The human, as Nietzsche recognized, is that animal with the capabilities of making promises, and forgetting [Nietzsche, 1968:307],[1] including forgetting

1 Ein Thier heranzüchten, das *versprechen darf*—ist das nicht gerade jene paradoxe Aufgabe selbst, welche sich die Natur in Hinsicht auf den Menschen gestellt hat? ist es nicht das eigentliche Problem *vom* Menschen? ... Dass dies Problem bis zu einem hohen Grad gelöst ist, muss Dem um so

to make good on promises made. Whether promises be explicit (as performative speech acts) or implicit (as tacit promises), power is an effect of a promise between an addressor(s) and addressee(s). Understood this way, power may be positive or negative, as Foucault noted, and Agamben's conception of power as sovereign legal exception can be understood as follows: the violence of invoking legal exception is a measure of last resort for any sovereign which has over-promised and is hence vulnerable to being unmasked as not credible, since unable to hold its promises. Promises kept are promises safely landed; promises not kept are messily crash-landed; and the Promised Land is a promise whose keeping or non-keeping is indefinitely postponed, hence its (e)utopian power.

9.3 Capitalism is a Mode of Organizing Promises

Capitalism, or the liberal allowing of a free reign to capital and capital's holders, is a force that makes humanity recombinant: the labor of humanity, and in post-Fordism the *life* of humanity [Virno, 2005:35],[2] is the DNA of capitalism. Capitalism divides and recombines humanity by organizing humanity's promises as either one-to-one or one-to-many promises. Mitigating against capitalism is the promise of a democracy that can organize humanity's promises as many-to-many promises. If democracy is a *ménage à trois*, opening truths of liberty, equality, and fraternity, then capitalism is a 3-way marriage of capital, state, and nation, conspiring trinity of Capital-Nation-State. Trade unionism, corporatism, the welfare state, social democracy, civil society, NGO activism, and globalization are together powerless against this capitalist nation-state, with its three mutually complementary forms of exchange [Karatani, 2003].
Whereas early capitalism strove to generate surplus value through the exploitation of labour, late capitalism strives to generate surplus value through the exploitation of consumers. The nation-state supports capital in all its endeavours to generate surplus value but especially through the exploitation of consumers, because the capitalist nation-state is sustained by tax revenues, and tax revenues are maximized

erstaunlicher erscheinen, der die entgegen wirkende Kraft, die der Vergesslichkeit, vollauf zu würdigen weiß. *Vergesslichkeit* ist keine bloße vis inertiae, wie die Oberflächlichen glauben, sie ist vielmehr ein aktives, im strengsten Sinne positives Hemmungsvermögen, dem es zuzuschreiben ist, dass was nur von uns erlebt, erfahren, in uns hineingenommen wird, uns im Zustande der Verdauung (man dürfte ihn "Einverseelung" nennen) ebenso wenig ins Bewusstsein tritt, als der ganze tausendfältige Prozess, mit dem sich unsre leibliche Ernährung, die sogenannte "Einverleibung" abspielt.

2 Contemporary capitalist production mobilizes to its advantage all the attitudes characterizing our species, putting to work *life* as such. [...] To life involved in flexible production is opposed the instance of a "good life." And the search for a good life is indeed the theme of ethics.

when the income of both labor and capital are high, in other words, when labor is first well-paid as labor and then well-exploited as consumer.

9.4 Tensegrity System as Concept

Financial markets are best understood neither as a liquid equilibrium surface (with escaping bubbles of exuberance), nor as a structure/architecture, but as a system of *tensional integrity*, as a *tensegrity system* [Fuller, 1963:212–213].[3]
A tensegrity system is a system in a self-equilibrated state comprising a discontinuous set of compressed components (for example, struts) within a continuum of tensioned components (for example, cables). In B. Fuller's analogy of islands and ocean, a tensegrity system is an *archipelago of islands of compressed components* within a *continuous ocean of tensioned components*. In the terminology of network and graph theory, the islands of compressed components are a *disconnected graph*, whilst the ocean of tensioned components are a *continuous network*. The crucial point is that the self-equilibrium of a tensegrity system is based not on compression (which is the situation in architecture, of construction as an articulation of adjacent, of touching, compressive components), but on tension; self-equilibrium based on tension is not usual in the history of constructions, hence the "surprise" and "fascination" of tensegrity systems.
This self-equilibrium of tensegrity systems, based as it is on tension, is completely unlike that of non-tensegrity systems: tensegrity systems do not so much fail (as structures do), as *change their whole topology*. Such adaptive changes in the topology of a tensegrity system are triggered either by a buckling of a compressive component, alternatively, by an increase in tensile force in a tensile component. Unlike structures whose self-equilibrium remains unchanged until over-stressing causes complete failure, tensegrity systems, by continuously changing their whole topology in response to incremental changes in compressive or tensile components, are effectively always in self-equilibrium, only this self-equilibrium of tensegrity systems is of an ever-changing self-adapting kind, hence tensegrity systems are of paramount interest to civil engineers designing for earthquake-prone locations.
Tensegrity is a powerful concept for understanding not only material complexities, but also immaterial complexities: for example, the ever-changing but seemingly continuity of our self may be understood as an archipelago of disconnected compressed selves amidst a continuous ocean of tensioned selves. Likewise, memory

3 Tension is comprehensive. Universe tensionally coheres non-simultaneous events. […] Universe is tensional integrity.

may be understood as a tensegrity topology: memory, individual or collective, is sustained by narrativizing acts of memorization, where each narrativizing act slightly changes the topology of memory: it is not narrators which construct narratives, but rather the narratives which affect and constitute the narrators of those narratives [Welzer, 2002:233].[4] Furthermore, the love between any two persons is kept *in play* not by fixing love as structure as Promised Land, but by *archipelagizing* love as islands ('I'-lands) amidst ocean, by *topologizing* love as tensegrity: existing 'neither separate nor fused' [Nancy, 2001:40].[5] In other words, love is not access to *jouissance* because *jouissance is* access [Nancy, 2001:44],[6] and not accessoire.

9.5 Finance Capital as a Tensegrity System

In financial tensegrity, capital (that which need not be repaid: equity, branding, social capital) corresponds to the discontinuous islands of compressive components, and credit (that which needs to be paid back, or refinanced, hence secured or collateralized or insured: bank deposits, loans, bonds, derivatives) corresponds to the continuous ocean of tensile components. Unlike tensegrity systems that have been built as self-standing and non-changing sculptures (for example, sculptural objects by the artist-engineer Kenneth Snelson), financial tensegrity is a tensegrity system whose entire topology is continuously changing, and maximally changing as capital valuations are falling (corresponds to buckling of compressive components), or as capital is leveraged (corresponds to increasing the tensile force of tensile components). A tensegrity system is strengthened, in other words made more resistant to change, through pre-stressing: by provisioning one's obligations with additional security reserves (*economic capital*, in capital management jargon), one reduces the expectations of defaulting (of reneging) on one's financial promises, hence one works towards making the tensegrity system less flexible, less liberal, and more fixed.

4 Das Gedächtnis ist an die Akte des Sich-Erinnerns gebunden, und die fiktive Einheit dieses Gedächtnisses besteht in der Kontinuität der Aktualisierung von Geschichten aus der Vergangenheit, in der sozialen Praxis gemeinsamen Sich-Erinnerns.

5 En un sens, il confine au simple sentiment—ou au simple étoudissement—de l'exister lui-même: mais précisément, de l'exister ni séparé ni fusionné, car ce sont là les deux manières de manquer à *exister* au sens véritable du terme.

6 Il n'y a pas d'accès à la jouissance parce que la jouissance est *un accès*: ce qui la constitue sans doute aussi dans une proximité fragile ou pénible avec une *crise*, et avec tout ce qui peut se déployer autour d'elle, pour peu que le sexe ne s'y retrouve pas; car le sexe peut se manquer, il peut manquer à se sexuer ou à s'excéder: faute de quoi il ne porterait pas son enjeu.

Precisely, the topology of financial tensegrity is continuously changing, for example:

- as capital valuations fall (pre-figuration of future equity recapitalization including debt-for-equity recapitalization, or of future restructuring/asset sales/downsizing/outsourcing)
- as capital valuations rise (pre-figuration of future growth and/or future leveraging)
- as financial contracts are entered into (primary market activities: bank deposit, loan origination, security issuance, insurance underwriting)
- as financial products are traded (secondary market activities, including the packaging of less complex financial products into more complex structured financial products)
- as financial contracts mature, or default (loan repayment, bond repayment, insurance claim payout, equity dividend payout)
- as financial contracts expire (derivatives)
- as financial contracts are exercised, or default (option derivatives)
- as financial contracts terminate (deposit withdrawal, mortgage pre-payment, life insurance early termination).

Financial tensegrity is not non-destructible, but the resilience of financial tensegrity, thanks to its immanent topology of self-adaptivity, and its conspirative marriage within the capitalist nation-state, far exceeds the resilience of structures, con-structions, and arch-tectures. If financial tensegrity, and capitalism as credit economy, is destructible, then not by violence from outside (demonstrations, or weapons of mass destruction), but only by a *collective pulling of the plug*, in other words a *collective evacuating* of the banking and insurance balance-sheets, through acts of population-wide deposit withdrawal from banks, payback of outstanding loan obligations, liquidation of savings and the withdrawal of cash proceeds, early termination of life insurance, non-renewal of property and casualty insurance. Furthermore, any such evacuation of financing for the financial industry would have to be accompanied by a *collective hollowing-out of one's tax obligations* to the state, for example, as a consequence of population-wide trends towards non-consumption of value-added taxable sales, towards bartering of services within circles of friends, and a willful going-bankruptcy of corporations and individuals, "well damn our credit ratings: if banks have no one to lend to, then the system can only implode."

Financial crisis is a deleveraging process that propagates itself across financial tensegrity. Financial crisis is a symptom of an increasing collective anxiety that capitalism as a mode of organizing promises has had its day. Since no system of social organization has gone on *forever*, and capitalism is a liberal mode of organization, capitalism is not just open towards, but even prone to, speculating on its own imminent, and immanent, death. Indeed, many of the greatest prophets of capitalism's doom are themselves capitalist speculators, hence any talk of doom may just be manipulative theatre, panic talk 'of the end' for the end of generating opportunities for buying on the cheap assets sold off in panic, à la Rothschild after Waterloo in London's capital markets.

Through an understanding of finance capital as a tensegrity system, financial crisis propagation may even be understandable with concepts from epidemiology, notably with the concept of 'self-organized percolation' [Henley, 1993]. The crucial parameters are *tensile density* and *compression diversity*, with the susceptibility of financial tensegrity to financial crisis epidemic being conditioned by *high tensile density*, and *low compression diversity*. Density can be controlled at levels that keep financial crisis epidemics at bay either by moderating credit birth rate, or by increasing age-independent default (mortality) rate, or by decreasing the programed credit maturity (life span). Diversity is defined as the total number of distinct immune risktypes, with immunization being the process of allocation of economic capital to risk. But do we, individually or collectively, really want to tame financial tensegrity, or are we secretly hoping for its massive failure?

9.6 Conclusion: Alternative Modes of Organizing Resources

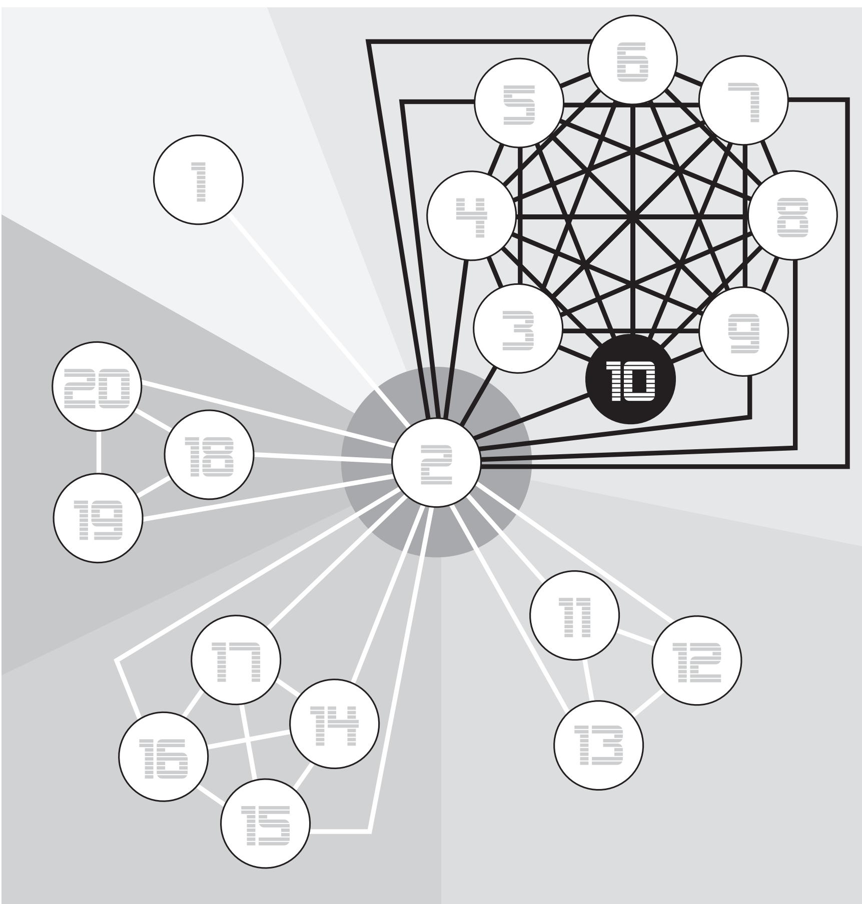
The radical social question for humanity is not whether there are alternatives to capitalism for the purpose of organizing promises, but whether there are modes of organizing resources *without resorting to promises*, and the power effects that these promises generate, *including not even resorting to a promise of not resorting to promises*. History is littered with the experiments of alternative modes of organizing promises, all of which proved non-liberal and arbitrary: communism, fascism, and innumerable theocracies.

Reality may be imagined as an archipelago of possibilities amidst an ocean of impossibility. Within such a tensegrity conceptualization of reality, the birth and death of islands of possibility may be imagined as the emergence and sinking of atolls. But can we know what will always be oceanic impossibility, and what might emerge, some day, as an atoll of new possibility?

The radical question is whether we can, using the terms of Spinoza, "imagine simply, and neither as necessary, nor as possible, nor as contingent" a mode of organizing resources (land, water, labour, knowledge, …) that is convivial and free, and hence free of the effects of power: and therefore *not an organizing of promises*.

10 The Poverty of Economic Explanations

Peter Štrukelj



This article is not concerned with an in-depth analysis of economic RISC-processes or with a critique of economic RISC-models. Its goal is more modest and more profound at the same time. The article wants to show that a typical rare event with strong repercussions like the current financial crisis is hardly understood by those professionals who are supposed to represent the master thinkers on economic and financial development, namely by well-known economists in economic think tanks or in international organizations like the International Monetary Fund (IMF) or the OECD.
More specifically, the aim of this article is to provide a thorough analysis of the current style of economic explanations for the severe global financial crisis from 2007 onwards. Until now, economists were believed to be capable of *ex post* explanations and, due to the complex nature of the economic system, unable to produce accurate forecasts, despite Karl R. Popper's emphasis on the symmetry of explanation and forecasting schemes.
This article tries to establish that economists, by and large, are incapable of generating reliable and robust *ex post* explanations. Phrased differently, although these accounts look *prima facie* explanatory and although their proponents believe that they have accomplished an economic explanation, these economic *ex post* explanation schemes should not even be considered as explanation sketches, let alone as explanations.[1] Rather, these explanatory accounts on a financial RISC-process are an expression of the nearly perfect blindness of an entire profession *vis a vis* the evolution of our global economic and financial system.

10.1 Introduction: Our Present Global Economic Situation

Since our focus lies in the current global economic and financial crisis, our initial question can be phrased in the following way. What is our present global economic situation? Thus, initially, we want to determine our present global economic situation in different economic domains.

1 Within this article, the differences between the three concepts of explanations, explanation sketches and explanatory schemes can be summarized in the following way. Explanations follow the basic rules of the classical HO-scheme [Hempel, 1965], explanation sketches fulfill the weaker requirements for implicit laws and generalizations whereas an explanatory scheme is the most general term, covering, explanations proper, genuine explanation sketches and, finally, a vast number of explanatory accounts beyond explanations and explanation sketches which are used as in an explanatory fashion and within an explanatory context.

GDP, Trade, Credits, Profits

According to preliminary estimates, Gross Domestic Product [hereafter, GDP] in the OECD decreased by 1.5% in the fourth quarter of 2008, the largest decrease since OECD records began in 1960. In the United States of America, GDP decreased by 1.0% in the fourth quarter of 2008, following a 0.1% decrease in the previous quarter. Japan's GDP decreased by 3.3%, following a 0.6% decrease in the previous quarter. GDP in the Euro area decreased by 1.5%, following a 0.2% decrease in the previous quarter [OECD, 2009c].
It is expected that global trade will decrease in 2009 for the first time since 1982. Foreign investments and short-term credits are decreasing. Developing country exports are decreasing.
GDP growth in 2009 in developing countries is expected to decrease to 4.5% from 7.9% in 2007. Private capital flows are expected to decrease from $1 trillion in 2007 to $530 billion in 2009. Remittances that workers send to home countries are expected to decrease. In many developing countries, exports and credits are decreasing while interest rates increase [The World Bank Group, 2009].
Toyota Motor Corporation expects its first-ever operating loss since it began such reports in 1941.[2] Toyota expects to lose money on an operating basis of 150 billion yen (1.66 billion $) for the fiscal year ending March 2009. General Motors recorded a 31 billion $ loss in 2008, Ford had a 14.6 billion $ and Chrysler an eight billion $ loss in 2008. Sony expects a 1.7 billion $ loss in 2009, Samsung expects a first-ever quarterly 67.7 million $ net loss, LG Electronics reported a 487 million $ loss. Symantec had a 6.81 billion $ loss in the third quarter of 2008.
Royal Bank of Scotland had a record loss for the United Kingdom of 24.1 billion £. American International Group had the largest quarterly loss in the history of American business. In the fourth quarter of 2008, American International Group had a 61.7 billion $ loss. UBS AG, the largest Swiss bank, had a 20.9 billion Swiss franc (18 billion $) loss in 2008. Caisse de depot et placement, a Canadian pension fund manager, had a record 25% minus in 2008 (40 billion $ loss). Lloyd's Banking Group profit decreased by 80 % [from 4 billion £ in 2007 to 807 million £ in 2008].

Employment

The International Labor Office says that "the global economic crisis is expected to lead to a dramatic increase in the number of people joining the ranks of the

2 Operating income shows a company's core business performance. In 2008, Toyota had an operating profit of 2.27 trillion yen.

unemployed, working poor and those in vulnerable employment." Global unemployment in 2009 could increase over 2007 by a range of 18 million to 30 million workers, and more than 50 million if the situation continues to deteriorate—in this case some 200 million workers, mostly in developing economies, could be in extreme poverty [ILO, 2009b].

The International Labor Organization [ILO] provides the following summary:

> "What began as a crisis in finance markets has rapidly become a global jobs crisis. Unemployment is rising. The number of working poor is increasing. Businesses are going under. Concern is growing over the balance, fairness and sustainability of the sort of globalization we have had in the run up to the financial crash." [ILO, 2009a].

The number of the working poor—people who do not earn enough so that their families would get more than 2 $ US per person per day (poverty limit)—may increase to 1.4 billion, or 45% of all the world's employed [ILO, 2009b].

In 2009, the proportion of people in vulnerable employment—either contributing family workers or own-account workers who are less likely to benefit from safety nets that guard against loss of incomes during economic hardship—could increase considerably, in the worst case to reach 53% of the employed population [*ibid*.].

Compared with 2007, the largest increase in regional unemployment rates was in developed economies and in the EU, from 5.7% to 6.4%. The number of unemployed in this region [32.3 million in 2008] increased by 3.5 million in one year (*ibid*.). The highest increase in unemployment will probably be among young people, immigrants, low-skilled and older workers and workers on temporary contracts [OECD, 2009a].

The highest increase in unemployment will probably be in construction and automobile manufacturing. In Germany, Japan, Spain and the United States, car sales have decreased because of decreasing consumer confidence and credit. Employment in the US auto manufacturing in December 2008 was almost 17% lower than a year ago. Increasing unemployment in the EU auto manufacturing is expected [*ibid*.].

Wages

Between 1995 and 2007, each additional 1% in the annual GDP per capita growth led to, on average, only a 0.75% increase in annual growth of wages. As a result, in almost three-quarters of the countries worldwide the labor share in GDP has decreased [ILO, 2008a].

Between 2001 and 2007 inflation was low and the global economy grew at 4.0% per year, while wages grew by less than 2% per year in half of the world's countries [*ibid*.].

In Germany, Poland and the United States (developed countries), the differences between highest and lowest wages have increased most rapidly. In Argentina, China and Thailand, wage inequality has also increased considerably [*ibid*.]. Based on an analysis of wages around the world in recent years, the ILO report shows that while wage growth was smaller than economic growth during conjunctures, wage decreases were larger than GDP decreases during recessions. Between 1995 and 2007, for each 1% decrease in GDP per capita, average wages decreased by 1.55%. In recent years, minimum wages around the world have been reactivated to reduce social tensions resulting from increasing inequalities [*ibid.*].

Based on the latest IMF growth figures, the ILO predicts that the global growth in real wages will be 1.1% max. in 2009, compared to 1.7% in 2008, but wages are expected to decrease in many countries, including the major economies. Globally, wage growth in industrialized countries is expected to decrease, from 0.8% in 2008 to -0.5% in 2009. This follows a decade in which GDP was increasing more than wages [*ibid.*].

Our present global economic crisis is expected to decrease wages of millions of workers worldwide in 2009. "For the world's 1.5 billion wage-earners, difficult times lie ahead", says ILO Director-General Juan Somavia. "Slow or negative economic growth, combined with highly volatile food and energy prices, will erode the real wages of many workers, particularly the low-wage and poorer households. The middle classes will also be seriously affected." Tensions are likely to intensify over wages [*ibid.*].

Income Inequalities

Despite large economic growth that produced millions of new jobs since the early 1990s, income inequality grew substantially in most regions of the world and is expected to increase due to the present global financial crisis. A major share of the cost of the financial and economic crisis will be borne by hundreds of millions of people who have not shared in the benefits of recent growth [ILO, 2008b].

As global employment increased by 30% between the early 1990s and 2007, the income difference between richer and poorer households has increased substantially at the same time. Compared with past conjunctures, workers got a smaller share of the benefits of economic growth as the share of wages in national income decreased [*ibid.*].

ILO states, for example, that "the ongoing global economic slowdown is affecting low-income groups disproportionately /.../ this development comes after a long expansionary phase where income inequality was already on the rise in the majority of countries" [*ibid.*].

A continuing increase in income inequality could be associated with more crime, lower life-expectancy, and in the case of the poor countries malnutrition and an increased probability of children being taken out of school in order to work [*ibid.*).

Developing Countries

Aside from the financial and unemployment crises, developing countries have recently also experienced food and fuel crises which have caused millions to be in poverty and hunger—between 130 and 155 million people are in extreme poverty, according to the World Bank's estimates. Another 44 million children are malnourished. Decrease in credit and growth will lower government revenues and their investments into education, health and gender goals, as well as the infrastructure expenditures needed to increase growth. Each 1% decrease in growth could trap another 20 million in poverty. Global financial crisis will decrease trade in emerging markets [The World Bank Group, 2009].

Conclusions on the Dimensions of the Economic/Financial Crisis

Thus, globally, GDP growth, profits, credits, trade, employment, wages are decreasing and poverty is increasing. This is our present global economic situation. We name this situation global economic/financial crisis.

Our next question is explanatory in nature and can be stated in the following way. Why do, from a global perspective, GDP growth, profits, credits, trade, employment, wages decrease and why does poverty increase, *i.e.*, what are the reasons for the present global economic situation (crisis)? In the following sections, I will present how well-known and highly renowned economists[3] explain economic phenomena. For this purpose, I will present explanations of the crisis by:

- Joseph E. Stiglitz[4]
- International Monetary Fund (IMF)[5]
- Adrian Blundell-Wignall,[6] Paul Atkinson[7] and Se Hoon Le.[8]

---

3 See especially the credentials for Joseph E. Stiglitz in the subsequent footnote.

4 Joseph E. Stiglitz is University Professor at Columbia University, New York, USA. He is teaching at the Columbia Business School, the Graduate School of Arts and Sciences (Department of Economics) and the School of International and Public Affairs. In 2001, he was awarded the Nobel Prize in economics for his analyses of markets with asymmetric information, and he was a lead author of the 1995 Report of the Intergovernmental Panel on Climate Change, which shared the 2007 Nobel Peace Prize. As of February 2009, Stiglitz is the most cited economist in the world, according to the University Connecticut, Department of Economics.

5 The International Monetary Fund is an organization of 185 countries, working to foster global monetary cooperation, secure financial stability, facilitate international trade, promote high employment and sustainable economic growth, and reduce poverty around the world.

6 Adrian Blundell-Wignall is Deputy Director of the OECD Directorate for Financial and Enterprise Affairs.

7 Paul Atkinson is a Senior Research Fellow at Groupe d'Economie Mondiale, Paris.

8 Se Hoon Lee is Financial Markets Analyst in the Financial Affairs Division of the OECD Directorate for Financial and Enterprise Affairs.

The common thread through all these explanations is their *ex post* nature. These explanations have been offered after the onset of the global crisis and during its unfolding.

10.2 How Economists Explain Economic Phenomena

My purpose in the subsequent section is to test whether these *ex post*-explanatory schemes can be considered as valid and therefore as acceptable explanations or whether these explanatory accounts, although mimicking explanations or explanation sketches, should not be considered as such.[9]

Explanatory Schemes of the Economic/Financial Crisis by J. E. Stiglitz

Subsequently, different explanatory schemes by Joseph E. Stiglitz will be analyzed as a test for intra-personal consistency in *ex post* explanations.

How to Prevent the Next Wall Street Crisis: Stiglitz' First Explanatory Factor

In his writing *Commentary: How to prevent the next Wall Street crisis* [2008a], Stiglitz explained the economic/financial crisis in the following way.[10]
For all the new-fangled financial instruments, this was just another one of those financial crises based on excess leverage, or borrowing, and a pyramid scheme.

Critique of Stiglitz' First Explanatory Scheme

In this writing, Stiglitz does not say what exactly he means by financial crisis—he could mean bankruptcies of some banks or bank losses or increasing interest rates or decreasing credits or global decreasing of GDP growth, profits, credits,

9 I would like to differentiate between explanations, explanation sketches and explanation schemes or, alternatively, explanation accounts.

10 This writing was published on September 17, 2008. Global financial crisis supposedly began in July 2007 and deepened in September 2008. The sub-prime mortgage crisis reached a critical stage during the first week of September 2008, when there was a severely contracted liquidity in the global credit markets and insolvency threatened investment banks and other institutions. Lehman Brothers went bankrupt on September 14, 2008. Prominent American and European banks failed and so did efforts by the American and European governments to rescue distressed financial institutions. As the crisis developed, stock markets fell worldwide, and global financial regulators attempted to coordinate efforts to contain the crisis. Already in September 2008, there were expectations that bankruptcies of major banks and stock markets crashes worldwide will lead to our present global economic situation, *i.e.* global decreasing of GDP growth, profits, credits, trade, employment, wages and increasing of poverty.

trade, employment, wages and increasing of poverty or maybe something else. In this writing, Stiglitz does not say what is the meaning of the financial crisis. He does not say what exactly he is explaining.

Stiglitz says that the basis for this crisis (as for other past financial crises) was excess borrowing. Stiglitz says that there was too much borrowing which caused the crisis. But that is all he says. He does not say how excess borrowing and the crisis are connected. He does not prove that the crisis necessarily follows from excess borrowing.

Stiglitz says that excess borrowing caused the crisis.[11] He does not say that borrowing itself caused the crisis, but that too much of borrowing caused the crisis. This presupposes that if there was a right (optimal, appropriate) quantity of borrowing, then the crisis would not happen. Stiglitz does not say what this right quantity would be. He also does not say how much borrowing there was and how much of this quantity was too much (excessive). And since he does not say how much of borrowing was too much and what would be the right quantity of borrowing, he does not explain, why a certain quantity of borrowing would be right (optimal, appropriate), and he does not explain, why only and exactly excessive borrowing caused the crisis.

But suppose that there really exists a right (optimal, appropriate) quantity of borrowing which is not too much, which is not excessive and would therefore not cause the crisis. This means that this right quantity of borrowing would be limited and determinate, because it would be less than too much. Suppose also that the purpose of private production (including banks) is maximization (growth) of profits and that the purpose of states is GDP growth.

If all this were so, then profits of private production (including banks) would be limited and determinated and so would be GDP, since borrowing and markets (both are means of maximizing profits of private production) would be limited and determinate. This means that GDP growth would necessarily reach a point where GDP growth would be 0%, because a limited and determinate quantity of borrowing and markets would both limit growth (and growth in itself is limitless, because growth itself means limitless increasing of a certain measure quantity). If a limited and determinate quantity of borrowing and markets would necessarily limit GDP growth and this GDP growth would necessarily be 0%

11 In his writing Obama's Ersatz Capitalism, which was published in March 31, 2009, so when data were already proving that globally, GDP growth, trade, credits, profits, employment, wages are decreasing and poverty is increasing—and that this is going to continue—Stiglitz says that our present global economic situation was caused by overleveraging of banks, that is, using relatively little capital of their own, banks borrowed heavily to buy extremely risky real estate assets. In the process, they used overly complex instruments like collateralized debt obligations.

at the end, then states (central banks) would decrease interest rates in order to increase borrowing, which would then increase investments and profits (which is the purpose of private production) and GDP would increase (which is the purpose of states). So this increase in borrowing—excess borrowing in relation to limited and determinate (right/appropriate) borrowing—would cause GDP, trade, profits to increase. But if this would be so, then excess borrowing would cause at least two things:

- decrease in GDP, trade, profits (which is what Stiglitz says, when he says that excess borrowing caused the present crisis) and
- increase in GDP, trade, profits.

So, excess borrowing would cause at least two things—both decreases and increases in GDP, trade, profits. But these two things are inverse to each other. Thus, one thing (excess borrowing) would be the reason for two things which are in an inverse relation to another (decrease and increase in GDP, trade, profits). Stiglitz does not say what he means by a pyramid scheme and how this is connected to the crisis. He does not prove that the crisis necessarily follows from a pyramid scheme.

Stiglitz' Additional Explanatory Component

The new "innovations" simply hid the extent of systemic leverage and made the risks less transparent; it is these innovations that have made this collapse so much more dramatic than earlier financial crises. But one needs to push further: Why did the Fed fail?
First, key regulators like Alan Greenspan didn't really believe in regulation; when the excesses of the financial system were noted, they called for self-regulation—an oxymoron.

Critique of Stiglitz' First Explanatory Scheme

Stiglitz does not say whether it is innovations or the extent of systematic leverage and risks that caused the crisis and whether these things caused the crisis or have made it only more dramatic than past financial crises, while something else caused it. Stiglitz states that one of the reasons for the crisis was the failure of the Fed and the failure was that key regulators did not believe in regulation.[12] This

12 In his writing Developing Countries and the Global Crisis, which was published in April 2009, so when data were already proving that globally, GDP growth, trade, credits, profits, employment, wages are decreasing and poverty is increasing—and that this is going to continue—Stiglitz says that financial deregulation WAS among the root cause of the crisis (our present global economic situation).

presupposes that it was not necessary for this crisis to happen in our economy—if only key regulators believed in regulation. That regulators did not believe in regulation can be a contradiction. If they were regulators this means that they regulated and probably had some belief in what they were doing.

Stiglitz does not say what it is that the Fed was regulating and how it was regulating it. He asserts that it was the non-existence of a belief in regulation that co-caused the crisis. This means that Stiglitz is saying that the non-existence of something caused something which exists (the crisis).

Stiglitz' saying that it was the non-existence of a belief in regulation that co-caused the crisis presupposes that a proper belief in regulation would not have caused the crisis. This presupposes that our present situation (that which is happening now), our present actions are co-caused by our past subjective relations to some of our past events, some of our past situations, some of our past actions. Stiglitz is thus saying that our past subjective relation to our past actions co-caused our present situation. This means that not only do our past actions cause our present situation but that also our past subjective relation to these actions cause our present situation.

Stiglitz states furthermore that one of the reasons for the crisis was a failure of the Fed. But Stiglitz does not say how this failure is connected to the crisis and he does not prove that the crisis necessarily follows from this failure.

Stiglitz' Second Key Explanatory Factor

Second, the macro-economy was in bad shape with the collapse of the tech bubble. The tax cut of 2001 was not designed to stimulate the economy but to give a largesse to the wealthy—the group that had been doing so well over the last quarter-century. The coup d'grace was the Iraq War, which contributed to soaring oil prices. Money that used to be spent on American goods now got diverted abroad. The Fed took seriously its responsibility to keep the economy going.

It did this by replacing the tech bubble with a new bubble, a housing bubble. Household savings plummeted to zero, to the lowest level since the Great Depression. It managed to sustain the economy, but the way it did it was shortsighted: America was living on borrowed money and borrowed time.

Critique of Stiglitz' First Explanatory Scheme

Stiglitz does not say what it means that the macro-economy was in bad shape with the collapse of the tech bubble and how such a bad shape is connected to the crisis. He does not prove that the crisis necessarily follows from a bad shape of the macro-economy. Our present global economic situation is in bad shape, it is in crisis. So crisis means bad shape of macro-economy. Saying that bad shape caused bad shape (crisis) is tautology.

Stiglitz does not say how tax cut of 2001 and the crisis are connected and he does not prove that the crisis necessarily follows from tax cut in 2001.

Stiglitz does not say whether it is the Iraq war or an increase in oil prices or a diversion in spending that caused the crisis. Stiglitz does not say how these events are connected to the crisis and does not prove that the crisis necessarily follows from these events.

Stiglitz' Final Key Explanatory Factor

Finally, at the center of blame must be the financial institutions themselves. They—and even more their executives—had incentives that were not well aligned with the needs of our economy and our society.

They were amply rewarded, presumably for managing risk and allocating capital, which was supposed to improve the efficiency of the economy so much that it justified their generous compensation. But they misallocated capital; they mismanaged risk—they created risk.

They did what their incentive structures were designed to do: focusing on short-term profits and encouraging excessive risk-taking.

Critique of Stiglitz' First Explanatory Scheme

Stiglitz says that one of the reasons for the crisis was bad alignment of incentives of financial institutions with the needs of our economy and society. Stiglitz says that incentives were focusing on short-term profits and encouraging excessive risk-taking, but he does not say what the needs of our economy and society were.

Saying that the crisis was caused by a bad alignment of incentives and needs presupposes that there could be a good alignment of short-term profits and encouraging excessive risk-taking.[13] Stiglitz is not saying that short-term profits and encouraging excessive risk-taking caused the crisis, he is saying that bad alignment of short-term profits and encouraging excessive risk-taking with the needs of our economy and society caused it. Stiglitz presupposes that if short-

13 In his writing Obama's Ersatz Capitalism, which was published in March 31, 2009, so when data were already proving that globally, GDP growth, trade, credits, profits, employment, wages are decreasing and poverty is increasing—and that this is going to continue –, Stiglitz says, when explaining the cause of the global crisis, that ''the prospect of high compensation gave managers incentives to be shortsighted and undertake excessive risk, rather than lend money prudently. Banks made all these mistakes without anyone knowing, partly because so much of what they were doing was "off balance sheet" financing."

term profits and encouraging excessive risk-taking were well aligned with the needs of our economy and society, then the crisis would not happen.

Stiglitz does not say how a bad alignment of incentives and needs is connected to the crisis and does not prove that the crisis necessarily follows from this bad alignment.

Stiglitz does not say what he means by misallocation of capital, by mismanaging risk, he does not say how these two failures are connected to the crises and he does not prove that the crisis necessarily follows from these two failures.

Stiglitz says that the crisis was caused by failures of financial institutions. This presupposes that it was not necessary for this crisis to happen in our economy—if only financial institutions allocated capital and managed risk rightly. Stiglitz does not say what a right management would be.

Tentative Conclusions for Stiglitz' First Explanatory Scheme

In his writings, Stiglitz says that there was not one reason for the crisis, but many. He does not say how these reasons were connected and how they were connected to the crisis. He also does not prove that the crisis necessarily follows from these reasons.

Stiglitz presupposes that the crisis was caused by some failures and that it was not necessary in our economy. From this follows that the crisis was caused by some failures which happened in the past but do not happen now. Stiglitz thus says that failures which caused the crisis do not happen now and that the crisis happens now. Stiglitz does not say that the crisis is being caused by some failures which happen now.

Stiglitz presupposes that the reasons for our present crisis are past events and not something that is happening now. This means that if our present crisis necessarily follows from some past events, then this crisis will be eternal and will not change, because the past (things that happened) is a fact and cannot ever be changed.

Stiglitz presupposes that the reasons for our present crisis are past events and not something that is happening now. This means that the reasons for our present crisis are things that do not exist now. This means that the reasons for the crisis do not exist now and that the crisis exists now. This means that there is the crisis and there are no reasons for the crisis.

In this writing, Stiglitz explained the crisis in the following form: he identified past events/actions as factors/reasons/causes for the crisis without going into the specifics of choosing a small set of key elements out of a cloud of potential contributing factors/reasons/causes. *Post hoc, propter hoc*: This is the form of Stiglitz' explanatory scheme of the crisis.

The Fruit of Hypocrisy: Stiglitz' Second Explanatory Scheme

In his writing *The fruit of hypocrisy* [2008b], Stiglitz explained the economic/ financial crisis in the following way.[14]

Stiglitz' Second Explanatory Scheme

The new low in the financial crisis, which has prompted comparisons with the 1929 Wall Street crash, is the fruit of a pattern of dishonesty on the part of financial institutions, and incompetence on the part of policy makers.

Critique of Stiglitz' Second Explanatory Scheme

In his article, Stiglitz does not say what exactly does he mean by financial crisis—he could mean bankruptcies of some banks or bank losses or increasing interest rates or decreasing credits or global decreasing of GDP growth, profits, credits, trade, employment, wages and increasing of poverty or maybe something else. In this writing, Stiglitz does not say what is the meaning of the financial crisis. He does not say what exactly is he explaining.

Stiglitz says that the crisis was caused by dishonesty of financial institutions and incompetence of policy makers. But he does not say how this dishonesty and this incompetence are connected to the crisis and he does not prove that the crisis necessarily follows from this dishonesty and this incompetence.

Stiglitz does not say to what financial institutions have been dishonest and he does not say regarding to what policy makers are incompetent. Stiglitz says that dishonesty and incompetence are the reasons for the crisis. But dishonesty means inexistence of honesty towards something and incompetence means inexistence of competence to do something. This means that Stiglitz is saying that inexistence of something caused something which exists (the crisis).

---

14 This article was published on September 16, 2008. The global financial crisis supposedly began in July 2007 and deepened in September 2008. The sub-prime mortgage crisis reached a critical stage during the first week of September 2008, when there was a severely contracted liquidity in the global credit markets and insolvency threatened investment banks and other institutions. Lehman Brothers went bankrupt on September 14, 2008. Prominent American and European banks failed and so did efforts by the American and European governments to rescue distressed financial institutions. As the crisis developed, stock markets fell worldwide, and global financial regulators attempted to coordinate efforts to contain the crisis. Already in September 2008, there were expectations that bankruptcies of major banks and stock markets crashes worldwide will lead to our present global economic situation, *i.e.* global decreasing of GDP, profits, credits, trade, employment, wages and increasing of poverty.

Stiglitz says that the crisis was caused by dishonesty of financial institutions and incompetence of policy makers. This presupposes that it was not necessary for this crisis to happen in our economy—if only financial institutions had been honest and policy makers competent. Stiglitz does not say what this honesty and competency would mean.

Stiglitz' saying that it was inexistence of honesty by financial institutions that co-caused the crisis presupposes that honesty by financial institutions would not cause the crisis. This presupposes that our present situation (that which is happening now), our present actions are co-caused by our past subjective relation to some of our past events, some of our past situations, some of our past actions. Stiglitz is thus saying that our past subjective relation to our past actions co-caused our present situation. This means that not only do our past actions cause our present situation but that also our past subjective relation to these actions cause our present situation.

Stiglitz' Second Explanatory Scheme Continued

We had become accustomed to the hypocrisy. The banks reject any suggestion they should face regulation, rebuff any move towards anti-trust measures—yet when trouble strikes, all of a sudden they demand state intervention: they must be bailed out; they are too big, too important to be allowed to fail.

Critique of Stiglitz' Second Explanatory Scheme

Stiglitz says that there is hypocrisy, but he does not say how this hypocricy is connected to the crisis and he does not prove that the crisis necessarily follows from this hypocricy. Stiglitz also does not say what is the reason for this hypocricy.

Stiglitz' Second Explanatory Scheme Continued

The present financial crisis springs from a catastrophic collapse in confidence. The banks were laying huge bets with each other over loans and assets. Complex transactions were designed to move risk and disguise the sliding value of assets. In this game there are winners and losers. And it's not a zero-sum game, it's a negative-sum game: as people wake up to the smoke and mirrors in the financial system, as people grow averse to risk, losses occur; the market as a whole plummets and everyone loses.

Financial markets hinge on trust, and that trust has eroded. Lehman's collapse marks at the very least a powerful symbol of a new low in confidence, and the reverberations will continue.

The crisis in trust extends beyond banks. In the global context, there is dwindling confidence in US policy makers.
America's financial system failed in its two crucial responsibilities: managing risk and allocating capital. The industry as a whole has not been doing what it should be doing—for instance creating products that help Americans manage critical risks, such as staying in their homes when interest rates rise or house prices fall—and it must now face change in its regulatory structures. Regrettably, many of the worst elements of the US financial system—toxic mortgages and the practices that led to them—were exported to the rest of the world.

Critique of Stiglitz' Second Explanatory Scheme

Stiglitz says that the reason for the crisis is collapse in confidence. But he does not say in what confidence collapsed and by whom.
Stiglitz says that the crisis was caused by collapse in confidence. Collapse means becoming inexistent. This means that Stiglitz is saying that inexistence of something (confidence) caused something which exists (the crisis).
Stiglitz says that the crisis was caused by collapse in confidence. This presupposes that it was not necessary for this crisis to happen in our economy—if only there were confidence. Stiglitz does not say what this confidence would mean.
Stiglitz's saying that it was inexistence of confidence that co-caused the crisis presupposes that confidence would not cause the crisis. This presupposes that our present situation (that which is happening now), our present actions are co-caused by our past subjective relation to some of our past events, some of our past situations, some of our past actions. Stiglitz is thus saying that our past subjective relation to our past actions co-caused our present situation. This means that not only do our past actions cause our present situation but that also our past subjective relation to these actions cause our present situation.
Stiglitz says that the crisis was caused by collapse in confidence. But Stiglitz does not say how this failure is connected to the crisis and he does not prove that the crisis necessarily follows from this failure.

Tentative Conclusions for Stiglitz' Second Explanatory Scheme

In this writing, Stiglitz says that there was not one reason for the crisis, but many. He does not say how these reasons were connected and how they were connected to the crisis. He also does not prove that the crisis necessarily follows from these reasons.
Stiglitz presupposes that the crisis was caused by some failures and that it was not necessary in our economy. From this follows that the crisis was caused by

some failures which happened in the past but do not happen now. Stiglitz thus says that failures which caused the crisis do not happen now and that the crisis happens now. Stiglitz does not say that the crisis is being caused by some failures which happen now.

Stiglitz presupposes that the reasons for our present crisis are past events and not something that is happening now. This means that if our present crisis necessarily follows from some past events, then this crisis will be eternal and will not change, because the past (things that happened) is a fact and cannot ever be changed.

Stiglitz presupposes that the reasons for our present crisis are past events and not something that is happening now. This means that the reasons for our present crisis are things that do not exist now. This means that the reasons for the crisis do not exist now and that the crisis exists now. This means that there is the crisis and there are no reasons for the crisis.

In this writing, Stiglitz explained the crisis in the following form: he identified past events/actions as factors/reasons/causes for the crisis without going into the specifics of choosing a small set of key elements out of a cloud of potential contributing factors/reasons/causes. *Post hoc, propter hoc*: This is the form of Stiglitz' explanatory scheme of the crisis.

Capitalist Fools: Stiglitz' Third Explanatory Scheme

In his writing *Capitalist Fools* [2009], Stiglitz explained our present global economic/financial crisis in the following way.[15]

Stiglitz' Third Explanatory Scheme

There will come a moment when the most urgent threats posed by the credit crisis have eased and the larger task before us will be to chart a direction for the economic steps ahead. This will be a dangerous moment. Behind the debates over future policy is a debate over history—a debate over the causes of our current situation. The battle for the past will determine the battle for the present. So it's crucial to get the history straight.

Critique of Stiglitz' Third Explanatory Scheme

In this writing, Stiglitz does not say what exactly does he mean by credit crisis and what exactly he means by our current situation—he could mean bankruptcies of

---

15 This writing was published in January 2009, when data were already showing that globally, GDP growth, trade, credits, profits, employment, wages are decreasing and poverty is increasing—and that this is going to continue.

some banks or bank losses or increasing interest rates or decreasing credits or a global decrease of GDP growth, profits, credits, trade, employment, wages and increasing of poverty or maybe something else. In this writing, Stiglitz does not say what is the meaning of the credit crisis or what is the meaning of our current situation. He does not say what exactly he is going to explain.

In the following, suppose that by credit crisis and by our current situation Stiglitz means a global decrease of GDP growth, profits, credits, trade, employment, wages and an increase of poverty (global economic crisis). He says that there is not one cause of the crisis but many. He also says that these causes are some things that happened, which means that causes for the crisis are past events. He says that what we should/have to do is based upon past events and not upon what is happening now in our world. He says that our future is based upon the past and not upon the present. He says that the past is crucial and not the present.

Stiglitz' Third Explanatory Scheme Continued

What were the critical decisions that led to the crisis? Mistakes were made at every fork in the road—we had what engineers call a "system failure," when not a single decision but a cascade of decisions produce a tragic result. Let's look at five key moments.
[These key moments were (P.S.)]:

- *In 1987 the Reagan administration decided to remove Paul Volcker as chairman of the Federal Reserve Board and appoint Alan Greenspan in his place.*
- *In November 1999, Congress repealed the Glass-Steagall Act—the culmination of a $300 million lobbying effort by the banking and financial-services industries, and spearheaded in Congress by Senator Phil Gramm.*
- *Bush tax cuts, enacted first on June 7, 2001, with a follow-on installment two years later.*
- *On July 30, 2002, in the wake of a series of major scandals—notably the collapse of WorldCom and Enron—Congress passed the Sarbanes-Oxley Act.*
- *The final turning point came with the passage of a bailout package on October 3, 2008—that is, with the administration's response to the crisis itself.*

Was there any single decision which, had it been reversed, would have changed the course of history? Every decision—including decisions not to do something, as many of our bad economic decisions have been—is a consequence of prior decisions, an interlinked web stretching from the distant past into the future. You'll hear some on the right point to certain actions by the government itself—such as the Community Reinvestment Act, which requires banks to make mortgage money available in low-income neighborhoods. (Defaults on C.R.A. lending were actually much lower than on other lending.) There has been much finger-pointing at Fannie Mae and Freddie

Mac, the two huge mortgage lenders, which were originally government-owned. But in fact they came late to the sub-prime game, and their problem was similar to that of the private sector: their C.E.O.'s had the same perverse incentive to indulge in gambling.

Critique of Stiglitz' Third Explanatory Scheme

Stiglitz supposes that there were some critical decisions that caused the crisis. This means that the crisis was caused by some past events. The reasons for the crisis are in the past and not in the present. Stiglitz thus presupposes that the reasons for our present crisis are past events and not something that is happening now. This means that if our present crisis necessarily follows from some past events, then this crisis will be eternal and will not change, because the past (things that happened) is a fact and cannot ever be changed. But this is in contradiction with Stiglitz's saying that there will come a moment when urgent threats of our present crisis will ease.

Stiglitz says that one of the reasons for the crisis was the administration's response to the crisis itself. But response to something always happens after that thing had happened. Saying that the reasons for the crisis are events that happened before the crisis and that one of the reasons for the crisis is an event that happened after the crisis is a contradiction.

Stiglitz says that the crisis was caused by false/mistaken decisions. There was not one decision that caused the crisis, but many. Stiglitz also says that every decision is a consequence of prior decisions. This means that there is not one decision that caused all other decisions, which means that decisions have no beginning. This also means that all decisions are both consequences of past decisions and causes of future decisions. Every decision is thus both a consequence and a cause.

Stiglitz does not say how these critical false/mistaken decisions are connected to the crisis and he does not prove that the crisis (our present global decrease in GDP growth, profits, credits, trade, employment, wages and increase in poverty) necessarily follows from these critical false/mistaken decisions.

Stiglitz' Third Explanatory Scheme Continued

The truth is most of the individual mistakes boil down to just one: a belief that markets are self-adjusting and that the role of government should be minimal. Looking back at that belief during hearings this fall on Capitol Hill, Alan Greenspan said out loud, "I have found a flaw." Congressman Henry Waxman pushed him, responding, "In other words, you found that your view of the world, your ideology, was not right; it was not working." "Absolutely, precisely," Greenspan said. The embrace by America—and *much of the rest of the world—of this flawed economic philosophy made it inevitable that we would eventually arrive at the place we are today.*

Critique of Stiglitz' Third Explanatory Scheme

Stiglitz says that most of the individual mistakes (failed decisions) were caused by one mistake, which was a belief that markets are self-adjusting and that the role of government should be minimal. This is in contradiction with Stiglitz's saying that every decision is a consequence of past decisions and not one past decision. Whether every decision is a consequence of many other past decisions or many decisions are a consequence of only one decision. Stiglitz says that both are true. Stiglitz says that the main reason for the crisis was a mistaken/false belief that markets are self-adjusting and that the role of government should be minimal. But Stiglitz does not say how this mistaken/false belief is connected to the crisis and he does not prove that the crisis (our present global decrease in GDP growth, profits, credits, trade, employment, wages and increase in poverty) necessarily follows from this mistaken/false belief.

Stiglitz says that main reason for the crisis was a mistaken/false belief that markets are self-adjusting and that the role of government should be minimal. This presupposes that it was not necessary for this crisis to happen in our economy—if only we did not believe that markets are self-adjusting and that the role of government should be minimal. Stiglitz says that economic philosophy is a belief, when he equates flawed economic philosophy with the belief that markets are self-adjusting and that the role of government should be minimal.

Stiglitz says that not only the belief that markets are self-adjusting and that the role of government should be minimal caused the crisis, but also that our acceptance of this belief/philosophy co-caused the crisis. But an acceptance presupposes a belief in something, which means that Stiglitz is saying that our belief in false belief/philosophy co-caused the crisis. So our belief in false belief also caused the crisis, which means that our belief in something that caused the crisis (false belief/philosophy) also caused the crisis.

Stiglitz's saying that it was our acceptance of false belief/philosophy that caused the crisis presupposes that our non-acceptance (non-belief) of false belief/philosophy would not cause the crisis. This presupposes that our present situation uzhsubjective relation to some of our past events, some of our past situations, some of our past actions. Stiglitz is thus saying that our past subjective relation to our past actions co-caused our present situation. This means that not only do our past actions cause our present situation but that also our past subjective relation to these actions cause our present situation.

Stiglitz says that it was our acceptance of false belief/philosophy that caused the crisis. But Stiglitz does not say how this acceptance is connected to the crisis and he does not prove that the crisis (our present global decrease in GDP growth, profits, credits, trade, employment, wages and increase in poverty) necessarily follows from this acceptance.

Tentative Conclusions for Stiglitz' Third Explanatory Scheme

In this writing, Stiglitz says that there was not one reason for the crisis, but many. He does not say how these reasons were connected and how they were connected to the crisis. He also does not prove that the crisis (our present global decrease in GDP growth, profits, credits, trade, employment, wages and increase in poverty) necessarily follows from these reasons.

Stiglitz presupposes that the crisis was caused by some failures and that it was not necessary in our economy. From this follows that the crisis was caused by some failures which happened in the past but do not happen now. Stiglitz thus says that failures which caused the crisis do not happen now and that the crisis happens now. Stiglitz does not say that the crisis is being caused by some failures which happen now. Stiglitz presupposes that the reasons for our present crisis are past events and not something that is happening now. This means that if our present crisis necessarily follows from some past events, then this crisis will be eternal and will not change, because the past (things that happened) is a fact and cannot ever be changed. Stiglitz presupposes that the reasons for our present crisis are past events and not something that is happening now. This means that the reasons for our present crisis are things that do not exist now. This means that the reasons for the crisis do not exist now and that the crisis exists now. This means that there is the crisis and there are no reasons for the crisis.

In this writing, Stiglitz explained the crisis in the following form: he identified past events/actions as factors/reasons/causes for the crisis without going into the specifics of choosing a small set of key elements out of a cloud of potential contributing factors/reasons/causes. *Post hoc, propter hoc*: This is the form of Stiglitz' explanatory scheme of the crisis.

The Explanatory Scheme by the International Monetary Fund (IMF) for Our Present Global Economic/Financial Crisis

In its writing *Lessons from the Crisis: IMF Urges Rethink Of How To Manage Global Systemic Risk* [2009], the IMF explained our present global economic/financial crisis in the following way.[16]

IMF's Explanatory Scheme

Understanding what went wrong is key to restoring stability to the global economy, which is suffering the worst recession since the Second World War. "A key failure during the boom was the inability to spot the big picture threat of a growing asset price bubble. Policy makers only focused on their own piece of the puzzle, overlooking the larger problem," Reza Moghadam, head of the IMF's Strategy, Policy and Review Department said.

Critique of the IMF-Explanatory Scheme

In its writing, IMF says that the key to restore stability to the global economy is understanding what went wrong and not what goes/is wrong. IMF presupposes that there was a stable global economy and that now the global economy is unstable. This presupposes that instability was caused by stability. IMF says that one state caused its contrary state. IMF presupposes that something went wrong but does not say in relation to what something went wrong—IMF could mean banks or bank losses or interest rates or credits or global decrease in GDP growth, profits, trade, employment, wages and increase in poverty or maybe something else.

IMF also says that the economy and not people is suffering from the recession. Suffering presupposes life, which means that IMF says that economy is a living being.

Reza Moghadam, head of the IMF's Strategy, Policy and Review Department, says that the key failure during the boom was the inability to spot the big picture threat of a growing asset price bubble. Suppose that he is talking about the causes of our present crisis (our present global decrease in GDP growth, profits, credits, trade, employment, wages and increase in poverty).

16 This article was published in March 6, 2009, when data were already showing that, globally, GDP growth, trade, credits, profits, employment, wages are decreasing and poverty is increasing—and that this is going to continue.

He says that there was a key failure which caused the crisis. This presupposes that there were many failures and at least one of them was the key one. Moghadam does not say what were other failures that were not key ones.

He says that there was a key failure which caused the crisis. This presupposes that it was not necessary for this crisis to happen in our economy—if only policy makers saw the larger problem, if only they were able to spot the big picture threat of a growing asset price bubble.

Moghadam says that the main reason for the crisis was the inability to spot the big picture threat of a growing asset price bubble. He does not say that the threat of a growing asset price bubble was the reason for the crisis and he does not say that a growing asset price bubble was the reason for the crisis.

Moghadam says that the main reason for the crisis was the inability to spot something. But inability means inexistence of ability to do something. This means that Moghadam is saying that inexistence of something caused something which exists (the crisis).

Moghadam says that the main reason for the crisis was the inability to spot the big picture threat of a growing asset price bubble but he does not say how this inability is connected to the crisis and he does not prove that the crisis (our present global decrease in GDP growth, profits, credits, trade, employment, wages and increase in poverty) necessarily follows from this inability.

IMF's Explanatory Scheme Continued

The IMF's analysis points to failures at three different levels:

- *Financial regulators were not equipped to see the risk concentrations and flawed incentives behind the financial innovation boom. Neither market discipline nor regulation were able to contain the risks resulting from rapid innovation and increased leverage, which had been building for years.*
- *Policy makers failed to sufficiently take into account growing macroeconomic imbalances that contributed to the buildup of systemic risks in the financial system and in housing markets. Central banks focused mainly on inflation, not on risks associated with high asset prices and increased leverage. And financial supervisors were preoccupied with the formal banking sector, not with the risks building in the shadow financial system.*
- *International financial institutions were not successful in achieving forceful cooperation at the international level. This compounded the inability to spot growing vulnerabilities and cross-border links.*

Critique of the IMF-Explanatory Scheme

IMF says that one of the reasons for the crisis was the fact that financial regulators were not equipped to see the risk concentrations and flawed incentives behind the financial innovation boom and the fact that market discipline and regulation were not able to contain the risks, resulting from rapid innovation and increased leverage. IMF does not say which financial regulators were not equipped, what exactly they were doing, what the incentives were and why they were flawed, it does not say what financial innovation was, what market discipline was and what regulation was regulating and why. IMF does not say that it was financial regulators that caused the crisis, nor risk, nor risk concentrations, nor flawed incentives, nor financial innovation boom, nor market discipline, nor regulation, nor rapid innovation, nor increased leverage. IMF does not say how a non-equippmance of financial regulators and an inability of market discipline and regulation are connected to the crisis and IMF does not prove that the crisis (our present global decrease in GDP growth, profits, credits, trade, employment, wages and increase in poverty) necessarily follows from non-equippance of financial regulators and inability of market discipline and regulation.

IMF says that one of the reasons for the crisis was the fact that financial regulators were not equipped to see the risk concentrations and flawed incentives behind the financial innovation boom and the fact that market discipline and regulation were not able to contain the risks, resulting from rapid innovation and increased leverage. This presupposes that it was not necessary for this crisis to happen in our economy—if only financial regulators were equipped and if only market discipline and regulation were able to contain the risks.

IMF says that one of the reasons for the crisis was the fact that financial regulators were not equipped to see the risk concentrations and flawed incentives behind the financial innovation boom and the fact that market discipline and regulation were not able to contain the risks, resulting from rapid innovation and increased leverage. But being not equipped means the inexistence of something and inability means inexistence of an ability to do something. This means that IMF is saying that inexistence of something caused something which exists (the crisis).

IMF says that one of the reasons for the crisis was the fact that policymakers failed to sufficiently take into account growing macroeconomic imbalances that contributed to the buildup of systemic risks in the financial system and in housing markets, the fact that central banks focused mainly on inflation, not on risks associated with high asset prices and increased leverage, and the fact that financial supervisors were preoccupied with the formal banking sector, not with the risks building in the shadow financial system. Critique of this explanation is the same as above.

IMF says that one of the reasons for the crisis was the fact that international financial institutions were not successful in achieving forceful cooperation at the international level, which compounded the inability to spot growing vulnerabilities and cross-border links. Critique of this explanation is the same as above.
IMF also presupposes the existence of forceful cooperation—forceful cooperation is a contradiction, because cooperation presupposes free volition, uniformity of interests and absence of force/command, because when there is uniformity of interests, force/command is unnecessary. Only when there are interest collisions/contraries, then force/command is necessary.

IMF's Explanatory Scheme Continued

The crisis was preceded by a long period of robust global growth and low interest rates. This encouraged investors to seek higher returns, fueling demand for the riskier products generated by financial innovation. "At the root of the crisis was the optimism that was brought about by a long period of prosperity. This optimism led to risks in the global economy not being assessed as carefully as they should have been," Olivier Blanchard, Economic Counsellor and Director of the IMF's Research Department, said. "With large failures in regulation and supervision, this fuelled high leverage and build-up of risky assets." While monetary and fiscal policies did not play a major role in the run up to the crisis, the crisis still holds a number of lessons for policy makers on the macroeconomic level.

Critique of the IMF-Explanatory Scheme

IMF says that before the crisis there was global growth and low interest rates, which encouraged investors to seek higher returns, fueling demand for the riskier products generated by financial innovation. IMF does not say how this is connected to the crisis and IMF does not prove that the crisis (our present global decrease in GDP growth, profits, credits, trade, employment, wages and increase in poverty) necessarily follows from global growth and low interest rates, which encouraged investors to seek higher returns, fueling demand for the riskier products generated by financial innovation. IMF only says what happened before the crisis.
Olivier Blanchard, Economic Counsellor and Director of the IMF's Research Department, says that the cause of the crisis was optimism that was brought about by a long period of prosperity. This optimism led to risks in the global economy not being assessed as carefully as they should have been. Blanchard does not say about what there was optimism and he does not say what prosperity is. He does not say that prosperity caused the crisis, nor risks in the global economy, nor not careful

assessment of these risks. He does not say how optimism brought about by a long period of prosperity is connected to the crisis and he does not prove that the crisis (our present global decrease in GDP growth, profits, credits, trade, employment, wages and increase in poverty) necessarily follows from this optimism.

Blanchard says that the cause of the crisis was optimism that was brought about by a long period of prosperity. This presupposes that it was not necessary for this crisis to happen in our economy—if only there were no such optimism.

Blanchard is saying that it was optimism that caused the crisis. This presupposes that our present situation (that which is happening now), our present actions are caused by our past subjective relation to some of our events, some of our situations, some of our actions. Blanchard is thus saying that our past subjective relation to our actions caused our present situation.

Tentative Conclusions for the IMF-Explanatory Scheme

In its article, IMF says that there was not one reason for the crisis, but many. IMF does not say how these reasons were connected and how they were connected to the crisis. IMF also does not prove that the crisis (our present global decrease in GDP growth, profits, credits, trade, employment, wages and increase in poverty) necessarily follows from these reasons.

IMF presupposes that the crisis was caused by some failures and that it was not necessary in our economy. From this follows that the crisis was caused by some failures which happened in the past but do not happen now. IMF thus says that failures which caused the crisis do not happen now and that the crisis happens now. IMF does not say that the crisis is being caused by some failures which happen now.

IMF presupposes that the reasons for our present crisis are past events and not something that is happening now. This means that if our present crisis necessarily follows from some past events, then this crisis will be eternal and will not change, because the past (things that happened) is a fact and cannot ever be changed.

IMF presupposes that the reasons for our present crisis are past events and not something that is happening now. This means that the reasons for our present crisis are things that do not exist now. This means that the reasons for the crisis do not exist now and that the crisis exists now. This means that there is the crisis and there are no reasons for the crisis.

In this writing, IMF explained the crisis in the following form: IMF identified past events/actions as factors/reasons/causes for the crisis without going into the specifics of choosing a small set of key elements out of a cloud of potential contributing factors/reasons/causes. *Post hoc, propter hoc*: This is the form of IMF's explanatory scheme of the crisis.

OECD-Economists Explaining Our Present Global Economic/ Financial Crisis

In their writing *The Current Financial Crisis: Causes and Policy Issues* [2008], OECD economists Adrian Blundell-Wignall, Paul Atkinson and Se Hoon Le explained our present global economic/financial crisis in the following way.[17]

The Explanatory Scheme by Blundell-Wignall *et al.* (OECD)

The current financial crisis is being caused at two levels: by global macro policies affecting liquidity and by a very poor regulatory framework that, far from acting as a second line of defence, actually contributed to the crisis in important ways. The policies affecting liquidity created a situation like a dam overfilled with flooding water. Interest rates at one per cent in the United States and zero per cent in Japan, China's fixed exchange rate, the accumulation of reserves in Sovereign Wealth Funds, all helped to fill the liquidity reservoir to overflowing. The overflow got the asset bubbles and excess leverage under way. But the faults in the dam—namely the regulatory system—started from about 2004 to direct the water more forcefully into some very specific areas: mortgage securitization and off-balance sheet activity. The pressure became so great that that the dam finally broke, and the damage has already been enormous.

So, the current financial crisis is caused by *global macro liquidity policies and by a poor regulatory framework*.

Critique of the OECD-Explanatory Scheme

In their writing, Blundell-Wignall *et al*. do not say what exactly they mean by the current financial crisis—they could mean bankruptcies of some banks or bank losses or increasing interest rates or decreasing credits or global decreasing of GDP growth, profits, credits, trade, employment, wages and increasing of poverty or maybe something else. In this article, Blundell-Wignall *et al*. do not say what is the meaning of the current financial crisis. They do not say what exactly are they explaining.

Blundell-Wignall *et al*. say that the crisis is being caused at two levels. They do not say that the crisis was caused. They also say that the crisis is being caused at

17 This explanation arose from research presented to a non-OECD conference, and the discussion it generated. While this research was circulated to the OECD Committee on Financial Markets, the views are those of the authors and do not necessarily reflect those of the OECD or the governments of its member countries.

two levels, which means that they say where the crisis is being caused and not by what. Contrary to that, they then say that the crisis is being caused by global macro policies affecting liquidity and by a very poor regulatory framework that, far from acting as a second line of defence, actually contributed to the crisis in important ways. They do not say what these global macro policies are and who makes them, they say what these policies affect. They do not say how these policies affect liquidity, how these policies and liquidity are connected, they only say that these policies affect liquidity. They do not say what the regulatory framework is, what it regulates and how and who makes it. They do not say why this framework is poor. They only say that it is very poor and that it contributed to the crisis in important ways. But if a very poor regulatory framework contributed to the crisis, this means that it does not contribute to the crisis now. This means that the crisis was caused, in important ways, by a very poor regulatory framework, which means that the crisis is not being caused by a very poor regulatory framework now. But this is in contradiction with their saying that the crisis is being caused at two levels: by global macro policies and by a very poor regulatory framework. They say that the crisis was/is being caused by a very poor regulatory framework in important ways. They do not say what these important ways are and they do not say what are the causes that are/were causing the crisis in unimportant ways.

They say that the crisis is being caused by global macro policies affecting liquidity and by a very poor regulatory framework that, far from acting as a second line of defence, actually contributed to the crisis in important ways. They do not say how global macro policies and a very poor regulatory framework are connected to the crisis and they do not prove that the crisis necessarily follows from global macro policies and a very poor regulatory framework.

Blundell-Wignall *et al*. say that the policies affecting liquidity created a situation like a dam overfilled with flooding water. They do not say what a situation like a dam overfilled with flooding water means. They do not say how policies affecting liquidity created a situation like a dam overfilled with flooding water. They do not say how a situation like a dam overfilled with flooding water is connected to the crisis and they do not prove that the crisis follows from a situation like a dam overfilled with flooding water.

Blundell-Wignall *et al*. say that the policies affecting liquidity created a situation like a dam overfilled with flooding water, but they do not say that the policies affecting liquidity created a situation like a dam overfilled with flooding water. Their saying that the policies created a situation which caused the crisis presupposes that the policies do not create that situation now and do not cause the crisis now and this saying is thus in contradiction with their saying that global macro policies are causing the crisis.

Blundell-Wignall *et al.* say that interest rates at one per cent in the United States and zero per cent in Japan, China's fixed exchange rate, the accumulation of reserves in Sovereign Wealth Funds, all helped to fill the liquidity reservoir and led to its overflowing. They say that small interest rates, a fixed exchange rate and the accumulation of reserves all helped to fill the liquidity reservoir and led to its overflowing. They presuppose that something other than small interest rates, fixed exchange rate and the accumulation of reserves caused the liquidity reservoir to overflow and that small interest rates, fixed exchange rate and the accumulation of reserves only helped in causing the liquidity reservoir to overflow. They do not say what these other things were that caused the liquidity reservoir to overflow and how these causes are connected to the overflowing of the liquidity reservoir.

Blundell-Wignall *et al.* say that small interest rates, fixed exchange rate and the accumulation of reserves all helped to fill the liquidity reservoir and led to its overflowing. They do not say what overflowing means. In the following, suppose that overflowing of the liquidity reservoir means too much liquidity. Blundell-Wignall *et al.* say that the overflow got the asset bubbles and excess leverage under way. Supposing that overflowing of the liquidity reservoir means too much liquidity, then Blundell-Wignall *et al.* say that too much liquidity caused the asset bubbles and excess leverage. They do not say what an asset bubble means. In the following, suppose that an asset bubble means excess prices of assets.

Blundell-Wignall *et al.* say that too much liquidity caused excess prices of assets and excess leverage and therefore the crisis. They do not say that liquidity itself caused excess prices of assets and excess leverage, but that too much of liquidity caused excess prices of assets and excess leverage. This pressuposes that if there was a right (optimal, appropriate) quantity of liquidity, then there would not be excess prices of assets and excess leverage and therefore the crisis would not happen. Blundell-Wignall *et al.* do not say what this right quantity would be. They also do not say how much liquidity there was and how much of this quantity was too much (excessive). And since they do not say how much liquidity was too much and what would be the right quantity of liquidity, they do not explain, why certain quantity of liquidity would be right (optimal, appropriate), and they does not explain, why only and exactly excessive liquidity caused the crisis.

But suppose that there really exists a right (optimal, appropriate) quantity of liquidity which is not too much, which is not excessive and would therefore not cause the crisis. This means that this right quantity of liquidity would be limited and determinate, because it would be less than too much. Suppose also that the purpose of private production (including banks) is maximization (growth) of profits and that the purpose of states is GDP growth.

If all this were be so, then profits of private production (including banks) would be limited and determinate and so would be GDP, since liquidity and market (both are means of maximizing profits of private production) would be limited and determinate. This means that GDP growth would necessarily reach a point where GDP growth would be 0%, because a limited and determinate quantity of liquidity and market would both limit growth (and growth in itself is limitless, because growth itself means a limitless increase of a certain measured quantity). If a limited and determinate quantity of liquidity and market would necessarily limit GDP growth and this GDP growth would necessarily be 0% at the end, then states (central banks) would decrease interest rates in order to increase liquidity, which would then increase investments and profits (which is the purpose of private production) and GDP would increase (which is the purpose of states). So this increase in liquidity—excess liquidity in relation to limited and determinate (right/appropriate) liquidity—would cause GDP, trade, profits to increase. But if this were so, then excess liquidity would cause at least two things:

- a decrease in GDP, trade, profits (which is what Blundell-Wignall *et al*. say, when they say that excess liquidity caused the present crisis) and
- an increase in GDP, trade, profits.

So, excess liquidity would cause at least two things—both a decrease and an increase in GDP, trade, profits. But these two things are inverse to each other. So, one thing (excess liquidity) would be the reason for two things which stand in an inverse relation to each other (decrease and increase in GDP, trade, profits).
Blundell-Wignall *et al*. say that too much liquidity caused excess prices of assets and excess leverage and therefore the crisis. They say that the basis for this crisis was excess liquidity. They say that there was too much liquidity which caused the crisis. But that is all they say. They do not say how excess liquidity and the crisis are connected. They do not prove that the crisis necessarily follows from excess liquidity.
Blundell-Wignall *et al*. say that the faults in the dam—namely the regulatory system—started from about 2004 to direct the water more forcefully into mortgage securitization and off-balance sheet activity and that the pressure became so great that that the dam finally broke, and the damage has already been enormous. This presupposes that it was not necessary for this crisis to happen in our economy—if only the regulatory system did not direct the water more forcefully into mortgage securitization and off-balance sheet activity. Blundell-Wignall *et al*. do not say how the faults in the dam are connected to the crisis and they do not prove that the crisis necessarily follows from these faults in the dam.

The Explanatory Scheme by Blundell-Wignall *et al.* (OECD) Continued

When economists talk about causality they usually have some notion of exogenouty in mind; that relatively independent factors changed and caused endogenous things to happen—in this case the biggest financial crisis since the Great Depression. The *crisis itself was not independent, but originated from the distortions and incentives created by past policy actions.*

In 2004 four time specific factors came into play. (1) the Bush Administration 'American Dream' 3 zero equity mortgage proposals became operative, helping low-income families to obtain mortgages; (2) the then regulator of Fannie Mae and Freddie Mac, the Office of Federal Housing Enterprise Oversight [OFHEO], imposed greater capital requirements and balance sheet controls on those two government sponsored mortgage securitization monoliths, opening the way for banks to move in on their "patch" with plenty of low income mortgages coming on stream; (3) the Basel II accord on international bank regulation was published and opened an arbitrage opportunity for banks that caused them to accelerate off-balance-sheet activity; and (4) the SEC agreed to allow investment banks (IB's) voluntarily to benefit from regulation changes to manage their risk using capital calculations under the 'consolidated supervised entities program'. (Prior to 2004 broker dealers were supervised by stringent rules allowing a 15:1 debt to net equity ratio. Under the new scheme investment banks could agree voluntarily to SEC consolidated oversight (not just broker dealer activities), but with less stringent rules that allowed them to increase their leverage ratio towards 40:1 in some cases.) The combination of these four changes in 2004 caused the banks to accelerate off-balance sheet mortgage securitization as a key avenue to drive the revenue and the share price of banks.

Critique of the OECD-Explanatory Scheme

Blundell-Wignall *et al*. say that when economists talk about causality they have some notion of exogenouty in mind; that relatively independent factors changed and caused endogenous things to happen. They do not say which economists usually have some notion of exogenouty in mind when they talk about causality. They do not say what relatively independent means and what endogenous means.

Blundell-Wignall *et al*. say that the combination of four changes/factors in 2004 caused the banks to accelerate off-balance sheet mortgage securitization as a key avenue to drive the revenue and the share price of banks. They do not say how these changes/factors were combined/connected. They do not say how these four changes/factors are connected to the crisis and they do not prove that the crisis necessarily follows from these four changes/factors in 2004.

Blundell-Wignall *et al*. suppose that there were some policy actions that caused the crisis. This means that the crisis was caused by some past actions. The reasons for the crisis are in the past and not in the present. Blundell-Wignall *et al*. thus presuppose that the reasons for our present crisis are past actions and not something that is happening now. This means that if our present crisis necessarily follows from some past actions, then this crisis will be eternal and will not change, because the past (things that happened) is a fact and cannot ever be changed.

Tentative Conclusions for the OECD-Explanatory Scheme

In this writing, Blundell-Wignall *et al*. say that there was not one reason for the crisis, but many. They do not say how these reasons were connected and how they were connected to the crisis. They also do not prove that the crisis necessarily follows from these reasons.

Blundell-Wignall *et al*. presuppose that the crisis was caused by some failures and that it was not necessary in our economy. From this follows that the crisis was caused by some failures which happened in the past but do not happen now. Blundell-Wignall *et al*. thus say that failures which caused the crisis do not happen now and that the crisis happens now. Blundell-Wignall *et al*. do not say that the crisis is being caused by some failures which happen now.

Blundell-Wignall *et al*. presuppose that the reasons for our present crisis are past events and not something that is happening now. This means that if our present crisis necessarily follows from some past events, then this crisis will be eternal and will not change, because the past (things that happened) is a fact and cannot ever be changed.

Blundell-Wignall *et al*. presuppose that the reasons for our present crisis are past events and not something that is happening now. This means that the reasons for our present crisis are things that do not exist now. This means that the reasons for the crisis do not exist now and that the crisis exists now. This means that there is a crisis now and that there are no reasons for the crisis.

In this writing, Blundell-Wignall *et al*. explained the crisis in the following form: they identified past events/actions as factors/reasons/causes for the crisis without going into the specifics of choosing a small set of key elements out of a cloud of potential contributing factors/reasons/causes. *Post hoc, propter hoc*: This is the form of their explanatory scheme of the crisis.

10.3 How Joseph E. Stiglitz, IMF and OECD-Economists "Explained" the Economic/Financial Crisis

In their writings, Stiglitz, IMF and OECD economists do not say what exactly they do mean by the crisis—they could mean bankruptcies of some banks or bank losses or increasing interest rates or decreasing credits or global decreasing of GDP growth, profits, credits, trade, employment, wages and increasing of poverty or maybe something else. In their writings, they do not say what is the meaning of the crisis. They do not say what exactly they are explaining. In their writings, they say that there was not one reason for the crisis, but many. They do not say how these reasons were connected and how they were connected to the crisis. They also do not prove that the crisis necessarily follows from these reasons.

They presuppose that the crisis was caused by some failures and that it was not necessary in our economy. From this follows that the crisis was caused by some failures which happened in the past but do not happen now. They thus say that failures which caused the crisis do not happen now and that the crisis happens now. They do not say that the crisis is being caused by some failures which happen now.

They presuppose that the reasons for our present crisis are past events and not something that is happening now. This means that if our present crisis necessarily follows from some past events, then this crisis will be eternal and will not change, because the past (things that happened) is a fact and cannot ever be changed.

They presuppose that the reasons for our present crisis are past events and not something that is happening now. This means that the reasons for our present crisis are things that do not exist now. This means that the reasons for the crisis do not exist now and that the crisis exists now. This means that now there is the crisis and there are no reasons for the crisis.

There is also a tautology in one of the explanatory schemes of the crisis by Stiglitz and there are some contradictions in the explanatory schemes of the crisis by Stiglitz and OECD economists.

In their writings, Stiglitz, IMF and OECD economists explained the crisis in the following form: they identified past events/actions as factors/reasons/causes for the crisis without going into the specifics of choosing a small set of key elements out of a cloud of potential contributing factors/reasons/causes. *Post hoc, propter hoc*: This is the form of their explanatory scheme of the crisis.

Inconsistencies in the Explanatory Schemes of the Crisis by Stiglitz, IMF and OECD-Economists

In each of his three writings, Stiglitz identified reasons for the crisis that were different and inconsistent with the reasons for the crisis that he identified in the other two writings. In his first writing *Commentary: How to prevent the next Wall Street crisis* [2008a], Stiglitz says that, for example, excess borrowing, pyramid scheme, failure of the Fed, inexistence of belief in regulation, tax cut in 2001 were among the reasons for the crisis. But in the other two of his writings, he does not say that these things were the reasons for the crisis. In his second writing *The fruit of hypocrisy* [2008b], Stiglitz says that, for example, dishonesty of financial institutions, incompetence of policy makers, hypocricy, collapse in confidence were the reasons for the crisis. Again, in the other two of his writings, he does not say that these things were the reasons for the crisis. In his third writing *Capitalist Fools* [2009], Stiglitz says that, for example, the administration's response to the crisis itself, mistaken/false belief that markets are self-adjusting and that the role of government should be minimal and our acceptance of this false belief/philosophy were the reasons for the crisis. Once again, in the other two of his writings, he does not say that these things were the reasons for the crisis.

So, in his first writing, Stiglitz identified reasons of the crisis which were different and inconsistent with things that he identified as reasons for the crisis in other two of his writings. In his second writing, Stiglitz identified reasons of the crisis which were different and inconsistent with things that he identified as reasons for the crisis in other two of his writings. And in his third writing, Stiglitz identified reasons of the crisis which were different and inconsistent with things that he identified as reasons for the crisis in other two of his writings.

Stiglitz identified some of the reasons for the crisis (dishonesty, collapse in confidence, increasing oil prices, failure of the Fed, for example) that were different from those identified by the IMF and OECD economists. IMF identified some of the reasons for the crisis (non-equippance of financial regulators, international financial institutions not being successful in achieving cooperation at the international level, for example) that were different from those identified by Stiglitz and OECD economists. OECD economists identified some of the reasons for the crisis (global macro policies affecting liquidity, becoming operative of the Bush Administration 'American Dream' 3 zero equity mortgage proposals in 2004, for example) that were different from those identified by Stiglitz and the IMF. So, each economist or institution identified reasons for the crisis, which were different from things that other economists or institutions identified as reasons for the crisis.

So, the explanatory scheme of the crisis by each economist or institution was different and inconsistent with explanations of the crisis by other economists or institutions.

We can therefore conclude, that there is an inconsistency between Stiglitz's three explanatory schemes of the crisis and that there is inconsistency between explanatory schemes of the crisis by Stiglitz, IMF and OECD economists.

Critique of the Form of the Explanatory Schemes of the Crisis by Stiglitz, IMF and OECD

The form of the common explanatory scheme of an economic phenomenon is similar to what Lawson [2003] and Hausman [2001] think is the right form of explanation of economic phenomena. We search for/determine causes that cause an economic phenomenon. Lawson also says that when explaining economic phenomena in the right way, we state hypotheses about causes of an economic phenomenon that lies at the surface and these causes are always at a deeper level than an economic phenomenon we want to explain. All causes of an economic phenomenon have their own causes at a deeper level and so on (multi-level spatial reality), so this process of determining causes of an economic phenomenon is limitless.

The basic idea of all these forms of explanations is that when we want to know/understand an economic phenomenon, we have to move away from this economic phenomenon to other things and we have then to identify some of these other things as causes for an economic phenomenon we want to know/understand.

The form of explanation of the crisis by Stiglitz, IMF and OECD economists does not presuppose a multi-level spatial reality, but it presupposes a multi-level temporal reality (present level and limitlessly many past levels). The explanation of the crisis by Stiglitz, IMF and OECD economists is partially contradictory and tautological, and it excludes necessity (it is arbitrary). The form of explanation of the crisis by Stiglitz, IMF and OECD economists only appears to be a form of explanation, but in fact it is not a real form of explanation. The form of explanation of the crisis by Stiglitz, IMF and OECD economists does not really explain economic phenomena and so we do not know/understand economic phenomena based on the form of explanation of the crisis by Stiglitz, IMF and OECD economists. And because of all this, there are no benefits of the form of explanation of the crisis by Stiglitz, IMF and OECD economists.

What Do We now Understand/Know about Our Present Global Economic Situation?

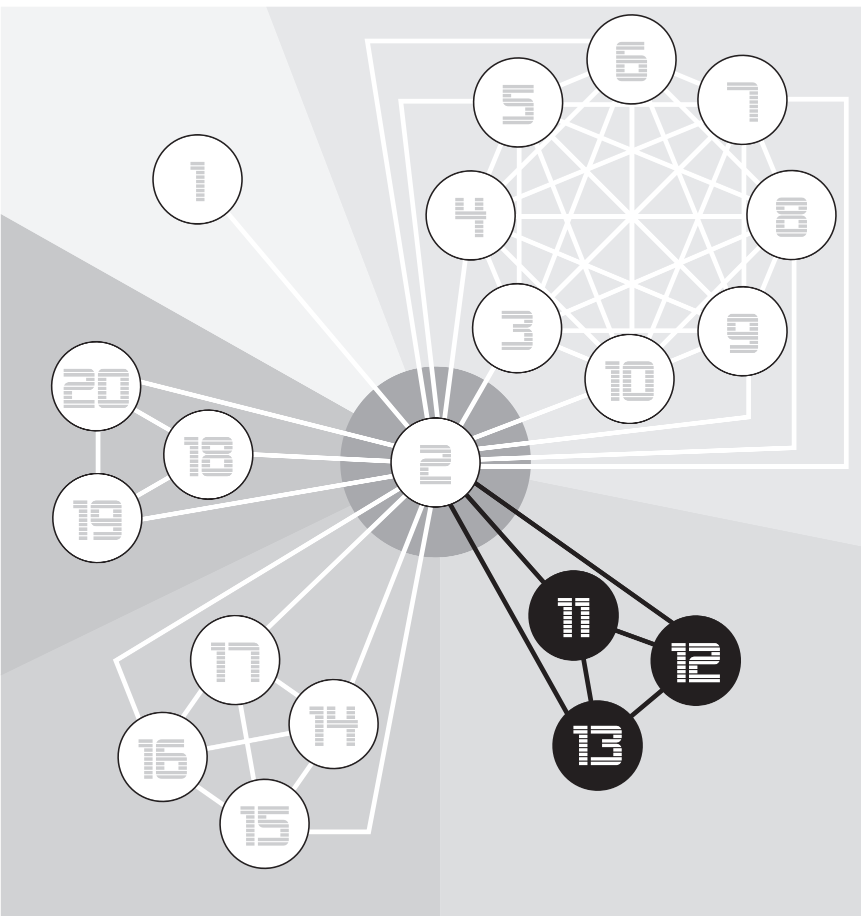
At the outset, we wanted to know how to characterize our present global economic situation. We ended with a description whereby, globally, GDP growth, profits, credits, trade, employment, wages are decreasing and poverty is increasing. We named this situation as our global economic/financial crisis.

But we also wanted to know why our present global economic crisis occurred. So, we wanted to find suitable explanations for our present global economic crisis. By now, we know that there were many attempts to explain the crisis and that a group of explanations of our current crisis was put forward by Joseph E. Stiglitz, by the IMF and by OECD-economists.

So, based on these proposed explanatory schemes of the crisis by Stiglitz, IMF and OECD economists, do we now understand our present global economic situation and know what are the real reasons for this situation? Based on these proposed explanatory schemes of the crisis, do we now understand why, globally, GDP growth, trade, credits, profits, employment, wages are decreasing and poverty is increasing? I think that we do not.

I think that the proposed explanatory schemes of the crisis by Stiglitz, IMF and OECD economists only seem to be explanations and I think that they are surface explanations only and do not pass an in-depth test for validity or robustness. In fact, they do not really explain our present global economic situation. I think that the proposed explanatory schemes of the crisis by Stiglitz, IMF and OECD economists are not valid (and therefore acceptable) in our present global economic situation and I think that the form of the proposed "explanations" of the crisis by Stiglitz, IMF and OECD economists is misleading and wrong. I think that we do not know more about the underlying causes (reasons) for our present global economic situation (crisis) based on proposed explanatory schemes of the crisis by Stiglitz, IMF and OECD. I think that a satisfactory explanation and, therefore, an adequate understanding of our present global economic situation is still missing.

Part III — RISC Applications



Introduction to Part III

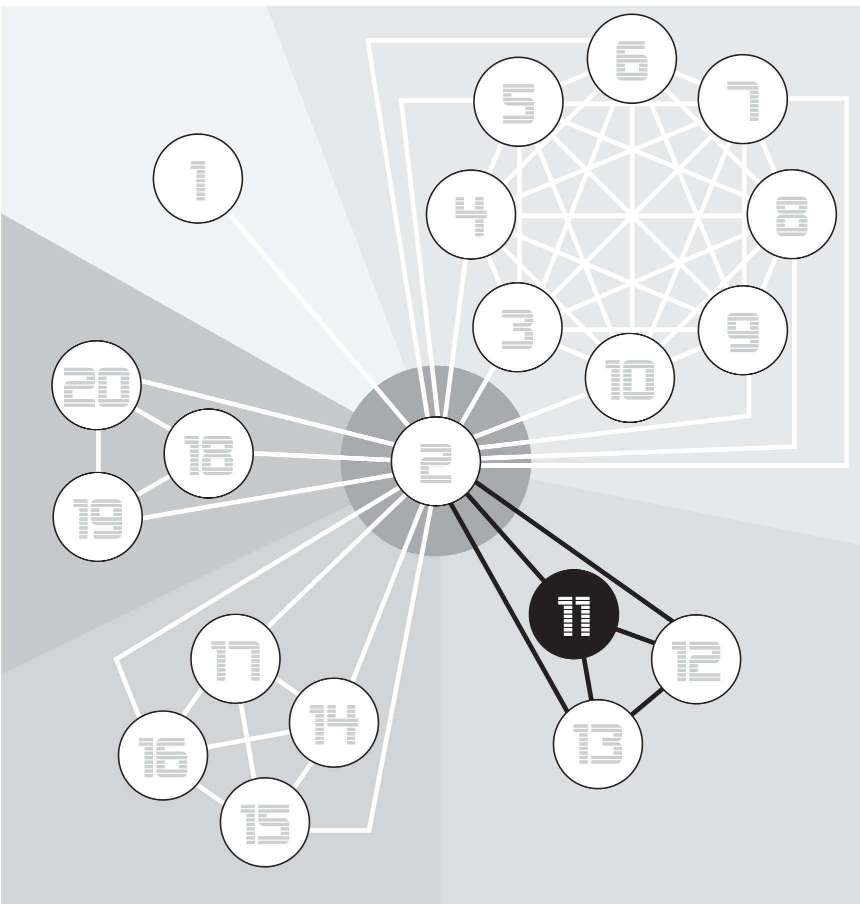
The field of RISC-applications in Part III of the book is devoted to three broad areas which cover a considerable amount of RISC-processes and RISC-related phenomena. As an overview, these broad areas lie in

- weather-related natural hazards and early warning systems with a special emphasis on the case of the strong precipitation, flash floods and landslides on September 18, 2007 in Slovenia [Jože Rakovec]
- a special brand of new technologies under the label of convergent technologies which recombine the areas of nano-technology, biotechnology, information technology and cognitive science [Toni Pustovrh]
- the subjective and cultural side of the perception of RISC-processes [Marko Polič].

In his article, Marko Polič points to a particularly important open problem which has to be solved within the RISC-framework. Looking at several contributions in Part II, especially the ones by Monika Gisler and Didier Sornett, by Günter Haag and by Günter Haag, Karl H. Müller and Stuart A. Umpleby, looking at Marko Polič' article and looking at the contributions in Part IV of this volume on RISC-prevention and damage control, the RISC-framework needs a general model of situated cognition which can serve as the basis for the social bubble hypothesis, for the self-reflexive boom-bust cycles as well as for the general problem of risk-perceptions and on perceptions and expectations in the case of actual disasters. Following Marko Polič, actions depend on risk perceptions, but they depend even more on subjective control, culture and social factors like trust or stigma. The cognitive sciences, with a special emphasis on situated cognition, should be capable of providing new models of cognition-based and emotion-based actions which move well beyond the scope of currently available models of bounded rationality or of psychological models of risk-perception. These new models should be able to highlight a logic of fear which serves as the missing link in the currently available stock of generative RISC-mechanisms and RISC-models.

11 Weather- and Climate-Related Natural Hazards

Jože Rakovec

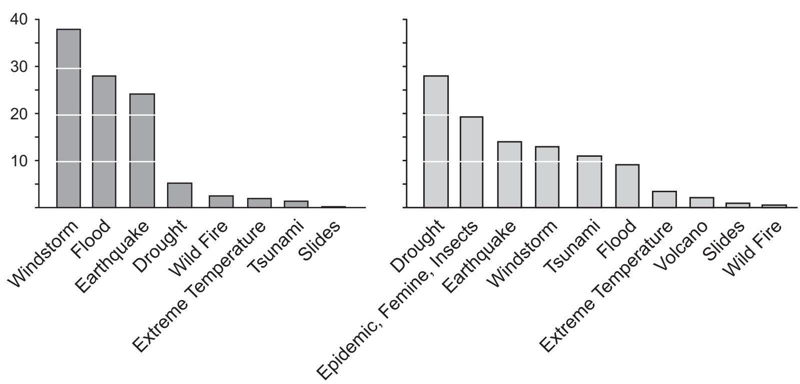


11.1 Introduction and Global Picture

Weather and climate-related natural hazards, including water-related hazards, account for nearly 90% of all natural disasters [WMO, 2007]. Thus, information that supports advance warnings, which save lives and reduce property and environmental damage, is of vital interest. Studies have shown that, apart from the incalculable benefit to human well-being, every dollar invested in meteorological and hydrological services produces an economic return many times greater, often ten times or more [WMO, 2007].

In different parts of the world, natural hazards cause damage of different magnitudes. In some places, tropical cyclones, hurricanes and storm surges are the most devastating phenomena; yet, in terms of casualties, cold spells or heat waves can also be very dangerous, while locust swarms or droughts, for example, may cause immense economic losses in many less developed countries. For example, in northern Africa droughts prevail as a cause of human loss, while in the Pacific region tsunamis are the biggest cause of tragic results. An alarm system has been established under the patronage of the World Meteorological Organisation [WMO] and covers all parts of our planet—[WMO: http://severe.worldweather.org/]. Regularly updated information and warnings are available in real time.

FIGURE 11.1 **Percentage of Global Economic Losses (Left) and Human Losses (Right) 1980–2005 According to Different Types of Hazard**



Source: M. Golnaraghi, WMO, 2008 [with acknowledgements]

11.2 Regional Scale

In the Central European regions, the most important and damaging losses are connected with severe thunderstorms and mid-latitude cyclone precipitation, which is often followed by floods; in mountainous terrain this often involves flash floods, landslides, debris flows, mudflows and in winter also snow avalanches.

An alarm and information system has been established for Europe [Meteoalarm, 2008, http://www.meteoalarm.eu/], which is also linked on the above-mentioned, globe-spanning Internet page. Almost all countries of the EU and the EEA as well as some other countries in Europe are participating with real-time information—one can click on the country to see warnings concerning specific natural hazards with five grades of danger (five colors). The system was originally developed within the scope of the Interreg IIIb program Meteorisk for the Alpine region.

In Slovenia there is a specific protocol for civil protection with two subsystems in place at the Slovenian Environmental Agency ARSO—one for weather-related hazards [ARSO, 2008a http://www.arso.gov.si/vreme/opozorila] and the other for earthquakes [ARSO, 2008b http://www.arso.gov.si/potresi/potresna%20 nevarnost]. The country also has a specialized, yearly publication devoted to natural and other hazards—UJMA (the word "ujma" means the rigors of the weather and the damage caused by them)—[UJMA 2009 http://www.sos112.si/slo/page.php?src=li11.htm].

11.3 The Specific Case of September 18th, 2007 in Slovenia

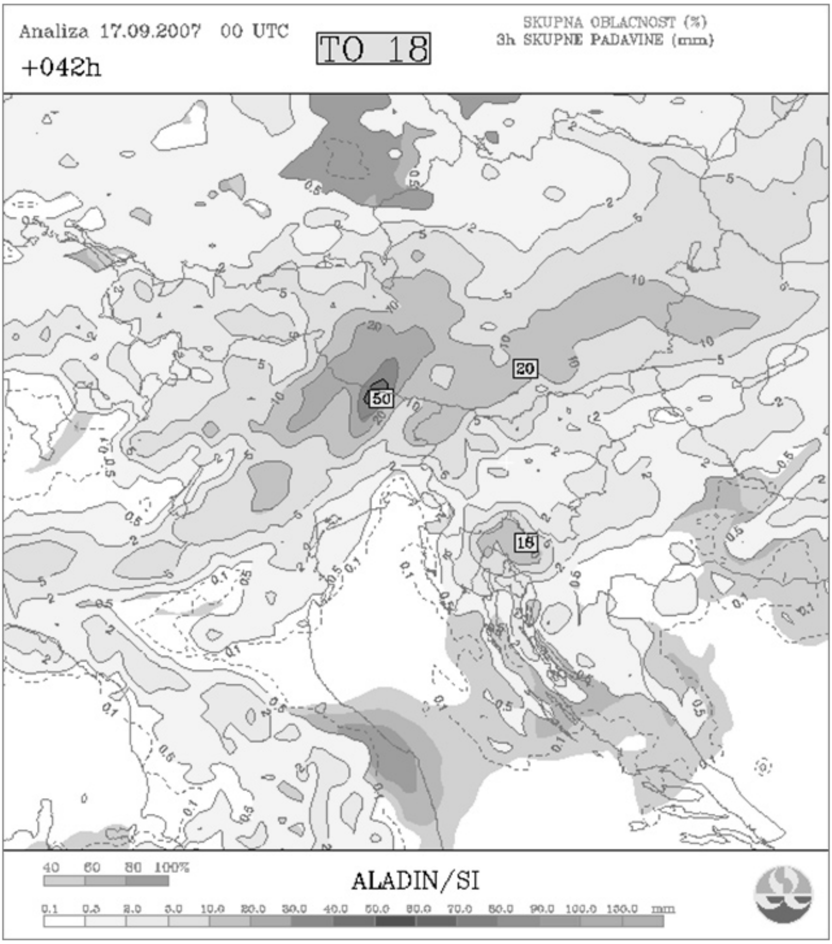
On September 18, 2007, Slovenia—mostly in the northwest—experienced a serious hazardous event of strong precipitation that had all the consequences associated with it occurring in a mountainous region: flash floods, mud flows and landslides, which unfortunately also involved casualties. From a meteorological point of view, the case resulted from a long-lasting advection of warm, humid air ahead of a cold front with stationery convection, persisting and triggering again and again at more or less the same locations for hours. Although the strong precipitation had been forecast well in advance, the intensity, duration and the exact location were not captured entirely [compare Figures 11.2 and 11.3] because it was difficult to forecast the exact location of the individual cells. The spatial accuracy was at about 50 km [Žagar, 2007 and ARSO].

An a posteriori view of the event reveals what still needs to be improved to properly handle this type of event: a forecast of the probability of extreme events and a high spatial resolution of forecasting. Running the same forecasting model with a finer, 2 km horizontal resolution fundamentally improved the quality of the forecast [Figure 11.4].

In addition, a high spatial density of on-line rain-gauges is essential for monitoring the evolution of the process in real time. Statistics on so-called "maximum probability precipitation" [Figure 11.5] shows high probability and intensity of such events during the autumn.

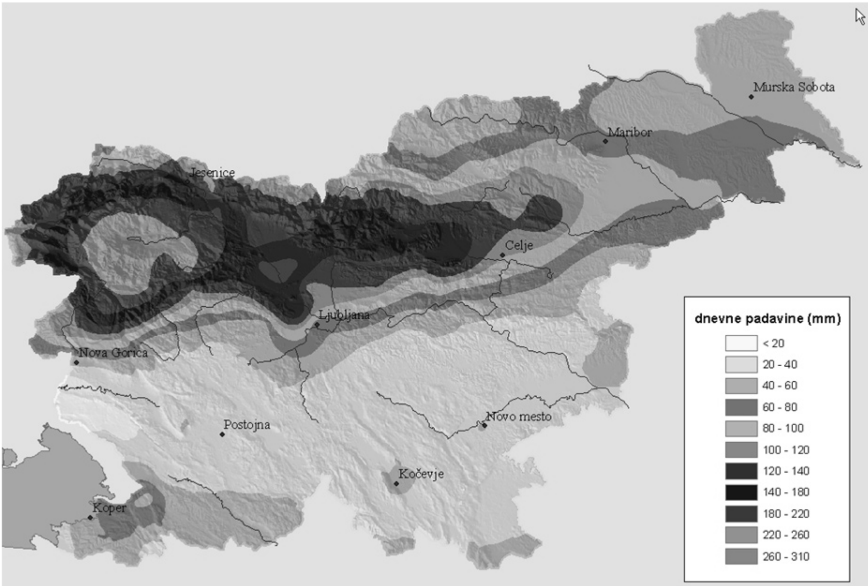
The event of September 18th is well documented [*e.g.*, in UJMA, 2008], and a video presentation about it is also available on the Internet: http://www.hydrate.tesaf.unipd.it/Movies/MovieSlo1.htm.

FIGURE 11.2 **Strong Precipitation was Forecast well in Advance (42 hrs) by the Operational ALADIN/SI with a 9 km Horizontal Resolution, but the Exact Intensity, Location and Timing were not Captured Entirely with ARSO's Operational Forecasting Model ALADIN/SI**



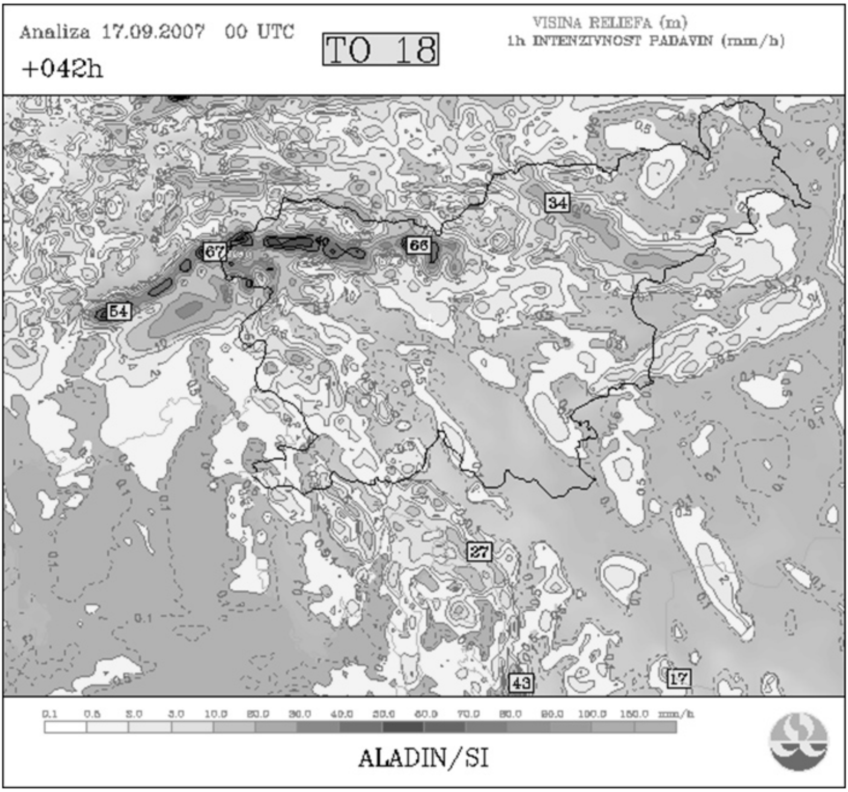
Source: Žagar, 2007, personal communication, Žagar, 2008 and ARSO; from the ARSO archive of operational forecasts [with acknowledgements to ARSO].

FIGURE 11.3 **The Regional Daily Precipitation Distribution for the Case of September 18th as Recorded by Rain Gauges**



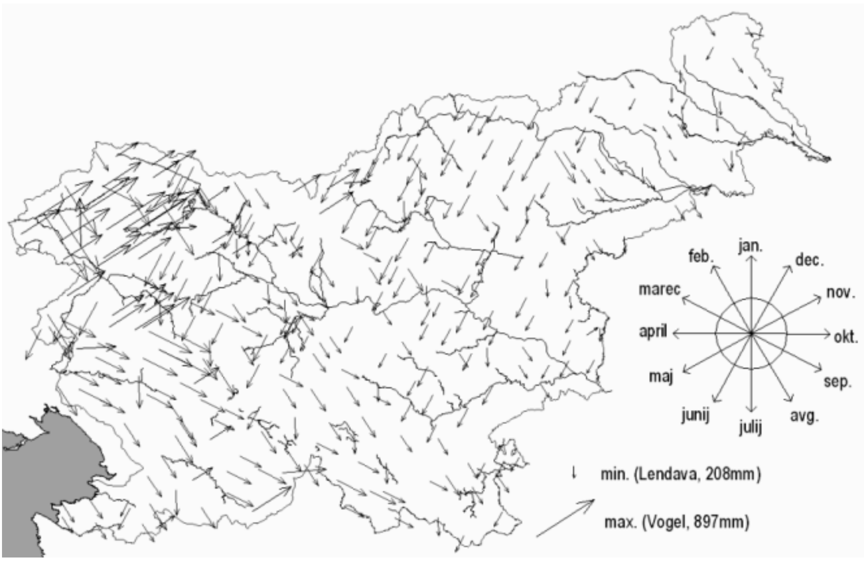
Source: Žagar, 2007, personal communication, Žagar, 2008 and ARSO [with acknowledgements].

FIGURE 11.4 **The Forecast Precipitation Amount for September 18th, 2007 with the Model Using a Finer, 2 km Horizontal Resolution**



Source: Žagar, 2007, personal communication, Žagar, 2008 and ARSO [with acknowledgements].

FIGURE 11.5 **The Computed Daily Probably Maximum Precipitation Accumulations According to Month of the Year**

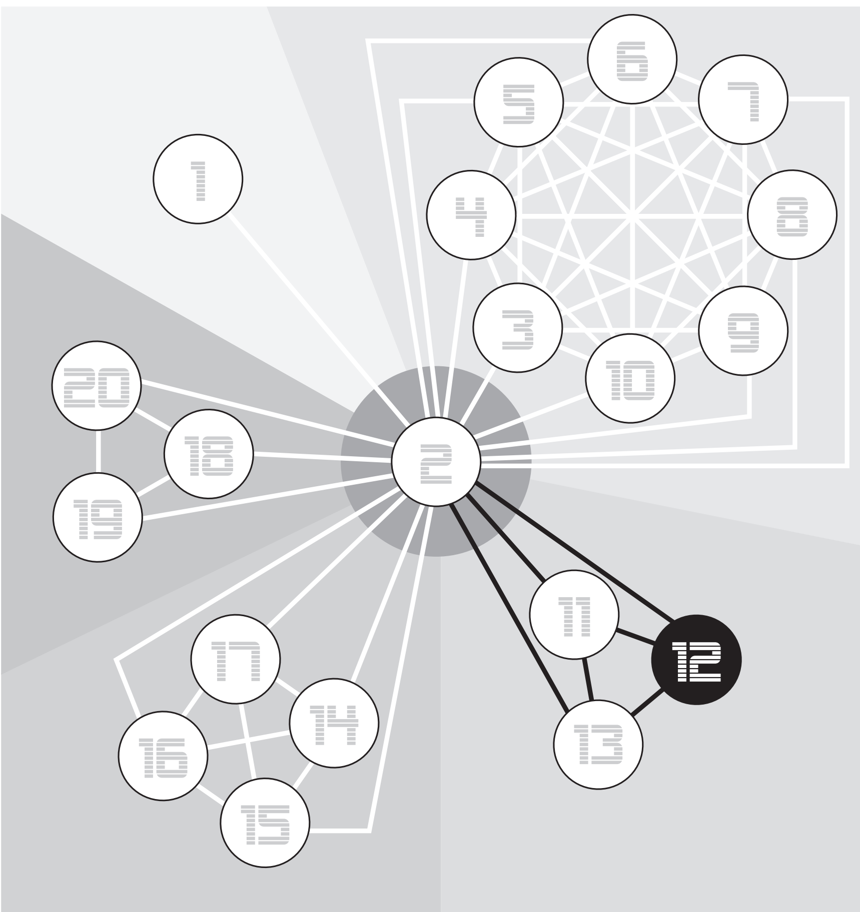


Note: The arrow lengths correspond to the precipitation amount and their orientation to the month of the year

Source: Rakovec and Vertačnik, 2007.

12 The RISC Potential of Converging Technologies

Toni Pustovrh



12.1 Introduction

Insights from chaos theory and complexity science have shown us that we inhabit a universe composed of interconnected, complex systems, where even small perturbations can produce events of rare incidence with strong consequences [RISC] on a global scale, affecting and transforming the functioning and structure of the systems inside of which they have emerged. Complex systems can be defined as composed of a population of diverse, connected agents, whose behavior and actions are interdependent and exhibit adaptation [Page, 2009]. Examples of such systems range from the multilayered, interconnected elements of the molecular and cellular machinery of humans and other multicellular organisms, through ecosystems and human societies, to the entire biosphere of the Earth. While complex systems tend to be quite robust and resilient, emergent events with wide-ranging consequences can, through the operation of feedback mechanisms and tipping points, cause severe disturbances and even breakdown across many levels.

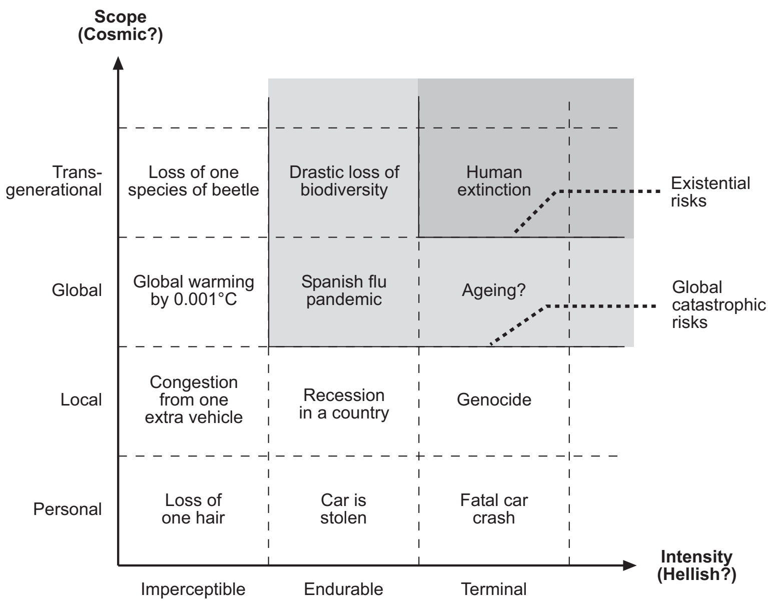
This article examines some of these large events and their potential ramifications, and it includes a short overview of major catastrophic events caused by the operation of physical systems without the influence of humans, as well as an examination of events arising from human actions that might be triggered by present or future developments in the fields of advanced technologies, especially technologies engaged in the molecular engineering of organisms. Such events could, on the one hand, lead to severely destructive, global catastrophic risks, like those that have already caused mass extinctions in the Earth's past, but they could also lead to advances that could enable human societies and individuals to become more resilient and better able to adapt to future changes in the environment. This article also argues that, despite containing large risks of their own, convergent developments in Nanotechnology and nanosciences, Biotechnology and biosciences, Information technology and information sciences and Cognitive technologies and cognitive sciences [NBIC] will be necessary to prevent or at least mitigate the consequences of "natural" and also of anthropogenic global catastrophic risks. Some of the mechanisms that have been proposed for controlling the risks of advanced technologies are also examined, along with potential wider implications for society.

12.2 Global Catastrophic Risks

"I think the odds are no better than 50/50 that our present civilization will survive to the end of the present century."
Sir Martin Rees

When we consider the magnitude of potential risks to humans, societies, species, ecosystems or the entire biosphere, we need to establish a conceptual framework within which we want to operate. Various risks can be found in all aspects of existence, but the severity of risks, as perceived from a generalized human perspective, can be categorized according to scope, ranging from personal to global and even to transgenerational, as well as according to intensity, ranging from imperceptible to terminal, as shown in the diagram in Figure 12.1. A third dimension of the probability of occurrence could be mapped on the Z axis.

FIGURE 12.1 **Qualitative Categories of Risk**



Source: Bostrom and Ćirković, 2008:3

While death in an accident or the loss of all personal property surely presents a catastrophic event for almost any individual, it does not represent a global catastrophe. A global catastrophic risk, as defined by Bostrom and Ćirković [2008:2], refers to a risk that might have the potential to inflict serious damage to human well-being on a global scale, for example, an event that results in the loss of 10 million lives or 10 trillion dollars. A rampant influenza pandemic would qualify as such an event, with large amounts of resulting damage and loss of life on a global scale.

An extreme subcategory of global catastrophic risk is existential risk. For numerous species throughout the history of the Earth, the global catastrophes that caused mass extinction events were existential risks that actually led to their extinction. Existential risks, as defined by Bostrom [2002], refer to the threats that might cause the extinction of Earth-originating intelligent life or drastically and permanently reduce its potential for future development. While the processes that might cause global catastrophes and existential disasters are basically the same, there is a difference in the magnitude of the consequences. Human civilization might recover from a global catastrophic event but not from an existential disaster. As there would be no opportunity to learn from experience, the approach in this case needs to be proactive and no existential disaster may be allowed to happen.

Depending on the nature of the processes that trigger them, global catastrophic risks can be categorized into "naturally" occurring, or non-anthropogenic risks, and human-made, or anthropogenic risks, which can be further divided into risks from unintended consequences and risks from hostile acts. Non-anthropogenic risks can, and have, occurred without the presence of human beings, while anthropogenic risks arise from human interventions in the various, complex systems comprising the Earth's geosphere and biosphere, either through the unintended side effects of technological development or through the deliberate, hostile use of technologies as weapons. Such divisions tend to be mostly conceptual; for example, earthquakes, triggered by plate tectonics, would occur even if humans did not exist, but the extent of the risk they pose to humans depends largely on the locations and architectural design of human habitations. With time, risks can also transition from one category into another; for example, the risk of starvation once depended primarily on natural factors, but it is now heavily influenced by political and social decisions and breakdowns [Bostrom and Ćirković, 2008:7].

12.3 Past and Present Global Catastrophic Risks

"Civilization exists by geological consent,
subject to change without notice."
Will Durant

The history of life on Earth is one of diverse life forms struggling to adapt to the new conditions of a constantly changing environment. Viewed on a geological timescale, the environmental changes and the stresses they place on organisms can remain localized and gradual over long periods of time, yet are occasionally punctuated by relatively sudden large-scale shocks with catastrophic consequences, which radically alter the global environment. These shocks have usually been followed by mass extinctions of numerous plant and animal species, with the gradual recovery of biodiversity taking from a few million to tens of millions of years.

Around 251 million years ago, multiple catastrophic events, probably worsened by the preceding gradual changes in the environment, caused the "Great Dying," the most massive known extinction in Earth's history, which wiped out an estimated 96% of all marine and 70% of all land species on the supercontinent Pangaea, including plants, insects and vertebrate animals [Benton, 2003]. Among the likely triggers of the Permian-Triassic mass extinction event are increased (super)volcanic activity, multiple impacts of comets or asteroids and a sudden release of methane hydrates from the sea floor. The gradual, detrimental changes preceding the catastrophic event might have included sea-level change, anoxia and increasing aridity [Tanner *et al.*, 2004]. While no comparable extinction event of this magnitude has transpired in the timeline of the human species, all the geological and cosmic processes underlying the catastrophic trigger events are still operating and may again initiate global changes with catastrophic consequences for life.

Some 65 million years ago, most probably a large asteroid [Alwarez *et al.*, 1980] punctured the Earth's crust, causing massive destruction around the impact site, and triggered severe earthquakes, tsunamis and volcanic activity on a global scale. The material from the impact was catapulted into the atmosphere; the debris crashed down, causing widespread conflagration of the forests, and the dust and particles blanketed the sky, blocking out the sun for months, which made photosynthesis extremely difficult. The gasses from the volcanic activity further poisoned the atmosphere, and the carbon dioxide released from the heated limestone caused severe increases in temperature. This Cretaceous-Tertiary event caused one of the larger extinctions, in which 75% of the existing species, among them nearly all of the dinosaurs, perished rapidly [Fastovsky and

Sheehan, 2005]. Asteroids and comets have frequently bombarded the Earth, and catastrophic collisions with particles of even greater magnitude cannot be ruled out in the future.

Between approximately 70,000 to 75,000 years ago, at the present site of Lake Toba in Sumatra, Indonesia, a supervolcano exploded with the force of 1,000 megatons of TNT and ejected an estimated 2,800 km^3 of lava and ash, enough material to cover an area the size of the United States. The ejecta severely changed the climate, triggering a large plunge in temperature, followed by a global volcanic winter [Linden, 2006], an ice age, which quite probably almost caused the extinction of the human race, reducing the global population to no more than 10,000 but possibly even to only 1,000 breeding pairs [Ambrose, 1998]. Although the Toba supervolcanic event is believed to be the most massive in the last 25 million years, at least eight other "mega-colossal" eruptions have occurred in the history of life on Earth, and such events might again threaten the existence of humans and other life forms.

The first two extinction-level events number among the "Big Five" [Raup and Sepkoski, 1982], the five major mass extinctions that have significantly exceeded the "normal" background extinction rate, with the death of over 50% of existing animal species at each event. Along with these major extinctions, more than a dozen minor extinction events are believed to have occurred in the last 550 million years of the current Phanerozoic Eon. The number of such events in the history of life is probably even higher, but fossil remains and other geological records are often incomplete, and a lack of animals with hard body parts that could have left a significant fossil record from the preceding Proteorozic and Archean Eons makes the investigation of earlier mass extinction events very difficult.

While all of these mass extinction events threatened the continued existence of life on Earth, as well as the subsequent evolutionary developments that eventually led to modern humans, the Toba global catastrophic event effected the human line directly, causing the extinction of all other human species, except small groups of the two branches that later became *Homo neanderthalensis* and *Homo sapiens* [Ambrose, 1998], thus probably coming closest to a total extinction of humanity so far.

Natural global catastrophes, such as the ones that caused several mass extinctions in the long history of life on Earth, occur intermittently on a geological timescale, rarely as observed from a human viewpoint, even though their consequences can have profound impacts on the affected environments and species. One theory of the general process of mass extinction is the "press/pulse" model [Arens, 2008], which postulates that large extinctions result when an ecosystem under long-term stress ("press") undergoes a short-term shock, a sudden catastrophe ("pulse") towards the end of the period of pressure. The theory is a response to the observation that neither long-term pressure nor a catastrophe alone has been sufficient to cause a significant increase in the overall extinction rate.

Among the most widely supported explanations for the causes of natural global catastrophic events, as also noted by Bostrom and Ćirković [2008], are impact events, supervolcanos, sea-level falls, flood basalt events [Courtillota and Renneb, 2003], sustained and significant global cooling and warming [Mayhew *et al.*, 2008], methane eruptions [Hecht, 2002], anoxic events, hydrogen sulfide emissions from the seas, oceanic overturn, superstrong solar flares, radiation from a nearby supernova or gamma-ray burst, continental drift and plate tectonics. It is probable that in many extinction events several of these geological and extraterrestrial processes reinforced each other, providing the "press" and "pulse" needed for global catastrophe.

The catastrophic results of many of these processes have also spurred evolutionary development and the eventual rise of myriad new species, as well as cleared already occupied ecological niches. Impacts of asteroids and comets have played an especially dramatic and possibly leading role in the development of the planet and the evolution of life on Earth [Schirber, 2009]. The Cretaceous-Tertiary impact event, for example, caused the extinction of the dinosaurs and had, in all probability, cleared the ecological niches that were gradually occupied by mammals, thus enabling the eventual rise of the human species. But while global catastrophic events have so far played a role of "creative destruction" in the evolutionary development of life on Earth, any one of them might just as well have caused the extinction of all complex life forms or even the total extinction of life on the planet.

Until the rise of humanity, no species was capable of anticipating, let alone understanding, such catastrophic changes in the environment. The life forms that survived the initial destruction of the event either adapted to the changed conditions or died out. Before the development of technological civilization, there was practically no possibility of intervening in the processes of the natural systems that produced such global catastrophes. Although all of these events lie in the comparably distant past, we still do not have sufficient knowledge of the underlying physical processes to be able to predict or to rule out the risk of their recurrence in our near future. With modern science and technology, we are, at least in theory, capable of averting some of the naturally occurring catastrophic events, or, at the very least, mitigating some of their destructive consequences. Some technologies that might enable such interventions will be mentioned in further sections. There, it will be shown that while relinquishing further research and development in the NBIC technologies might prevent some of the risks associated with their use, it would also deprive humanity of the tools that could prevent or mitigate non-anthropogenic global catastrophes and leave it vulnerable to threats that have already plagued it in the past and that have caused the extinction of countless other species. Since contemporary human civilization practically spans the entire globe, any comparable event in modern times would also present a global catastrophe for humanity, leading to a large loss of life, massive destruction of infrastructure and potentially even endanger the continued existence of the human species.

While our future survival may depend on continuing scientific and technological advances, our technological development has also historically had many unintended consequences. From the earliest primitive techniques, used to guide the evolution of edible plants and, later, of useful animal species, humans have started processes that have had long-term impacts on the environment. The clearing and burning of forests, followed by farming and the massive grazing of domesticated animals were the first human activities that eventually led to dramatic, unintended consequences: to extensive deforestation and soil erosion. While the employment of simple tools and proto-scientific techniques, gathered through accumulating traditional wisdom, provided great benefits for the survival and quality of life of early humanity, it also strengthened the human ability to influence and alter the environment in adverse ways. But it was not until the pace of scientific and technological development began to accelerate during the Western Enlightenment and Industrial Revolution that human activities spread across most of the world and our influence became global. Human activities since then have greatly transformed the planetary environment, affecting its climate and ecosystems in such profound ways that Paul Crutzen proposed the latest geological era in Earth's history, starting in the late eighteenth century, should be termed the *Anthropocene*, because of the global human impact on the planet and the changes this has caused [Crutzen and Stoermer, 2000]. Given that modern humans have evolved to thrive in a certain kind of world, in the mild, moderately wet and biologically abundant Holocene-type environment, radical changes in the climate and various ecosystems might have severe consequences for human societies [Steffen, 2009].

We are currently observing two major trends caused by the unintended consequences of using technology: climate change from global warming and an increasing loss of biodiversity. Climate change, as is now popularly widely known, is caused predominantly by energy generation processes that, as an unintended side effect, increase the amount of atmospheric carbon dioxide and other greenhouse gasses, adversely affecting the carbon cycle and numerous other processes [McElroy, 2003]. The other, associated trend is the current, widespread mass extinction of animals and plants, which began with the development and spread of humanity throughout the Holocene epoch. Some experts estimate that the present species extinction rate is approximately 100 to 1,000 times higher than the average background extinction rate throughout the history of life on Earth [Lawton and May, 1995]. The present extinction rate might be as high as 140,000 species per year [Pimm *et al.*, 1995], based on upper bound estimates. Almost all causes of the current mass extinction are related to human activities, among them deforestation and other habitat destruction, hunting and poaching, the introduction of non-native species, pollution, and climate change. Although some controversy concerning the "Holocene extinction event" does exist, especially concerning the number of species going extinct, we should keep in mind that most extinctions are never documented and that some species perish before they are even discovered. Numerous species are already "extinct" in the wild and now exist only on reservations. Unchecked, such developments could eventually lead to a drastic loss of biodiversity, which could further destabilize the environments in which human societies are embedded, and the sources of nutrition, pharmaceuticals and other materials we have come to depend on.

12.4 RISC in Converging Technologies

"We are as gods, and have to get good at it."
Stewart Brand

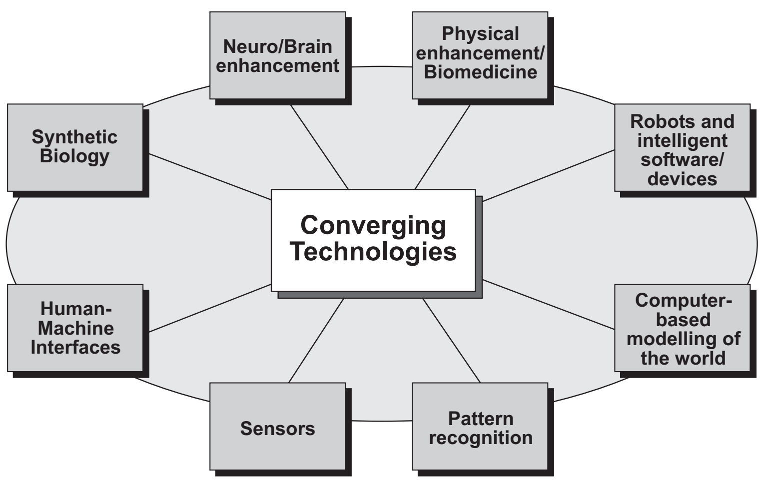
The closing decades of the twentieth century saw a rapid progression of biological and genetic sciences, an expanding understanding of the human brain, increasingly powerful and sophisticated information technology and the start of several initiatives aimed at stimulating progress in nanotechnologies and nanosciences. In 2001, a group of scientists, experts, business leaders and National Science Foundation officials from the United States formulated the concept of converging technologies and defined this as the synergistic combination of four major "NBIC" (nano-bio-info-cogno) provinces of science and technology. Each of these areas is progressing at a rapid rate:

a) nanoscience and nanotechnology;
b) biotechnology and biomedicine, including genetic engineering;
c) information technology, including advanced computing and communications, and
d) cognitive science, including cognitive neuroscience [Roco and Bainbridge, 2003:1–2].

The first and additional reports [Roco and Montemagno, 2004; Bainbridge and Roco, 2005; Bainbridge and Roco, 2006] anticipate a number of transformative applications emerging in the first half of the new century, ranging from advanced materials, microscopic robots, novel manufacturing processes, wearable miniature sensors and computers, through cybernetic implants and brain-machine interfaces, to intelligent software agents and the advanced genetic engineering of various life forms.

The United States' reports were followed by a European report that defined converging technologies as enabling technologies and scientific knowledge systems that support each other in the pursuit of a common goal [Nordmann 2004: 4], where insights and techniques of basic science and technology would enable convergence towards achieving a common aim, and the NBIC technologies would likely contribute to such a convergence [Nordmann, 2004:19]. In contrast to the more potential-benefit-focused US report, the European report centered largely on the potential risks and negative trends that might emerge from converging technologies.

FIGURE 12.2 **Application Areas of Anticipated Converging Technologies**



Source: Beckert *et al.*, 2008:8

The European CONTECS project, aimed at investigating and clustering the numerous applications of converging technologies envisioned in the US report, identified the application areas of neuro/brain enhancement, physical enhancement/biomedicine, robots and intelligent software/devices, computer-based modeling of the world, pattern recognition, sensors, human-machine interfaces and synthetic biology, as shown in Figure 12.2. Convergence itself can be seen as an abstract concept, providing guiding principles for general scientific development (top-down) in the sense of a guiding vision, or as a process that is already occurring in concrete application areas without comprehensive planning and principally even without knowledge of the concept (bottom-up) [Beckert *et al.*, 2008:8].

Many well-known futurists, innovators and science writers have identified the same broad fields as sources of future transformative and disruptive technologies. Ray Kurzweil [2005] writes of GNR (genetics, nanotechnology, robotics), Douglas Mulhall [2002] of GRAIN (genetics, robotics, artificial intelligence and nanotechnology) and Joel Garreau [2005] of GRIN (genetic, robotic, information and nano processes).

While the European report and the CONTECS project are more reserved regarding the timeframes and even skeptical of the feasibility of many of the advanced technological applications proposed in the US reports, development in the fields engaged in the genetic and structural engineering of organisms is progressing rapidly, and the anticipated benefits and risks are large. The rest of this section will focus on the technologies enabling molecular engineering of biological, self-replicating organisms, since these are subject to evolutionary processes and might be more prone to functioning in unanticipated ways.

Although the practice of altering natural systems so that they serve human needs is not entirely new, as domestication and "traditional" techniques for the selective breeding of plants and animals have been employed for at least ten thousand years, new technologies of manipulating matter with increasing precision at ever smaller scales, that is, molecular engineering, brings a new dimension to the endeavor of altering biological entities.

There are a number of qualitative differences between the classical trial-and-error approaches of selective breeding and modern genetic manipulation technologies. The human communities practicing the crossbreeding of crops or domestic animals were geographically distant and often isolated from each other. The experiments extended over several generations of plants or animals; the amount of changes that could be induced in the genome was quite limited, and if the results produced toxic or other negative effects, those remained confined to the affected community. In the worst case, the community, together with the unsuccessful hybrids, died out without affecting a significant number of other human populations, as the modified organisms could not spread to more distant regions of the world.

But conditions have changed greatly since the times when the total population of humans on Earth still numbered in the millions. Developments in genetic and other sciences over the past decades have greatly extended the scope of physiological features that can be achieved through alterations at the molecular or cellular level as compared to what can be created through classical reproduction. Expression of desired traits no longer requires selective breeding over several generations of plants or animals, but can be achieved through direct genomic interventions in a single generation. Also, the world in which we live nowadays is highly interconnected, a "global village," where transportation networks enable access even to remote regions of the world in a matter of hours.

Although many of the desired primary effects of manipulating biological organisms are known, the potential side effects and unintended consequences of such changes for the organism itself and the wider systems it interacts with are not. Though historical selective breeding operated on the basis of gathering knowledge with much the same trial-and-error approach that is used in modern genetic and reproductive sciences, the consequences from these modern interventions could have a much greater impact.

We are now beginning to realize that the world is composed of complex systems and that testing in the controlled conditions of the laboratory or on single-type cell cultures may yield completely different interactions than would the use of the technology in the "wild" of the human body, society or ecosystem. Such multilayered interactions can potentially affect the health and well-being either on the physiological and mental level of the individual or on the societal level in the form of undesirable economic or social trends. On yet another level, they can adversely impact individual ecosystems and disrupt the intricate networks of animal and plant interactions. The introduction of species from other habitats into new ecosystems has already created severe imbalances, and it remains open what unforeseen effects altered or even newly created species of plants and animals might have on existing food webs. Higher organisms themselves can be viewed as complex systems, and altering specific genes or pathways affects the functioning of the entire network of molecular and cellular interactions, possibly yielding completely new and unanticipated results.

Moreover, human technologies are enabling the operation of processes at speeds that are many times faster than those at which evolution through natural selection operates, which leaves ecosystems and societies less and less time to adapt to the changed conditions. Also, the creation of transgenic animal and plant species enables the "transplantation" of genes between species, and even between plants and animals. This might not be problematic in cases of organisms that are used in closed, controlled environments, such as the laboratory or a production facility, but when transgenic organisms advance into commercial livestock animals or crop plants employed in open ecosystems, they might affect the existing networks in unforeseen and possibly adverse ways [Horn, 2004].

The overwhelming pressure from private and increasingly even public investment capital to reap immediate financial rewards from the commercialization of new technologies demands that new products be rapidly brought to the market, even though not nearly enough time has passed for potential long-term side effects to manifest themselves. Goods are thus quickly available to the consumer, and potentially dangerous products can be found in the stores or fields of any country, rapidly commercialized and delivered through global economic and transportation networks. Potentially dangerous effects of medical, industrial, agricultural or other technologies would thus not remain confined to a particular region or country, but could break out all over the globe simultaneously, possibly producing an international or even global crisis.

A more recent development in the category of genetically modified organisms alongside GM crops is the research aimed at producing meat in vats. The prospect of muscle tissue grown in vitro [Edelman *et al.*, 2005] offers the potential of producing large quantities of protein without having to rely on the biological mechanisms and requirements of the whole animal. Such advances could enable the nourishment of a greater number of people while consuming fewer resources, such as feed and grassland, producing less methane and eliminating some of the ethical concerns associated with the treatment and status of animals used in food production.

On the other hand, all the intricacies of the genomic, proteomic and metabolomic processes are not yet completely understood, and molecular-level alterations of materials we ingest daily might produce defects or changes that would not be immediately apparent.

For example, the emerging science of nutrigenomics [Trayhurn, 2003] shows that the myriad phytonutrients, found in various grains, fruits and vegetables, interact with our genes and effect favorable genetic expression. In short, the type of food we ingest directly affects our health, an idea that also forms the basis of the whole-food versus processed-food debate. Changes at various levels might produce a lack of previously present micronutrients, proteins or other bioactive molecules, or create defective or functionally altered bioactive molecules. What effects such permutations might have on the modified organism itself, on the greater environment in which it operates or on the consumer of products that are derived from it is very difficult to foresee, but if they reduce the health or impair the function of other organisms in an ecosystem, or adversely affect human health, a prolonged time of testing in limited but actual conditions of use might be warranted, as adverse effects accumulate over longer periods and operate synergistically with others, producing often unconsidered negative effects on human and environmental health.

Other concerns regarding GM crops have also been expressed, among them the horizontal transfer of inserted and novel genes into unaltered plants of the same or of other species, as well as a decisive competitive advantage over other plants. Such developments could result in the loss of biodiversity and thus the reduced adaptability of ecosystems and human societies to changed environmental circumstances. Projects like the Millennium Seed Bank [KMSBP, 2009], which aims to store the seeds of as many plant species as possible to preserve and potentially reintroduce endangered and extinct species, might serve as a type of backup against such risks. Similar projects storing human and animal embryos, germ cells or decoded genomes might help preserve ancestral diversity, although in the case of animals, possible "proto-cultural" elements that are not encoded in the DNA but transmitted through interaction with offspring might be lost. In the case of extinct species, there might also be problems with finding an animal that is genetically similar enough to successfully carry out the gestation of the embryo.

Conversely, decreased amounts of fertilizers and pesticides, herbicides and fungicides, which are massively and constantly released into the environment in conventional agriculture—absorbed into the soil and water and ingested by numerous animals and non-crop plants—could count in favor of the more "genetically" resilient GM crops.

The importance of the latter could increase, especially if the effects of climate change indeed worsen the weather and climatic conditions needed for agriculture. Engineered plants, more resistant to droughts, torrential rains and other extreme weather conditions, could enable continued food production even under worsening conditions. The same could be said of muscle tissue grown in vats. Depending on future conditions, it might no longer be a question of choice but of necessity.

While GM plants and animals involve multicellular organisms, another area of molecular engineering that promises great benefits and also great risks works to engineer autonomous microorganisms, such as bacteria, as part of molecular biology, synthetic biology and the wider conceptual field of artificial life.

There are numerous efforts to produce microbes that could be employed for various medical or industrial tasks, from producing biofuel [Williams, 2008] or transforming waste into reusable materials [Burkart, 2009], to synthesizing novel pharmaceuticals or serving as medical biodevices. This could either be accomplished by modifying existing microbes or by creating novel microbes through assembling various component parts. One of the goals of synthetic biology is to produce standardized, modular components that can be inserted into a cellular chassis, thus creating the components for a customizable microorganism. Several milestones towards the goal of creating customizable microorganisms have already been achieved, such as the open source, BioBricks Foundation [BBF, 2009] registry of standard biological parts and the commercial, Gingko Bioworks [Singer, 2009] strings of specific genes, while a number of companies are working towards putting the various components together and creating microorganism life de novo or transplanting a genome into a cellular chassis and letting the internal machinery do the work [Herper, 2006; Pilkington, 2007].

Parallel to the academic and industrial efforts in synthetic biology, with the increasing availability and falling costs of molecular biology tools needed to perform molecular interventions, a new hobby movement has begun to take shape.

Like the classic do-it-yourself [DIY] home fabrication, improvement and repairs that began in the 1950s, and the later-appearing computer code hackers, we can now observe the rise of biohackers and a DIY biotechnology community. The biohackers use homemade and purchased molecular biology equipment in makeshift attic and garage labs to cultivate viruses, breed algae or experiment with genetic modifications of bacteria [Whalen, 2009]. Part of the scientific community is not unwilling to cooperate with the DIYBio community, sharing insights, knowledge and enthusiasm as well as similar goals [Riddel, 2006]. One of the goals of DIYBio is to open molecular biology, and possibly synthetic biology, to everyone, just as the open source movement did for computer codes. While it does not seem very probable that hobby biohackers, using homemade, makeshift equipment and engaging in various molecular biology experiments, could produce breakthroughs to rival the biotechnology industry, there are some concerns regarding safety and security for both communities.

Evolutionary processes on the microbial level proceed much faster than those on the level of macroscopic animals and plants, and unanticipated consequences and adverse side effects can arise quite rapidly as viruses and bacteria mutate over many generations in a matter of weeks.

That deadly pathogens can be created accidentally in the laboratory was already proven in 2002, when Australian researchers accidentally created a modified mousepox virus with a 100% morbidity rate while trying to create a contraceptive virus for mice. It is not inconceivable that a similar process might yield a human pathogen from the smallpox virus [Bostrom, 2002:7–8].

But in the end, the threat posed by the accidental release of unintentionally engineered pathogens or invasive microorganisms is not as alarming as the intentional creation and release of weaponized, designer pathogens by rogue states and non-state actors, such as terrorist groups or vindictive individuals. Engineering a pathogen might achieve increased morbidity, long latency and high virulence, and a strategic release of a pathogen with such properties in a global transportation hub would ensure the rapid spread of the dormant virus among air travelers and dispersal to all parts of the world, creating a deadly, global pandemic. Pathogens might also be tailored to target crop plants or livestock, which would also pose the threat of an eventual pathogen transfer to humans, as in the cases of the avian and swine influenzas. Even predominantly unsuccessful attempts at bioterrorism might cause large economic costs and social disruption through panic and other psychological effects [Nouri and Chyba, 2008:466–468].

An investigation into the availability of needed tools, especially DNA synthesizers, showed the equipment to be widely available for purchase, even through eBay, and that most materials could be ordered from companies synthesizing various molecular building blocks [Boutin, 2006]. Although it also showed that even with all the needed equipment at hand, the creation of tailored pathogens would still take skilled personnel and time, the increasing sophistication of genetic engineering tools, decreasing prices and the free access to knowledge online are making such a threat a growing possibility, especially at a time of asymmetric warfare.

Several calls and initiatives have been voiced to limit such threats; these range from limiting the open purchase and availability of molecular biology equipment to the screening of orders for custom-made DNA.

Some guidelines for increasing the safety and security in synthetic biology through community self-regulation have been drafted [Maurer *et al.*, 2006]; these have similar goals to what the Asilomar conference in 1975 achieved for genetic engineering, which yielded a temporary moratorium on some experiments until their safety could be further assessed. The Synthetic Biology 2.0 meeting rejected the self-governance guidelines, arguing that the field should be subject to further public debate and government regulation and that it was too early to impose the limiting protocols set forth in the guidelines [Aldhous, 2006]. They did, however, agree to develop better software detection for orders of potentially dangerous DNA sequences and to report suspect experiments.

Recommendations for the development of a national biological defense system, Bioshield [LF, 2009a], have also been made and have received some support in the US Senate. Such a system would encompass rules and regulations intended to slow the development of bioweapons (screening orders for synthesized DNA, consultations with researchers regarding the safety of their experiments), the development of security systems (stockpiling breathing protection equipment, antiviral medication and the placement of UV sterilizers in air ventilation systems in airplanes and public buildings), as well as technologies to fight pathogens (detection and identification, smart materials with antiviral coating, sequencing technologies and software for the modeling of antiviral agents).

Prominent scientists have also cautioned against making the sequenced genomes of pathogens, such as the 1918 influenza strain, publicly available online [Kurzweil and Joy, 2005], because these might be used to create engineered pathogens. But the balance between restricting data and making it publicly available is hard to determine, since a vaccine for the strain of the 1918 influenza was developed using the very same publicly available genome sequence [Hughes, 2008:82]. On the other hand, researchers have already synthesized the complete genomes of the polio virus in 2002 and the 1918 influenza in 2005 using only published DNA sequence information and mail-order raw materials [Bailey, 2007].

While no concrete proposals have been made so far for the creation of a regulatory body that would, in addition to synthetic biology, cover the DIYBio community to prevent potential biosafety and biosecurity threats, US security agencies have already shown interest in the activities of individual biohackers [Whalen, 2009]. Proponent scientists and hobbyist have argued that too strict regulations imposed from the outside would stifle innovation and interest in working in molecular biology fields, and that having a significant segment of citizen scientists be biotechnologically literate would be positive in case of a biotechnology-related disaster or bioterrorist attack. The discoveries and innovations in the scientific and DIYBio communities could also enable and hasten the development of prophylactic measures against bioterrorist attacks. Too restrictive regulations or even bans might slow down research and development in the professional and hobby scientific community but not necessarily for rogue research projects. Such restrictions would also slow down efforts to keep pace with accidentally occurring pathogens responsible for pandemics, such as the 1918 influenza, the bird flu and the swine flu.

The expert opinions on whether it is even possible that a bioengineer might create a pathogen which causes high morbidity and mortality as well as high virulence differ greatly. That is the reason some [Anissimov, 2009a] have called for an experiment or demonstration of a highly virulent, genetically engineered pathogen, released in a containment facility with the intention of killing a specific test species, such as mice, or human tissue, such as lung cells. The goal of this would be either to prove that an engineered organism can successfully infect and kill a significant number of test animals, which would raise awareness of the risk and confirm the need for further studies and biosecurity and biodefense measures, or, if proven unsuccessful, to ameliorate the concerns about engineered pathogens. Since biodefense research laboratories have operated for decades with thousands of naturally occurring pathogens, it is unlikely that such a proof-of-concept creation of a pathogen would increase the risk of accidental release, although there have been cases in which laboratory personnel have become infected and spread the infection to the outside [Nouri and Chyba, 2008:460].

Molecular and synthetic biologists are also trying to engineer microbes that could be employable for various energy generation and industrial purposes. With increasing concerns over the waste of resources used in non-recyclable and non-biodegradable products as well as their impact on continued environmental pollution and ecotoxicity, engineering microorganisms capable of decomposing, for example, plastics and glass, as well as able to break up dangerous chemicals into reusable or at least nontoxic materials, thus greatly contributing to recycling efforts and the remediation of toxically polluted areas, is an approach that is increasingly garnering attention. Similarly, the anticipated catastrophic effects of global warming, caused by carbon-based energy generation technologies, and the potentially declining deposits of oil are creating a push for novel types of renewable and clean energy technologies, one of which might be bacteria capable of producing biofuel and storing energy [Chopra and Kamma, 2006], or microorganisms that bind greenhouse gasses.

As in the case of tailored pathogens, one concern is that such engineered, industrial bacteria might escape control and survive outside the zone of operation, replicating out of control and continuing to feed on human-made materials, such as plastics, or fuels, such as petroleum. On the other hand, bacteria that can break up oil already exist in nature [Sanderson, 2007], and some tweaked varieties have been employed for bioremediation in oil or petroleum spills [Valente, 2003] without causing runaway accidents. Some [Graham-Rowe, 2006] claim that the organisms employed so far were quite inefficient and that more efficient versions could be developed with newer techniques. If the metabolic processes could be sufficiently improved and the bacteria themselves made more robust, the risks they might pose would increase.

The greater risk, as with pathogens, would again be intentional hostile use either by national militaries or by terrorist organizations, rather than accidental release. Such microorganisms would not directly target the human body but rather the infrastructures of civilizations, and such runaway processes might, if left unchecked, lead to a global catastrophic event comparable or even exceeding a global pandemic caused by a tailored pathogen. The probability of such a development might be very low, but the degree of uncertainty and the extremely high costs of an adverse event do warrant at least some further investigation and possibly safety measures.

As insights and tools from the biotechnologies and biosciences converge with developments in nanosciences and nanotechnologies, as well as with increasingly powerful software and hardware from information technologies, the capability for manipulating matter on the micro- and nanoscale with greater precision promises great advances in medicine, computation and manufacturing [Hall, 2005]. We can observe the first phase in the production of nanoparticles and nanomaterials with novel properties, which have already opened debates concerning health and environmental safety, but the creation of nanodevices capable of self-replication and manipulation on the micro- and nanoscale holds even greater disruptive and transformative possibilities.

Some experts [Freitas and Merkle, 2004] conjecture that such advances in molecular nanotechnology might eventually produce less biological and more mechanical—and thus more easily controllable and programmable—nanotools and nanodevices, especially in the areas of nanomedicine and molecular manufacturing. Whether engineering such devices will continue to employ exclusively biological components and be limited to producing biologically inspired "soft machines," as Richard Jones speculates [Jones, 2004], or whether we will eventually see "mechanical" nanoscale robots and production facilities remains open. It seems likely, however, that hybrid nano-biotechnological devices, employing both biological and non-biological components, will probably represent the norm in the mid-term development [Vogel and Baird, 2003].

Just as with genetically engineered bacteria, plants or animals, one of the critical steps towards making such devices, manufacturing tools or robots practically useful would be the capability of replication, either through self-replication, imitating biological systems or through mass production in miniature assembly lines. Medical applications might range from nanodevices capable of locating and destroying tumor cells, to removing arterial plaque and delivering drugs to specific sites. While such breakthroughs would have enormous implications for individual health as well as for issues related to healthcare expenditure, they carry their own, specific risks. The human body is a chemically highly reactive place, where an enormous number of interactions between various components take place. In such an environment, molecular and cellular machinery becomes damaged and its functionality changed, and nano-biotechnological or other synthetic devices would be no exception.

Alan Goldstein [2006] proposes a scenario in which billions of nanobiorobots are introduced into the body as part of cancer therapy, each equipped with a protein arm designed to dock with a tumor cell. If the arm of one was damaged through catalytic recombination or chemical damage so that it bound to a different type of cell, the nanobiobot could remain in the body indefinitely, like cryptic viruses such as Epstein-Barr. Thus there could eventually be thousands of people carrying cryptic nanobiobots. As part of further therapies, nanomedical devices, designed to reside permanently in the body by using metabolic energy as a power source, might be introduced into people already carrying cryptic nanobiobots. If some of the former and the latter were to meet, they could conceivably combine or exchange components through physio-chemical damage or some type of catalysis mediated by the host's own complex biochemistry, thus producing a "mutated," hybrid nanobiobot, possibly with completely novel functionalities and tasks. Another possibility would be a "prion" scenario, where one of the billions of nanobiobots in the body is damaged or modified and, as a result, gains the ability to convert other nanobiobots in a manner that alters their longevity, tissue target, etc., similar to what prions do.

Beside having potential effects on the health of the affected individual, further recombination or exchange of information between the altered nanobiobot and other nanobiodevices, the body's own biological machinery or invading viruses or bacteria might produce the capability of crossing over to another person through the air by using aerosols, similarly to flu viruses, or even crossing to human offspring by attaching to germ cells or by invading the growing fetus. Thus they might spread through the wider population.

Moreover, as Goldstein notes, the defensive mechanisms and immune systems of living beings that make up Earth's ecosystems, from human bodies to tropical rainforests, have developed to recognize RNA- and DNA-based invaders, employing quite similar cellular machinery. The introduction of life forms based on novel information storage and construction machinery might make them unrecognizable to cellular defense mechanisms, or they might be equipped with membranes too resilient to attack.

Just as “naturally” occurring life is subject to constant change and continually adapts to an altered environment, so exists the possibility that nano-biotechnological devices will be subject to the same processes.

As we have seen, there are numerous realized and anticipated breakthroughs through the convergence of the expansive domains of NBIC sciences and technologies that could be labeled as “molecular engineering of organisms.” All are expected to have highly transformative consequences, both in the sense of benefits as well as risks. One type of taxonomy has been proposed [LF, 2009b] in order to help keep better track of developments and thus potentially enable the timely assessment and harnessing of the risks and benefits that might follow research and development and eventual deployment.

This taxonomy does not categorize by scientific discipline or technological field but by type of organism produced, thus dividing the results of molecular engineering of organisms into natural-biological, genetically-engineered-biological, synthetic-biological and synthetic-nonbiological.

The Type 1 life form category “natural-biological” encompasses organisms in which all information necessary to execute the minimum set of physical and chemical operations needed to complete a life cycle (operational information) must be stored in the DNA and/or RNA. Such forms must have been produced either by terrestrial evolution or by human manipulation at or above the cellular level of organismal structure, which includes plants and animals produced through conventional breeding as well anything down to the products of in vitro fertilization.

The Type 2 life form category “genetically-engineered-biological” also has all operational information stored in the DNA and/or RNA. Such organisms are created through direct human intervention below the cellular level of organization, using a top-down strategy where existing biomolecules are rearranged or chemically modified. Such organisms could be created using recombinant DNA and the other tools of biotechnology, as well as subcellular methods such as somatic nuclear transfer.

The Type 3 life form “synthetic-biological” also has all operational information stored in the DNA and/or RNA but is created by direct human intervention, using a bottom-up strategy whereby the biomolecules necessary to initiate life cycling (DNA, RNA, proteins, cell membrane) are synthesized and assembled in the laboratory de novo from nonliving chemical precursors rather than created from pre-existing biomolecules.

The Type 4 life form "synthetic-nonbiological" or "animat" has the defining characteristics that all operational information is *not* stored in the DNA and/or RNA. A completely synthetic-nonbiological organism would not use any biomolecules to store information or execute life cycle operations. The first synthetic-nonbiological life form will likely be a hybrid organism where one or more essential life-cycle operations is carried out using chemistry outside the parameters of biological life.

In the coming decades, we will probably see the development of multi-hybrid life forms containing natural, genetically-engineered and synthetic-biological components as well as one or more synthetic-nonbiological components. This "breaking of the carbon barrier," the elimination of the distinction between living and non-living matter through the creation of Type 4 organisms, or artificial life, could represent one of the events of very rare incidence with very large consequences, possibly comparable to the rise of biological life itself. Part of such consequences is also the level of risk that "animats" or the other types of engineered organisms might pose to natural-biological organisms and to the wider complex systems comprising the Earth's biospehere.

Further development of engineered biological, nano-biotechnological or possibly "mechanical" machines and tools on the micro- and nanoscale could lead to their employment as assembly-line robots, enabling the development of macroscale nanofactories [Phoenix, 2008], which would be capable of using a wide range of simple materials to produce a wide range of products when given the proper assembly instructions, including currently regulated products in medicine and pharmaceutics, industry and military, possibly including even the capability to replicate the nanofactory itself. Such production capabilities would represent another highly transformative and disruptive technology with a wide range of potential consequences for society, the economy, military, security, and geopolitics.

On the one hand, such capabilities might produce cheaper and more efficient water filtration systems, solar energy collection and energy storage systems, housing systems and computation devices and reduce the generation of pollutants currently created in agriculture and industrial manufacturing [CRN, 2008a]. On the other hand, they could cause economic disruption through an abundance of cheap products, economic oppression through artificially inflated prices, social disruption through new products and lifestyles, risks from criminal or terrorist use or even an unstable arms race [CRN, 2008b].

While there is still considerable disagreement among experts as to whether such nanofactories are actually feasible [Jones, 2005], molecular manufacturing would not have to necessarily rely on the workability of the "dry" type of molecular nanotechnology [Drexler, 1992] but could alternatively also be achieved using biologically inspired "wet" molecular nanotechnology [PNWG, 2007]. For example, a synthetic ribosome could be employed as part of a molecular assembly line, producing functionally desirable proteins, which could be further processed by a tailored Golgi apparatus, along with other necessary organelles. Of course, the range of products and novel materials that could be produced in this manner might be more limited than what could theoretically be produced using "dry" molecular nanotechnology. Further progress in enabling technologies, especially in efforts like diamondoid mechanosynthesis but also in synthetic biology, will show whether the nanofactory type of molecular manufacturing deserves greater attention regarding potential future impacts.

All the previous investigations have dealt with the benefits and risks that might arise from increasingly precise molecular engineering of living organisms, ranging from unicellular bacteria to increasingly complex forms. But as Michael Anissimov [2009b] has pointed out, novel self-replicating entities might not need to be living or even be at the complexity level of a virus. Advances in chemical technology might produce non-biological molecules with novel properties, which could serve many useful applications but could possibly also react with the human body or the environment in new ways, one of which might result in the capability to spontaneously self-replicate. Autocatalytic processes are already found in nature, but just as synthetic-nonbiological organisms could introduce a completely new set of rules into the complex systems of the biosphere, so might chemical molecules with properties that have thus far not been present on Earth trigger unforeseen and potentially disastrous reactions. We are already on the verge of introducing novel nanomaterials into our production and consumption cycles, both in household products, cosmetics, pharmaceuticals and possibly as fertilizer [Khodakovskaya *et al.*, 2009], although we still know very little of their short- and long-term effects and whether they might be able to accumulate in human, animal or plant tissue or in soil when released into the environment. Possibly, some nanomaterials might even be able to penetrate cell membranes and damage intracellular machinery.

12.4 Conclusion

As we have seen in the sample cases of "molecular engineering" developments, there are many new and potentially transformative technologies that are already emerging or are anticipated to emerge from the convergence of advances in NBIC sciences and technologies. While they are expected to provide great benefits for humanity, all of them seem to carry risks, ranging from those to individual health and well-being, through disturbances and dangers to communities and ecosystems, to potentially global catastrophic risks, either from unintended consequences or from deliberate hostile use.

Fearing that such risks might be so large that they outweigh any potential benefits, some [McKibben, 2003] have already called for a relinquishment of further research and development in converging technologies, while others [Joy, 2002] have proposed that fields such as genetics, robotics and nanotechnology require, at the very least, strict regulation and oversight, or possibly even comprehensive bans of technological research, in order to reduce their risks.

As the short overview of global catastrophic risks of non-anthropogenic origin shows, various physical mechanisms that operate in the universe can trigger events that are highly destructive for human and other life on Earth. In the end, it might be the deeper understanding of the mechanisms driving such phenomena combined with the use of advanced technologies that enable humans to avert global catastrophes, or at least lessen their effects, thus ensuring the preservation and continuation of life on Earth or, in the case of a severe event, possibly in extraterrestrial habitats.

NBIC innovations could enable more efficient sensors, computational devices, molecular engineering tools, and thus better agricultural, manufacturing and energy generation processes, driving the resolution of some of the current problems in health, energy, transportation, manufacturing and the environment. Miniaturization of sensors and machines, with more efficient access to space, might enable the early detection [Mason, 2009] and diversion [Keim, 2009] of a comet or asteroid on a probable collision trajectory with the Earth. Similarly, new technologies and more realistic models, powered by more powerful computation devices, might be used to identify and intervene at predicted supervolcanic sites before explosive pressure builds up to a critical point. Similar advances in computation could enable better modeling of pandemic proliferation patterns, rapid sequencing of pathogen genomes and the timely development of vaccines. Crop plants and animals, or specific animal tissues, engineered to be more resilient or productive, could help support populations threatened by a declining traditional agricultural yield due to environmental degradation and climate changes from anthropogenic greenhouse gas buildup or other catastrophic events. Social innovations supported by technologies could also make local communities more resistant to adverse geopolitical or physical conditions. On the downside, as we have seen, these same technologies could enable the development of engineered pathogens or synthetic-nonbiological organisms for hostile use, and the accidental proliferation of organisms or genetic sequences that could unfavorably alter and possibly severely damage individual humans and other life forms, populations, ecosystems or even the entire biosphere. The same applies to simpler nanomaterials that might be used or disposed of in an open environment. The effects of such transformative technologies could also disrupt or stress the economic, political, cultural and societal systems of human communities, either directly or through environmental impacts. If we recall the press/pulse model of "natural" extinction events, we can see the possibility that each of the technological risks separately might not represent a serious global catastrophic risk, but that a number of such adverse developments combined, coupled with global economic, cultural and political crises and stressed by adverse environmental influences could constitute an extremely perilous situation.

While highly restrictive regulations or global technology bans might control and stifle research and development of specific NBIC technologies in the scientific communities of some first world countries, it is not certain that such measures could prevent further work on such technologies in other, possibly rogue countries or underground by militant extremist groups, as the price and availability of molecular biotechnology equipment is already favorable for such endeavors. In addition, it is questionable whether such work would not continue covertly in military laboratories, even in countries that had officially stopped such research, but without public debate and oversight and without simultaneously developing the civilian benefits of these technologies. In the worst-case scenario, the "conscientious" countries would be faced with opponents possessing offensive NBIC technologies, without themselves possessing adequate defensive capabilities.

Scientific and technological advances change our modes of life on many levels, and not necessarily always for the better, but still, much of what we value about our current human condition and our human civilization is artificial and originates from altering and manipulating the "natural" world. So rather than impose highly restrictive general technological regulations or bans, more specific safety and security mechanisms would possibly better minimize potential risks.

One option would be that regulation focus on individual products of advanced technological research, assessing their potential risks and downsides before development and commercialization. However, the current emphasis on funding more applicative rather than basic research might be a problem, since there would either be a stronger pressure to proceed with commercialization regardless of risks, or else far less incentive for researchers to work in such fields or for those fields to receive funding. We can also already observe a shift from high-risk/high-payoff research, with less measurable, long-term impacts, to low-risk/low-payoff research, with more visible short-term impacts, because public funding for science has been reduced in many countries, and there is more demand for "tangible" results that the funding bodies can present to the governments and the constituency.

While prohibiting entire fields of scientific inquiry clearly does not present the best course of action, history shows that many technologies, such as carbon-based energy technologies, and technological products, such as asbestos and various pesticides, can have completely unforeseen, adverse consequences on the complex systems of the climate and of living organisms. In order to prevent the introduction of technologies that might have strong negative effects, policy instruments such as the precautionary principle have been created. Employing the principle would ideally ensure that all reasonably feasible investigations of possible harmful effects on living beings and the environment have been made, and that precautionary and protective measures have been taken when developing and deploying new technologies [Andorno, 2004]. Fearing that a strict interpretation of the precautionary principle would prohibit further scientific inquiry and technological development, Max More [2005:1] has formulated the proactionary principle as a response that stresses the importance and the societal benefits of continued innovation and research as opposed to the abandonment of specific lines of scientific investigation. While the "European" precautionary principle and the "US" proactionary principle seem to be diametrically opposed, their best use is not as political tools for either blocking specific research and innovation or dismissing the costs of potentially harmful side effects in favor of profit, but as policy instruments that might provide us with a better assessment of technologies which could alleviate many of the urgent problems of modern societies, though also produce risks which could range all the way to global catastrophes.

A third type of a technology regulation principle, proposed by Jamais Cascio [2006], does not focus solely on caution and action, but tries to address the problem that adverse, unintended effects of technologies only become evident once deployed in the "real" world, affecting mechanisms whose significance or even existence was previously unknown. By incorporating a degree of reversibility into the technology from the start, adverse processes might be more easily reversed and the damage at least somewhat lessened. The reversibility principle states,

> "When considering the development or deployment of beneficial technologies with uncertain, but potentially significant, negative results, any decision should be made with a strong bias towards the ability to step back and reverse the decision should harmful outcomes become more likely. The determination of possible harmful results must be grounded in science but recognize the potential for people to use the technology in unintended ways, must include a consideration of benefits lost by choosing not to move forward with the technology, and must address the possibility of serious problems coming from the interaction of the new technology with existing systems and conditions. This consideration of reversibility should not cease upon the initial decision to go forward to hold back, but should be revisited as additional relevant information emerges."

For example, using the reversibility principle in biotechnology, genetically engineered organisms would be designed in a way that would make it possible to remove them from the environment in case of unexpected or low-probability adverse events. This could be done through the integration of "suicide genes" that would make the engineered organisms dependent on specific chemicals or environmental cues. Such an approach is intriguing, though its implementation in practice might prove difficult, especially considering the demand for financial profit from a project once the initial investments have been made, as well as the social and political inertia of its path dependency. On the other hand, even partial reversibility of technologies and innovations that have begun to exhibit adverse effects far exceeding their benefits would greatly reduce the societal burden of externalities and the damage done to living beings and the environment.

As many advanced technologies have large benefits for society when employed for civilian uses, but can also be easily converted to highly destructive military applications, controlling the proliferation of such dual-use technologies is another important aspect of regulating converging technologies. James J. Hughes [2007] has proposed creating a global technology regulatory regime, which could be inspired by mechanisms and institutions developed to monitor and control the proliferation of weapons of mass destruction, including nuclear and biological weapons, although the miniaturization of enabling technologies is making such endeavors progressively harder.

Finally, we can see that the magnitude of possible impacts of such technologies combined with the complexity and unpredictability of the living world requires a multidisciplinary, systemic approach to examining their potential risks and benefits. One aspect of such an approach is the examination of ethical, legal and social implications [ELSI] of specific technologies, and one step in this direction was taken by the UK Center for Synthetic Biology at Imperial College London by integrating social scientists into its research team [Sanderson, 2009]. ELSI investigations should ultimately not be employed as a priori antagonistic to the research in question, striving to prevent developments that the investigators might personally disagree with, nor as simple public relations liaisons, but as mutually cooperative efforts that would help identify potential risks, and help maximize the benefits and minimize the unintended consequences and adverse effects of emerging technologies, while maintaining a public dialogue.

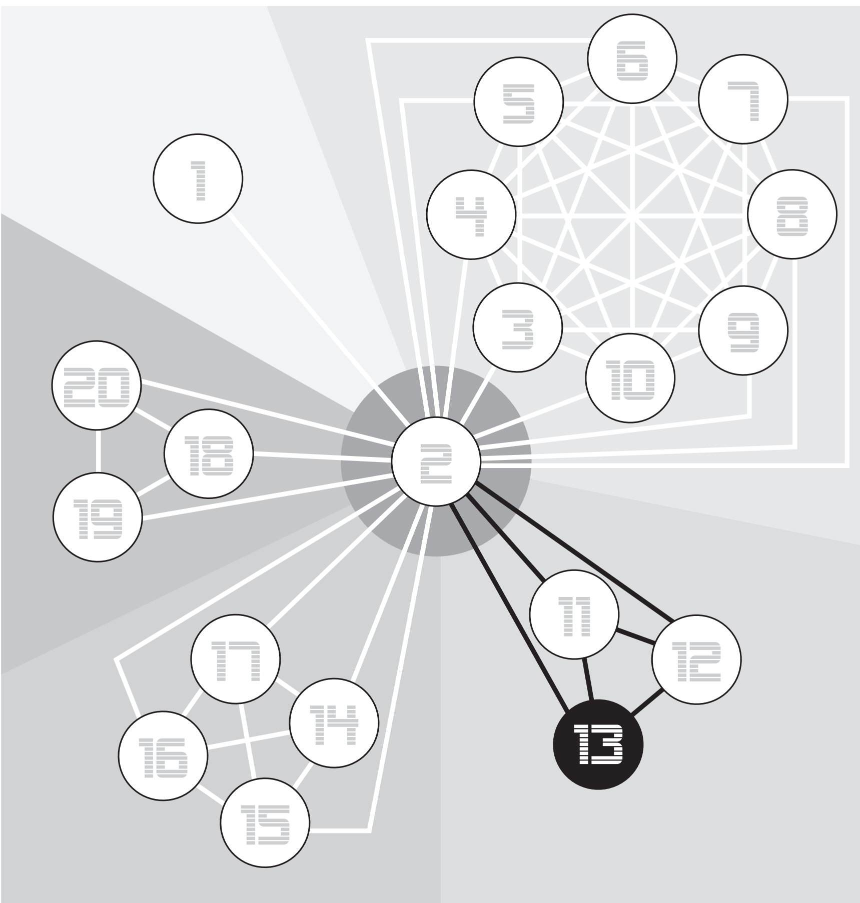
Building on the Fermi Paradox, in the absence of observable activity of intelligent extraterrestrial life, Robin Hanson [1998] has proposed the great filter theory, which postulates that life must pass through a series of barriers throughout its evolution into more complex forms, one or each of which might be progressively harder to cross. One implication of this is that the development of intelligence and use of technology might lead to barriers that increasingly have the probability that life will self-destruct once it reaches a specific stage. Among such barriers are surely external factors, such as naturally occurring global catastrophes that have caused mass extinctions in the Earth's past, but probably also internal factors, such as specific advanced technologies and applications, which we have already developed, for example, nuclear technology, and those which we are in the process of developing, for example, genetics, robotics and nanotechnology. One problem is that the great filter, which could ultimately destroy our potential, might be due to a research path that we decide to prohibit for fear of possible risks. So despite the uncertainty regarding the dangers of converging technologies, we should be wary of prohibiting extensive avenues of scientific inquiry. As Carl Sagan [1997:249] wrote,

> "Who would do the censoring? Who among us is wise enough to know which information and insights we can safely dispense with, and which will be necessary ten, or a hundred, or a thousand years into the future? Surely we can exert some discretion in technology, on which kind of machines and products it is safe to develop. ... But censoring knowledge, telling people what they must think and what ideas are impermissible, which lines of evidence may not be pursued, is the aperture to thought police, foolish and incompetent decision-making and long-term decline."

A complex environment poses problems that require complex tools and solutions, and their use, in turn, again increases the complexity of the environment, of human societies and of technology. And as systems of greater complexity are more prone to generate large events with strong consequences [Page, 2009], it seems that humanity will have to continue walking the narrow middle path of continued technological development between precaution and proaction, striving to understand enough of the complex processes of the universe to be able to adapt to future challenges.

13 Risk, Crises and Control: Between Fear and Negligence

Marko Polič



13.1 Crises and Beyond

Perhaps there is no science with so many myths[1] connected to it as psychology. Since ancient times, people have wanted to understand their own nature and the reasons for their behavior. The subject, however, was too complex and somehow too fuzzy to be understood in one grasp. Therefore a number of different explanations appeared simultaneously; scientific and naïve, the first views slowly replaced the last. The understanding of crises is no exception to this pattern. Though crises are not only psychological, every crisis has its psychological aspect in addition to its sociological, economical, organizational, ethical, military, technological and other facets.

Crises have existed from the very beginning of humankind. Ulrich Beck, in his influential book *Risk Society*, published in 1992,[2] even introduces the concept of *risk society* as a global phenomenon within the processes of modernization and increased actual risk. Crises could be defined as *situations deriving from the changes in the organization or community or its environment, characterized by actual and/or perceived threats to basic values, the loss of control over the situation, urgency, uncertainty and a need for fast decision-making and action. Response demands, as a rule, exceed the available resources of the affected community*. This definition is based on a number of others [*e.g.*, Heath, 1998; Rosenthal *et al.*, 1989; but especially Stern, 1999].

It is evident that solutions to the crises are important for the survival of the individual, organization or community, and that these solutions result from human coping with the crises. Therefore, to understand crises and efficient ways of overcoming them, we must understand humans in crises, their cognition, emotions, motivation, behavior, social relations, etc., as they apply to crises. A crisis is a complex phenomenon, and as much as humans are active in managing it, are victims of it or simply witness it—but always involved in it—to this degree, we are dealing with psychological questions. Psychological aspects appear crucial to understanding crisis management, and there is perhaps no discussion of crisis without mentioning at least some of them. Of course, crises are a way of existence for our societies (wars, disasters, economic crises, etc.) and, as such, involve much wider issues than just psychological realities. But in this contribution, I shall limit myself to the psychological reality, mainly to psychological theories (models) and their applications in the field of crisis.

Crisis represents a complex system that is not easy to understand. Without a theory, successful crisis management is not possible, because the measures undertaken

1 An imaginary interpretation of a past, present or future event.
2 The original German edition was published in 1986, just before the Chernobyl disaster.

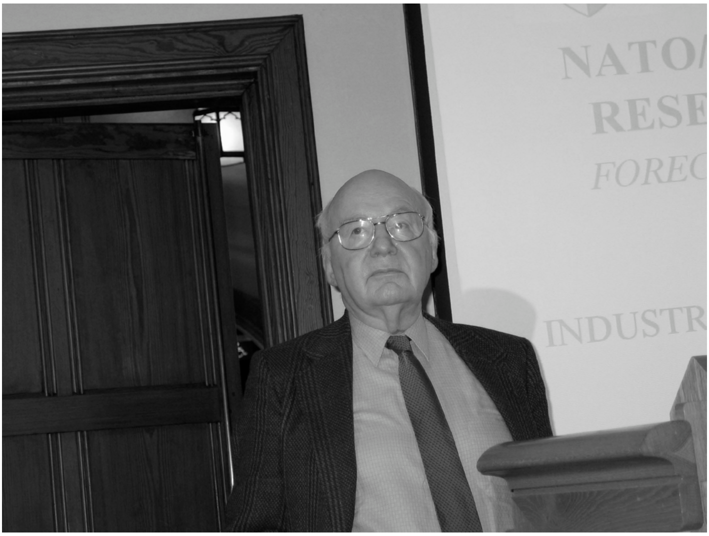
will be more like blind trials. Unfortunately, neither psychology as a whole nor the field of crisis management has a consistent and general theory of human behavior. The matter is too complex to be explained entirely by any single theory; therefore, different theories coexist, each explaining only certain aspects of the phenomena. Yet, our knowledge of human behavior is under constant development, and what was truth yesterday, may not be so today. This can be seen in the examples of classical decision-making theories versus naturalistic decision-making theories, or between heuristics as a way to the mistake and heuristics as an adaptive toolbox. In the field of crisis management, we encounter psychological theories from a number of different areas: decision-making, stress, problem-solving, personality, risk-taking, perception, communication, leadership, organizational psychology, etc. Therefore, this chapter, although perhaps one-sided, will capture only some aspects of individual and group activity that influence efficacy in crisis management. It will cover the narrow psychological questions about individuals as well as those about groups and communities, where the psychological approach encounters other approaches. Crisis management, which means *careful and considerate management of circumstances in which troubles and dangers that could have serious and dangerous consequences exist* [Purvis, 1994], will be psychologically examined.

13.2 Crisis and Disaster

The discussion will be limited mainly to one type of crisis, to disasters. Perhaps we should start by defining what we are talking about: a disaster. Though at first glance the meaning of the term *disaster* seems clear, closer examination reveals that this is not so. One of the pioneers of social science research on disasters, Enrico Quarantelli [1982, 1991, 1998], has shown that even the very definition of disaster brings with it serious organizational and planning consequences, and thus proposes a new way of approaching disasters. He notes that organizational and functional changes appear after shifting from using 'disaster' to refer primarily to *a physical agent* (*e.g.*, earthquake, hurricane, flood, fire) to using it to *mostly emphasize social features* of the event (behavior that occurs during the emergency period as the consequence of a sudden and widespread impact on a community). Destructive agents are no longer seen as a cause but as a precipitant for crisis, and disaster behavior as directly related to social context [Gilbert, 1998]. The thinking of disasters in generic or general rather than agent-specific terms is suggested. For Quarantelli [1982], this is a fundamental question about what should be considered important and significant in the characteristics of the phenomena, the conditions that lead to them, and the consequences that result. Considering disaster planning in agent-specific terms leads to separate and distinct planning around specific disaster agents, and separate plans for each of them, implemented by different organizations. This is based on the idea that disaster agents differ qualitatively, rather than just quantitatively, and that each of them requires its own mode of understanding and management. The generic approach assumes just the opposite. It represents a shift away from a focus on the physical aspects towards a more social conception of disasters. Without significant, socially negative consequences, such events remain only physical or chemical processes. Conceptualized in this way, disaster can be identified only in terms of the characteristics of the social situation. It can be viewed as an *imbalance in the demand-capability ratio in a consensus crisis occasion*. Such a conception of disaster emphasizes the common or similar properties of the social event, and not the physical features of disaster agents. This is supported by social science data acquired during the studies of real disasters, which show that most socio-behavioral characteristics of disasters are not agent specific, but generally manifest in many different types of disaster agents [Drabek, 1986]. The same general activities have to be undertaken irrespective of the specific agent (*e.g.*, warning, evacuation, sheltering, search and rescue, communication, coordination, organization). Most human aspects of disasters do not depend on the specific type of agent involved. As Quarantelli [1991] rightly demands, we should focus on the similar underlying or genotypic characteristics of disasters and not on surface and manifest phenotypic ones. He has distinguished between *hazard* (*i.e.*, the phenomenon itself) and *disaster* (*i.e.*, its impact on a given community). This view has a number of implications [Quarantelli, 1991], from stressing the social rather than physical solutions, to rejecting the opinion that disaster planning is only a matter of technology implementation, to demanding a *proactive* rather than reactive stance, through to the awareness that a disaster is a manifestation of internal flaws and weaknesses in the society and that perceiving the activities of disaster prevention and mitigation is an integral part of development and planning.

The generic approach does not deny the existence of differences between disaster events—only that they are not linked to a specific agent. It is not physical difference that is important but meaningful characteristics of social situations, for example, that certain kinds of hazards do not allow time for warning. Therefore Quarantelli [1991] suggest that typologies of disasters should combine generic social dimensions, such as predictability, relative loss impact, recurrence, unfamiliarity, rapidity of onset, length of threat, inclusiveness of involvement and the social centrality of the affected population.

FIGURE 13.1 **Enrico Quarantelli, Pioneer of Social Science Disaster Research at NATO/Russia Advanced Research Workshop in Aberdeen, 2003**



[Photo: M. Polič]

13.3 Facts and Fiction in Disaster Management

The concept 'scientific' constantly changes over time. But even now in this scientific century, there is a field—the behavior of people in crisis[3] and disaster—where many myths, for example, those about widespread panic, looting, community disorganization, dysfunctional reactions, have an independent existence of their own.

People have been coping with crises and disasters since ancient times. Yet, the systematic research of the psychological aspects of disasters dates to only about half a century ago. Until then, and quite often even now, instead of facts, common myths regarding people's disaster responses have prevailed. I shall try to confront many of these current fictions about the behavior of people during

3 Every disaster is a crisis, while opposite is not true. In both cases, the demands of the situation exceed community resources, and while crises may have different origins—from natural to social causes, *e.g.*, political or economic crises, crises caused by nature or technology—disasters are caused by non-societal (natural and technological) events, though they are conceptualized as social events.

disasters, which appear in popular belief, mass media and elsewhere—even among psychologists. People somehow try to make sense of the threatening events, but their true nature might have been masked or prejudices might have influenced their interpretation, thus resulting in a flawed interpretation. Emergent dangers affect people both directly and indirectly, but people's behavior can prevent or mitigate the consequences of the danger. This means, that we need to understand human behavior in emergent situations, when people feel threatened. This relatively new psychological[4] field, on the one hand, seeks to ask the right questions and find procedures for their solutions, but on the other hand, is still lost in the traditional images of humans, in prejudices and in mistakes.

A number of controversial attitudes and beliefs are known. Acceptance of one of these beliefs also means a different way of working, planning, and behaving, as we saw in the previous section. Inadequate conceptions hamper the effectiveness of emergency planning and measures. And this is where the boundary between the life and death, between drama and tragedy, sometimes lies. Therefore an overview of the behavior during emergencies will be given. Explanations will be based on empirical research of real disasters, and mainly from on-site research. This field of psychology is one in which psychologists must leave the laboratory and enter "real life" in order to get answers for the problems. Only in this way can right answers be acquired. Popular images of panic, irrationality, role conflict, disorganization, individual pathology, antisocial behavior will be rejected, and a more optimistic view of people's behavior during emergencies will be presented. We shall see that disasters create unity rather than disorganization, because during emergency period, a consensus on the priority of values within a community emerges, as does a set of norms, which encourages community members to act in an altruistic fashion; disaster also minimizes conflicts.

Beliefs that disasters have immediate, widespread, deep, persistent, long lasting and dysfunctional effects prevail in the public and mass media. But there is also another view, which claims that though widespread, these reactions are superficial, nonpersistent, of short duration, not behaviorally dysfunctional, and that even positive psychological effects may appear. Many studies during World War II and afterwards clearly show that anticipated personal and social disorganization in disasters did not occur [Quarantelli, 1985]. Behavior of individuals during disaster was usually controlled, functional and organized, that is, adaptive to the situation. There were a number of problems at the societal level: problems with mobilizing relevant organizations, tasks done poorly, a lack

4 As well as sociological, philosophical, economical, historical etc. field. Human behavior is, in principle, an interdisciplinary research field, and findings from the different sciences overlap.

of inter-organizational coordination, etc. Often the organizations involved in disasters caused the problems, because they acted in such a way that magnified the crisis or created difficulties for threatened people. We can even talk about *secondary disasters* caused by inadequate help. Thus researchers distinguish between *agent-generated demands* and *response-generated demands*. The latter are not generated by the disaster agent but by the activities taking place during the response to the disaster event (*e.g.*, communication, mobilization, coordination, control, authority).

The first researchers believed that responses during disaster would be [Quarantelli, 1985]: (1) relatively homogeneous (behavior of the type either/or); (2) inappropriate (*e.g.*, panic, looting, hysteria); (3) directed primarily at the disaster agent or its immediate effects, and (4) mainly explainable by the social-psychological dynamics of the individual victims. On the basis of the research evidence, a new model emerges, which claims that disaster responses are [Quarantelli, 1985]: (1) always heterogeneous (variety of differentiated responses); (2) functional or dysfunctional depending on a variety of factors, but overall functional and organized; (3) just as concerned with what occurs after the impact as with what occurs during it (response demands), (4) more dependent on the social context than the victim's internal dynamics.

On this basis, two approaches to disaster conceptualization can be distinguished: (1) an *individual-trauma* approach, which holds that disasters are traumatic life events with negative psychological effects, and (2) a *social-sponge* approach, which holds that community disasters have differential effects, positive as well as negative, and that many problems for victims are more closely related to the response demands.

Many studies [see Quarantelli, 1985 for an overview] support this latter view. Large percentages of the affected people had extremely positive reactions to the disasters (*e.g.*, they could handle crisis better than they thought, there was a better quality of social relations). Efforts in obtaining services were often a generator of anger, concern, worry and anxiety (secondary disaster). Also in our studies [*e.g.*, Polič, 1987; 1989; 1990] we have found support for this view. It is therefore surprising that quite often rescue institutions emphasize the importance of psychical trauma, stress and even PTSD. But perhaps the reason for this is to shift the attention from the demanded services to the victims' psychological states.

In general, people from affected areas usually react actively and do not wait around for assistance from outsiders or for offers of organizational aid. People usually cope successfully with most of the immediate disaster problems except those necessitating special equipment or highly specialized skills. This does not mean that individual trauma does not exist—only that it is not so widespread.

13.4 Risk-Perception and Trust

The public understanding of an issue depends on its framing. The concept stems from the work of Erving Goffman [1974:21], who defines frames as '*schemata of interpretation*' which enable their users (individuals or groups) '*to locate, perceive, identify, and label*' events and occurrences, and thus enable them to render meaning, organize experiences and guide actions. Framing is a part of broader processes of selecting and structuring of social problems. Actually, framings are changeable results of the continuing "*social construction*" of the reality—in this case of the crisis perception. The one who structures and selects is the one who has the power to determine what is more and what is less important, safe, dangerous, etc. In this respect, the framing process is an attempt to "*invoke a particular image of an idea*" about the safety or danger of an object, event or process.

In a number of domains, mainly those connected to any kind of possible risk, be they real or imaginary, the distrust of official actors is increasing, as is evident both through public opinion polls and in the concrete political behavior of people. Cvetkovich and Löfstedt [1999] have even published a book entitled *Social Trust and the Management of Risk*, while numerous papers and book chapters cover the same topic. In reality, solutions to many urgent problems that are perceived as risky or annoying nowadays depend, at least in democratic societies, more on public acceptance than on technical possibilities. The necessity of involving the public rather than simply "educating" the people is increasingly evident. The apparent superiority of the purely technical approaches is diminishing in the presence of the socially based strategies. There are many such cases connected to so called new, dread, involuntary or uncontrollable risks [Slovic, 1993; Morgan *et al.*, 2002].

Following Cvetkovich and Löfstedt [1999:3] and reflecting the changes in public attitude, we can trace the characteristic evolution in the research related to risk assessment and management through the following stages: (1) the initial issue of determining the levels of acceptable risk; (2) risk perception with concern about the differences between lay people and experts; (3) the resolution of conflicts and the application of concepts about risk perception to risk communication, and (4) the current stage of focusing on trust, which has broadened the concern from only assessing the physical processes to understanding social systems and their actors. Social trust, defined in essence as "*assured reliance on the character, ability, strength, or truth of someone or something*" ["trust." *Webster's Third New International Dictionary, Unabridged*. Merriam-Webster, 2002], also has some additional characteristics [after Cvetkovich and Löfstedt, 1999; a similar position can also be found in Kasperson and Dow, 1993], such as the implications of differences in power and control, risk involvement, expectations regarding a person's interests, choices of when and whom to trust, impersonality aspects, etc. In their studies, Earle and Cvetkovich [1999] found support for the cultural-values hypothesis; namely, social trust is based on value similarity. *Pluralistic* social trust, rooted in the pasts of existing groups, and *cosmopolitan* social trust, which is multiple and based on new sets of values, and as such more suitable for successful risk management, could be distinguished. For Löfstedt and Frewer [1998], risk perception is socially constructed. According to the theory of *cultural biases* [Adams, 1995; Löfstedt and Frewer, 1998], risk assessments are consistent with predominant worldviews and reflect them (hierarchists, fatalists, individualists, egalitarians and environmentalists).

13.5 Decision-Making

All crisis management, if anything, involves decisions. During the times of crises and disasters, adequate decision-making is of critical importance. It is interesting to trace the development of this field, with its shift from rational models to decision models in natural settings, from the laboratory to reality. According to Collyer and Malecki [1998], we can distinguished three periods in the development of decision-making theories:

- *Rational models*. The models based on rational choice and behavior (*e.g.*, SEU, multi-attribute utility theory, Bayesian inference models) were prevalent during the period from 1955 to 1975. In these approaches, the decision problem was decomposed into its elements in a form that makes explicit the choices, the uncertainties of outcomes and the outcomes themselves. Due to their limitations, new models appeared.
- *Descriptive models.* Descriptive models indicate that humans deviate from the prescribed procedures (heuristics) and correct responses (biases) described by rational models. This approach was appealing in the period between 1965 and 1985. Herbert Simon [1956], one of the pioneers of these models, introduced the concept of *bounded rationality* and explained it through the metaphor of a pair of scissors, where one blade represents the 'cognitive limitations' of actual humans and the other stands for the 'structure of the environment'. Our world is, according to Simon, too complex for us to be able to understand it in its entirety; therefore, we make a simpler model of it, a model that is useful for our everyday activities. In many situations, Simon believes, people do not attempt to evaluate all available response choices to maximize their subjective expected utility, but rather consider only as many alternatives as needed to discover one that is satisfying. In solving their problems, people use heuristics—mental short cuts. As Gigerenzer and Selten [2001]

comment, "*minds with limited time, knowledge, and other resources can be nevertheless successful by exploiting structures in their environments*". Gigerenzer and his colleagues from the Max Planck Institute clearly show that heuristic tools can be simple but still effective in a given environment, calling them an adaptive toolbox. They show that (1) the limitations of knowledge and computational capability need not be a disadvantage, (2) simple heuristics can exploit a regularity in the environment, and (3) bounded rational heuristics are to some degree domain-specific rather than universal strategies.

– *Decision models in natural settings*. This approach, starting in 1980, presents quite a new emphasis, shifting research from the laboratory to dynamic, natural settings, from naïve decision-makers to experienced ones, and from decision events to the real-world processes and to larger tasks into which decisions are embedded. Making a decision is not an end in itself but achieves a larger goal. The study of decision-making is more a part of the study of action than the study of choice. Recognition-primed decision-making [Zsambok and Klein, 1997], metacognitive and critical-thinking models [Cohen, Freeman, and Wolf, 1996], and schema-based models of problem-solving [Marshall, 1995] have appeared [Collyer and Malecki, 1998]. These models throw new light on human decision-making in a crisis and offer new training techniques, which emphasize shared mental model training, teamwork behavior training, coordination and adaptability training, guided practice and feedback training, instructor and team-leader training, etc.

This last period differs from the previous ones especially because of its realistic approach. Naturalistic decision settings differ from laboratory ones through a number of characteristics, but mainly eight factors complicate the decision task [Orasanu and Connolly, 1995]: (1) ill-structured problems, (2) uncertain, dynamic environments, (3) shifting, ill-defined or competing goals; (4) action/feedback loops, (5) time stress, (6) high stakes, (7) multiple players, and (8) organizational goals and norms. By definition, crises have some or all of these characteristics, and naturalistic decision-making models, *e.g.*, Klein's [1995] recognition-primed decision (RPD) model, appear as a suitable tool in explaining what happens during crisis management. According to RPD, proficient decision-makers rarely compare alternatives. Instead they assess the nature of the situation and, based on this assessment, select an appropriate action. This process consists of three phases: situation recognition, serial option evaluation and mental simulation; it is very convenient in explaining decision-making during accidents and disasters.

13.6 Groupthink

From the analysis of good and bad decisions, Irving Janis [1971] developed the theory or model of *groupthink*, defined as "*a mode of thinking that people engage in when they are deeply involved in a cohesive in-group, when members' strivings for unanimity override their motivation to realistically appraise alternative courses of action*". His model describes antecedent conditions for and consequences of groupthink, which presents a dangerous possibility in crises for accepting a wrong decision. The occurrence of groupthink depends on three groups of factors [after Fuller and Aldag, 1997; Middlebrook, 1980; Parrot, 1995; Schafer and Crichlow, 1996]: cohesiveness, structural faults of the organization and a provocative situational context. Janis discusses it as 'an illness' with eight symptoms.

Deficiencies of decision-making that lead to groupthink can be classified into two main categories: those connected with *acquiring information* important for decision-making and those connected to the *evaluation of information*. All these deficiencies can be prevented by different measures.

13.7 Organizations in Disaster

People usually organize themselves adequately during disasters and take adaptive steps to deal with the threats. In conjunction with other people, individuals will generally take whatever protective measures they deem possible. In comparison with everyday life, people are nowhere near as rational as they are when their lives and possessions are at stake.

It is often believed that local organizations are unable to cope with disasters because they are overwhelmed by disaster impact, while their employees are so affected by the disaster impact—not to mention the role conflict between emergency-relevant occupational responsibilities and obligations to one's family—that their efficiency is reduced. This belief stems from overestimating the amount of disaster-occasioned demand on facilities and underestimating the resources still available after impact.

The most important findings about the behavior of organizations in crisis comes from sociological research on disasters. Quarantelli and Dynes [after Stallings, 1978] identified four types of groups and organizations in the aftermath of disaster. Some organizations perform the same task during disasters as they usually do, while others perform disaster-related tasks that are new for them. Some organizations respond without fundamental changes in their pre-disaster structure, while others undergo great transformations. Cross-classification of these dimensions produces four distinct types of organizational behavior [Table 13.1].

TABLE 13.1 **Types of Organized Behavior in Disaster**

		Tasks	
		Regular	**Nonregular**
Structure	**Old**	*Esteblished* (*e.g.* Police, Firedepartment)	*Extending* (*e.g.* Construction company, Scouts)
	New	*Expanding* (*e.g.* Red Cross, Caritas)	*Emergent* (Operation, coordination groups)

[Stallings, 1978]

The four types of organizations become involved in disaster activities in a definite sequence: first established, then expanding, followed by extending and finally emergent groups [Stallings, 1978].

In some of our cases [*e.g.*, fire at Gorenje; Repovs, Polič and Kranjcec, 2004], transitional organizational changes can be traced according to Stallings's findings. Namely, the change of the executive board into a crisis management group marks it as an expanding organization, while the two special groups that be-came responsible for preparing suggestions for the long-term solution for the lost plant can be seen as an emergent type of organization.

13.8 Panic

Panic is perhaps the concept most closely connected in our minds to human behavior during disasters. There is almost no report about disasters in the mass media that does not mention it. If someone were to ask an individual from the general public about typical behavior during disaster, undoubtedly the word "*panic*" would be mentioned. Is this really so, and if not, why do so many people believe in this myth?

A number of studies have shown that widespread panic in disasters is very rare. Even if panic occurs, it is on a small scale, extremely localized and of short duration. Instead of wildly fleeing, people will more probably stay in a potentially threatening environment. People have very strong tendencies to continue with on-going behavior and not start a new course of action. The flight behavior that occurs is primarily by transients (*e.g.*, tourists). Even when an area is under evacuation, the majority of people simply do not leave.

When speaking about panic, we should not confuse it with flight behavior. Though both terms refer to withdrawal from a situation, they are otherwise not equivalent. While panic behavior occurs without any consideration for others, flight involves playing traditional social roles (*e.g.*, taking care of others, mutual aid). Sometimes withdrawal from the danger may seem the most rational step possible.

Panic should also not be confused with fear. Panic appears only when fear is uncontrolled.

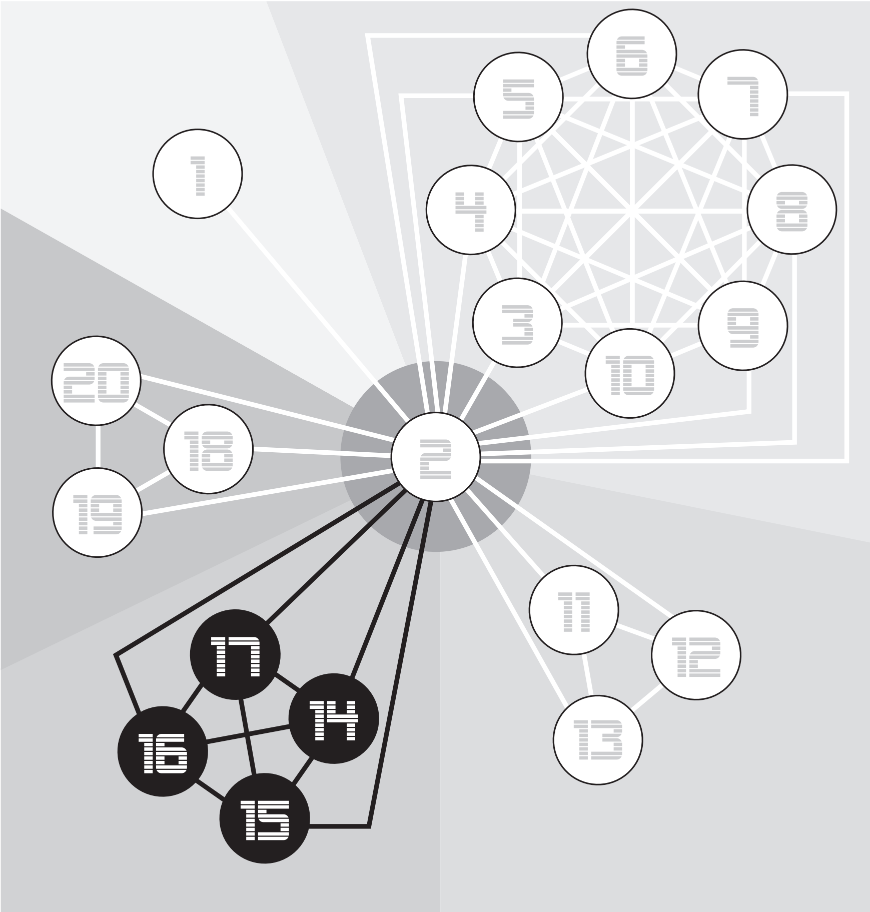
The overwhelming majority of people maintain self-control and evacuate in a generally civil way—until it appears that the flow is too slow for all to escape successfully. At that point, those who perceive that they are unlikely to get out alive may well use physical force in an attempt to save their own life. But panic is not the reason for dysfunctional flow.

The term "panic" is so often abused because of different reasons [Sime, 1980]: (1) the circular emphasis on the outcome of a disaster as evidence for panic behavior; (2) the confusion of fear and panic, and (3) the use of panic as an excuse for inadequate behavior.

13.9 Instead of a Conclusion

The concepts subsumed under the terms risk, crisis and disaster are complex and were discussed only superficially and not in their entirety. Nevertheless it is evident that the social science approach is necessary for their understanding and for enabling adequate responses from communities, groups and individuals. The understanding of risk and other phenomena is necessary for adequate planning and possible preventive measures. Unfortunately, quite often prejudices and inadequate conceptions amplify the negative consequences and the suffering of victims. On the other side, a number of studies [*e.g.*, Quarantelli, 1985] have revealed a more optimistic image of people and their behavior during danger. Unfortunately, 'risk society' and 'normal accidents' are realities too.

Part IV — RISC Prevention and Damage Control



Introduction to Part IV

The fourth part offers a variety of highly interesting case studies on the scope and dimensions of RISC-protection systems with a special emphasis on the available support capacities in case of catastrophic RISC-events like floods, droughts or tsunamis. These articles reflect two of the basic theoretical propositions of the RISC-program. First, these contributions show that RISC-protection networks in general and RISC-support networks in particular suffer from the discrepancy between their capacities which are targeted according to average events and smaller deviations from the average and the catastrophic impact of rare events which surpasses the RISC-support capacities by a factor of three, four, ten or even higher. Second, several articles of Part IV point to the necessary discrepancies and clashes between the available local structures and support networks and the support systems or networks moving in from outside.

Turning to the articles in closer detail, Romana Zidar, Mojca Urek, Vili Lamovšek, Nino Rode and Jelka Škerjanc present a highly interesting overview, focused on the municipality of Ljubljana, on the vulnerability of individuals and groups, the accessibility of institutions and services in times of disaster, the implementation of rights for those affected by disasters, the service coordination, the voluntary initiatives, the non-discriminatory practices, and the sensitivity to the needs of the affected population. Results indicate that there are deficiencies in the existing formal, semi-formal and informal systems of protection, rescue and relief. Through the research, the authors were able to identify ten categories of deficiencies: too great a response time, disconcerted performance of some organizations and inappropriate informing of people, lack of available staff or crucial person in some institutions, lack of clearly defined common protocols, lack of criteria for and opacity of relief distribution, imbalance of power and unequal distribution of resources and relief among the population, frequent discrimination and human rights violations, overlooking vulnerable poor groups of the population, inaccessibility of different forms of support in the field during and after the disaster, resorting to bureaucracy because of nonexistent protocols, lack of psychosocial support and relief for rescuers.

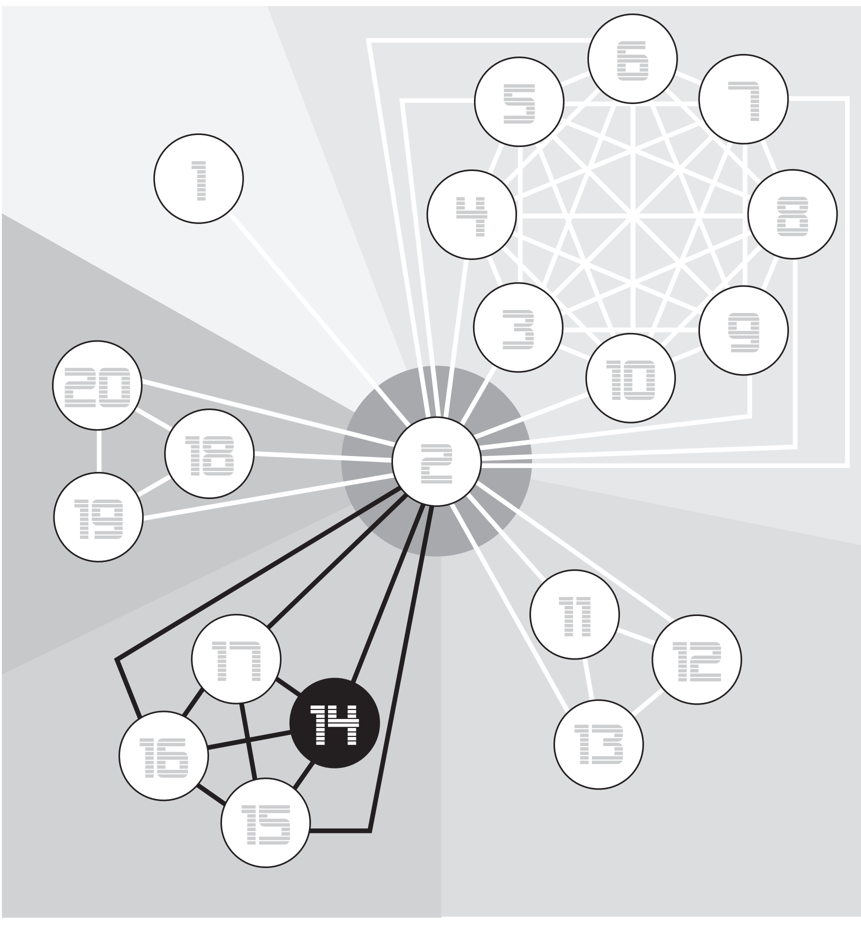
Jelka Škerjanc shows in her article on "Secondary Disaster and Social Work" that in organizing support for residents after a natural disaster, social work has an important role to play. The article strongly argues that the place of social work must be with the residents and at their side. From this standpoint, social work should act to support residents, making sure their voices are heard and that they maintain control over the support they receive.

Mojca Urek and Bogdan Lešnik stress in their article "Tsunami Project: A Case of a Colla-borative Project Between Two Universities" the different perceptions of help and support between an affected local population and the rescue and support teams from outside. The article is mainly focused on the views and experiences of humanitarian aid as expressed by the people of a village, strongly affected by the tsunami of December 26, 2004. The local population keenly observed the distribution of aid and saw irregularities and abuses that only increased their distress. Among other issues, the local population questioned the methodology that caused less visible and socially excluded members of the community to be excluded once again from the distribution of aid, and they particularly resented being forced into submission.

David Koren and Vojko Kilar offer a highly interesting perspective on the issue of RISC-controls. In their paper "Seismic Isolation for Asymmetric Building Structures" they point to architectural designs which offer a high ex ante protection to the impacts of smaller or even high-level earthquakes. In particular, the paper examines architectural-structural particularities of asymmetric buildings in earthquake-prone areas and the possibilities for the implementation of advanced technologies to increase earthquake resistance of such structures. In doing so, it examines new dimensions offered by the use of advanced technologies which focus on various devices of seismic isolation such as bearings, dampers or systems for displacement reduction. Finally, the paper demonstrates the influence of these new technologies on architectural building design in earthquake-prone areas and show, thus, one of the possibilities for combining ex ante RISC-controls for a non-controllable process, namely for the dynamics and outbreaks of earthquakes.

14 Natural and Other Disasters: A Social Work Perspective

Romana Zidar | Mojca Urek | Vili Lamovšek
Nino Rode | Jelka Škerjanc



14.1 Introduction

This article aims to present the results of the research entitled *The Analysis and Evaluation of Needs for Social Services in Cases of Natural and Other Disasters in the Municipality of Ljubljana,* conducted from 2007 to 2009 by the Faculty of Social Work, Ljubljana, on behalf of the Municipality of Ljubljana. The study was approached with the presumption that social work in cases of natural and other disasters is not sufficiently researched and that the social institutions are not adequately prepared for major disasters with emergency situations. One of the key objectives of the study was to analyze the readiness of various organizations to cope with the consequences of natural and other disasters, as based on the perspectives of residents who survived the disasters and of the individuals who were actively involved in rescuing and offering relief to the people affected. Additionally, we assumed that social workers have defined disasters primarily in terms of the social and psychological impact from the natural and technological hazards [Zakour, 2008:1].

The exposure to natural and other disasters is increasing. Norris [1992] reported that approximately one seventh of the population is at risk of being affected by a natural hazard [*ibid.*:1]. The United Nations predicts that this number will double to two billion people by 2050 [United Nations News, 2004]. In Slovenia, the additional risk is to be found in a large part of population migrating into areas which tend to flood or are otherwise exposed to risk because of earthquakes or other threats. This increases the risk from natural disasters. Additional risk is also the phenomenon of centralization in Slovenia, which influences daily migrations, thereby increasing the risk of road accidents.

In the study, we primarily wanted to give the people directly affected by natural and other disasters the opportunity to describe their experiences and any deficiencies in the rescue process. We also strove to research the experiences of those individuals whose mission is formally and systematically defined by rescue processes (civilian protection, rescuers, firemen, voluntary firemen, workers in humanitarian and other organizations). Considering that social work is not formally a part of the protection system against natural and other disasters, we were interested in the ways the social protection organizations dealt with the situations, primarily from the perspective of organizing and implementing relief, and what their roles and experiences were. By recording the personal stories of those involved in major disasters, we recorded and analyzed the strengths and weaknesses of the steps and solutions taken during the rescue process. This enabled us to assemble the whole picture and to define the strong and the weak points of the existent system as well as the way the situation was perceived by the affected population. The final objective of the study was to present the views, experiences, needs and above all suggestions from the population that experienced some critical event with long-lasting effects.

The Models of Response to Natural Disasters and the Mission of Social Work

The complexity of the disasters we face today bears numerous consequences; these are not merely physical but also affect the broader social circumstances. The times when we approached disaster plans purely with a top-down approach, organized at the level of system, when the activities of certain services were provided as packages and not based on individual needs are over and need thorough reexamination. Active public or local community participation is now a matter of urgency, as it represents a basis for sustainable development and brings into focus the people who tend to be affected by disasters. Additionally, linking different services and communities and reaching a consensus about a long-term approach for controlling risk are essential for dealing with the consequences of natural and other disasters successfully.

The majority of models for responding to natural and other disasters aims at harm reduction [Ronan, Johnston, 2005] and derives from the 4Rs of Community Resilience model, which focuses on four phases of activites before, during and after the event: readiness, risk reduction, response, and recovery [Miller, Rollnick, 2002]. An appropriate extension of this model would allow for a strengthening of the individual members of the community and, through this, a building of community resilience for coping with potentialy dangerous situations in a local environment. This would and should be an essential component of policy-making and practice in the field of protection and rescue. A potential model for extending the 4R model has been developed by Ronan and Johnston [2005] and is called *The Strenghtening System 4R Prevention Model*—SS4R. This model utilizes concepts such as sustainable development, system approach and the utilization of the community's own models of problem solving.

The SS4R model aims to prevent problems from occurring in the first place by strengthening the community—equipping the community with the means necessary to cope with response and recovery [*ibid*.]. Thus, we avoid the planning that merely aims at loss reduction and instead aim for planning that develops communities capable of efficiently approaching the consequences of natural and other disasters by using their own sources of power.

The theory and practice of social work correspond to the flexibility in the model SS4R, since "social work is not a profession of methods encoded in advance, but adapts them to a specific situation and as such establishes them from the start according to a situation. Social work functions in unforseen and unpredictable situations which demand innovative and original resolving of the situation" [Flaker, 2003].

Social work, in keeping up with the multi-dimensional character of natural disasters, focuses on different communities, groups and individuals, taking into account the cultural, economic, social and ecological particularities of each environment. As such it aims to support the circumstances and conditions that enable the population to have a high quality of life.

Of central concern to social workers in times of disaster, which was given special attention in our research, are the vulnerability of individuals and groups, the accessibility of institutions and services in times of disaster, the implementation of rights for those affected by disasters, the service coordination, the voluntary initiatives, the non-discriminatory practices, and the sensitivity to the needs of the affected population.

Vulnerability of Individuals and Groups

The elderly population, immigrants, migrant workers, children, the unemployed, the working poor, people with problems in mental health and people with disabilities are more exposed to the consequences of disasters. In such circumstances, poverty and social isolation frequently mean that the vulnerable individuals, households or communities find it hard to reestablish themselves, especially in terms of finances and health, because they unlikely have the necessary insurance to cover the consequences of disaster, their income is relatively low or nonexistent, they do not have secure employment or they have loans and therefore no savings. Often income level is related to social isolation. Social isolation from neighbors, kin, and formal organizations means that individuals and households are unable to mobilize social capital for recovery after a disaster [Zakour, 2008:6].

Vulnerability is defined at the community level by the community's demographic, historical, cultural, and ecological characteristics. The poverty rate is a demographic variable negatively associated with community survival and recovery during major, long-term disasters [Sherraden, Fox, 1997:23–45; Sundet, Mermelstein, 1996:57–70].

Service Accessibility Established at the Time of the Disaster and the Implementation of Rights of Those Affected by Disaster

A central concern for social work is facilitating access to needed services. The mission of the social work profession includes linking vulnerable populations and service systems, and linking between different service systems to make resources more accessible [Minahan and Pincus, 1977:347–352].

During natural and other disasters, marginalized and already vulnerable individuals and groups tend to become even more vulnerable, so service accessibility becomes more limited. The service capacity decreases, the response is weaker because of the circumstances, and this directly affects the capacity to implement people's rights and to enable access the services needed.

In urban areas, the proportion of such vulnerable groups is larger which makes them more exposed. However, the service network in urban areas is generally more widespread, more accessible and more complex. Yet there is greater risk for individuals from the vulnerable groups in urban areas to suffer more from the disaster than individuals in non-urban areas due to social isolation, loneliness and deficient social networks.

The social work profession approaches these issues through a variety of working methods, primarily through fieldwork, advocacy, mediation, providing information, relief and document management, direct assistance, etc. Fieldwork increases service accessibility by creating remote (dislocated) units that implement programs in the field, thus providing better access and enabling direct work with people in their living environment. Advocacy refers to the use of professional and informal contacts within organizations, the use of specific knowledge and experience in order to provide access to services an needed resources. Mediation refers to coordinating various programs and services in order to design a set of services from different service providers that is adapted to individual needs, to enable the transition from one program or service to another and to implement different rights.

Service Coordination

In social work, emergency management is defined as a set of management programs and services in the field of social protection that aim to provide immediate, quality services that respond to people's direct needs and that can simultaneously design plans for program and service implementation. Emergency management brings into focus the preparedness for disasters and the planning for coordinating community resources during disasters [Gillespie, 1991:55–78].

From the perspective of social work, a crucial objective of emergency management is to involve representatives from different population groups (*e.g.*, representatives of different vulnerable groups, and ethnic or other minorities), influential representatives from the community and the representatives from different organizations responsible for preparing the plans of protection and rescue [Harell and Zakour, 2000:61–83].

Working With Volunteers

In cases of natural and other disasters, voluntary workers become involved in different ways: as members of voluntary fire brigades, humanitarian organizations or groups that organize themselves solely for the purpose of assuring help and support during and after disaster. The mission of volunteers may include repair; however, these individuals are also indispensable in reestablishing social and support networks as well as in recovering individuals or groups affected by the disaster.

The role of social work is indispensable to the coordination of volunteers. Groups of volunteers who are experts in social work or related area make important contributions to the recovery and renormalization of the situation, because their professional knowledge, provision and access to various services helps to improve coordination. Effective and coordinated services established ad hoc, *i.e.*, at the time of the disaster or afterwards, help individuals, households and communities recover and thus avoid long-term psychological and social problems [Zakour, 1996:19–29].

The involvement of social work is important because it ensures the establishment of programs and service networks in the field at the time of disaster. The diverse approaches and methods, characteristic of social work, may be a creative source of support for the existing rescue and protection system since they enable a long-term provision of adequate resources. This then increases the quality of life and ensures a more efficient recovery for the community.

Non-discriminatory Practices and the Sensitivity to the Needs of the Affected Population

When creating an efficient and non-discriminatory practice of working with individuals affected by disaster, it is important to comprehend the concepts of power and oppression. Power in the context of social work is often related to individual and social power, when a certain group of people is systematically deprived of access to vital sources of social power, which prevents them from fulfilling their life goals and aspirations. Oppression is a consequence of a lack of power, in which a group internalizes this lack and takes it for granted [Payne, 2008:298].

Therefore, a non-discriminatory practice of social work requires an approach that aims to empower by creating relationships based on partnership and cooperation, and by minimizing the rate of intervention, which could additionally diminish the power of vulnerable individuals and groups affected by disaster. Sensitivity is closely related to the concepts of power and oppression since it is based on the principle of uniqueness of both the individual and the environment he or she comes from. In cases of natural and other disasters, sensitivity to the situation,

circumstances and needs of individuals and groups preserves dignity and the principle of uniqueness on the individual and collective levels.
On a large scale, these views may help create strategies and practices for protecting and rescuing that demonstrate sensitivity to the needs of the people and community that were affected by the disaster. Embedding social work into the system may provide a better outcome for everyone involved, but above all it may reduce the negative effects of disasters that may not be visible or measurable at first sight. These effects are, nonetheless, there, and in the long-term they appear in the disintegration of the community, the worsening of mutual relationships, and in the numerous problems people face with job-seeking, inclusion and dealing with everyday stressful situations and mental health.

14.2 Methodology

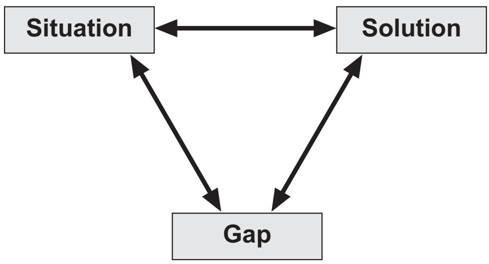
The sense-making methodology, developed by Brenda Dervin and colleagues in 1972, is based on the triangle of sense-making, *i.e.*, on three central assumptions:

1) That it is possible to design and implement communication systems and practices that are responsive to human needs.
2) That it is possible for humans to enlarge their communication repertoires to pursue this vision.
3) That achieving these outcomes requires the development of communication-based methodological approaches.

This methodology enables individuals who survived a natural or other disaster, irrespective of their role in it, to reflect on their real experiences. This allows the research to focus on the event itself instead of on the formal social structures and/or societal roles in which the individual operates, as is typically done.
The sense-making methodology may be abstractly and metaphorically presented as "a methodology between the cracks," which deals with the gaps between chaos and order, structure and person, facts and illusions, inner and outer world, the universal and the particular. Reality is not viewed as entirely orderly or entirely chaotic. In the sense-making methodology, reality is partly orderly, partly chaotic and partly in the making [Dervin, 1999, in Vodeb, 2004:13].
This methodology was applied in *micro-moment time line* interviews [Dervin *et al.*, 2003]. Such interviews are organized with the model of simultaneous sense-making. According to this model, any event may be viewed as a sequence of situations we go through when something changes, when we or others do something, or when a decision is made. The passage from one situation to another is some-

times smooth; however, there is frequently a stopping point or gap between the situation and our wishes. The gap is bridged by sense-making—figuring out the problem or the question that we need to solve so that we find a solution to the problem. The process is shown in the triangle of situation, gap/obstacle and solution/desired situation.

FIGURE 14.1 **Analysis of the Events According to Dervin's Methodology**



[*Ibid*. 2003]

Understanding the gap/obstacle/problem faced by the individual prior, during and after the disaster is linked with understanding the situation as well as with understanding the intended solution or desired events that might be helpful in a given situation. The solution also depends on the situation itself and the obstacle faced in the given situation. Finally, our situation is linked to other things and has a meaning only in relation to the problems we have come across and in relation to the solutions we might want to reach. Any activity or event can be described through a sequence of steps, of which every step comprises a triangle "situation-gap-solution." The respondents were asked to choose appropriate sections of happening before, during and after disaster, which could be described in such a way.

14.3 Population

We conducted 30 interviews (with 34 respondents) in the field, *i.e.*, with individuals who experienced different types of natural and other disasters (hailstorms, earthquakes, fires, river accidents, road accidents) from all areas of Slovenia. We interviewed people from numerous organizations who offered their support as well as the population that was affected by the natural or other disaster. The analysis of the responses revealed both the gaps and strengths in the organizations' practices and responses to the emergency situations.

The respondents and situations selected were partly planned and partly coincidental. The only selection criteria was that different types of accidents and different types of affected people be covered (the affected population and different types of services and organizations who provided the rescuing); therefore, the interviewees were carefully chosen accordingly. During our field work, other important events took place, so we randomly included them in the research [Blanca, hailstorms in the summer of 2008]. This gave us the opportunity to observe the experiences of some individuals immediately after a disaster in addition to those given to us by the respondents after a period of time [Posočje, 2004, etc.].

TABLE 14.1 **Gender Distribution of Interviewees—The Structure**

Role	Women	Men	∑
Professional role	11	9	20
Those affected in the accident	9	5	14
Sum total	20	14	34

The interviews covered 20 women, 11 of whom were professionally involved in rescuing and protecting (humanitarian organizations, social protection organizations, civilian protection) and nine of whom were affected by the consequences of the natural or other disaster.

We also interviewed 14 men, nine of whom were professionally involved in the system of rescuing or civilian protection, *i.e.*, systems providing relief for the population affected by natural disasters, and five of whom suffered directly from the consequences of the natural or other disasters.

TABLE 14.2 **Conducted Interviews According to the Type of Event**

No.	Event	Location	Interviewee
1	homeless people in an extremely cold winter in Ljubljana	Ljubljana	head of Civilian Protection
2	river accident near hydroelectric power station Blanca	Nova Gorica	fireman and rescuer
3	river accident near hydroelectric power station Blanca	Sevnica	director of the Center for Social Work
4	river accident near hydroelectric power station Blanca	Brežice	head of Civilian Protection
5	river accident near hydroelectric power station Blanca	Krško	police officer at Police headquarters Krško
6	humanitarian aid	Ljubljana	Caritas Slovenia
7	hailstorms	Nova Gorica	voluntary fire brigade, Nova Gorica
8	hailstorms	Murska Sobota	resident (f)
9	hailstorms	Kamnik	representative of Civilian Protection
10	hailstorms	Kamnik	representative of the Center for Social Work
11	hailstorms	Ptuj	representative of the Center for Social Work
12	hailstorms	Ptuj	resident
13	hailstorms	Ptuj	family
14	hailstorms	Ptuj	family
15	hailstorms	Ptuj	resident
16	hailstorms	Ptuj	fireman
17	hailstorms	Murska Sobota	representative of the Red Cross
18	hailstorms	Murska Sobota	resident
19	hailstorms	Murska Sobota	representative of the Center for Social Work
20	hailstorms	Murska Sobota	2 representatives of the Roma Community
21	hailstorms	Murska Sobota	head of Civilian Protection
22	hailstorms	Ljubljana	worker in the Red Cross, Ljubljana

CONTINUING TABLE 14.2

23	earthquake	Tolmin	2 social workers from the Center for Social Work
24	earthquake	Čezsoča	resident (m)
25	earthquake	Čezsoča (Bovec)	home nurse
26	earthquake	Čezsoča (Bovec)	public worker employed at the Center for Social Work at the time of the earthquake
27	earthquake	Čezsoča	resident (f)
28	earthquake	Čezsoča	resident (f)
29	fire	Ljubljana	2 social workers at the Center for Social Work
30	major road accident	Ljubljana	anonymous fireman

The narratives collected about the different events were put in a special data sheet and processed by using qualitative thematic analysis. The statements from the individuals involved in the different disasters were then, according to similarity of experience, arranged into larger themes, which were identified through having been common to many of the respondents.

We are fully aware that the sample is small and that any generalization tends to raise questions. On the one hand, we were interested to find out how frequently the individuals involved in the disasters experienced certain gaps in the system, which revealed where the systematic solutions tended to be insufficient for many people; but on the other hand, we also paid attention to individual, singular and contextual experiences of respondents, which turned out to be relevant for service planning. We also focused on the inconsistencies we came across in the views and experiences of the effectiveness of relief for different types of respondents (especially differences in perception of the event by the population and services).

14.4 Results and Discussion

The analysis of the interviews has shown the nature of the existing practices and has revealed deficiencies. The analysis also included good practice and solutions, although more attention was given to *deficiencies*, since the objective of the research was to examine the weak points of the system and suggest possible strategies for their elimination.

Irrespective of the type of disaster, the common finding of all involved respondents was, that the main gap is connected to the significant lack of community and social support. The authors believe that this is the consequence of social work being *formally and systematically excluded from the system of rescuing and protection*. The consequences of this exclusion are deficiencies in received services as experienced and expressed in our conversations with different respondents involved in the disasters; we classified these deficiencies according to 10 categories:

1) long response time
2) disconcerted performance of organizations and inappropriate informing of people
3) lack of available staff or crucial person at the institution
4) lack of clearly defined protocols
5) lack of criteria for and opacity of relief distribution
6) Imbalance of power and unequal distribution of resources and relief among the population
7) discrimination and human rights violations
8) overlooking vulnerable (poor) groups of the population
9) inaccessibility of different forms of support in the field during and after the disaster
10) resorting to bureaucracy because of nonexistent protocols
11) lack of psychosocial support and relief for rescuers.

Long Response Time

> "The hailstorms took place on Sunday; on Monday at 10 a.m. we were already at the spot of the disaster" [two interviewees from two different social work centers].

Social service workers perceived that they quickly arrived in the field when the disaster happened. This fast arrival may be true from the service perspective, where the role is not formalized in the process of rescuing; however, from the perspective of the affected person, the response time was still too long. If, for example, the accident were to happen over a weekend, no social service would be available to instantly come to the area. Since there is no systematic regulation regarding the social protection services' tasks and roles in the case of a disaster, the response time frequently depends on the internal organization of the service.

> "The first six hours there was no competent, *i.e.*, adequate, person at the place of the event to talk to the relatives" [representative of the operative-communication center at the police directorate].

The lack of timely professional relief intended for the relatives puts additional stress on the rescuers, whose primary role and concern is to rescue; furthermore, the rescuers have neither time nor sufficient knowledge to offer this kind of relief.

> "Psychosocial relief is not adequately organized within the system of civilian protection. Things pretty quickly fell in the right place just because of personal connections and friendship, not because of system adequacy regarding the provision of psychosocial relief at the time of disaster. I called my friend on the mobile phone; she happened to be head of the social work center, so she immediately sent her colleague in the field" [rescue coordinator in a major disaster].

The advantage of smaller, local communities in a predominantly rural environment of Slovenia lies in the connection between residents, who tend to help each other. However, this does not mean that such relief is binding, efficient or system-regulated; it is left to the informal networks of individuals who take part in the system of rescuing and protection.

> "In emergency situations, I press a red button to call the firemen … for other servces, I should also have the possibility of just pressing the button to call a particular center that would activate (the same way as other services) and coordinate everything necessary regarding psychosocial relief. It shouldn't be us dealing with coordination, looking for counselors … This is true for any type of disaster" [rescue coordinator in a major disaster].

An adequate response time in cases of natural and other disasters is crucial; the response is directly connected to organization, distribution of working tasks and preparations. The systematic arrangement of psychosocial relief, which would become a part of the existing network, could contribute to eliminating the gap.

The long response time was a complaint among the affected population, especially when it came to repairing buildings. One of the interviewees, whose roof was damaged in a storm, stated:

> "This (long response time) is also the case now. My house was damaged by the storms, so I need to stay in my house and use an umbrella; it's right now that I need relief, not next year."

Disconcerted Performance of Organizations and the Inappropriate Informing of the People

If psychosocial relief and humanitarian organizations are not part of a system of protection, a coordinated performance in the field frequently tends to be rather coincidental; it depends on the acquaintances among involved people and is therefore not provided by the system.

"There was a lack of common strategy on the municipal level. There was a lack of cooperation among different institutions. Each of them responded according to their competences. So, one family could be seen by many institutions while another wasn't seen by anyone" [interviewee at the Center for Social Work].

"At a certain point there were three different lists of people to receive relief going around. One was drawn by the firemen after their inspection, one by the Red Cross and one by us according to the field situation we had known before. Some people got relief three times, some not even once" [interviewee at the Center for Social Work].

The residents frequently reported that it was impossible to get clear information about what to expect from different organizations.

"The people suffering from damage didn't know whether they should go to the municipality and report the damage or wait for somebody from the municipality to see them" [anonymous interviewee from the regional Red Cross].

Often we were told in the interviews, *"Perhaps people could be better informed about who they should turn to for relief, which organizations are responsible for that and which are not"* (resident in the area affected by storms). Better awareness could erase the distrust experienced by many: *"A visit meant a great deal to me; there was no information available, some people were angry, because their neighbors already had their roofs repaired"* (a resident affected by hailstorms).

Usually, the readiness to offer relief is greater at least in the initial period after a disaster. Frequently, problems arise regarding the coordination of volunteers or the collection of material relief.

"Often relief is inadequate and inefficient because good people also give away their furniture, which is not needed at such moments: those affected have nowhere to put it. The problem is that emergency appeals are announced by the Red Cross, Caritas, municipalities etc., so people get confused" [representative of a humanitarian aid organization].

The Lack of Available Staff and Key Figures in the Institution

"It happened at the time when people were on leave; many of my colleagues weren't at work" [interviewee at the Center for Social Work].

A lack of available staff emerged as a serious problem that interfered with the functioning of both the rescue and protection services as well as the services that became involved with rescuing and protection when the need arose. Almost as if deliberately, natural disasters tend to be more frequent during the time of year when people are on leave—when the services, whose staff are not prepared in advance, do not fully function. However, such an event may cause staff complications even when a disaster strikes at other times.

> "So we had to redistribute work; we all have our own tasks to perform, well, … other tasks we also do … so who's got enough time to work in the field during this special situation and at the same time do all he does normally, right? … That was the first problem. We had quite a lot of problems, yes. The additional work. We knew it had to be done, we knew that was our responsibility to examine the needs in the field, to see people, but we wondered who should come with us. Lack of time and all … that was the first thing"[interviewee at the Center for Social Work].

As a consequence of the lack of human resources, people who did not get timely, adequate relief were unsatisfied. Another problem was the lack of key figures who could provide information and at the same time serve as a reference person for people suffering damage.

Our team suggested that not only a system be established, *i.e.*, key figures, preparedness plans and better coordination within social work centers, but also that coordination and movement of personnel on the state level between social work centers be improved (protocols be drawn up that would enable flexible movement of personnel from one Center for Social Work to another as circumstances require).

The Lack of Clear Protocols

The difficulty due to the lack of guidelines, protocols and working methods were described by two interviewees from the Center for Social Work:

> "I was scared because I didn't know how things would go on, how I was going to deal with it all because I had no experience whatsoever" [interviewee at the Center for Social Work].
>
> "All we did the first day was collect data. People dropped by later. For example, I'm responsible for first social relief, so people who find themselves in distress for the first time come to see me; there were some neighbors of an old woman who called me to report that a tree fell down on her house … The next day we had a meeting. And we were wondering what our responsibilities were in this situation, what the Center for Social Work was supposed to do. We were wondering who would cooperate with us. Who was responsible for performing certain tasks and doing the rest of his work?" [interviewee at the Center for Social Work].

As we noticed in the field, the service practices (of the municipality and of the Centers for Social Work) differed from one municipality to another. In some areas, the Centers for Social Work got involved automatically, but in others this occurred later or not at all.

> "There was an intervention meeting beforehand, when the groups were formed to examine the field and make a list of the storm damage. On Monday, I waited for a call from the municipal office. As no one called me, I called them. Though I am not

> sure what would have happened had I not made the first contact with them; would there have been any cooperation at all? I was really scared they would have simply left us out" [interviewee at the Center for Social Work].
>
> "A committee for the equitable distribution of relief was established. This committee had been established beforehand, even before it was commissioned by ministry. The municipality initiated it, and I find this really good, because we, *i.e.*, the Center for Social Work, were involved automatically ..." [interviewee at the Center for Social Work].

Many services do not have clear protocols to ensure better response and preparedness. The first findings demonstrate that response and efficiency of relief tend to be greater in those municipalities that have included the social work centers and humanitarian organizations in the municipal crisis teams right from the start. An interviewee stated,

> "the result [of the cooperation of the Center for Social Work with the municipal crisis board] was that people didn't need to walk from door to door, so they were pleased. At the beginning, the municipality wasn't informed about everything our center could offer to people."

Not only should the existing services that are formally included in the rescue and protection system have protocols, but all organizations should be required to have them.

The Lack of Criteria for and Opacity of Relief Distribution

> "My colleagues and I, who work in the area of financial and social assistance, sat down and defined the criteria to meet in order to get the assistance. Although we made an appeal to the government to establish criteria, this wasn't done, so we had to establish our own criteria. We abided by the law, though we acted independently, and I think that was right, because a Center for Social Work should be able to act independently in cases where no directions are given from higher authorities" [interviewee at a Center for Social Work].
>
> "The state founded a natural disasters' fund some time ago, however the criteria for allocations are extremely rigid; the state defines the amount of financial assistance, the sums are very low and don't mean much for the people, especially when it comes to extensive damage. The state was not aware of the reality, which was to be examined on the field; that's why we had to manage for ourselves" [interviewee at a Center for Social Work].

The lack of criteria for relief distribution is not only a problem for social and humanitarian workers, it may also arouse resentment and suspicion among residents. One of the interviewees at a Center for Social Work reported,

> "but then it also happened that one of them already got relief, whereas another didn't, so he was asked (at the Center for Social Work) why he still hadn't received anything. They blamed the mayor because he didn't care for the people; I noticed

> this myself—people wanted him to come and see things for himself, but he preferred to stay on holiday."

It is necessary to construct and implement a single system of organization, responsibility and liability for disaster relief. This should be based upon a single methodology designed for damage assessment and a unified set of standards that ensure state funds rely on social equality and solidarity principles, comply with the needs of vulnerable groups, aim at prevention, and consider the responsibilities of natural and legal persons against the risks and the possibilities for protecting against them. For this purpose, it is necessary to involve the social services and representatives of population who can contribute to designing such criteria.
The social workers pointed out that not only the lack of criteria but also the rigidity of financial and social assistance criteria, which were drawn up late by the state, put the Centers for Social Work communicating with the affected population in a tight spot, because they did not conform to the needs in the field.

> "For example, the state decided to allocate state aid to anyone whose damage assessment exceeded the sum of € 3,000, but this applied only if the damage was done to residential buildings. Since our village is an agricultural village, there are many agricultural buildings that did not meet the criteria for aid allocation, so we had to make use of humanitarian aid" [an interviewee at a Center for Social Work].

Imbalance of Power and Unequal Distribution of Resources and Relief Among the Population

As a rule, the lack of clear and professionally determined criteria resulted in, for example, the allocation of resources and relief being governed by criteria based on "the law of the stronger." As reported by an interviewee,

> "Somebody who was influential got two residential facilities in order to keep his things in a safe place, whereas an old lady next door, who hadn't slept for several nights in her cracked house, got none, so she couldn't have had a good night sleep because someone had assessed that the damage done to her house just wasn't grave enough" [testimony of a participant in the Posočje working camp, 2004].

Relief therefore depended on personal acquaintances (*"Acquaintances are very important here, we all know each other"*) and the current political situation (*"Relief was quick and efficient because it was election time"*). Unprofessional relief—organized ad hoc, carelessly planned, motivated politically or by the media—will increase the imbalance of power in a community struck by disaster. Some groups of the population that tend to have less influence thus become victims in two ways, as victims of disaster and victims of discrimination:

> "Since we're still paying off the loan for our house damaged in the second earthquake, we're experiencing terrible financial distress, because we have to partly cover the costs

of the new house we got after the third earthquake. The first residents got everything for free, the second were more under pressure, because they were running out of money; some were more materially deprived than others who already got houses, but didn't get it for free; some received the loan twice, but after the third earthquake they were not given a donated house as they were promised" [resident].

"The Caritas organization allocated money to people who had the roofs of their houses damaged after the storms. Everyone got the same amount irrespective of criteria, such as the degree of damage, house insurance, or whether there was a new Mercedes parked in front of the house. Briefly, irrespective of the social status, everyone got the same amount, 1000 Euro per house. Caritas was also the first to distribute financial aid" [an interviewee at a Center for Social Work].

The Center for Social Work based in the area struck by heavy hailstorms recognized the need to link with humanitarian organizations and the municipality in order to coordinate the lists of people to receive relief so that the affected people would be less likely left to themselves. *"We've discovered something, the Red cross has its own list of people in need, so does the municipality, and now we're trying to figure out how to bring the lists into line ... we've decided to work out a single strategy for material relief distribution, because there are significant social differences."* They also managed to improve their own criteria for financial relief distribution as they observed the significant social differences among the people:

"For example, there is a multi-storey dwelling: two families, separate households, low social status, unemployment, low pension. But their roof is damaged; it isn't insured, which means that they need to receive more than someone else whose roof is insured, because he or she will be compensated. We respected that, so we also distributed two application forms for exceptional financial social assistance, because each person can exercise the rights for him or herself" [interviewee at a Center for Social Work].

Discrimination and the Violation of Human Rights

In disasters and chaotic circumstances, social groups who are usually discriminated against and socially isolated are prone to explicit violations of human rights.

"The Caritas organization paid a total value of € 1000 in aid per house. But not for the houses in Roma villages. There, Caritas paid a total value of € 500 in aid per house. One would have expected it the other way around, because that's where unemployed people live and nobody has got home insurance ... I don't know why this happened, perhaps because their houses are smaller or cheaper, so their roofs are poor" [interviewee at a Center for Social Work].

"The state hasn't offered anything yet; we're waiting for them to fulfill their promise. Caritas is the only one who helps; just today, each household received € 500" [interviewee in the Roma village].

The above quotations are part of the story incidentally heard by our research team in the field. At the Center for Social Work, we found out that the people in the Roma village got one half of the financial assistance distributed to others by Caritas; an hour later the residents in the Roma village, who at the time were not aware of this fact, happily reported that the only organization which responded to their needs was Caritas, so they received concrete relief. As we were not in a position to verify the accuracy of the information, we did not investigate the situation, but later the media reported protests on the part of the Roma community. The head of the Slovenian Roma council, Mr. Darko Rudaš, pointed out that the financial assistance had been distributed on the basis of ethnic background, and that it was absurd that this was done by a Christian organization since there are many Catholics in the Roma community.

> "Caritas had already collected money from good people and distributed it. We Roma people got € 500 per household, which is nice, but people of non-Roma background received € 1000 per house. They received relief, so we had heard, for the same reason, *i.e.*, to repair the damage caused by storms, but they got twice as much as we did, *i.e.*, € 1000; some of them got even more. If this is the case, the financial assistance was distributed on the basis of ethnic background, not on the basis of the amount of damage or equally for everyone affected. This is a typical consequence of stereotyping, which should be fought against. Now, that's no longer nice. Worse still, I'm surprised and appalled; this approach is discriminatory. This is discriminatory treatment of people and their property purely on the basis of their ethnic background, in our case, race or nationality. A Christian organization that claims to be humanitarian should never allow something like this to happen; it should act responsibly, responsibly with regard to people, their feelings and the financial means it collects from good people for a good cause. For a good cause in general, not just for "non-Roma people." Caritas is a Catholic humanitarian organization. Roma people are religious people, too; we believe in God. That's why I'm asking dear God, for whom Caritas also does good deeds, in the name of all Roma people, to make a fair distribution of common sense. We Roma people have enough common sense, but we ask Him to help us and see that a fair amount of common sense is also given to that charitable organization called Caritas. It seems He will have a lot of work to do" [interview with Darko Rudaš, *"God, make a fair distribution of common sense!"* Interview by Milena Dora, Nedeljski dnevnik, August 20, 2008].

This case clearly demonstrates that we no longer speak about hidden discrimination; we speak about explicit, open discrimination, which should be a subject of concern for human rights organizations and legal institutions. After all, Caritas has been given some sort of "concession" from the state to collect money, so its activities should have been controlled by the state, even though it is a non-governmental organization.

Regarding the slow distribution of relief on the part of the state, our interviewees stated,

> "Pušča is believed to be the best-organized Roma village in Europe; so if it is left to itself and if no relief is given, we'll just stare at each other. We'll get no state relief or municipal relief; if we don't take a step forward, we'll lag behind. It will all be the same as 20 years ago."

Unfair and discriminatory distribution of relief has far greater consequences, as demonstrated by experiences around the world. If one wants to make neighbors hate each other, simply give more to one than to the other. In Prekmurje, where Roma people have good relations with "non-Roma" people, this would cause irreparable damage.

Overlooking Vulnerable and Poor Groups of the Population

A non-individualized approach neglects the specific needs of the people and tends to be insensitive to vulnerable groups of the population, who lack the power or competency to demand relief, or worse, who feel that the relief is not meant for them. This includes people who have trouble finding work and who are at the bottom of the social power hierarchy.

> "But then, we came across situations in the field we hadn't heard of before. For example, an old, tired woman who lived alone and had her house almost swept away ... well, it turned out she should have been given the sort of care one gets in an elderly home" [interviewee at a Center for Social Work].
>
> "We were in severe distress because the disaster was exceptional and we had to work with people we usually don't deal with, for example, with the working-poor, who haven't got enough money to survive on their own" [interviewee at a Center for Social Work].
>
> "Social distress—a married couple who lives on one pension, suffers from nerve disease, is constantly worried about their grand-daughter, because she's a little girl; this means they will find it very hard to support their daughter" [part of the interview with a married couple whose roof was damaged by the storms].

One professional contribution of social work in emergency situations (as elsewhere) is the "pointing out" of such groups by means of knowledge and sensitivity, because these are the people who are also frequently deprived of relief resources and whose life stories are not interesting for the media, until their poverty and vulnerability is (mis)used for purposes of media coverage.

Quite frequently, donations are made conditional on appearing in the newspapers and other media.

> "Many people refused relief, because that would mean they would have to reveal their distress in the newspapers; they are at social risk and that would only attach

> additional stigma to them." "A social worker suggested that somebody from the newspaper Nedeljski dnevnik come, column Iskrica (Sparkle), and they promised to help us with house building" [resident of Destrnik, Municipality Ptuj].

Absence of Experts in the Field

The continued presence of experts in the field is crucial for assuring efficient support, for providing information and for increasing the resilience of people affected in disasters. One of our interviewees affected by the storms said, *"It is important not to make people feel like they have been forgotten."* Another interviewee felt that the presence of support was important while coping with different losses caused by disasters: *"In such moments, when you lose that tiny little house, you feel that nothing will ever get better. In such moments you need a lot of support."* The presence in the field is necessary for reducing damage and responding to people's urgent needs that are overlooked by other services.

> "There was no available material to cover the windows; everything was wet. The windows were broken, so we had nowhere to sleep. There was a draught because of the wind; everyone was shocked by the extent of damage. Our children spent two days in this wet house" [a resident affected in the storms].

Contrary to the things mentioned above, some interviewees from the Centers for Social Work felt that their services were available and that people had different needs:

> "At the Center for Social Work, we offered psychological relief to the people. They were all given the possibility to receive individual relief; they had the possibility to be seen on the spot of disaster; all emergency numbers were published on the internet site of the municipality and of the Center for Social Work; we also sent messages to the field through members of civilian protection in order to inform the people that they had a psychologist available at the Center for Social Work. I felt it was a waste of time and energy to see people on the spot of the disaster because they needed material, not psychological, relief" [interviewee at a Center for Social Work].

"Flight into Bureaucracy"

The unclear role of social work in the system of rescuing and protecting and the lack of protocols in disasters (staff provision etc.) causes some professionals to remain strictly bureaucratic in their roles and follow the principle of "minimum involvement." We have not explored the reasons behind this (defense mechanism against intense emotions, overburdened with other tasks, etc.), but such a "flight into bureaucracy" surely hinders efficient, thoughtful and adequate responses to disasters.

> "The interviewees told us that the role of a Center for Social Work is not legally defined in such disasters (fire). That's why their role in this case was restricted to providing information about rights—exceptional financial and social assistance. They told us that they abide by the regulations and procedures, so because there is no other law to require them to provide other sorts of relief, they don't even provide it" [a part of the interview at a Center for Social Work].

The Lack of Psychosocial Support and Relief to Rescuers

Almost all the stories about rescue in disasters we heard from the rescuers, firemen, members of civilian protection etc., stated that the act of rescuing brings about emotional stress and psychological pressure, especially in cases where there are fatalities involved.

> "The rescuers are tough guys; they don't break down just like that, but rescuing was extremely stressful. The men had to pull out the dead bodies of their colleagues, friends, relatives. All the time everyone had to wait for something, the equipment, the right time ... That's what put additional psychological pressure on them. Waiting was wearying. They knew the whole time that they were no longer looking for survivors, just dead bodies" [an interviewee from civilian protection].
>
> "The rescuers were physically exhausted, psychologically broken. It seemed it was all done in vain. They were demoralized. We felt we wouldn't be able to find the people; some people broke down. The professionals who provided psychological relief moved around, and when there were no relatives, or the rescuers didn't need them, they talked to them ... Nobody gives a thought to that; nobody thinks that rescuers should also need relief. That's something we have to pay attention to next time" [interviewee from civilian protection].
>
> "Even if we talk about the disaster and try to get rid of the burden we're carrying, we need someone who will ask 'the right questions' and really help us to get rid of the burden" [professional fireman].

It is necessary to provide professional psychosocial relief for rescuers, *i.e.*, "someone who will know how to ask the right questions," during and after disasters. Such relief needs to find its place within the system; otherwise, as one of the interviewees, a professional fireman, reported, "long-term stress and problems that occur because of the hard experiences, which are ignored by the person involved, leads to alcoholism and other problems."

14.5 Conclusion

The results have demonstrated that institutions in the area of social protection are not sufficiently prepared to cope with natural and other disasters. They respond to the situation ad hoc, *i.e.*, when the disaster has already happened. This has several disadvantages, such as a long response time, a lack of available staff and crucial persons at the institution, and an inadequate distribution of resources and relief among the population. The interest of politicians, humanitarian organizations, media, "people of good will" gradually fades after the intense emotions stirred up by disaster settle down. But that is when the residents affected by disasters begin a long, tiring journey. Some geographical areas that are frequently affected by natural disasters (earthquakes, storms, floods) tend to become less prosperous and underdeveloped; the population suffers from poverty and unemployment, which drives younger generations to settle down elsewhere. Continuous developmental support provided for communities that are frequently affected by natural disasters is therefore a priority which also reflects the role of social work. For this reason, it is necessary to assure a more extensive approach within the national program of protection against natural and other disasters, and to include the complexity of such disasters in other strategic documents.

14.6 Recommendation

The research findings presented here have enabled us to suggest ways of improving the system of protecting and rescuing.

Areas Prone to Natural Disasters

The system of responsibilities and liabilities in damage repair after disasters is to be based upon a single methodology for damage assessment and equal measures for allocating state aid. The system should aim at prevention and respect the risk-responsibility of natural and legal persons as well as the possibilities for protecting against them. One priority for social work should be continuous developmental support for communities frequently affected by natural disasters (community social work, empowerment and the development of social networks).

Social Work During and After Natural Disasters

The presence of social services in the field is necessary to provide efficient support, information and to improve people's feelings of resilience. It seems sensible to introduce a crisis "social team" (a team of social workers, psychologists, nursing staff and a coordinator) to be on call and who would become active in natural and other disasters. At first, a pilot crisis team should be introduced, and its activities should be monitored over a certain period of time.

In order to provide better response and more efficient relief, the social services and humanitarian organizations should be involved in municipal teams from the start (a cooperation of representatives from social services and humanitarian organizations in municipal crisis teams and structures that respond in emergency situations). It is necessary to create a professional role of coordinator in order to upgrade the existing system of relief. This would allow access to quality, timely and clear information about the operation of social protection and relief provisions. Systematically organizing this coordination to provide psychological and social relief as part of the existing network could help the response adequately address the needs and distress of the population and especially those individuals who have been overlooked by other services; it would link the system of social protection, non-governmental organizations and other actors in the community.

It is necessary to establish a system, *i.e.*, crucial persons, preparedness plans, to improve coordination between the Centers for Social Work, to establish cooperation among the different centers at the state level, and to improve coordination in cases of disasters (drawing up protocols that would enable personnel to move easily from one center to another as circumstances require).

Criteria

It is necessary to draw up action protocols for social protection services for the time of the disaster and for afterwards. The protocols should involve the current tasks of the services that are formally included in the system of rescuing and protection, as well as the duties of other public, non-governmental and private organizations involved in social protection. For this purpose, the system needs to involve social services, humanitarian organizations and representatives of the population.

It is necessary to make relief distribution, including that by humanitarian organizations, transparent and based on ethical values. The population suffering from damage must not have to depend on humanitarian organizations when receiving relief and means for damage repair that make them expose their distress in the media, thus exposing their social vulnerability. In designing a sustainable system, it is necessary to recognize that relief should not depend on political beliefs or involvement in politics (promotion of equality).

Rescuers

The system of rescuing and protection must include a permanent, accessible and individual-oriented psychological and social relief (crisis social teams).

Civilian Self-protection

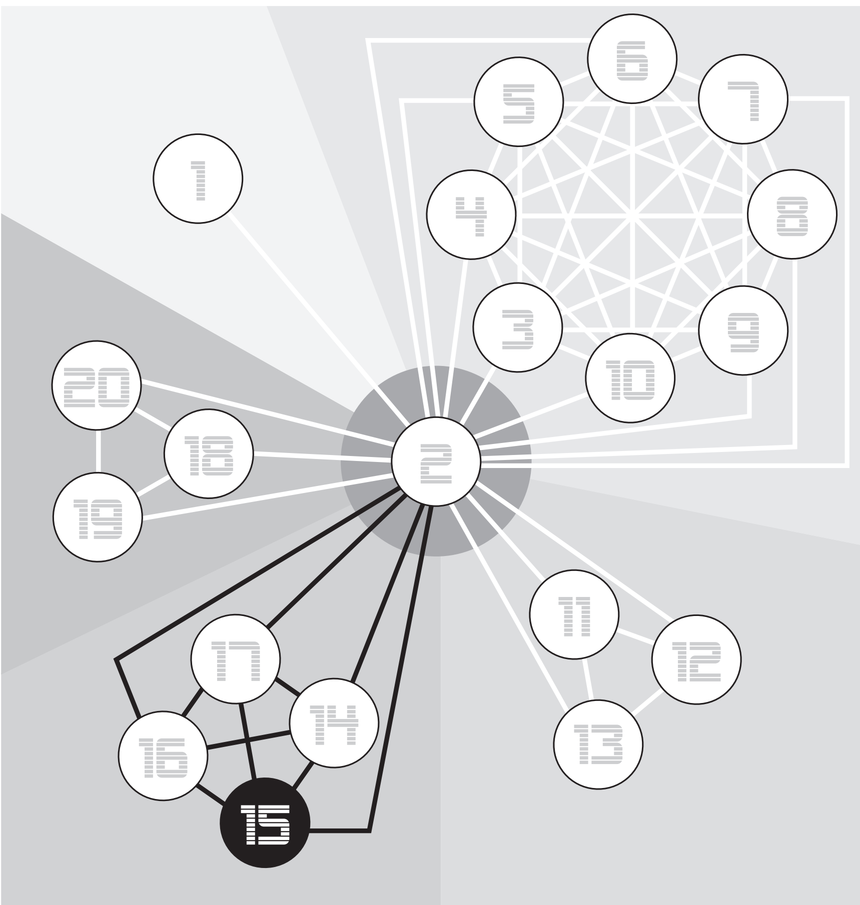
The public needs to become well-informed about natural disasters and self-protection.

Our research has probably revealed more gaps than it has offered solutions. In order to provide more credible and thoughtful solutions and models, which could be examined in a pilot action project, we would certainly need to research further the options in the services and communities. This is the direction we are aiming for in the future. Some Centers for Social Work that cooperated in the research have already shown interest in further cooperation with us in this project, which they find necessary. These findings must concretely alter the response models in the communities so that the fears that promised changes will never be realized, as expressed by one of the interviewees from Pušča, do not come true: "… there's no problem if you come and we talk, but if nothing happens afterwards and if it turns out we've only sat here and had small talk…"

[English translation: Mateja Petan]

15 Secondary Disaster and Social Work

Jelka Škerjanc



15.1 The Bovec Area and Support After Earthquakes

The municipality of Bovec is located in the extreme northwest of Slovenia, surrounded by the Julian Alps and in a specific geostrategic and seismic area. Half of the 3,500 inhabitants live in the town and the rest live in 16 villages along four river valleys. Statistically, in the municipality of Bovec, there are as many vacation homes as households. In recent decades, the tourist industry has created new jobs under generally scarce employment conditions. Other characteristics unfavorable to the prosperity for this area are brain drain, poor infrastructure and modest economic potential. Demographic data shows a high rate of older people living alone in remote locations that are hard to reach.

A Continuous Threat to Homes

Some older residents in this area have lost their homes five times in their lives: in World War I, during the battle on the Soča Front; in World War II, when the Italian fascists burned down their homes and later when the Nazis bombed them; and during the last three decades, through three earthquakes and one land slide, which caused seven fatalities and eroded entire villages.

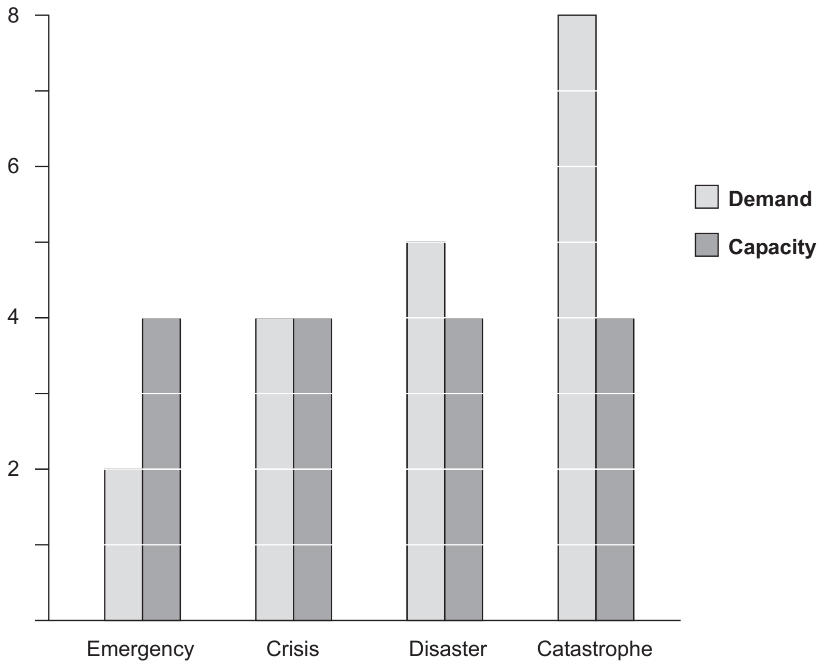
One week after the earthquake of July 2004, rescue teams left Čezsoča. The first assessment showed that the most affected was the village of Čezsoča. With around 400 villagers, this was a community of traditional unity and solidarity. Of the 150 houses in the village, 40 needed complete rebuilding and 80 a substantial reconstruction. The continuous hits of earthquakes, the fear of being manipulated or cheated, and the uncertainty regarding the future paralyzed residents both in their minds and actions. They found it hard to concentrate and think about the future.

Three main facts have previously defined the support after earthquakes in the Bovec area: the support for residents has not been sufficient; the support has been short-term and focused mainly on the material living conditions of residents, and there has been almost no support for people struggling with their every-day living conditions [Škerjanc, 2004].

For many residents in Bovec area, reconstruction after the first and second earthquakes has been a painful experience because it has been slow and the inhabitants have had no say in the reconstruction of their homes, although they pay the loans for them. The third earthquake of 2004 caught some families whose homes had been damaged in the earthquake of 1998 still living in provisory housing. Because of their past experiences, the residents were preoccupied and claimed that for them reconstruction was itself another ordeal to be suffered.

Schock [2009], in an analysis of the natural disaster response, shows that the more demanding the disaster, the more aspects of it remain unaddressed.

FIGURE 15.1 **The Relationship Between Capacity and Demand in the Response to Natural Disaster**



Source: Schock, 2009

Figure 15.1 demonstrates that the existing systems of preparedness cannot respond to the demands of disasters and catastrophes. This proved to be true in the Bovec area case particularly regarding the restoration and reconstruction phase after the two earthquakes.

Social Work Volunteer Camp

In July 2004, in the Bovec area, the Faculty of Social Work at the University of Ljubljana organized a three-month-long, social work volunteer camp to provide support for residents most affected by the earthquake. The aim of the project was to provide support for residents in coping with the consequences of the earthquake by organizing the following: a) providing supplies and support for individual residents and the community, b) supporting residents with reconstruction, c) networking key actors in the community, and d) researching the work performed in the project. It was also expected to bring new knowledge and experience in emergency situations to social work theory and practice in Slovenia.

The volunteers arrived in the field one week after the earthquake. The recruitment of volunteers was organized by invitation, using the network of professionals who had previously shown interest, an ability to cooperate, and the competence to develop or support innovative initiatives in social work. These initiatives included practices or actions demanding exceptional efforts or time commitments and attention to the persons in need and in distress. The volunteers invited to participate were mainly social workers with years of professional practice, lived experiences and who held university degrees. The knowledge and skills described above were part of their study program and trainings. Because of that, the interventions did not need much conceptual discussion and adaptation. Between July and September 2004, the project brought together 42 volunteers, mainly social workers. They performed 335 working days of support for the residents and the community.

15.2 Theoretical Framework and Methodology

The Relevance of Resident Expertise

The support was founded on the residents' expertise in organizing their lives and in choosing the support they need. The graph in Figure 15. 1 is helpful in developing the converse interpretation to the one presented above. This converse interpretation says that the lack of support available after the earthquake created a second disaster for the residents. This lack resulted in damaged relationships, damaged individual mental health and community life, which had to be restored, reconstructed and healed by all the people in the Bovec area, for the third time in the last three decades.

We could say that residents in the Bovec area are experts in recovering from earthquake damage, both material and psychological. They are also experts in organizing their lives after these natural disasters. Their expertise is a valuable resource for designing approaches, measures and practices for social work in emergency situations after natural disasters.

Collecting data on the support that residents said they needed brought about information on the services that residents wanted during the restoration and reconstruction phase. Dervin [2003] claims that seeking and using the information is explained best by how people see their situations, the constraints they face, the gaps they need to bridge, and the kinds of bridges they would like to build across the gaps. Dervin articulates a philosophical perspective that asserts ordinary human beings are theorists, the real theory-makers. Dervin argues that theory-making is a mandate of the human condition, given the pervasive discontinuity which manifests in the diversity of human internal and external worlds and structures. The strategies of defining situations are the *hows* of communicating.

A similar conclusion to Dervin's comes from a survey of residents' earthquake preparedness that was carried out in Slovenia in 1998 [Jeraj, 2008]. In connection with other sources, it shows that the adequacy of people's responses to emergency situations differs from the views expressed before the occurrence of a disaster. The author states that residents' attitudes are not a reliable predictor of their behavior and the outcome of their responses when a disaster strikes. Informing residents about risk, preparation and action is not sufficient. Instead, bridging the gap between knowledge and attitude is necessary.

Both Dervin and Jeraj emphasize the connection between experience and information; they use the term 'bridging the gap' to approach this. Here, the shift occurs from focusing on *what* is going on to addressing *how* to approach, organize, provide, overcome and so on. In addition to training, which is organized for different focus groups and different accidents and disasters, learning from individual and group expertise in surviving, coping with and growing from natural disasters is also necessary. The question is: how is such learning possible?

Freire [1996] claims that humans transform their reality through dialogue, which enables experiential learning by transforming the reality. The individual's critical reflection of his or her experiences initiates the learning process and continues in a cycle in which reflection leads to action. This action leads to further learning through experiential reflection. The author claims that naming the world is not a privilege of a few people but the right of everyone.

Having power means that a person can express his or her situation in his or her own words, in his or her own way. Groups that suffer from the dominance of the greater culture and of social institutions frequently do not have their stories told or heard in the wider world [Saleebey, 1997]. The imbalance of power and control among service providers and service users in social care is widely elaborated and explored [Oliver, 1996, Morris, 1993, Beresford, 2005]. One of the major criticism deals with prevailing social work performance and social care practice, both of which cause the individual to lose control in his or her life. It reports disabling services, patronizing approaches, senseless responses, lack of commitment from social workers, and lack of respect for people receiving their services. In social work practice, the imbalance of power allows professionals to define the situations of the social service users, interpret them, make statements, analyze data for different purposes within the social care system and broader state system. Freire, countering these approaches, claims that each person has the right to name their world by themselves. "By speaking their word and naming the world, people transform it in dialogue" [Freire, 1996:69].

The right for a person to name their reality is gradually becoming a common issue in social work practice that addresses human nature as diversity. By acknowledging resident expertise, the balance of power shifts from those who organize and provide support, *e.g.*, politicians, professionals and public officers, towards those who receive help, *e.g.*, residents affected by a natural disaster. In social work practice based on service-user expertise, the social service users bring in concepts, semi-developed to highly elaborated theories about their situation, survival strategies, horizons, relationships and so on. Without all this information from the social service users about their situation, social workers have no chance to develop original solutions for the users' situations. Here, social work theory and practice get the source by learning from individuals about their realities, definitions of realities and their engagement in introducing change in their lives.

To design a theoretical framework that views the perspectives of social service users like those of experts, a strong moral and value-based standpoint is needed. In social work, moral thinking determines the quality of the relationship between the provider and the user, the quality of their cooperation and its outcome. Consequently, the moral thinking underlying social service performance affects the quality of the individual social service user's living situation and conditions. Banks [2001] promotes the idea of the reflective social work practice, which recognizes ethical dilemmas and conflicts of power relations and how they arise. Causes of these conflicts can be the unequal power relation with service users, problems within the social care system or society's ambivalence towards the social care system and social workers in particular. Such recognition demands a proactive commitment to social justice and solidarity from the social worker. It requires the social worker to enter the person's reality, a reality of being deprived of one's voice [Hegel, in Freire, 1996] and of struggling to get by.

When a person is in control of defining his or her situation and of identifying ways to overcome it, the *what* (needs to be done) shifts to *how* (to make it work). If we follow Dervin's idea that strategies of situation-defining for people are the *hows* of communicating, we see that the *hows* delve within resident expertise. The *whats* of the theoretical world, which tend to describe the realities, need to connect to the *hows* of the individual people world and communities, learn from them and develop approaches and practices that support people in actively improving their quality of living. In social work practice, this would mean individualizing the process of planning, delivering and evaluating support for each resident. By starting the design of social service delivery with the individual's goals for improving his or her life, the "translation" from words to action becomes possible.

The individualization of social service provision is based on human rights and the right of each person to get support in order to improve his or her quality of life. It builds on the experience and expertise of people who use social services and enables service-user control in social service delivery. By defining changes in his or her situation within life goals, the person directs his or her life.

Both the professional and the service user work together towards the same goal—the life goal set by the user. The purpose is for social services to support the person in organizing his or her life and in improving the quality of living. Following the concept of rights in designing social services, user control is essential in each phase of social service provision, from the first meeting with service provider to the final evaluation. From this evaluation, a new cycle of planning, action and reflection can start.

Methodology and Working Process

The volunteers from the project met with residents in an announced meeting at the center of the village Čezsoča, where the mayor of Bovec and the president of the local community Česzoča welcomed the initiative. In the following days, residents received leaflets in their mailboxes that provided some basic information and a phone number to call in case they wanted to meet with project workers. Volunteers also went door to door, introducing themselves and informing the residents about their tasks and role in the village. They set a date for a visit; afterwards the first meetings took place.

The distribution of power between the project workers and local actors (either individuals, groups, or structures) was drawn up in advance. The social work volunteers provided support in a way that acknowledged the local actors' expertise, both individually and as a community, in dealing with the consequences of earthquake and in their lives in general.

The service provision was organized according to the principle of freirean reflection cycle of planning, acting and reflecting [Freire, 1996] and on the right of each person to name their reality in designing social service support. Both principles are at the core of the method of Individual Planning and Goal Implementation [Škerjanc, 2006], that was developed for practical social work ten years ago at the Faculty of Social Work in Ljubljana. According to this method, social workers design support in cooperation with the person, in a bottom-up approach, where the individual resident has control and last word in each phase of service delivery.

The residents and social work volunteers recorded their cooperation and achievements with this simple tool:

TABLE 15.1 **Sample for Designing the Implementation of Goals**

GOAL: ....

Steps to goal	WHAT needs to be done	WHO will do it	Costs and payment	by WHEN

The tasks performed were recorded daily in the project's work diaries, which enabled a pool of data to be set up for further elaboration. The volunteers had daily meetings for emotional support and to coordinate their tasks. Supervision support was organized for social care assistants employed at the social work center who provided in-home care on a daily basis to disabled residents and elderly people.

Findings and Outcomes

The first findings of the mapping highlighted some facts that have determined social priorities in the municipality of Bovec, among which are caring for elderly people, drug abuse among young people, family violence and alcohol abuse.

The majority of interventions, both for individual residents and for the community, were performed in the village of Čezsoča. The support was organized according to the individual person's choice and the definition of support he or she reported wanting and needing from the social worker.

The dynamics of the first visits to each home seemed to follow the same pattern: during the first two or three visits, the women residents cried and shared their despair. From the third visit on, the residents started making short term plans connected to their every-day living conditions. The data on the tasks social workers performed to support residents in achieving their goals of improving their lives is presented in the following table:

The data from Table 15.2 shows that residents were looking for social work volunteers *to talk to* them and to spend time with them. Elderly and disabled residents mainly said that they felt safer knowing volunteers would be there for them in case of need or that they could just meet them in the street. Particularly important was the responsiveness from project members after each aftershock; volunteers walked around the village to check on how the elderly or disabled residents who lived alone were coping.

TABLE 15.2 **Frequency of Tasks Performed**

Task	Frq.
Socializing	190
Emotional support	87
Informing	61
Introductory meeting	41
Driving, Giving a lift	31
Delivery	25
Moving furniture	22
Personal assistance	21
Advocacy	13
Repair	12
Collecting crops	11
Cutting and sorting wood	8
Celebrating	7

The second most frequently performed task was *emotional support*. This was the support for those dealing with trauma. These residents wanted to share their concerns, pain and fears about the future—some were grieving a terminal disease or were overburdened by having to take care of others; for instance, in one family there was elderly mother with dementia and a brother with severe learning disabilities, and the one acting as care-giver was herself a patient with severe diabetes.

Psychological counseling was organized within the local health center to support residents in handling the consequences of trauma. It was a short-term service provided by one staff member from the Ministry of Defense on prescription of the GP in the Community Health Centre in Bovec. When the rescue phase was over, the army forces left. A project for psychological support for residents started with weekly meetings, but this was not enough. According to Nuša Pogačnik, a clinical psychologist and expert in helping people affected by trauma in the world's most exposed crisis areas, a person cannot handle the consequences of trauma alone. Without sustained support and help, the conditions of stress remain and cause changes in the person's mind and body. The project suggested extending the psychological support for residents for a longer period of time and also supporting the women's self-help group in the village Čezsoča that Ms. Pogačnik had already started.

Access to information was another relevant task for social work volunteers for many different reasons. First, the project had more power in the community and got information faster than the individual residents did. The project also had better access to information because of volunteers' skills and knowledge in addressing particular topics. The major obstacle in gaining information was the absence of a consistent, accessible and reliable information system.

The next four tasks can be jointly labeled *personal and technical assistance*. This set of tasks was mainly performed for residents and families with elderly members, members with dementia, a disability or chronic illness. They needed support with organizing personal assistance, sorting out procedural obligations in preparation for reconstruction, and visiting general practitioners. A 74-year-old woman from the village, as a disabled resident living alone, was invited to contribute her expertise in coping with the effects of earthquake. The workshop was held for Red Cross volunteer activists in a town on the Slovenian coast. For the first time in her life, the woman said she felt esteemed because of her expertise from surviving the earthquake. This was also the first time she saw and touched (and tasted) the sea.

Advocacy was another task that supported residents in receiving their entitlements. Most of the advocacy action was needed to arrange the preconditions that would ensure emergency accommodation and to advocate for residents from vulnerable groups in getting access to donated houses. Elderly residents needed assistance in writing applications, interpreting official correspondence, gaining access to donations and understanding procedures.

Technical teams' assessments of building damage became a source of stress for residents because the assessments determined the amount of support they would receive for reconstructing their homes. The teams were working under time pressure to allow the reconstruction to begin as soon as possible. In such conditions, there seemed to be no space for consulting with residents who needed time and more explanation to understand the state of their homes. The project informed the public officer in charge of assessing damages that residents were overlooked and ignored in their own homes, and that they were not informed about who the teams were, what their purpose was and what they were doing. The project organized a short training session for assessment team members on trauma, and together they developed a simple protocol for approaching residents. This called for the introduction of members, their roles and tasks in the team. The team members received some basic information on the consequences of trauma and got some guidelines on how to adjust communication style according to the individual resident's conditions, making sure that what they were saying was well understood.

The assessment of building damage presented by the technical teams was one criteria among many for defining the priorities for replacing the first 12 houses in the municipality of Bovec. In addition to the list made according to the damage assessments, a month later another priority list appeared with new criteria unknown to residents and to the project. Furthermore, the guidelines from the government created three groups of residents with different access to support for reconstructing their homes. In the first group were people who had already received a bank loan to rebuild their house after the previous earthquakes and now their home was damaged again and had to be destroyed and rebuilt with the governmental money. The new buildings meant smaller houses with no basement space, which residents found hard to accept. The main source of the family food budgets came from the gardens, and with these new solutions for the homes, all of a sudden they had no space to store the food. When a farmer asked the architect where they should keep their potatoes, she suggested putting them in the fridge.

The second group of residents were owners of houses severely damaged for the first time. The resources for new houses would be provided jointly by the owner who would contribute 60% of costs and the state contributing 40%. The contribution from residents would be covered through donations. According to the residents, this kind of financial support meant a race with time because they did not believe that the state would be able to find donors for all people entitled to this resource. Therefore, the residents demanded transparent criteria for accessing donations, and the project advocated a public announcement of the criteria, which was eventually done on a local cable TV program.

In the third group of residents were those who were still paying the loans from previous earthquake reconstruction and had houses that needed reconstruction and repair. They would have the costs for reconstruction covered by the state. What they got at the end of this reconstruction was an old, non-functional building that had already been damaged three times. The fourth earthquake will be crucial for these houses because they will not be able to withstand the hit.

When we compare the position of all three groups of residents, the following picture emerges: in the best position are the residents who had their home damaged for the first time and got access to resources early enough, when donations were still available. A bit worse is the position of the residents who had loans for reconstruction after the previous earthquake and needed a new house because of the poor state of their old one. The state covered the costs for the replacement building and the resident got a new, smaller house. The worst is the position of the third group of residents: those whose houses were reconstructed by the state according to its terms after previous earthquakes and who had no say in the process. They are paying loans for reconstruction they had no control over, and they will continue to live in old, damaged—albeit repaired—houses. Those in this group have experienced several losses: they have had their home damaged twice and they have taken on a loan for a reconstruction they had no control over, yet still lived in old, damaged houses. This group comprises mainly elderly people and those who lived alone. The project team visited the mayor of Bovec three times in order to present the living conditions and financial situation of the most vulnerable residents in the village: the elderly people who live alone, disabled people and people with dementia and chronic illnesses. The intention of these visits was to encourage the mayor to pay attention to residents from groups mentioned above, ensure that they would not be overlooked and that they would get support in accessing donated houses. The outcomes of the following years have shown that the majority of residents from these vulnerable groups do actually live in new, prefabricated, earthquake-safe houses in their village.

In one case, citizen advocacy was needed for a family to get a container shelter in their courtyard because the family was afraid to sleep in their house, which they considered dangerous. The procedure to get provisional container accommodation demanded the assessment of damage. Because of these procedural specifics, the family did not sleep for more than a week, and their health was worsening rapidly. In the next case, a physically disabled woman, a wheelchair user, felt her house was damaged and dangerous to live in, while the technical assessment stated otherwise. The woman could not sleep in her home, fearing that the next earthquake would destroy her house and she would not be able to escape quickly enough. Advocacy was needed for her to get access to emergency accommodation facilities on the ground floor in the vacation bungalow house in the same village.

The next three tasks performed were *technical aid*, and the last one, *celebration*, was about sharing feelings of success and achievements. The spirit of celebration was alive in the village in spite of all the losses. People organized traditional competitions to prove farming skills and celebrated the reconstruction of a village spring that apparently has healing properties. They also organized a farewell to the project in a celebration where words could not express the shared experience.

The recapitulation of support that the project delivered and recorded brings information about the support residents needed to restore their living conditions after the earthquake and to prepare for reconstruction. The project delivered support to residents in the village Čezsoča according to their definition of need for support. Social work volunteers performed tasks of informing, delivering and catering, emotional support, advocating, mediating, supporting programs and/or civil initiatives, structures and institutions. All these tasks needed to be accomplished, but in the community there are no long-term programs to develop responses and to provide these kinds of support to residents during reconstruction.

Residents needed support in asserting themselves to get what they were entitled to, encouragement, emotional support when things went bad, and support in celebrating achievements. They needed someone who would commit to their cause and negotiate for their interests. Most of these needs were recorded at the time when the project was about to end, while the reconstruction in the village had only just begun.

15.3 Discussion

When the project ended, the residents had no structures to carry on it's work. The support that social workers volunteers provided was not about physical survival, since the residents managed without it in the past, before the project took place. It was about supporting residents in their struggle to organize and improve their quality of life, focusing also on the recovery of the individual person and not, as had been the case until now, focusing solely on the reconstruction of walls.

The data analysis of the tasks performed for residents showed that both the demand and need for support did not diminish with time. This means that there is a constant need for services over a longer period of time and that need is not necessarily connected solely to the conditions of a natural disaster. From this statement we can draw the conclusion that natural disasters, in addition to creating loss and damage, help reveal already existing needs, distress and problems, which become more visible in emergency situations.

There were situations that residents defined as sources of high stress, almost traumatic, yet they were not caused by the natural disaster directly. Instead, the causes were the inappropriate and inefficient responses from civil services, politicians and state institutions. These were reflected in rigid procedures, wrong information, an insensitive communication style, the devaluing of resident expertise in survival strategies for coping with post-traumatic stress, the exploitation of residents' modest financial capacities through expensive loans for reconstruction, and in setting unreasonable conditions for architectural cultural preservation by ignoring residents' struggles and limited financial potential.

Other sources of stress were the lack of support for organizing the necessities for daily life; for accessing information, institutions and follow-up procedures that formalize the property status for reconstruction; the lack of consistent, long-term social services for vulnerable residents, and the unclear criteria for accessing donated resources and houses. The list goes on.

When we look at the above list and analyze the sources of stress that residents faced after being affected by the earthquake and experiencing trauma, we can identify at least three generators of trauma and distress:

a) the consequences of the natural disaster,
b) the problems that residents already had in their homes and which were revealed through these conditions,
c) the inadequate response to these new conditions for residents from structures, institutions and different centers of power.

Here we discover that in addition to the trauma caused by the earthquake, the residents suffered another one caused by structural, professional, political and cultural conditions which created a hostile and stressful environment for victims of the earthquake. On top of this, the problems that until then had been kept private emerged into the public space. What we find here is an accumulation of stress and trauma generators for residents who have little or no means of support for facing them, for reducing them or for actively coping with them. The condition of a destroyed home cannot be sorted out overnight. The personal issues and problems that became public cannot be swept away. And the inefficient responses to the losses create more fear, concerns and anger.

Every angle that we view the situation of the residents from shows us their loss of power in their lives and little or no control over the solutions to improve it. At the moment when natural disaster hits citizen reality, along with the consequences that disaster creates, there emerge additional generators of social problems.

Ulrich Beck [1992] problematizes the fact that inequalities in society disappear and become redefined in terms of an *individualization of social risks*. According to him, social problems are increasingly perceived as psychological dispositions, such as conflict, anxiety, inadequacies, guilt and also trauma. A social crisis appears as an individual crisis, which is no longer perceived in terms of its embedding in the social reality. Beck suggests that inefficient responses by centers of power, which are reflected in citizen trauma, are understood and interpreted as the individual citizen's own inability to cope with his or her problems. The theory of risk and the notion of individualization as sociological category can be instructive in the attempt to answer the question, what next?

Further, Beck recognizes that people are forced into political and social alliances as a means of coping with social problems; these alliances do not seem to follow any particular pattern. Instead, when a person lives a more isolated life, his or her alliances can be extremely heterogeneous. These are pragmatic alliances in the individual struggle for existence, and they occur in various fields of society. If they occur in various fields, social work may be one of them.

The social work practice performed in the project corresponds with Nino Rode's [2005] definition of social work as a practice in which, at the beginning, nobody, at least not the professional, knows what the problem is and where to find the right answers. Therefore, the social worker needs to enter the individual person's reality, look at his or her world through his or her eyes and start exploring answers together with that person. By organizing the support according to the paradigm of user control over support received, individuals get the support they need to organize their lives and improve their quality of living. Social service intervention and support from social workers become tools and means for residents to improve their quality of living.

15.4 Conclusion

The statistical records of the services delivered by the project brought to light the experiences residents had with structures and institutions, political subjects, media, volunteers, and charity organizations after being affected by a natural disaster. The records also revealed the impact of the project on the life of individual residents. The data recording produced a list of services that people needed as support in their struggles to restore their living conditions as quickly as possible.

The idea of the individual person being an expert in his or her life connects to each person's right to name their world and develop *generic themes* for a better tomorrow. From generic themes, personal goals for change emerge. Personal goals transform ideas into action: into tasks, support and social service provision. At this point, the *what needs to be done* shifts to the *how to do it*. The action-reflection cycle starts, creating the pattern for social work intervention in five phases: defining the situation, identifying resources and deciding the support needed, identifying the role of service provision, delivering service, and evaluating the support received. The individual resident is in control during each phase and has the last word on designing the support they get.

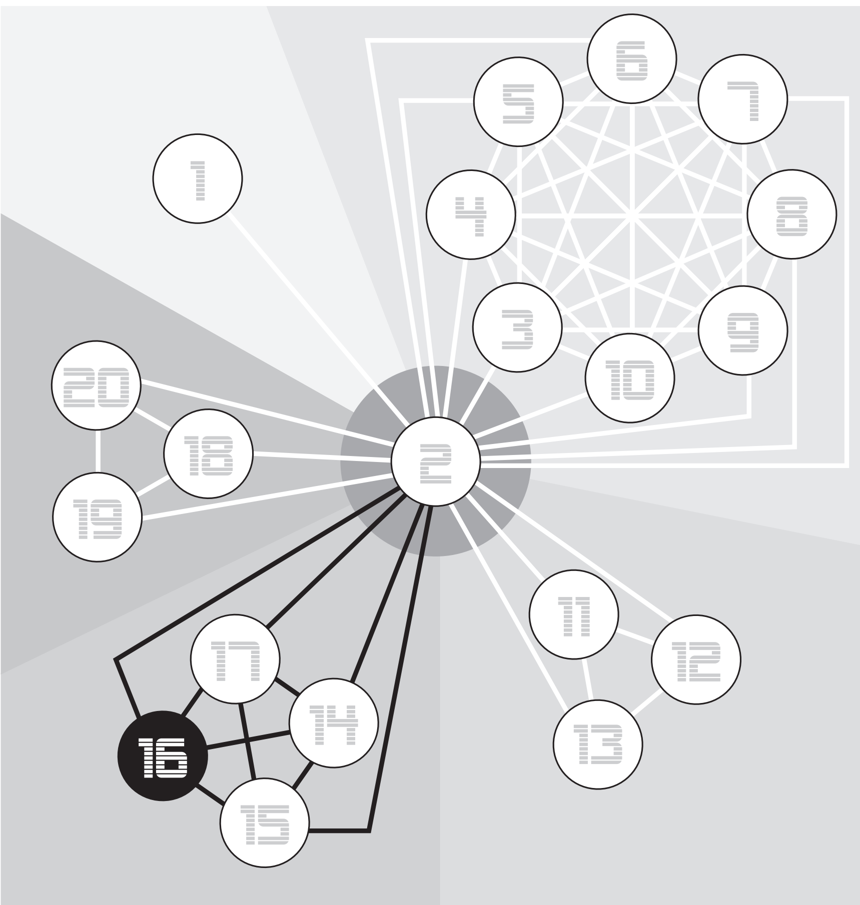
This approach demands from the social worker a knowledge about power relations and about the social implications of culture, gender, age, ability or social status for the living opportunities of individuals and social groups. It also demands skills and knowledge, ethics and personal competency in order to provide support while at the same time enabling residents to stand for themselves and keep control of their lives. Additionally, it presupposes the skills and knowledge necessary for approaching a person in trauma and giving emotional support, comfort and counseling.

The results also support the conclusion that in organizing support for residents after a natural disaster, social work has an important role to play. Its place is with the residents and at their side. From this standpoint, social work acts to support residents, making sure their voices are heard and that they maintain control over the support they receive. Thus, social work has a unique perspective on the residents' situation and on their need for support. The information gathered from the resident's perspective enables the design of original, genuine and creative answers to his or her situation. Since the answers respond directly to people's needs, they are also efficient.

16

"Tsunami Project": A Case of a Collaborative Project Between Two Universities

Mojca Urek | Bogdan Lešnik



Project Background[1]

Following the earthquake off the coast of Sumatra, a massive tsunami struck Sri Lanka on December 26, 2004, killing over 40,000 and creating a massive displacement problem for nearly half a million people on that island alone. Sri Lanka has been extremely hard-hit in terms of loss of life, infrastructure, and economic assets; the 2004 tsunami is widely acknowledged as the largest, most devastating natural catastrophe in the history of the country. The waves penetrated inland areas up to 500 meters in many places, leaving behind few intact structures. Coastal infrastructure systems, including roads and railways, power, communications, water supply and sanitation facilities, and fishing ports were all severely damaged. The most affected were the inhabitants in the eastern and northern coastal regions, who live mainly from fishing. They were also in the midst of civil war, which prevented much aid from reaching them; the war has also obstructed substantial systemic reconstruction [Herath and Lešnik, 2008].
Within households, the effects of a disaster vary considerably. Certain people may be especially vulnerable to disasters (*e.g.* women, children, disabled, elderly). This is illustrated starkly by the female death toll in the tsunami being higher than the male. This is due to a number of reasons—some cultural (women were more likely to be at home when tsunami struck and less likely to be able to swim) and some physiological (women may have found it physically harder to save themselves). While all the affected families have found it harder to sleep after the tsunami, children have faced particular problems and have often suffered from nightmares. The percentage is higher for female-headed households than for male-headed ones [Institute of Policy Studies, 2007].
Relief actions organized by the Sri Lankan military and by humanitarian organizations were soon followed by a large number of additional actions, both domestic and foreign. Professionals, individually and in groups, were sent by some states (*e.g.* India, Japan) to help restore the damaged infrastructure, such as water mains and housing. Others, both individuals and organizations worldwide, either sent goods or money or brought them themselves and settled in the country within one or another framework of aid. These actions are sometimes

---

1 This paper is also based on oral and written reports submitted by the participants in the project: Jagath Wellawatta, Witharanage Nirosha Nilmali, Handun Rasari Athukorala, Praveena Rajkopal, Aisha Liyanaarachchi, H. R. Malkanthi, Prashangani Dunuge, Rathnika Sanjeewanie, Anuruddhika Rajapaksha, Champika Prizadarishani, Gayani Muditha Kumari, Chandima Iayasena, Rawani Surangika, Thusari Fonseka, H.M. Achala Lakmali Jaya, Silvija Lešnjek,Verica Petrova, Maja Petrovič Gašpirc, Andreja Ivanušič, Mateja Ravnik and Anita Šobar.

difficult enough to assess individually, let alone collectively. This kind of relief involvement helped inspire people, who never seem to lose their sense of humor, to refer to the event (pars pro toto) as "the NGO tsunami."

Eight months after the tsunami, in August 2005, the majority of the financial donations from foreign countries still had not reached the people in the affected areas. At least two explanations circulated among the people in Sri Lanka: first, the Sri Lankan government and the central institutions in Colombo had retained this money and intended to use it for other purposes; second, saving the money in banks instead of giving it to the people in the affected areas brought higher interest rates, which could be used to pay living costs and other costs of the NGOs or the foundations' functionaries. Suddenly, there was a lot of money in the country, which only made prices of goods rise, but there was no money for the people who suffered in poverty after the tsunami. This contribution focuses on the story of a project, a cooperate response to the tsunami disaster in Sri Lanka by the University of Colombo Faculty of Arts Department of Sociology and the University of Ljubljana Faculty of Social Work.

Summer Camp in a Village on the Southern Coast of Sri Lanka

After quick, preliminary research into the needs of the tsunami victims of a coastal village [February 2005, conducted by Lešnik with sociology students from the University of Colombo, headed by their teacher Jagath Wellawatta], the idea of a wider collaborative project between the University of Ljubljana (UL) and the University of Colombo (UC) arose. The two universities signed a letter of intent that outlined the project. The first outcome of this was a two-week research camp in August 2005 at a tsunami-struck village on the southern coast.

The summer camp was devised, on the one hand, as social action (talking and socializing with villagers, offering physical help with everyday housework and outdoor work, etc.) and, on the other hand, as field research. The research part had mainly educational purposes for the students of both faculties and was primarily intended as a starting point for establishing social work study at the UC.

Actors

- UL: two teachers from the Faculty of Social Work and six students;
- UC: one teacher from the Department of Sociology, his assistant and 13 students;
- villagers.

Objectives

- To assess the psychosocial impact of the tsunami on the villagers;
- To map the psychosocial needs of tsunami affected villagers;
- To identify support systems available to the affected;
- To explore the distribution of aid.

A Note on Methodology

Starting in the 1960s, social work became actively involved in a plethora of different social projects and was in many ways implicated in the new social movements. Research methods and techniques, like action research and narrative methods or mappings, were appropriated and developed in social work. They were not used only in research projects but also in the reorganization of services and the reframing of provisions [Flaker, 2006]. We could claim that our research project has elements of collaborative research and of participatory action research, which involves all relevant parties in the examination of a situation considered to be problematic, to change and improve it by critically reflecting on its historical, political, cultural, economic, geographical and other determining contexts [Wadsworth, 1998]. The question for social work is not only "what is going on" but also "how to respond and act" [Grebenc, 2006; Zaviršek, 2006]. In social work, research and practice merge to a great extent: for research, practice is the major source of information, and for practice, research is the major source of ideas. The concept of social action has become manifestly value-ridden in the process, but now these values, too, may be submitted for reflection.

Collecting Data

We conducted several semi-structured interviews with individual villagers, with legal representatives of the village (such as the development, or samurdhi, officer and the village officer, called grama sevaka), a Buddhist monk from the village temple and the representatives from the NGOs active in the area. We worked in doubles—one Sri Lankan and one Slovenian student—to conduct the interviews with the villagers; these took place in their houses, usually together with other members of the family. We felt warmly accepted; the people actually had a need to share their stories about how they managed to survive the tsunami, about the painful experiences when they lost family members or homes, about their experiences with aid provided by the state or by international NGOs.

Further data was gathered by talking informally with the villagers, with public transportation drivers and with people we met in public places.
We are aware of the complexities of what we are trying to outline. Two weeks in the field is surely not long enough to grasp the intricate meanings and intents of the narratives developed in any relatively close community. Furthermore, unless a respondent spoke English, our understanding depended on translation. These shortcomings were mitigated by the help of Sri Lankan members of the group. Within these limitations, however, we believe the material presented is relevant and speaks for itself.

Entering the Community

Upon arrival in the village, we first had a meeting with the villagers and development officer in a destroyed school to explain the aim of our research and get their ideas, opinions and support. They set only one condition: we needed to visit all households without exception, including the people who have lost their houses and were temporarily resettled in wooden houses at the edge of the village. We received the first lesson about the unfair distribution of aid. They told us that the aid which had come over the past few months to the village did not find its way to all the villagers, which caused many conflicts among the villagers themselves. During the two weeks we spent there, the guests and villagers became closer and more trustful of one another; often the campers helped with the physical work around the houses, organized workshops with children and paid visits to isolated villagers, etc.
The objectives of our research changed over the course of time and exceeded the objectives we defined at the beginning. In addition to the distribution of aid and the needs of the villagers, we gained many insights into the culture, the place of religion in the life of the people, gender differences, etc. Every evening we discussed and evaluated the data gathered by the circle of students.

Damage, Victims of the Tsunami

In the southern part of the village, there were 240 houses (with more than one household in the house). 150 houses were damaged fully or partly. 56 persons died. Of the 130 houses in the northern part of the village, about 70 remained. 22 persons died.

Work, Income

In the village, the main source of income is fishing. Only a handful of people work in the government and private sectors. Other sources of income come from the fiber industry, retail sales, three-wheeled taxi operation and the sale of vegetables. These jobs are mostly considered self-employment. A factory in the village, producing brooms and brushes from coconut trees, employed mainly women. The tsunami flushed it away along with the fishing boats. The people who used to work together dispersed. There used to be a kind of a production chain—fishing, processing of fish products, fishmongers buying the catches. Now this was broken. The fishmongers either died or turned elsewhere for fish and fish products. One NGO sought to provide the equipment for manufacturing brooms and brushes so that women could be self-employed. This has created an interesting turn in the family economy as well as in the gender distribution of work and power. Men who cannot work because they have not been able to buy new fishing boats are no longer the bread-winners; this position has been taken over by women. Formerly, they had experienced good living conditions. Most people had good houses with all the necessities, such as water and electricity. Some of them had luxurious appliances, such as a washing machine or a fridge.

School

There had been a school in the village, serving grades 1 to 11 (general certificate of ordinary level—primary school). The school had not been in good condition, but children from poor families had had the opportunity to finish the ordinary level there. During the fishery season, the students of grades 9, 10, and 11 usually left school. The former headmaster mentioned that she had made quite an effort to keep her pupils at school. Sometimes she had gone to the beach with a stick and sent them back. Since tsunami waves destroyed the school building, some children have quit school or have gone to schools outside their home village. But parents are convinced that this is not a good alternative (public transportation is bad; private transportation is expensive; the parents must accompany children to school; these schools have logistical problems because of too many new children). The destroyed school had been located within a hundred meters from the beach, which means they cannot rebuild it on the same location. Some parents, who are themselves educated and value education, have tried to provide better education for their children. After the tsunami, that task became difficult as they lost a lot of things. The villagers want the school rebuilt, but there is a problem of resources (the state does not consider it a priority). The donations collected in Slovenia through the Red Cross and Caritas went to rebuilding a Catholic school in Colombo, a city which was not seriously affected by the tsunami.

Psychosocial Needs and Support Provided

The most often mentioned and appreciated support is that from the village monk. Religion has helped the villagers cope with losing the quality of life they used to have and with losing relatives and neighbors. They have often held funeral ceremonies in the temple, where they felt connected as a community. A lot of people say they cannot sleep at night; the fear of tsunami is still there. Men often wake up at night and go to the beach to check for the sound of a tsunami. The villagers say that the rate of alcohol abuse and related problems has increased among men, which has increased the poverty of the families. The parents, especially those who lost one child or more, say they are aware of having been overprotective of those who survived. Children have "changed;" they are afraid of the sea, some are angry, scared, aggressive and generally "different." Before the tsunami, families lived as close neighbors, friends and relatives. After the disaster, they have found themselves separated and they live in different places, some far away. They feel lonely, especially the children who cannot see their friends and play together very often. This might explain, in part, why, as the parents say, their children are no longer as active as they used to be.

We found some successful NGO projects in the village (free swimming classes and activities within the Montessori kindergarten). Counseling offered by an NGO has seemed a bit alien to the culture; still, some women say it has been a useful experience. The problem is that the counselor is not settled in the village, so the villagers have to take a bus to a nearby town.

Self-Help After the Tsunami

Self-help was the most appreciated and satisfying form of help for the villagers. After the tsunami, the people who had heard about the disaster came to help the affected villagers as best they could. Among them were villagers who hadn't been affected by the tsunami, people from other villages and even people from far away. They donated the small things that they had and could give away, especially food and clothes. They also helped clean up the rubbish and remove the dead bodies. Some villagers said that some of the bodies were not collected because they could not be identified by their relatives. Those bodies could be smelled all around the area. With the help of volunteers, the villagers slowly cleaned the village. Some bodies were found a week or more later. All respondents expressed deep appreciation for the volunteers. In the days following the tsunami, all the villagers who remained there stayed together and shared food, clothes and other necessities. They cooked together and shared everything. They felt deeply connected. Problems arose when outside aid came into the village. After the tsunami, another catastrophe hit the country: a flood of foreign NGOs and humanitarian organizations. According to the villagers, that was the moment when the unfair distribution, envy, and disintegration of the community started.

State-Support

Families were eligible for some governmental support; each family received 5,000 rupees (three times, except families in which one of the members was employed by a state service) and 375 rupees per week per member (for about six months). Of those 375 rupees, they got 200 rupees in cash; the rest (175 rupees) were given in commodities, such as rice, dhal, flour and oil. To repair damaged houses, families received about 25,000 to 30,000 rupees.[2] This money was determined on the basis of the damage. The families who had lost a house within 100 m of the shoreline were not allowed to rebuild there, which created problems for those who didn't have the means to buy land outside the 100 m "buffer zone" (later reduced to 30 m).

Gender Inequity in Aid Distribution: An Older Woman's Story

A closer look into this data shows some inequities in distribution on the basis of gender.

There is a story about an older woman who never married; her parents had not allowed her to marry a beloved man, who was 10 years her junior. Not having married means that she lived with a stigma and was partly excluded from the community. She continued to live in her parents' house after their deaths. Her widowed brother moved in recently. As a man and a married member of the family, he inherited the land and the house, so he was also the claimant for state aid after the tsunami. He decided not to reinvest in the house but rather save

2 The monthly salary of a fisherman is about 7,000 Rs, of a teacher 15,000 Rs, and monthly expenses for a child is around Rs 4,000. At the time, 100 Rs roughly equalled 1 USD.

the money in the bank. Then he became seriously ill, was hospitalized and was in bad condition. The woman, who was very concerned about her safety in the damaged house, was unable to claim the state money and was also unable to decide about how the money already given by the state was to be used.

Complaints about Government-Support

Government-support was distributed by the village officer and the development officer. Though they followed a method of allocating support based on the amount of damage to the houses, the villagers felt their methodology was wrong. Many stated that they were eligible for a specific allocation from the government but had not gotten it. The distribution of the money for repairing houses was especially unfair in the views of villagers. They complained, for instance, that some powerful neighbors received much more money (or more often), even though their houses were not that badly damaged. Some people's houses were not damaged, yet their boats were, but this did not make them eligible for money. Moreover, the money was granted per household, so the households that included more families felt deprived.

Food

Another complaint bitterly expressed by many inhabitants of the village regarded food. Food was mostly donated by foreign countries and delivered via the village officers; some of it was also brought in by NGOs. The complaints regarding food were as follows: the villagers frequently didn't know how to use the cans because the labels were in English or other foreign languages (we saw some chicken liver pâté cans with labels written in Cyrillic). Some NGOs just distributed the food without explaining how to use it. Much of it had already expired by the time it was delivered to the village. The impression was that many foreign countries that were supposedly donating food were simply getting rid of old, expired stocks. Another issue was that the people in the village were unfamiliar with the taste of the food. They also showed us canned dog and cat food. They couldn't understand the labels, but they could guess what they meant. They felt humiliated by that and, even though they were very grateful for any help, they were clearly aware of the unfairness and the indecency in some forms of aid.

Our interviewees often repeated that they used to have decent lives and did not feel good about depending on aid, especially about wearing clothes that were not their own. They were sensitive to the way the help was offered. What they wanted most of all was to get their lives back as much is possible, to rely on their own work and, with regard to help, to be asked what they needed.

NGO-Support

At the time of the camp, several NGOs were present in the village.

- Sewalanka—provided wooden, alternative homes, clothes, food items, furniture
- P.R.D.A.—People's Rural Development Association
- World Vision—donated furniture, provided some programs for children
- Johanita—gave money to build permanent homes.

Although the villagers regarded the NGOs' aid more positively than the state aid, they still mentioned several problems. The NGOs were mostly foreign, with foreign employees, though often also with Sri Lankan employees—which was good because the jobs are well paid and this also made communication with the villagers easier. Some villagers, however, thought that it would have been much better if members of their village had been employed, since they are more acquainted with the people in the community and more aware of their needs than outsiders. The NGOs distributed aid through their local headquarters or village officers. Their distribution was felt to be unfair, since most aid went to the powerful villagers or to the villagers who could understand and speak English. People on the margins, invisible but in real need, could not—as a rule —receive aid. The complaint was that their needs were not estimated on the basis of clear criteria, which would have prevented the less visible and socially excluded members of the community from being excluded from the distribution of aid. For instance, one NGO came to the village with trucks of food, clothes and other things, and those who lived nearby, spoke English well enough to understand what was going on, or were not working at that moment ran to the truck, whereas others (the resettled, old, handicapped, or those living a bit further on the edge of the village) were not informed about the arrival or could not come soon enough to get the aid. Such distribution has caused conflicts among the villagers. There are numerous cases of abuse regarding NGO support. While pretending to help, some NGOs had, in fact, other motives.

The Case of Alice

A case in point was the mysterious figure of a woman we shall name Alice. She became a legend in the village. People feared and respected her at once. She had first come before the tsunami. She was from England (some said from Italy). Together with her husband, she started rebuilding and buying boats, and also launched a project aimed at assisting children in developing swimming skills and in recovering from their fear of the sea. However, she delivered aid only to those who were willing to sell their land to her at below market value. Many villagers, suddenly impoverished, sold their land to improve their situation. Before the tsunami, some people had sold Alice land that was located on the hill. After the tsunami they asked her to sell it back to them (if they couldn't rebuild their house because it was in the prohibited buffer zone of 100 meters from the shoreline, or simply for fear of another tsunami), but she ignored them. They said she had already sold the land to Europeans and Americans at a much higher price. Rumors were that she planned to build a hotel complex in part of the village. At the time of our camp, she and her husband were believed to be abroad.

One of Alice's local land brokers, a man who went from house to house to persuade people to sell their land to her, showed us his new house and new furniture, TV, etc., which Alice gave him as a gift for his work. He was aware of the manipulation but was acting on several impulses. One was the opportunity he saw for himself. Another was that, in his words, even when Sri Lankan people are angry and recognize injustice and mischief, they will always be kind to foreigners and keep their feelings to themselves. He saw this attitude as a remnant from the colonial period.

Imposing Foreign Religion: A Three-Wheel Driver's Story

A three-wheeler driver told us the story of an American Evangelist congregation that did an excellent job of building good houses for the people who had lost their homes. They were luxuriously equipped with furniture and fridges, TVs and washing machines. There could have been more houses, he said, if they had been more modestly built and equipped, and if somebody had first asked the people what they needed. The congregation also planned to build a church in the complex, which was located in a mainly Buddhist community.

Stories of imposing Christianity on the Buddhist population were not limited to the tsunami-related aid. We heard of attempts to foist religion through English language courses by foreign teachers (praising Jesus, persuading children that the Buddha was an egotist and not a good man because, according to the Buddhist scriptures, he left his family, etc.). The unmarried woman mentioned above told us she converted to Catholicism after nuns from a nearby town kept visiting her and keeping her company. In the church, she found a new family. The religion was OK, she said, except that the Christian god was stricter than what she was used to.

Some Conclusions

The villagers strongly criticized the distribution of aid. They found it unfair and saw it as reserved for the "more important" people. According to the grama sevaka's estimations, only one eighth of the needs following the tsunami disaster has been met. What villagers want most is a house away from the sea and a source of an income, preferably the business they used to have, near the coast. Currently, most of them are living with their relatives and depend on the food rations provided by the government. Since the aid itself has become a source of tension and conflict in the community, future aid should be distributed fairly and justly; it needs to be distributed in a way that brings people together.

Aid programs should also be administered in a way that does not harm the dignity of the villagers who rely on them. The villagers were once successful, independent earners, proud of the way they lived. It is this that they want back. Although some villagers have fallen into the trap of dependency and passivity—as our respondents estimated—all of them wish for independence and autonomy. The lack of assessing needs and the lack of sensitivity to hidden vulnerable groups seem to have been the major problems with the current humanitarian aid administration.

As to psychological issues, some of the long-term, traumatic effects people have mentioned are a rise in addictions and violence, personality changes (in children) and a growing passivity that may indicate depression but may also be a result from the "submission to aid." The association of this passivity mainly with men is perhaps attributable to the expectations of men in the context of gender roles and does not necessarily mean that women have been more resistant, though some observations do suggest precisely that [Herath, 2008].

We did not include the abundant "tsunami stories," people's experiences of the tsunami itself, in this report. Everybody had a story about the event, about what had happened and about how he or she survived, etc. These stories never had the character of a complaint. People liked to share them because they contained heroic, uplifting elements (such as saving a life), because they allowed a release of grief (when life could not be saved), or simply because they were a way of working through this extraordinary experience. Narrative social-psychological research has demonstrated that traumatic experiences threaten basic assumptions about the resilience and the worthiness of the self, and they challenge the fundamental perceptions of meaning and justice. In the face of adversity, the assumptive world that had previously provided the person with a sense of coherence and continuity may be taxed beyond its capacity to adapt. The narrative processes and storytelling have been recognized as reflective efforts to cope with negative life outcomes and to deal with the impact of change and loss [Bruner, 1991; Borden, 1992].

The camp in the village was declared to be a remarkable event by both participating parties and local inhabitants. It was also agreed that the project should not be limited to the tsunami-related issues, as there are other pressing social problems in Sri Lanka that need to be addressed systematically. The participants believe that the narrow focus of the humanitarian and social aid on the effects of the tsunami has come at the expense of other long-term problems, such as the extreme poverty of the inland.

Further Developments of the Project

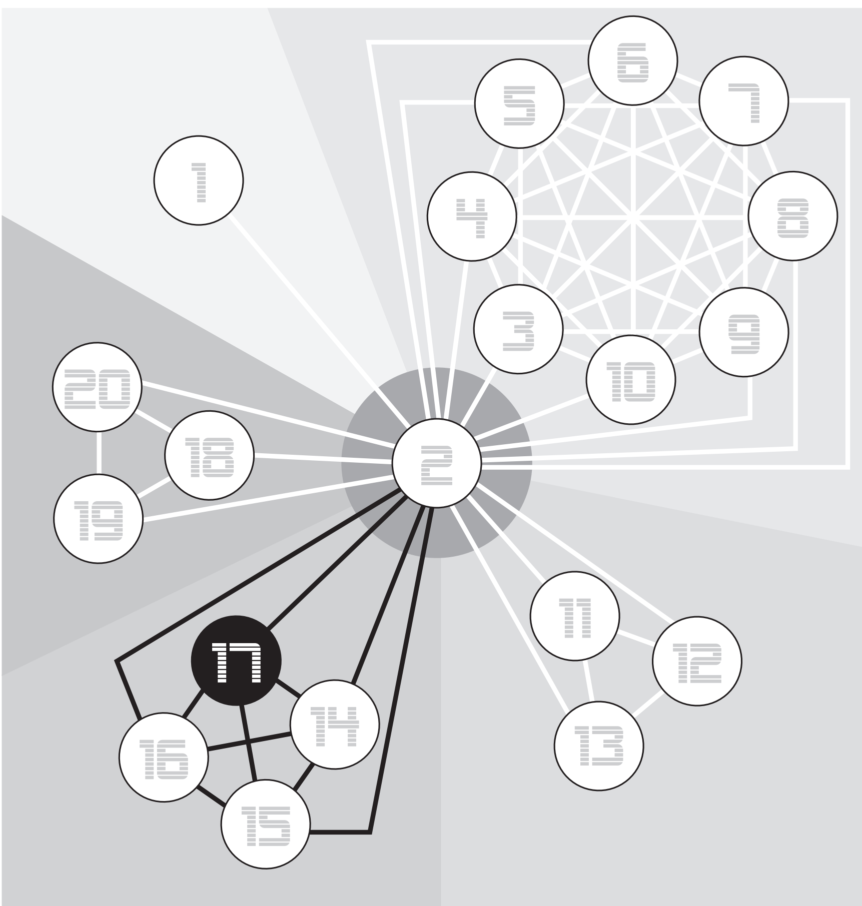
Looking for the presence of social work about two weeks after the disaster, we found a few social workers involved with various organizations (as aid workers) but no systematic, social-work response, even though the profession exists in Sri Lanka. Next, we looked at the state of social-work education in Sri Lanka. A school of social work was begun in 1952 with short-term courses and it evolved into a diploma program in 1978. It was incorporated into the National Institute of Social Development (under the Ministry of Social Service and Social Welfare) and developed a BSW program [NISD, 2005] and most recently an MSW program [NISD, 2008]. The school director has estimated that there are approximately 800 practicing social workers, while the country needs 30,000, especially in the fields of community work, disaster management, psychosocial help, poverty issues and (last but not least) conflict management. Social workers are needed in schools, psychiatric hospitals, orphanages, homes for the elderly, institutions for disabled people, as well as in prisons, rehabilitation camps, refugee camps and slums; they are needed to work with marginal or marginalized groups such as migrant workers, prostitutes and the homeless. There is a clear need for competent counseling to help individuals, families, groups, and communities overcome difficult situations.

The project that began as a summer camp in a tsunami-affected village led to signing of a Memorandum of Understanding between the University of Colombo and the University of Ljubljana for academic collaboration in social work. The preliminaries for establishing a stream of social work were discussed. In 2006, twelve students from the department in Colombo (the same ones who had attended the camp in the village), accompanied by a senior lecturer, visited Slovenia to participate in a month-long, intensive training program in social work, and the UC Department of Sociology was further invited to take part in the INDOSOW program (International Doctoral Studies in Social Work), in which several European universities participate. In March 2008, two members of the department visited the University of Ljubljana for three months as visiting scholars. During this period, the final decisions were made to introduce social work as a stream within the special degree program in sociology for a limited number of students. The program involves extensive practice training and close supervision, and the relevant course outlines were developed in collaboration. Seven senior lecturers from the Faculty of Social Work of the University of Ljubljana are to go to the University of Colombo to teach and conduct the courses for the first three years, until the first group of students completes the degree (two of them have already taught for two consecutive terms). It was also agreed that the department should take measures to train its own academics in the field. In our view, the role of the UL in its collaboration with the UC is to share methodologies and to critically rethink findings, rather than simply present models (of education or practice) to be copied.

17

Seismic Isolation for Asymmetric Building Structures

David Koren | Vojko Kilar



17.1. Introduction

The system of seismic isolation can present an important alternative for the construction of buildings in earthquake-prone areas. The basic idea of seismic isolation has been known from the beginning of the 19th century, but functional and affordable systems have only appeared in the last couple of decades. Currently, seismic isolation is mainly used in high seismicity regions in constructions of special importance or buildings containing extremely expensive equipment. Technically and economically, the recent development and cost reduction of various devices of seismic isolation (bearings and dampers) eliminates previous obstacles to using seismic isolation systems also with "architecturally special" residential and office buildings, such as buildings with asymmetrical floor plans or irregularities in height.

Here we can ask ourselves how the use of seismic isolation affects the designing of structures in architecture. Structure design in architecture, in contrast to simply considering the technical guidelines and recommendations for structure regularity preferred by civil engineering, is often based on starting points other the mere safety of structure. An architect always wants to apply recognizable solutions that win first prizes in competitions. Such structures are frequently completely irregular from the viewpoint of civil engineering (*e.g.* asymmetrical) and thus more exposed to earthquakes. In such structures, only the increase of the thickness of columns and walls, or an increase in the amount of reinforcement often does not help or even has a negative effect. In such cases, the damage, which is usually distributed through the entire structure, can concentrate locally in just one part of the structure, which is thus irreparably damaged during an earthquake.

From the architectural viewpoint, the use of seismic isolation is important because it enables freer architectural expression and reduces earthquake influence. The question arises whether a modern enough system of seismic isolation could, for example, enable the construction of a basic platform on which it would be possible to build any earthquake-resistant structure. This would also make it possible to shift certain interesting architectural concepts from earthquake-safe areas to the earthquake-prone ones. It would no longer be necessary to consider horizontal stiffness, ductility and other requirements when designing a structure, which would give architects more freedom in designing. This creates a new dimension in architectural design in earthquake-prone areas. More advanced, more daring and at the same time safe solutions become possible also in places where up to now this could not happen due to the requirements of earthquake-resistant construction. The pressure on the architect's architectural freedom would thus be alleviated, and architectural designers could more easily follow trends coming from the earthquake-safe areas of the developed world, where conformation to earthquake-resistant building is not of key importance. Such design also follows the recommendations of sustainable architecture.

17.2. Asymmetric Structures of Buildings in Architecture

Architectural-Urban Reasons Leading to the Design of Asymmetric Buildings

Asymmetry or irregularity of buildings in architecture might be a consequence of the various demands of the project task as defined by the architectural-urban demands of the actual object's location in the surroundings. In this case, asymmetry or irregularity is therefore reasonable and presents an unavoidable fact, which should be appropriately dealt with by the structural profession. On the other hand, there are often architectural proposals, where irregularity has been induced artificially and intentionally just to provoke the observer or as a kind of opposition to gravity laws. Such architectural realizations might lose all "favored additional value" by greater damage during an eventual earthquake. Unfortunately, such buildings are too often favored by the investors as well as by the architects. This kind of architecture does not consider architectural-urban relations and does not follow the main rules of architectural design, such as rhythm, continuity and transformation [Ching, 2007]. The form of architecture as a sculpture prevails over the careful consideration of the space in which this form is to be integrated. Nowadays, the feeling for tectonics is too often omitted or not adequately considered. Of course, in general it is not necessary that an asymmetric building shape or an artistic-spatial architectural irregularity also mean an asymmetric structural load bearing system of the building as a whole, which would result in any kind of constructional-technical imbalance.

The logic of different types of constructional-technical irregularities can be examined by the specification of the urban design methodology, *e.g.* [Rihtar, 1996] for the purpose of the topic discussed [Zupančič, 2008]. As factors to be considered in the method, all basic viewpoints of analyzing, assessing and spatial planning have been included. The basic viewpoint can be briefly summarized as:

- Position and connection: natural conditions (soil, topography, climate, the level of seismic activity, etc.), cultural transformations of space through time, material (transport, supply) and non-material (visible, social) connections.
- Use or function: activities in the (*e.g.* public) space and connections between buildings and associated facilities. The investigation scale is narrowed to the considered object and its elements as well as to internal relations.

- Realization: connection of artistic-spatial and material-technical characteristics. Kenneth Frampton [1995], in his evolutional research of 'tectonic culture,' concentrates on the levels of such connections. In his work, he deals with the period when the structural and artistic-spatial design of building has started to separate from each other.
- The importance of space connecting the three viewpoints mentioned above: importance according to position and connection, importance according to use, artistic-spatial meaning, social-spatial importance, psychological importance, philosophical importance and economic importance.

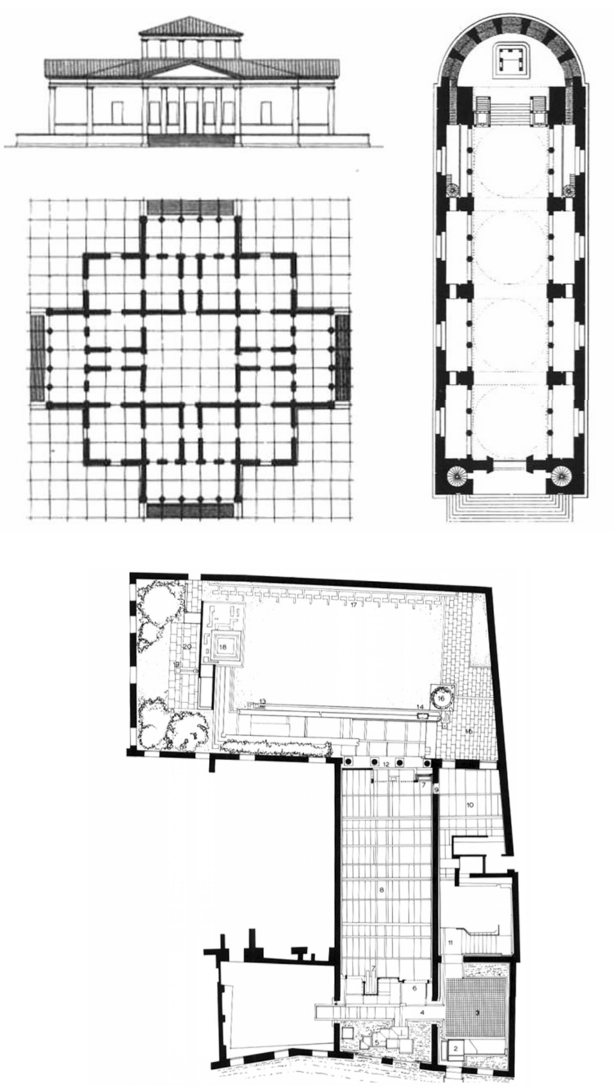
Examining from all viewpoints can verify the actual necessity of asymmetry in the architectural concept itself. Irregular architecture is, therefore, excusable only if it is a result of an integrated process of architectural design, while in other cases it presents an empty larpurlartism. Contemporary building technologies can alleviate the consequences of larpurlartism of any kind; however, in light of sustainable spatial development, a judgment about the rationality of such designs is more than necessary.

Seismic Behavior of Asymmetric Buildings

From the viewpoint of structural engineering, buildings with a pronounced floor-plan asymmetry are typical representatives of irregular structures that express much more vulnerability to earthquake load than the regular (*i.e.* symmetric) ones. The asymmetry can be uni- or bi-directional [Figure 17.1]. Technically, floor-plan asymmetry occurs with all structures where the center of stiffness of the load-bearing structure (CS) does not coincide with the mass center of the structure (CM). The distance between them is called structure eccentricity, and it is the main reason for the creation of torsion in a building [Figure 17.2]. Eccentricity can be divided into "stiffness" eccentricity, which is a consequence of an asymmetrical distribution of load-bearing elements, and "mass" eccentricity, which occurs as a consequence of an asymmetrical position of the mass center in relation to the geometrical center of the floor plan. In the actual structure, eccentricity in individual floors can change, since both CS and CM are different on each floor.

Many researchers who have studied the behavior of asymmetric structures have pointed out the importance of torsional resistance (*i.e.* the ratio between the torsional and lateral frequency) of the superstructure [Annigeri, 1996; Kilar, 2001; Fajfar, 2005; Ryan, 2006; Pettinga, 2007; Tena-Colunga, 2007]. The buildings with a majority of the load bearing elements positioned on the periphery of the structure and/or with the mass concentrated mainly in the center of the plan are called torsionally restrained (TR) structures. The buildings with a majority of load bearing elements positioned in the center of the plan (*e.g.* strong cores like lifts or staircase shafts) and/or with the mass distributed on the periphery of the structure (*e.g.* big balconies) are called torsionally unrestrained (TU) structures [Figure 17.2].

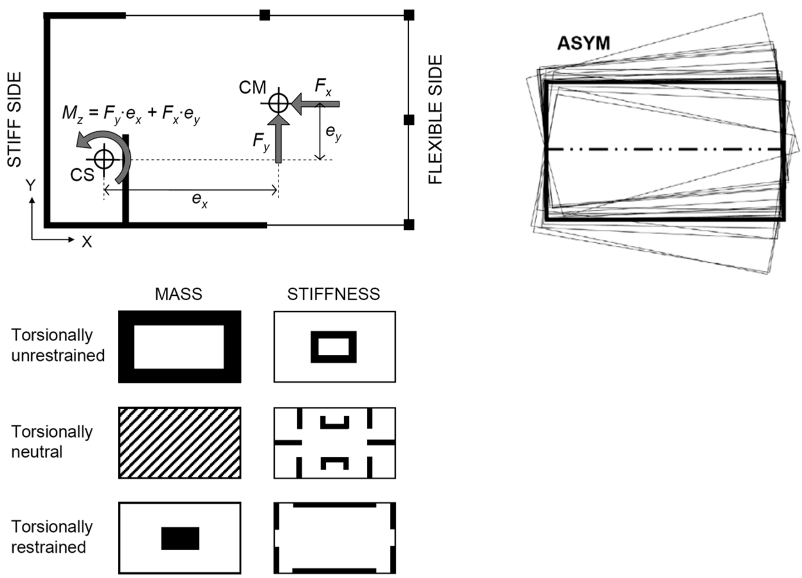
FIGURE 17.1 **Examples of Bi- and Uni-Directional Symmetry (top) and Completely Asymmetric Plan Layout (bottom)**



Source: Frampton, 1995.

In this case, the torsional-to-lateral frequency ratio is always smaller than 1.0. It was observed that maximal displacements of the torsionally restrained structure occur at the flexible side of the structure, while maximal displacements of the torsionally unrestrained structures occur at the stiff side of the structure. In general, the behavior of torsionally unrestrained structures is much more unpredictable and such structures are not favored by structural designers.

FIGURE 17.2 **Positions of the CS and the CM in Case of Bi-Directional Eccentricity of Plan Layout, its Behavior and Schematic Presentation of Design of Structures with Different Torsional Resistance**



Possibilities for Reducing the Unfavorable Effects of Asymmetric Structural Design

Often also in the cases where the asymmetry in architecture is not a consequence of the real demands of the given project task, structural asymmetry cannot be avoided. The reason may also lie in the desire to surpass previous achievements and to design new, recognizable buildings that win first prizes in competitions. In such cases, the asymmetry implemented or applied as an object of opposition to gravity laws is considered more as an added value than a structural defect. Such structures are frequently completely irregular from the viewpoint of civil engineering (*e.g.* asymmetrical) and as such are more exposed to earthquakes.

The building of irregular structures is not explicitly prohibited by codes, but from the structural viewpoint, it is in conflict with them. It should be noted that only if one criterion about structural (ir)regularity is not fulfilled, the analysis of such a structure is more refined and it requires more accurate mathematical models. Additionally, the forces acting on the structure are bigger, which could substantially increase the final costs of the structure. If structural asymmetry is considered an unavoidable fact, the structural profession offers more options for the efficient design of such structures:

- the mitigation of torsional effects with a redistribution of the stiffness or strength of the structural elements,
- the performance of more accurate structural analysis (*e.g.* nonlinear dynamic analysis),
- the use of an appropriate seismic isolation system.

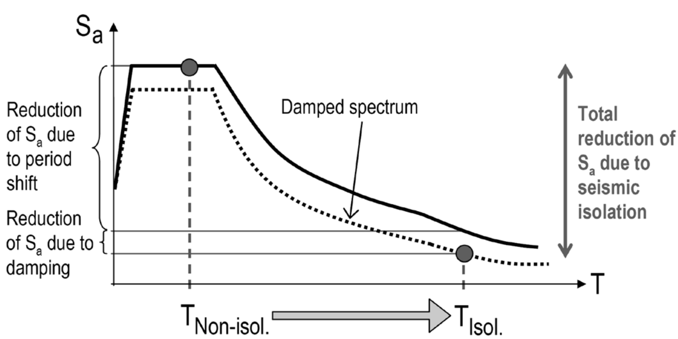
In the following chapters, the last of the above three possibilities is analyzed.

17.3. Implementation of Base Isolation to Asymmetric Structures

Basic Principle of Seismic Isolation

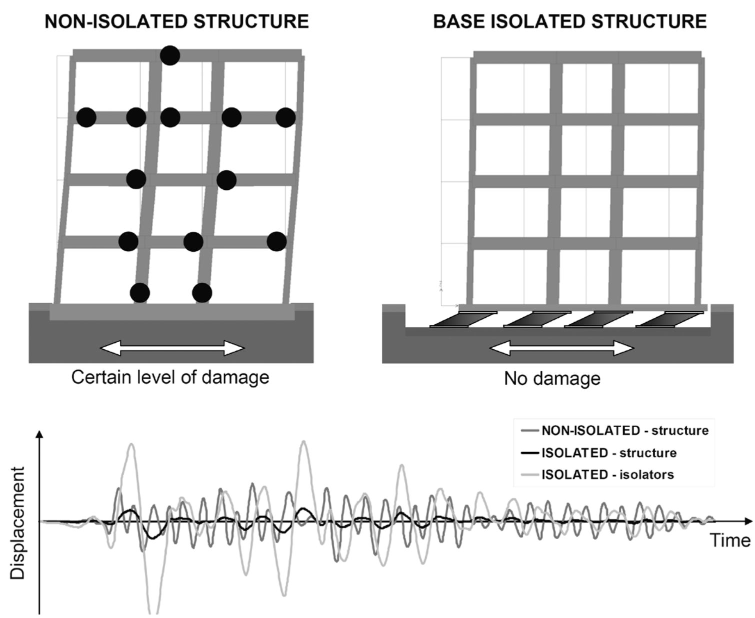
Nowadays, seismic isolation is increasingly used in high-seismicity regions in order to minimize the earthquake-induced loads in low- to medium-rise buildings and to mitigate structural and non-structural damage. Specifically, it shifts the period of low- to medium-rise buildings out of the dangerous resonance range. This phenomenon can be seen in Figure 17.3, which presents the top acceleration (S_a) of the structure with different periods of vibration (T).

FIGURE 17.3 **Effect of Seismic Isolation on Accelerations of Structure**



The periods of seismically non-isolated low- to medium-rise buildings are usually in resonance with the predominant earthquake periods. The modification of the dynamic characteristics of a building, in order to avoid resonance, is usually achieved by inserting flexible seismic isolators, which are often installed at the base of the building (*i.e.* base isolation) and typically work in the horizontal directions. The implementation of flexible seismic isolation devices lengthens the structural period and consequently reduces the induced seismic force. Additionally, the isolators are capable of offering quite a large amount of damping, which also reduces the seismic forces. By substantially decreasing the induced seismic loads, the inter-storey drifts and the floor accelerations, damage to the structural and non-structural components, as well as to equipment that is housed in a seismically isolated building, is avoided, and the superstructure can remain undamaged during strong earthquakes. This is the main difference in comparison with the seismic behavior of conventional (fixed-base) structures, which are designed to behave in controlling way, *i.e.*, the structure has to be prevented from collapsing, but some predetermined level of damage is allowed and expected to occur in the structure. While the relative displacements of the base-isolated superstructure are reduced to a minimum, the displacements of the isolators are usually substantially bigger [Figure 17.4].

FIGURE 17.4 **Comparison of Seismic Behavior of Non-Isolated (Fixed-Base) and Base-Isolated Structures**



The task of the structural designer is to apply the seismic isolation system that provides the elastic behavior of the superstructure and at the same time to keep the displacements of the isolation system under a reasonable level. This is required also by the EC8 code. In case of large displacements of the seismic isolation system, additional dampers and buffers can be applied. Among the most commonly used seismic isolation systems are the lead rubber bearings (LRBs), which provide both high initial stiffness and hysteretic energy dissipation.

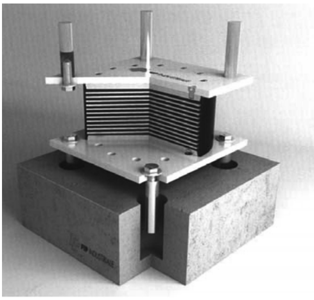
Seismic Isolation Devices

The descriptions and figures of seismic isolation devices presented in the following text are summarized according to the available literature, [*e.g.*, Naeim, 1999; Skinner, 1993; Kelly, 1997; Eggert, 2002; Kelly, 2007; Ibrahim, 2008] and other literature from the list of references at the end of this paper. Essentially, we can distinguish between two basic groups of seismic isolation devices [Figures 17.5 and 17.6]:

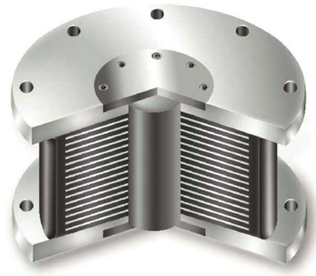
- Devices that lengthen the structural period of vibration. These devices possess a relatively large horizontal deformability and are capable of dissipating the limited amount of energy induced by earthquakes. For example: rubber bearings (RBs), lead rubber bearings (LRBs), PTFE sliding bearings, friction pendulum bearings (FPBs).
- Devices that reduce the force level and dissipate the energy induced by earthquakes. For these devices, elastic-plastic behavior with a very low level of hardening is characteristic. They have a high capacity for energy dissipation and consequently a large potential for reducing the displacements. Devices in this group are hysteretic steel dampers of different shapes, supporting steel and lead dampers, lead extrusion dampers, friction dampers, viscous hydraulic dampers, viscoelastic dampers and magnetorheological (MR) dampers. Recently, dampers based on Shape Memory Alloy (SMA), a smart material with several special properties, are also becoming more and more popular [Zuo, 2008].

Other systems for the seismic isolation of buildings are systems with tuning mass (TMD—tuned mass damper) and other systems based on springs. The latest research in the field of seismic isolation is based on the development of new intelligent devices in which the response of the building structure is controlled by a process unit and a control system regarding the seismic input load—see for example [Barbat, 1995], [Lu, 2008] or [Isaković, 2006].

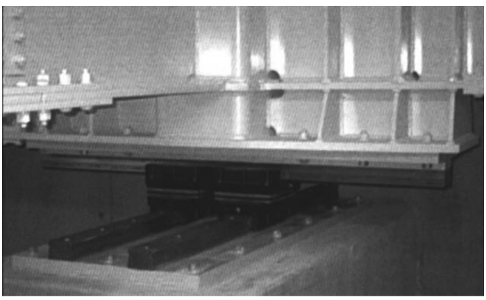
FIGURE 17.5 **Devices that Lengthen the Structural Period of Vibration**



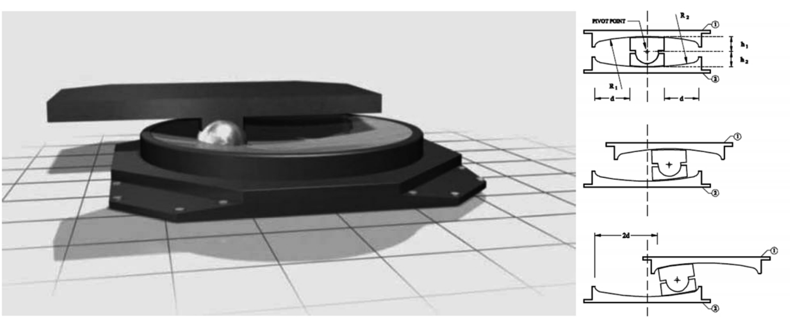
a)



b)



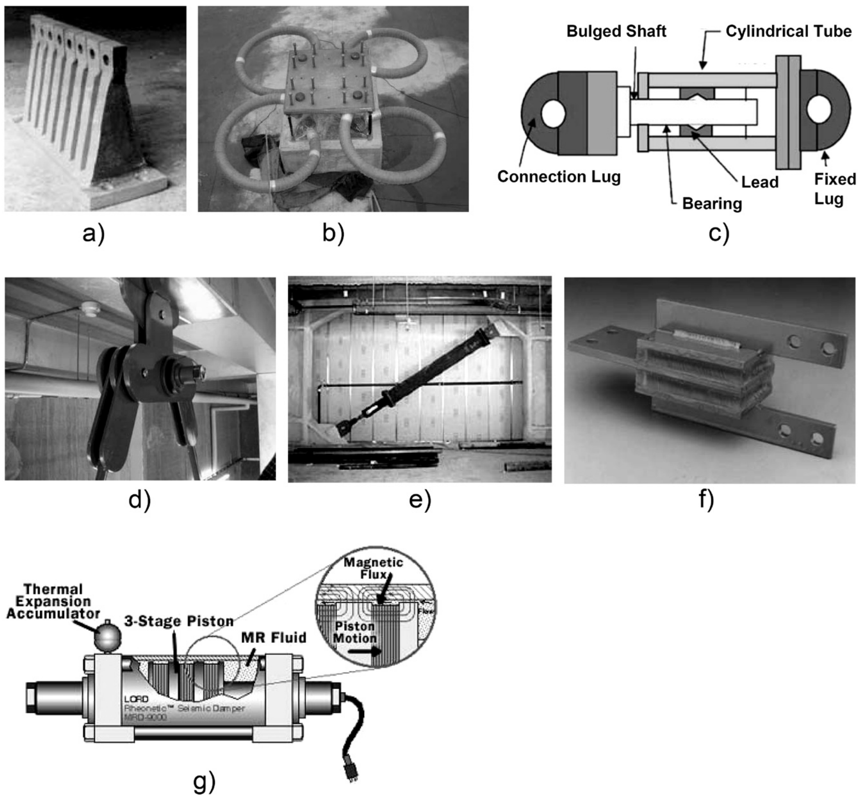
c)



d)

a) Rubber Bearing (RB), b) Lead Rubber Bearing (LRB), c) Sliding Bearing, d) Concave Friction Pendulum Bearing (FPB)

FIGURE 17.6 **Devices that Reduce the Force Level and Dissipate the Energy Induced by Earthquakes**



a) Hysteretic Steel Damper, b) Supporting Damper, c) Lead Extrusion Damper, d) Friction Damper, e) Viscous Hydraulic Damper, f) Viscoelastic Damper, g) Magnetorheological (MR) Damper

Usage of Seismic Isolation Devices for Asymmetric Structures

The seismic isolation of irregular structures, which are more exposed to unfavorable seismic effects, is still an ongoing research topic with relatively few works available. In general, two approaches are used in the seismic investigations into the response of base-isolated structures: in the first, the superstructure is assumed to be rigid; in the second, the flexibility of the superstructure is included when its elastic behavior is considered. The latter approach is used in most of the state-of-the-art research performed on multi-storey, 3D building models. A survey of the literature covering the research on base-isolated asymmetric structures is published, for example, in Kilar [2009a]. In general, researchers have concluded that using base isolation for asymmetric structures in cases of usual earthquake excitations substantially reduces the relative displacements of the superstructure. On the other hand, the displacements as well as the rotations of the base isolation system might be heavily increased. It is a common principle that a base isolation system with zero or a small amount of eccentricity (*i.e.* the eccentricity of the isolation system is equal or similar to the eccentricity of the superstructure) significantly reduces torsion in base isolation systems caused by superstructure asymmetry. This is also recommended by the code Eurocode 8 [CEN, 2005]. Among the other main conclusions, we should mention those of Jangid [1994], who stated that the base isolation system becomes less effective for greater eccentricities. Regarding the effects of mass and stiffness eccentricity of the superstructure in its seismic response, the study of Tena-Colunga and his co-authors [2007] shows that bigger torsional amplifications can be expected in the case of a mass eccentric structure than in the case of a stiffness eccentric structure. Also, the results of the experimental analyses on the seismic response of base-isolated asymmetric structures confirm the conclusions of numerical simulations—see, for example, Samali [2003].

The usage of seismic isolation in this manner is completely new in Slovenia. In the parametric study presented in the following chapters, we have focused on low- to medium-rise, multi-residential or office buildings, which are the most common building type in Slovenia as well as in many contemporary European cities. The main architectural characteristics (*e.g.* dimensions, heights, materials, structural systems, etc.) of common residential building were carefully studied. Based on the results, we have defined parametrical mathematical models of representative buildings that have been numerically analyzed. All structures were assumed to be base-isolated with tested and simple seismic isolation devices, which could be bought at affordable prices. Special attention has also been given to the irregular structures and the effect of structural as well as isolation system eccentricity on the seismic behavior of such structures. The basic assumptions and input data as well as partial results and conclusions are summarized in chapters 4 and 5. Chapter 4 analyzes the effectiveness of a base isolation system for different positions of the isolation system center in respect to the mass center of the superstructure. Chapter 5 presents a proposed modified N2 method for simplified analysis of base-isolated structures which is especially useful in the preliminary design stages and will also be used in our further research. Based on the results of our parametric studies, it has been concluded that seismic isolation could increase the earthquake safety of moderately irregular structures and enable freer architectural design; however, a cost increase for the whole building should be expected and verified with the investor before entering further design phases.

17.4. Effectivness of a Base Isolation System for Asymmetric Structures

Parametric Study

In our study, the effectiveness of seismic isolation was analyzed by computer simulations of a realistic, four-storey, reinforced concrete frame building with different mass-eccentric sub-variants and isolated with different distributions of isolators (lead rubber bearings). Since in our study the behavior of the superstructure was the main object under investigation, the complete, 3D, nonlinear model of both structure and isolation system was used, and it proved to be effective in tracking the potential development of damage induced by asymmetry of the superstructure
The original variant of structure is a doubly symmetric building, where the center of mass (CM) coincides with the center of stiffness (CS) and there are no irregularities in height [Figure 17.7].
The Eurocode 8 design spectrum for soil class B and peak ground acceleration 0.35g was used for the building design. The assumed reduction factor q was equal to 3.75 (medium ductility class). Storey masses amounted to 295 [237] tons for the bottom storeys and for the roof, respectively. The fundamental periods of the fixed-base structure amounted to T_x = 0.58 s, T_y = 0.56 s and T_z = 0.53 s. The investigated direction of response is the Y direction; in all considered variants, the eccentricities are produced in the X direction only. For the base isolation system we have selected 24 equal lead rubber bearings (LRBs) positioned centrically under all columns [Figure 17.8]. The additional mass of the foundation system amounted to 218 t. The stiffness of the bearings was carefully selected by iterative processes in order to obtain the bearings' stiffness that would bring the symmetric superstructure exactly to the limit of its elastic range. The effective period of such a base-isolated structure in the investigated direction of response amounted to T_y = 1.73 s. Such a case would probably never be used in practice, but in this way, all additional damage gained from the parametric studies can be contributed only to the studied effects of asymmetry.
A more detailed description of the base-isolated symmetric structure and its seismic behavior can be found in Kilar [2008].
Nonlinear dynamic analyses of 3D models were performed with the program SAP2000 [CSI, 2008]. The nonlinear behavior was simulated considering concentrated plasticity (plastic hinges with bilinear behaviour and hardening after yielding) modeled on both ends of each beam and column. The floor diaphragms were assumed to be rigid in their own planes and to have no out-of-plane stiffness. For the nonlinear dynamic analyses, we used horizontal components of ten accelerograms recorded in south and south-eastern Europe [Table 17.1].

Only uni-directional loading of the structure was taken into account where the N-S components of the considered accelerograms have been always oriented in the Y direction of the building. The accelerograms were scaled to design ground acceleration (0.35g). All the results of the nonlinear dynamic analyses presented in this article were obtained from the average value of the five earthquake records that have produced the biggest response [*e.g.* Bar, Focsani, Herceg Novi, Petrovac and Ulcinj 1].

FIGURE 17.7 **Analyzed Structure and Seismic Behavior of Fixed-Base and Base-Isolated Asymmetric Structures**

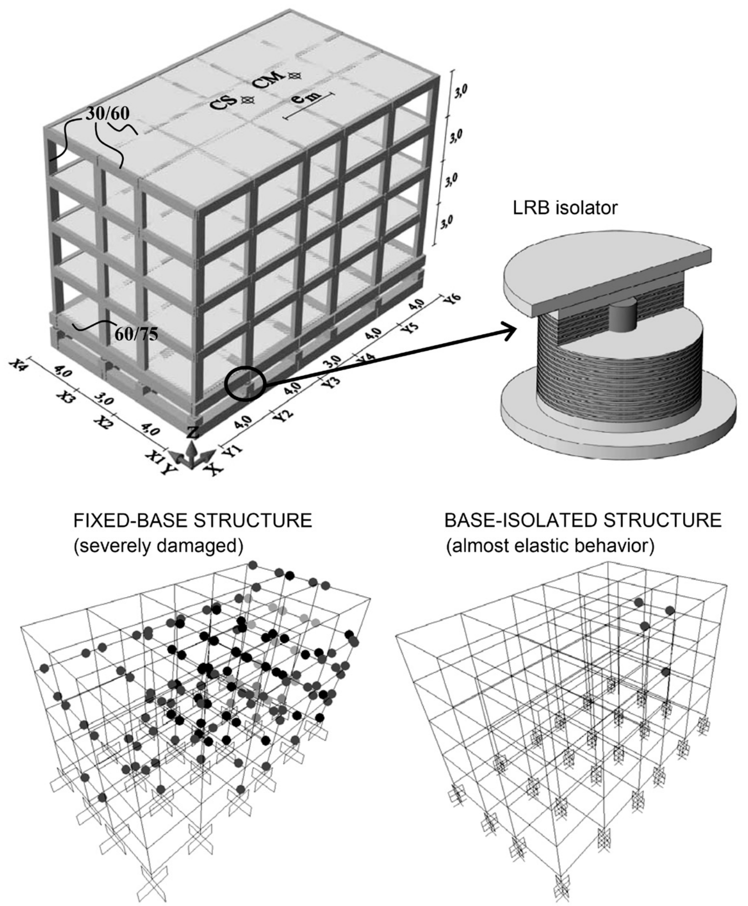
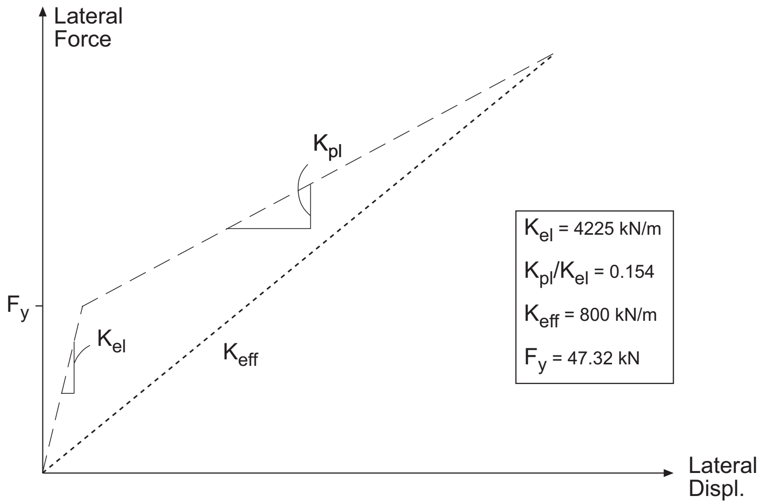


FIGURE 17.8 **Properties of Used Lead Rubber Bearings (LRBs)**



The asymmetric structural variants were simply obtained by shifting part of the loading of the superstructure and of the isolation floor toward the right-hand part of the building, which moved the mass center CM by 10% (A10), 20% (A20) or 30% (A30) of the larger floor plan dimension [see Figure 17.7]. In all cases, the asymmetric variants were obtained by changing only the +X mass coordinates while their Y coordinates remained the same. The mass of each storey was modeled in discrete points, *i.e.* the joints between columns and beams in each storey.

TABLE 17.1 **Used Earthquake Records**

Station	State	Date	$a_{g,max, N\text{-}S}$ [g]	Duration [s]
Banja Luka	Bosnia and Herzegovina	13.8.1981	0.516	10.0
Bar	Montenegro	15.4.1979	0.364	25.0
Focsani	Romania	30/31.8.1986	0.279	21.7
Forgaria	Italy	15.9.1976	0.305	15.0
Herceg Novi	Montenegro	15.4.1979	0.213	25.0
Petrovac	Montenegro	15.4.1979	0.438	19.6
San Rocco	Italy	15.9.1976	0.139	15.0
Tolmezzo	Italy	11.5.1976	0.349	15.0
Ulcinj 1	Montenegro	15.4.1979	0.285	25.0
Ulcinj 2	Montenegro	15.4.1979	0.171	25.0

Many researchers who have studied the behavior of asymmetric structures have pointed out the importance of the ratio between the torsional and the lateral frequency of the superstructure [Annigeri, 1996; Kilar, 2001; Fajfar, 2005; Ryan, 2006; Pettinga, 2007; Tena-Colunga, 2007]. The structure with the torsional first mode is also called a torsionally unrestrained (TU) structure. In this case, its torsional-to-lateral frequency ratio Ω_s is always smaller than 1.0. As Ω_s increases, the system gains stiffness in torsion relative to its lateral stiffness. A structure with Ω_s bigger than 1.0 is also called a torsionally restrained (TR) structure. In addition to the original mass distribution (Ω_s = 1.0, torsionally neutral structure), we analyzed two additional mass distributions where we changed the Y mass coordinates while keeping the X coordinates the same in all cases. A torsionally unrestrained (TU) structure was obtained by shifting all joint masses outward to the edge lines with Y=±7.5 m (measured from CM), while a torsionally restrained (TR) structure was obtained by shifting all the joint masses inward to the Y=0 central line.

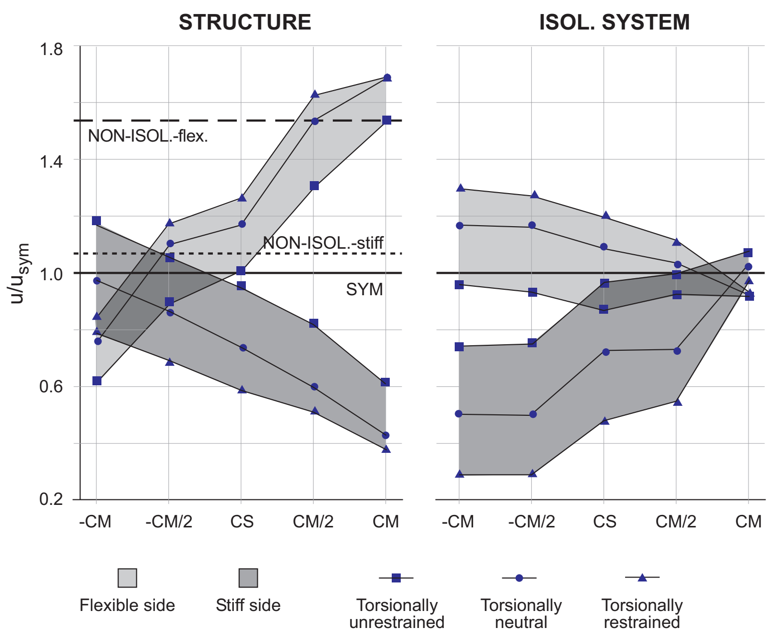
Five different distributions of isolators were considered in our study: one symmetric (uniform) and four asymmetric. There are many possibilities for producing a base isolation with an asymmetrical center of isolators (CI). In our case, we changed only the X coordinates of the isolators while keeping the Y coordinates, stiffness and total number (24) the same as for the original building. In this way, the center of isolators CI took the following positions:

- CI=CS: uniform distribution of isolators over the floor plan,
- CI=CM the center of isolators CI corresponds to the actual center of masses CM,
- CI=CM/2: the center of isolators CI positioned at the midpoint between CS (the center of stiffness of the superstructure) and CM,
- CI=−CM: the center of isolators CI is moved into the mirror position of CM over CS and
- CI=−CM/2: the center of isolators CI corresponds to mirror position of CM/2 over CS.

Selected Results

Selected results for structures with different torsional stiffness/resistance and asymmetric variant A20 with 20% eccentricity of the superstructure are presented in Figure 17.9. More detailed descriptions and the results of the performed analyses can be found in Kilar [2009a]. The effect of asymmetry is expressed by the displacement amplification factor for the stiff (frame Y1) and flexible (frame Y6) sides of the superstructure and of the isolation system. The amplification factor (u/u_{sym}) determines the increase (u/u_{sym} > 1,0) or decrease (u/u_{sym} < 1,0) of the maximal displacement of the asymmetric structure in comparison with the maximal displacement of the symmetric one, which amounts to 2.3 cm for the top of the superstructure and 9.3 cm for the base isolation system. It should be noted that the displacements were considered as positive (absolute) values of displacements in the +Y and –Y direction. The presented values show maximal displacements, which do not occur necessarily at the same time. It can be seen from Figure 17.9 that some of the investigated distributions of isolators tend to improve the torsional effects caused by the asymmetry of the superstructure more than others.

FIGURE 17.9 **Envelopes of Displacement Amplification Factors for the Superstructure (Variant A20) and Isolation System under Different Locations of the CI**



It seems that those which are able to better protect the superstructure have greater displacements at the level of the base isolation system and vice versa. The amplification factors strongly depend on the isolator distribution. For the superstructure, they take values that are in general smaller than in the case of a non-isolated (fixed-base) structure. As can be seen from Figure 17.9, the amplifications are usually bigger for the flexible than for the stiff side of the building. In the cases when the CI is shifted closer toward the CM, however, the bigger amplifications were recorded for the stiff side. It must be emphasized that the values of actual displacements are in all cases always substantially smaller in comparison to displacements of fixed-base structures.

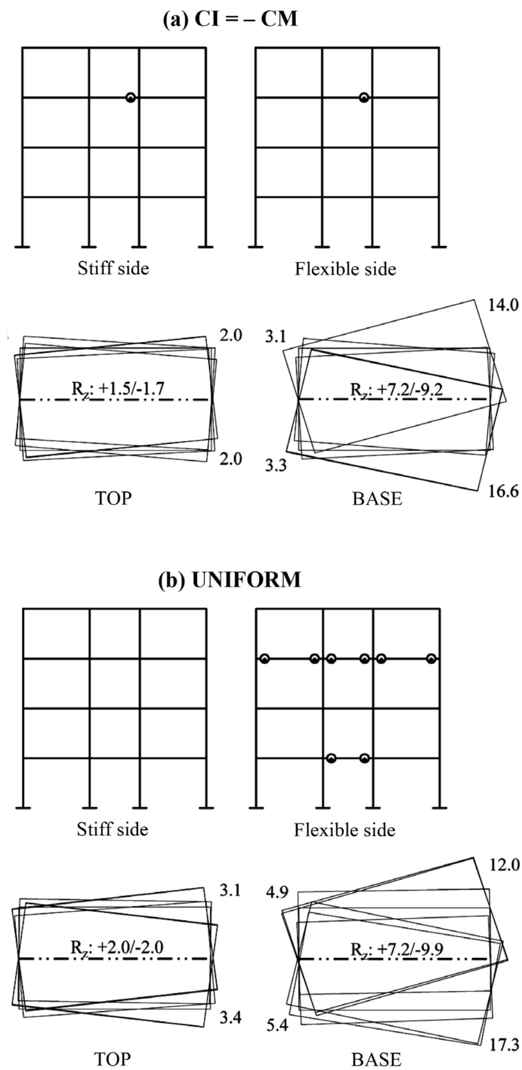
For torsionally restrained and also torsionally neutral variants of the superstructure with the CI positioned on the right side of the CS, the maximal top displacement amplification factors for the flexible side of are, in general, greater than for the stiff side of the structure. For positions where the CI is situated on the left side of the CS and especially for a torsionally unrestrained superstructure, the maximal top displacement amplification factors for the stiff side are, in general, greater than for the flexible side of the structure.

By observing the displacements of the superstructure, it can be seen that the best protection of the flexible side frames is not reached in the case of CI=CM isolator distribution, which is also favored by Eurocode 8 (where the eccentricity of the isolation system is required to be similar to the eccentricity of the superstructure). In this case, the maximal amplification factor reaches much larger values than in all other cases (up to 1.7). Much better protection was reached in all cases where the CI was positioned further away from the CM (*e.g.* CI=CS, CI=−CM/2 and CI=−CM distributions). The best situation seems to be the case of CI=−CM distribution, where the flexible side displacement becomes even smaller than the displacement of the corresponding symmetric structure. In this case, however, the stiff side displacements increase, and in some less torsionally restrained systems, they might even become larger than those of a symmetric structure (up to 1.2). The uniform CI=CS distribution of isolators also behaves well; the maximal amplification factor reaches up to 1.25.

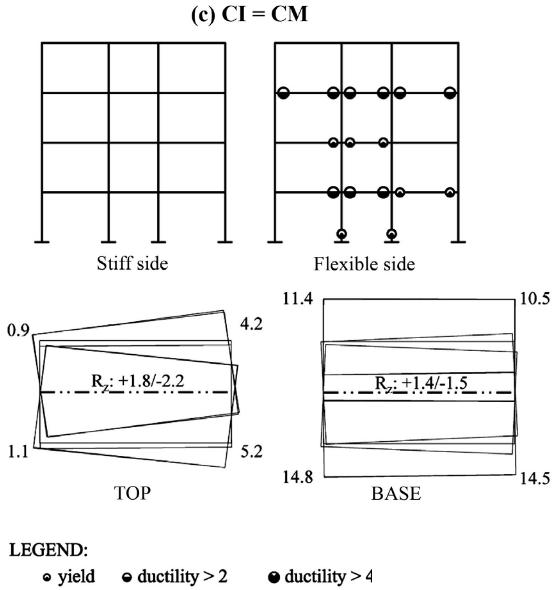
Observing the displacements of the base isolation system, it can be seen that the amplification factors are smaller than for the superstructure. Minimal rotations of the base isolation system, which can cause an excess of isolator design displacements or will demand wide dilatation gaps, were obtained for the isolator distributions where the CI is close to the CM (CI=CM and CI=CM/2). The maximum amplification factor was always obtained at the flexible side of more torsionally restrained systems (up to 1.30). The largest amplification factors were obtained for those isolator distributions that were able to best protect the superstructure (*e.g.* CI=−CM/2 and CI=−CM distributions).

Figure 17.10 shows an even more detailed insight into the damage distribution by presenting the maximal ductility factors for ends of beams and columns for stiff and flexible side frames of asymmetric building A20 for 3 selected distributions of bearings. Here, the ductility factor is defined as a ratio of response rotation to yield rotation of a flexural spring (ductility factor 1.0 presents elastic behavior). For each damage pattern, the corresponding max./min. flex/stiff side displacements and max./min. rotations are also shown together with the corresponding floor plan outline frame. The results are presented for Ulcinj ground motion (it produced maximal damage) and a torsionally neutral variant of the superstructure. The damage of the base-isolated structures is considerably smaller (only a symmetric base-isolated structure remains completely elastic).

FIGURE 17.10 **Maximal Ductility Factors for Asymmetric Variant A20 With Corresponding Floor Plan Displacement Envelopes (Ulcinj Ground Motion; Torsionally Neutral Superstructure; Units: cm, 10^{-3} Rad)**



CONTINUING FIGURE 17.10



It should be noted that the original base isolation system of the symmetric structure was selected to keep the symmetric structure subjected to the design loading exactly at the limit of the elastic range with a ductility factor below or equal to 1.0. All other structural variants developed some additional damage, which is a consequence of the introduced asymmetries and/or applied base isolation distributions. It can be seen from Figure 17.10 that a CI=CM isolator distribution develops significant damage of the flexible side frames (10c), which can be avoided if other distributions of the isolators are used. In these cases, the damage of the flexible side frame is limited to the yielding of beams in the third floor (10b) or even completely eliminated (10a). The behavior of the stiff side frame is elastic in most cases, except for the CI=−CM distribution, where the maximal ductility factor slightly exceeds the value of 1.0.

The results presented in Figures 17.9 and 17.10 show that the positions of the CI, which result in minimum displacement amplifications for the superstructure, generally induce maximum displacement amplifications for the base isolation system. The gradual shifting of the CI from CI=CM toward the position CI=−CM generally reduces the displacements (and the damage) at the flexible side and increases the displacement at the stiff side of the superstructure. In the extreme position CI=−CM, it even seems that the flexible and stiff side shifted sides. In this case, the superstructure is substantially more protected against unfavorable torsional effects, resulting in a more "symmetric behavior" of the superstructure.

Overall, it can be concluded that the most favorable distributions of the isolators are, in general, those where the CI is placed closer to the CS, resulting in the minimum and the most evenly planned distributed displacements of the superstructure and the isolation system simultaneously. For the displacements of the base isolation system, the position CI=CM is shown as evidently the most appropriate, but regarding the results of this study, this isolator distribution does not ensure sufficient safety for the superstructure.

17.5 Simplified Nonlinear Method for Analysis of Base-Isolated Structures

Description of the Method

In the design of structures under seismic actions, several methodologies can be used with distinct accuracy to describe the structural seismic response. The nonlinear dynamic analysis is the most accurate and complex. Although the accuracy and efficiency of the computational tools have increased substantially, there are still some reservations about the nonlinear dynamic analysis, which are mainly related to its complexity and suitability for practical design applications. This increases the computational effort significantly. However, design engineers need intuitive tools to determine the structural response under seismic actions. In this sense, several researchers are trying to develop simplified methodologies for analysis and design that can determine the structural response and that can be routinely used by the structural designers. In the majority of cases, nonlinear static analysis under monotonically increasing lateral loading (pushover analysis) is an important part of the methodology. This procedure involves applying a predefined lateral load pattern, which is distributed along the building height. The lateral forces are then monotonically increased in constant proportion with a displacement control at the top of the building until a certain level of deformation is reached. The target top displacement may be the one expected in the design earthquake or the displacement corresponding to expected structural collapse. The target top displacement may also be determined by the N2 method [Fajfar, 2000], which combines the pushover analysis of a relatively simple mathematical model and the response spectrum approach. The N2 method was originally developed for fixed-base structures, and as such it has also been implemented in the Eurocode 8 standard. For the design of base-isolated structures, most codes and regulations provide specifications for the use of equivalent linear elastic methods based on eigenvalue analysis and spectral values, *e.g.* CEN [2005]; Mavronicola [2009]. Recently, the combination of nonlinear static analysis (pushover analysis) and the capacity spectrum method has become increasingly known and popular in the practical design of fixed-base structures, *e.g.* References [ATC–40, 1996; Fajfar, 2000; Magliulo, 2007; Dolšek, 2008]. A proposal for base-isolated structures has been given in Colunga [2002] and Zhao [2007]. Simplified approaches for the analysis of base-isolated asymmetric structures are not frequently researched. A proposal for a simplified method for analysis of asymmetric structures with Displacement-Dependent Passive Energy Dissipation Devices (DDPEDDs) can be found in Li [2007].

In the present study, the N2 method has been applied for an analysis of base-isolated symmetric structures. One of the main assumptions of this method is that the response of a structure is governed by one mode, which is precisely the case for base-isolated structures, whose response is characterized by a motion of an almost rigid upper block on much more flexible isolators. For a fixed-base structure subjected to strong earthquake motion, some damage of the structure that was designed in accordance with the valid codes should be expected. In contrast, for base-isolated structures, it is expected that the superstructure remains elastic for the design earthquake. From this viewpoint, the first yielding point (*i.e.* occurrence of the first structural damage) of the superstructure is far more important than the "average yielding" point of the structure used for three-linear idealization in the original N2 method developed for fixed-base structures [Fajfar, 2000]. In this way, the N2 method should be able to detect the first yielding of the superstructure as well as to further estimate the behavior of the superstructure in the nonlinear range directly in relation to the first damage of the superstructure.

A three-linear idealization curve, presented in Figure 17.11, has been proposed by the authors. The first yielding of the superstructure is determined with the pushover analysis for selected lateral load distribution. The initial stiffness has been obtained by equalizing the areas below and above the actual pushover curve of the base-isolated structure. The secondary slope is obtained in a way so that it best fits the real pushover curve. Alternatively, it can be determined from a failure mechanism obtained with pushover analysis. It should be noted that our interest range is practically limited to the second hardening part of the idealized curve since it is not expected that the base-isolated structure would experience damage close to the failure mechanism. A consequence of such idealization is a three-linear shape with a much steeper secondary slope, which does not correspond to presumptions used in the original N2 method. With a parametric study of idealized SDOF systems performed by the authors [Kilar, 2009b, c], it was verified that the equal displacement rule [Fajfar, 2000; Priestley, 2007] and the same equations for calculating inelastic spectra as in the original N2 method could also be used for base-isolated structures.

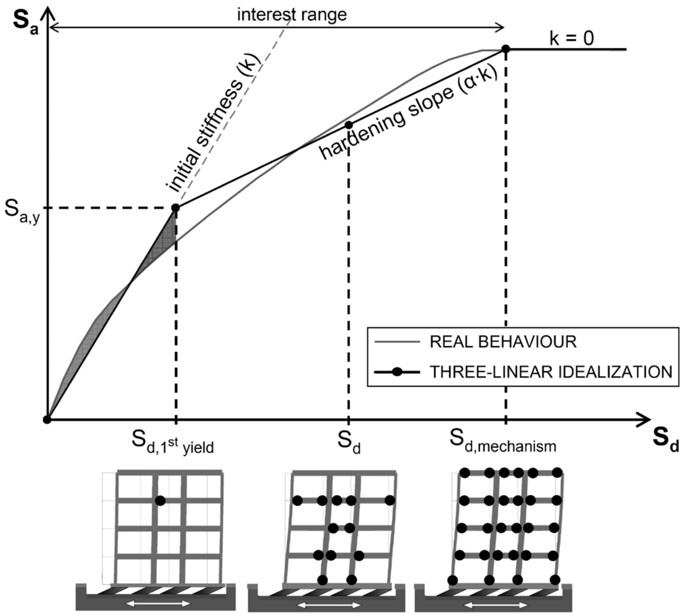
The inelastic spectra can be obtained from elastic ones by dividing the spectral ordinates by the total reduction factor, which can be expressed as a product of the reduction factor due to the nonlinear behavior and the damping of the superstructure (R_α) and the reduction factor due to the damping of the isolators. The target top displacement of the base-isolated structure is then defined as an intersection of the proposed idealized capacity curve and inelastic demand spectrum curve. Since the equal displacement rule could be applied, the target top displacement of the base-isolated structure can be alternatively defined as an intersection of the idealized initial stiffness line of the system and elastic spectrum curve for the appropriate damping ratio [Figure 17.11].

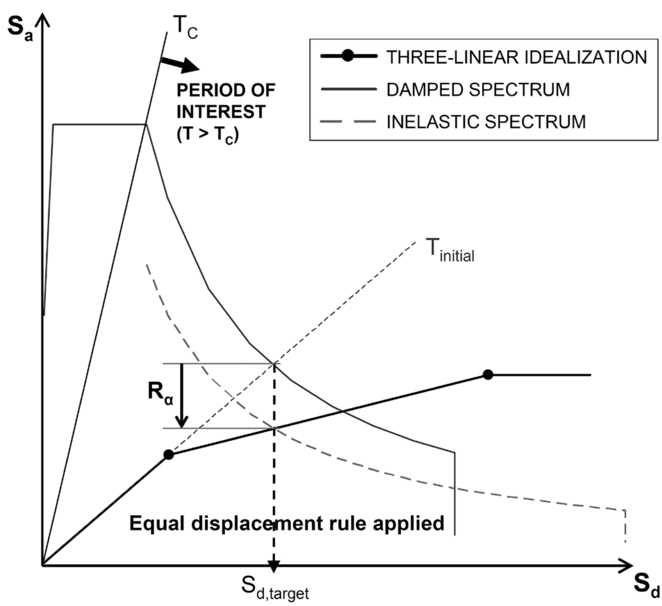
Case Study and Selected Results

The previously used base-isolated symmetric variant of the building was used as a test example. The ground motion records were the 7 shown in Table 17.1 [Banja Luka, Bar, Focsani, Forgaria, Petrovac, Tolmezzo, Ulcinj] additionally modified by the program SYNTH [Naumoski, 1998] in order to correspond best to the target spectrum. As a target spectrum, we used the Eurocode 8 elastic spectrum for soil type B. Three different ground motion intensities were considered by scaling the ground acceleration a_g to design ground acceleration (0.35g) as well as to 50% (0.525g) and 100% (0.70g) greater ground acceleration. No damage is to be expected for the base-isolated structure subjected to design ground acceleration (0.35g). For bigger ground motion intensities, however, the superstructure behavior becomes nonlinear and plastic hinges develop in the beams and columns of the superstructure.

The results of pushover-based procedures depend substantially on the lateral load distribution used. Whereas an inverted triangular distribution is the most common distribution used for fixed-base structures, it is not the most suitable for base-isolated structures. The main reason is that, in the triangular distribution, the force in the base storey is always equal to zero. Distribution proportional to the first mode of the base-isolated structure, which introduces much more force at the base, appears to be more appropriate. The problems related to neglecting inertia at the base level have been addressed, among others, by the current Protective Systems Committee (PSC) of SEAONC [SEAONC, 1986], who suggest using an inverted triangular lateral load distribution over the height of the superstructure with an additional concentrated force at the base level. It should be pointed out that all the suggested distributions of horizontal loads were developed for elastic static analysis, and are therefore adjusted in order to obtain the deformed shape of the elastic superstructure on the isolators. For this reason, they might not work equally well with the N2 procedure when examining the nonlinear behavior of the superstructure during stronger ground motions.

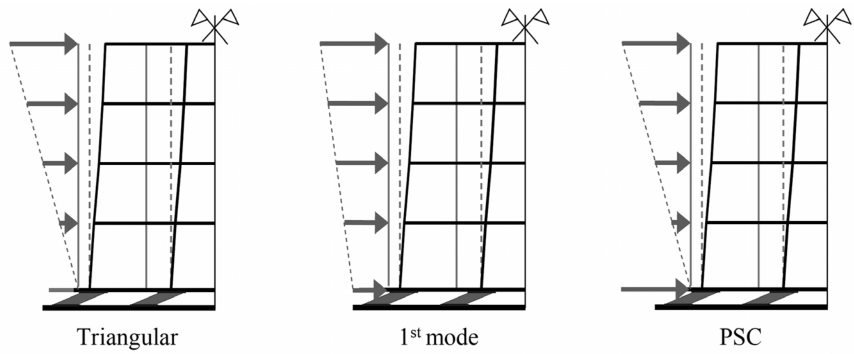
FIGURE 17.11 **Actual and Considered Idealized Three-linear Capacity Curve of Base-Isolated Structure (top) and Estimation of Target Top Displacement (bottom)**





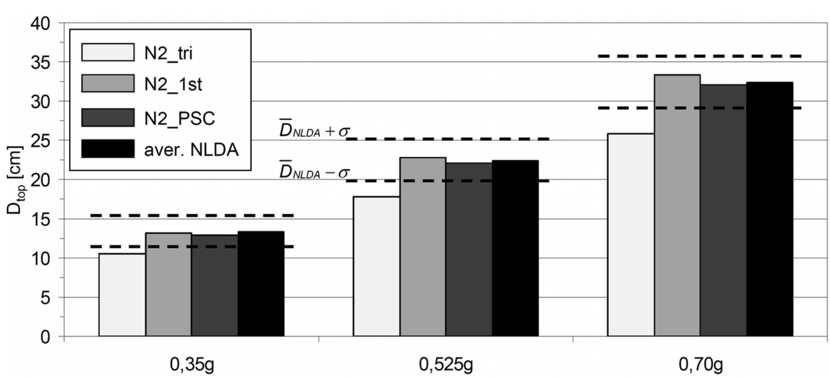
In our study, we have considered several different lateral load distributions in order to examine which works best for the proposed procedure. The following three distributions will be presented: a) 'Triangular,' b) mass proportional to displacement of the '1st mode' shape and c) 'PSC'—the proposal of the Protective Systems Committee. All considered lateral load distributions are schematically presented in Figure 17.12.

FIGURE 17.12 **Lateral Load Distributions Used for the Analysis of Base-Isolated Structures**



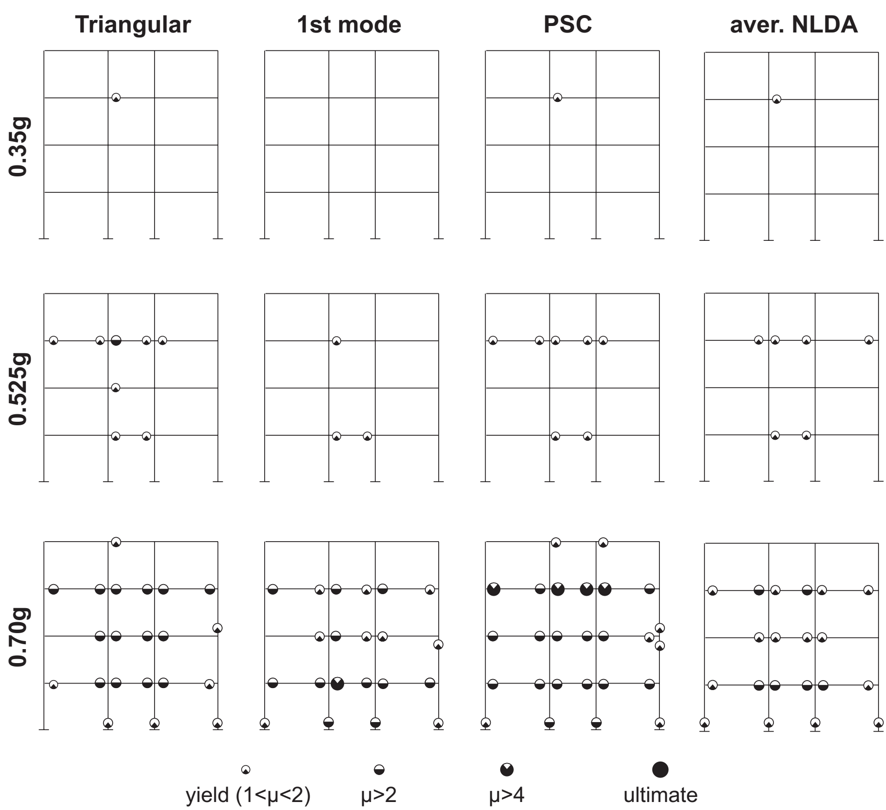
The results obtained by the N2 method are compared with the results of nonlinear dynamic analyses (NLDA). Results are presented in terms of obtained target top displacement (D_{top}) and plastic hinges (damage patterns) generated in the superstructure [Figures 17.13 and 17.14].

FIGURE 17.13 **Top Displacements Obtained With the N2 Method and Simplified Method (for 3 Different Lateral Load Distributions) in Comparison With the Results of NLDA for Three Seismic Intensities**



For more details, see the references in Kilar [2009b, c]. As can be seen from Figure 17.13, the N2 method in general gives better results, which generally agree very well with the average top displacements of NLDA for all considered lateral load distributions except the triangular distribution that underestimates the demand top displacements.

FIGURE 17.14 **Damage Patterns of the Superstructure Obtained with the N2 Method and NLDA for Three Different Seismic Intensities**



For this distribution, the obtained target top displacement is even outside the NLDA standard deviation (σ) range, which indicates that this distribution is not appropriate for base-isolated structures. The differences between the other two analyzed lateral load distributions are negligible.

The differences in the obtained relative displacements that generate damage are more distinctive. Figure 17.14 presents the rotational ductility factors (μ) for the ends of beams and columns obtained with the N2 method (for 3 considered lateral load distributions) and NLDA for three analyzed ground motion intensities. As expected, while there is a lot of damage for isolated structures subjected to records scaled to 0.70g, the records scaled to design ground acceleration (a_g = 0.35g) produce almost no damage, and the superstructure response is exactly at the limit of the elastic range, and selected LRBs seem to be appropriately designed for preventing the superstructure from becoming damaged.

For stronger intensities, *e.g.* a_g = 0.70g, the agreement with the results obtained by NLDA is satisfactory and tends to be conservative. In these cases, the differences between analyzed lateral load distributions are more distinctive. The damage patterns obtained by triangular and also PSC lateral load distribution were conservative in all examined cases. The 1st mode distribution slightly underestimates the damage in comparison with the damage obtained with NLDA, which is especially evident in cases of lower seismic intensities. For the lateral load distribution based on PSC distribution, the obtained damage patterns seem to fit best with those obtained with NLDA, which is not completely true in the case of the strongest ground accelerations, where the 1st mode distributions works better.

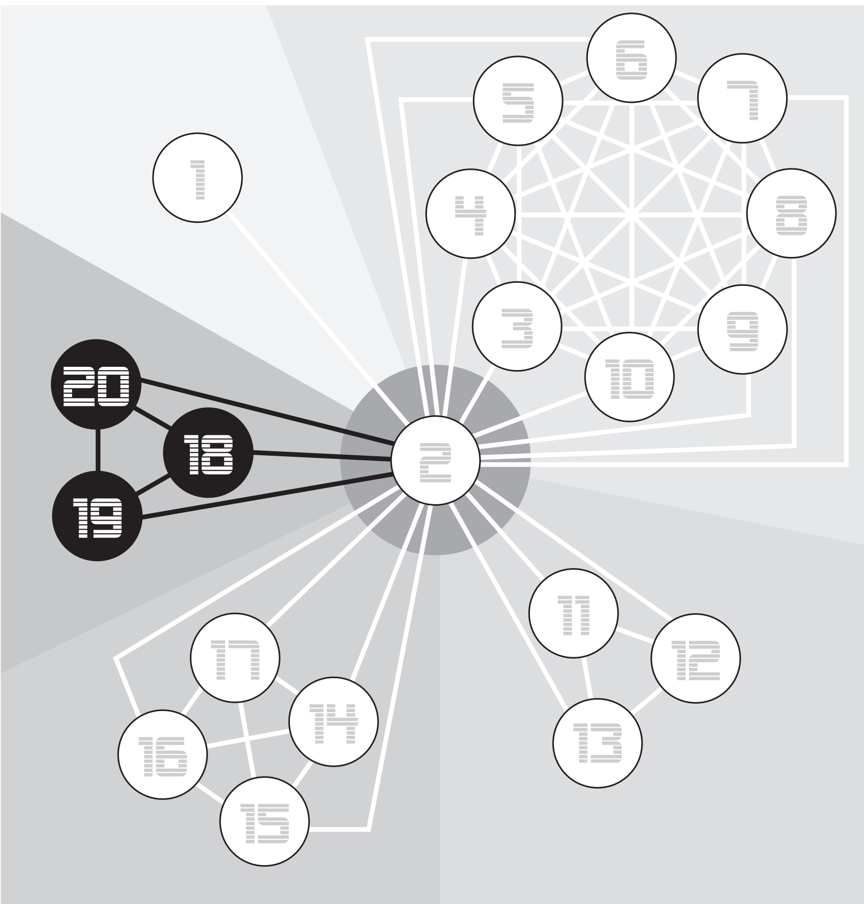
Detailed descriptions of the analyzed frame structure and comments on the results obtained can be found in Kilar [2009b, c].

17.6 Conclusions

The design of asymmetric buildings in architecture might result from the various project demands as defined by architectural-urban reasons. The structural profession offers many options for the efficient design of asymmetric structures, but it should be noted that those options are limited and the asymmetry always leads to less predictable seismic behavior of structures. Using the appropriate seismic isolation system is one of the promising, contemporary options and it has been studied in detail in the presented ongoing research. Although its application usually means additional costs for the structure, it does ensure greater earthquake safety and enables freer architectural structure design. In this way, it gives architects more design freedom in the building design process. The results of the analyses have shown that with an appropriately designed base isolation system, the unfavorable effects of asymmetric structures can be substantially reduced or even eliminated. In the case of a base-isolated structure, the torsion effects are transferred from the superstructure to its base isolation system. Although the behavior of base-isolated asymmetric structures is better in comparison with the non-isolated ones, the earthquake safety of asymmetric structures is still less than of the symmetric ones. The influence of isolator distribution on the seismic behavior of structure was shown to be of great importance. The main conclusion is related to the CI=CM isolator distribution, which is favored by many building codes. It perfectly reduces the torsional amplifications in the base isolation system, even if the asymmetry of the superstructure is large. On the other hand, it was found that this isolator distribution does not protect the superstructure well. Exactly the opposite conclusions were drawn for the CI= −CM (mirror) isolator distribution, which appears to protect the superstructure much better but inflicts greater negative torsional amplifications on the base isolation system. We should be aware in this case, however, that the substantially increased base displacements might be problematic for the isolators as well as for the required dilatation gaps. The best solution seems to be an intermediate position of the isolators with the CI close to the CS or even further away from the CS toward the stiff side of the building. These distributions are able to reduce the top displacements of the superstructure as well as the base displacements and keep them under the specified tolerance level.

Additionally, a simplified procedure for calculating seismically isolated structures has been suggested. The application of a simplified method (N2 method), which was originally developed for seismically fixed-base structures, to base-isolated structures is new, and according to information accessible to us it is the first such example in relevant world literature. In comparison with the original version of the N2 method, some modifications needed to be made. Because of the importance of the limit of elastic behavior of the seismic isolated superstructure, the new three-linear idealization of the pushover curve based on the first yielding point (*i.e.* occurrence of the first structural damage) of the superstructure has been proposed by the authors. The comparisons of the results with the described simplified approach and the 'exact' results determined by nonlinear dynamic analysis have shown a very good agreement. The results of the presented procedure, however, depend on the lateral load distribution used. The differences are more distinctive for the obtained relative displacements and consequently for the corresponding damage patterns. Regarding the obtained results, the simplified procedure using the N2 method might be—with appropriate modification—a valuable tool for the design, analysis and verification of behavior of seismically isolated symmetric as well as asymmetric structures. The latter should be verified by further research.

Part V — Towards Inter- and Transdisciplinary Forms of Science



Introduction to Part V

The fifth part of the book on modern RISC-societies focuses on the wider scientific environment and its structural changes towards more inter- and transdisciplinary forms of research and organization which has been identified as the essential background which enabled research programs like the RISC-program at the University of Ljubljana.

The paper of Rogers J. Hollingsworth, Karl H. Müller, Ellen J. Hollingsworth and David M. Gear argues that a new scientific landscape under the name of Science II is slowly emerging and can be seen as the successor to a traditional science landscape which could be qualified as Science I and which was dominated by a Descartes-Newtonian form of research. Science I has been dominant during the past several hundred years, after its rise to a hegemonic method for scientific research in the 18th and 19th century. The Science II landscapes place a great deal of emphasis on evolution, dynamism, randomness, self-reflexivity or pattern (re) construction. As a cause and effect of the new science landscapes, scholars in the physical, biological and social sciences are increasingly addressing common problems. In their research, these scholars from various disciplines in the social and in the natural sciences are using common models, methods, and metaphors. The paper focuses much of its attention on the field of the social sciences as an example of how the newly emerging landscapes in the age of Science II offer considerable potential for new hybrid fields between the social sciences and segments of the natural sciences.

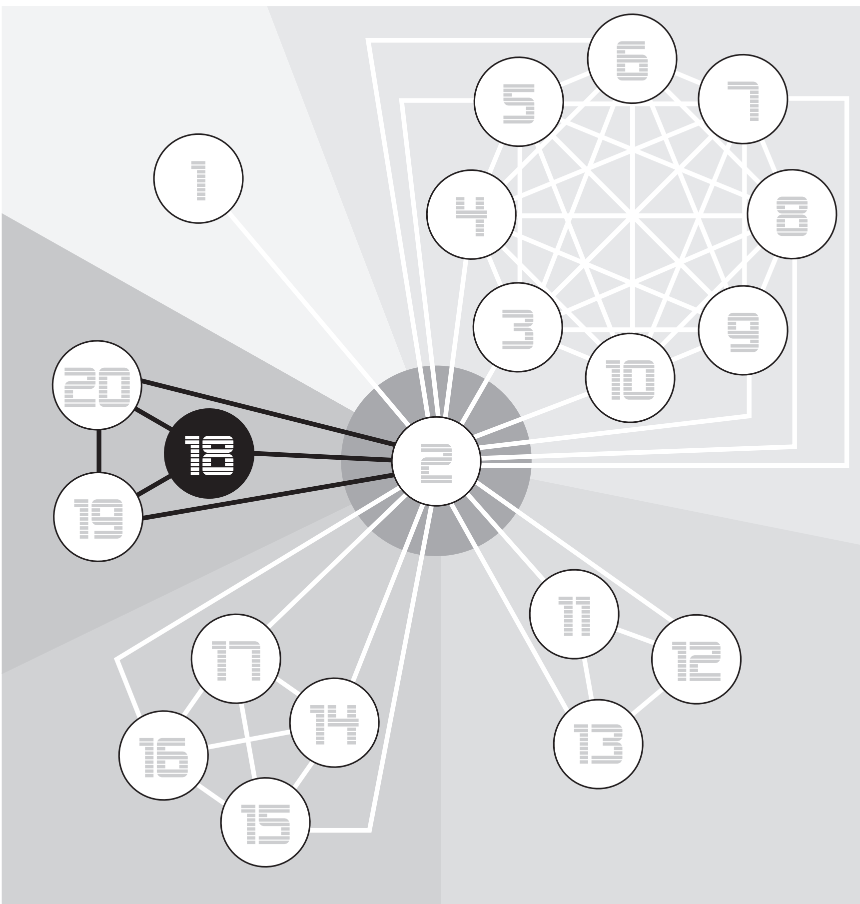
Franc Mali, in his paper "Turning Science Transdisciplinary: Is it Possible for the New Concept of Cross-Disciplinary Cooperations to Enter Slovenian Science and Policy?," points to important theoretical and empirical aspects of the growing importance of scientific trans-disciplinarity. Following along the lines of arguments for a new topology of scientific landscapes, Mali, too, stresses the growing orientation to trans-disciplinarity in science. For example, the whole 'philosophy' underlying the European Research and Innovation Area places a strong emphasis on cross-, inter- and trans-disciplinarity in science. Mali places a special emphasis on current barriers that hinder the realization of new forms of trans-disciplinarity in science and policy discourse in Slovenia.

Finally, Simona Tancig and Urban Kordeš provide a very useful overview on central issues in the area of inter-, trans-, cross-, and multi-disciplinary research work on complex problems. The focus of their analyses lies on concepts, theoretical frameworks, practical considerations and challenges, and possibilities of collaborative learning and problem solving.

18

Socio-Economics and a New Scientific Paradigm

Rogers Hollingsworth | Karl H. Müller |
Ellen J. Hollingsworth | David M. Gear



18.1 Introduction

For several hundred years, the dominant framework shaping Western science has been the Descartes-Newtonian paradigm. This framework was powerful in shaping the thinking not only of natural scientists but also of social scientists. An alternative view of explaining reality has slowly been emerging, and the influence of this new perspective has rapidly accelerated in recent decades. In the following discussion, we focus on these two scientific paradigms, especially the more recent one and suggest that it has considerable potential for enriching the field of socio-economics and for assisting socio-economists in understanding the connections between their research endeavors and those in other fields of the social and natural sciences.

The current status of socio-economics can be crudely summarized as follows: socio-economics has been quite strong in empirical and comparative analyses and in its relentless criticism of the neoclassical paradigm. However, socio-economics has remained relatively weak in developing a comprehensive theoretical alternative to the dominant neo-classical framework. A major exception was the effort some years ago by Amitai Etzioni [1988] when he provided some of the building blocks for the ethical and moral bases for a socio-economics research program. In our view, socio-economics would benefit from theory and model frameworks that are strictly independent from neo-classical rationality assumptions and, thus, situated far from neo-classical equilibrium. We suggest that the emerging alternative paradigm heightens the potential for such developments.

Despite the theoretical weaknesses and the strong commitment to interdisciplinarity in the socio-economic agenda, learning from other disciplines has remained as difficult for socio-economics as it has been for most other scientific fields. Learning from other disciplines, aside from being intrinsically difficult even in a hybrid field like socio-economics, confronts two different types of errors. Using a terminology from statistical test-theory, learning from other disciplines can produce α-type errors by accepting analogies, methods or models from other disciplines which turn out to be highly questionable and generate no cognitive value, let alone surplus value. On the other hand, learning from other disciplines may also generate β-type errors by rejecting highly appropriate and very fruitful analogies, models or methods from fields outside one's own domains. Socio-economics, like most other scientific disciplines, very seldom commits α-type errors, but like most other scientific fields, has a high propensity for β-type errors. One principal reason for this error distribution is the outdated mapping of scientific fields and the overall scientific landscape. A new form of mapping is needed, and we suggest a fundamental transition for the entire scientific knowledge base, a transformation which is already well under way.

We suggest that by searching across a new emerging scientific landscape, socio-economics may find the much needed theoretical alternative to neoclassical reasoning which so far has remained under a veil of interdisciplinary obscurity. Using perspectives and concepts developed by the natural sciences during the past half-century, socio-economists can uncover new models and theoretical components with which to engage in theory construction independent of the classical Descartian-Newtonian paradigm. As well, socio-economists have the potential to assist in advancing the theoretical insights of their natural science colleagues. Thus, we are at a moment in the history of modern science when there is the potential for more serious interaction among social and natural scientists.

18.2 The Transition from Science I to Science II

This paper focuses on the fundamental re-organization and re-configuration of scientific knowledge which is rapidly occurring. Building on insights by Nicholas Rescher [1978], we now realize that by the 1950s there had emerged a new phase in the structure and organization of scientific knowledge, a phase with the potential for dramatically altering interdisciplinary learning across both the natural and social sciences.

For several hundred years, much of western science has been influenced by a fundamental distinction, a leading metaphor and a dominant paradigm. The core paradigm was described at considerable length in Thomas S. Kuhn's *Structure of Scientific Revolutions* and was based on the *Principia Mathematica*, published in 1687 by Isaac Newton. The fundamental distinction and leading metaphor for the Newtonian paradigm had already been proposed by René Descartes. In his *Meditationes de Prima Philosophia*, Descartes constituted two ontological kingdoms, one under the heading of *res extensa* for the natural world and, accordingly, for the natural sciences and the other one for mental substances (*res cogitans*). This kind of Descartian dualism paved the way for separating science into two fundamentally different cultures, operating on two sets of principles, criteria and goals. With the rapid differentiation of scientific disciplines during the nineteenth century, philosophers and scientists such as Wilhelm Dilthey [1881], Max Weber [1905] and later, C.P. Snow [1959] addressed the issues of high cognitive distances and gaps between the natural universe and the mental or social universe and their corresponding scientific matrices.

For Descartes, the dominant metaphor for the natural world became that of a machine as put forth in Part IV of his *Discourse on Method*. While his metaphor was originally presented as a way of understanding living things, over time it has been generalized to be a view about the entire world. Descartes' metaphor has been interpreted not only as a description of how the world operates but as a prescription for how to study the world. Adopting his mechanistic view, we have all too often adopted an overly simplified view of the world, of the relation of parts to wholes, and of causes to effects, and the scholarly community has sometimes developed strategies for manipulating and predicting world events [Lewontin, 2000:3–4, 71–73]. Borrowing the machine metaphor, scholars have extended the metaphor to that of an engineer, a watch-maker or a designer.

Turning more specifically to the cognitive organization of the Newton-Descartes paradigm—to the period we term Science I—its characteristic features can be captured by a hierarchy of levels both in the scientific domains and in the socio-natural universe [see Table 18.1]. The leading epistemological vision within the Science I paradigm lies in its heavy emphasis on reductionism. For example, societies are built up from individuals, individuals from cells and their neural organization, cells from molecules, molecules from atoms and atoms from a small set of elementary particles. The key to understanding reality is to comprehend the parts of a system, and how they operate together. Finally, the dominant theory formation in the Newton-Descartes paradigm lies in the identification of universal laws and the clustering of universal laws.

Such a mentality suggests that we can understand the interactions among variables and that only a relatively few variables need be manipulated in order to change nature or a society's history. There is a widely shared view that we can easily design new institutions; even transfer them or various practices from one society to another. Practitioners talk about genetic engineering; policy makers draw up five-year plans for altering national economies or plans for nation and state building of entire societies [Hollingsworth, 2006].

Even though the visions are often grand, the mentality is that of the engineer with an emphasis on efficiency and redundancy: design projects as simply as possible and keep interactions among the necessary parts to a minimum. When the engineering mentality shapes policy or designs projects, logic is expected to prevail, but for failsafe purposes, designers usually include in their plans some redundancy (*i.e.*, the performance of the same function by similar elements). Whether the project is built from the ground up or whether there is a great deal of bricolage or incrementalism, the mentality of the design is to keep the components or plan as uncomplicated as possible. In very complex and sophisticated projects, there is some feedback modeling or other elements from control theory, but at all stages of the design, irrelevancy is to be avoided. Each part is designed to complement the next part.

TABLE 18.1 **Differences in the Paradigms of Science I and Science II**

	Science I	**Science II**
Dominant Paradigm	Classical Physics	Evolutionary Biology and the Science of Complexity
Theoretical Goal	General, Universal Laws	Pattern Formation and Pattern Recognition
Theory Structures	Axiomatic, Reductionist	Phenomena Nested in Multiple Levels of Reality Simultaneously
Forecasting Capacities or Ability to Make Predictions	High	Low
Complexity	Low	High
Ontology	Dualism (*res extensa/res cogitans*)	Monism
Leading Metaphors	Clocks	Complex Networks, Living Cells, Clouds
Cognitive Distances between the Social Science and the Natural Sciences	High	Medium
Inspirational Scientists	René Descartes, Isaac Newton, Adam Smith	Charles Darwin, John von Neumann, Ilya Prigogine

Contrary to the Cartesian design, a massive re-configuration has been slowly emerging for approximately 150 years, starting with the Darwinian Revolution in the middle of the nineteenth century, accelerating from the 1950s onward toward a new science regime here labeled Science II. In Science II, a broad range of trans-disciplinary foundations have led to a fundamentally new scientific paradigm with a complex configurative structure. Science II is not grounded on engineering and clockwork metaphors but is primarily concerned with an effort to comprehend both the natural and the social world in terms of evolution, complexity, self-organization, population dynamics, innovations, etc. Whereas a view of the world shaped by the influence of Newton and Descartes is comparatively tidy and predictable, the new configuration emphasizes the complexity and unpredictability of the world, open to many more possibilities than were previously realized [Kauffman, 1992].

The new perspective became increasingly widespread after physicists and computer scientists began to demonstrate in the 1960s and 1970s that even simple equations can produce surprising results which are essentially unpredictable. Advances in genetics and neurosciences have also led to different conceptions of science which increasingly emphasize the important role of chance and unpredictability in explaining events [Edelman, 1987, 1988]. Moreover, the cherished notions of general laws or axioms have been recast within the Science II world by notions like pattern formation and/or pattern recognition [Barabási, 2002]. Over the past two decades, specialists in discipline after discipline have increasingly recognized that the world is far more complex than experts had hitherto recognized. In the words of the economist Brian Arthur, more and more scientists realize "that logic and philosophy are messy, that language is messy, that chemical kinetics is messy, that physics is messy and finally that the economy is messy" [quoted in Waldrop, 1992:329; for similar views, see Lewin, 1993]. The new scientific paradigm so rapidly diffusing across academic disciplines suggests that the world does not change in predictable ways [Sornette, 2000; Mayr, 1991]. Systems have an inherently nonlinear dynamic quality to them. The games in which actors are engaged are ever changing, and even in the same game, the rules keep evolving. In short, there is an enormous amount of chance in shaping the world [see the papers by a group of mathematical economists who analyze economies as evolving complex systems: Arthur, Durlauf, and Lane, 1997]. There is a great deal of coevolution in the world, in which very small changes can have major long-term consequences. Science II analysts often engage in case studies over long periods of time and report a great deal of contingency and chance in explaining outputs.

Three scientists whose work very much inspired and embodied the Science II paradigm were Charles Darwin, the nineteenth century evolutionist; John von Neumann, mathematician, game theorist, physicist and meteorologist of the first half of the twentieth century; and Ilya Prigogine, a physicist and Nobel laureate during the later part of the twentieth century. Unlike the emphasis on static equilibrium and universal laws in the Descartes-Newtonian paradigm, Darwin, von Neumann, and Prigogine emphasized the importance of dynamic analysis, the uniqueness of historical events, the irreversibility of social and natural processes, and the difficulty of making successful predictions in complex systems. All three understood the importance of retrospective (*e.g.*, historical) analysis in order to understand reality [Prigogine and Stengers, 1984, 1997; Nicolis and Prigogine, 1989; Macrae, 1992]. In the Science II paradigm, scientists search for regularities within systems, but unlike neo-classical analysts they view systems as tending to move far from equilibrium. Because a system is always changing, the system at some point evolves into what appears to be a new system. Even when transitions occur incrementally, they must be understood with retrospective analysis. Science II rejects the idea that reality can be explained with determinism, linearity, and certainty. Darwin and Prigogine's methodological and theoretical frameworks argued that historical analysis was central to scientific understanding [Prigogine and Stengers, 1984; Wallerstein, 2004, Chapters Three and Four]. Some of the implications derived from von Neumann's work have advanced the theory of complexity: the idea that systems with a large number of interacting parts are open to their environment and have self-organizing internal structures [Waldrop, 1992; Macrae, 1992; Sornette, 2000]. Von Neumann's work has had enormous impact not only on the field of socio-economics but also in biology, geology, meteorology, and computer science. A central tenet of much of complex systems analysis is the understanding that large-scale collective behaviors result from repeated nonlinear interactions among constituent parts, whereby wholes tend to be much more than the sum of their parts [Bunge, 2003]. Increasingly analysts maintain that most complex systems are not susceptible to mathematical analysis. In the science of mathematical algorithmic complexity, complex systems must be understood by letting them evolve—either in time or with simulation analysis [Newman, Barabási, and Watts, 2006]. In short, the evolution of complex systems is inherently unpredictable [Sornette, 2003:15–17; Chaitin, 1987; Pines, 1986; von Neumann, 1966, Mayr, 1991].

Numerous Science II analysts have observed that in many systems some of the same functions are performed by similar structures (a world with potentially a great deal of redundancy). Others point out that many systems are characterized by degeneracy—situations in which elements which are structurally different lead to the same output. In short, fundamentally different structures often have similar consequences [Edelman and Gally, 2001; Tononi, Sporns, and Edelman, 1999]. More and more socio-economists are recognizing that at different moments in the same society, the same type structure can be associated with a different output or performance, and on the other hand that across societies, different structures are associated with the same output or performance. Interesting examples in recent socio-economic analysis pertain to the German and American economies which had relatively stable but different structures over the last twenty-five years. In some decades, one set of structures had much better performance than the other, but over time the performance situation reversed, suggesting how the same performance can stem from different structures [Crouch, 2005; O'Sullivan, 2005].

With respect to the cognitive organization of the new science regime, some of its typical aspects are identified in Table 18.1 which stresses in an ideal-typical manner basic or major differences between the two scientific paradigms. Unlike Science I, one finds in Science II a nested structure of science which is no longer hierarchical or reductionist. Rather, one is confronted epistemologically with a search for common trans-disciplinary patterns across scientific arenas. In this sense, the grand epistemological vision has turned to complex trans-disciplinary pattern construction. In short, the effort to engage in theory construction lies not only in the construction of patterns but also in much weaker requirements for scientific explanations than was the case with the Descartes-Newtonian paradigm.

Socio-Economics in the Framework of Science II

One of our arguments is that in recent decades the potential for major theoretical advance in socio-economics has increased dramatically. This has occurred for several reasons. First, unlike the situation with Science I, the cognitive distance between the dominant paradigm and socio-economics is now quite modest, suggesting that socio-economists have the potential to contribute to and borrow from theoretical insights and models developed in a large variety of other fields. While socio-economics has not been highly successful in the area of theory construction, it has considerable potential to adapt to the rapidly developing new methods, models, tools, and other building blocks necessary for the explanatory side of pattern recognition and pattern formation. Second, the stock of available models and mechanisms within the Science II paradigm is characterized by a steep increase in complexity and is focused predominantly on process dynamics and evolutionary perspectives which are quite compatible with socio-economists' interests in societal change and long term trends. Third, the interaction and communication among analysts in various fields of science is rapidly increasing due to the emergence of commonly shared information and communication technologies. Thus, in attempting to advance a theoretical research agenda for socio-economics, we should be cognizant not only of the desirability, but of the necessity of using the new potential for cooperation and interfaces available across the Science II landscape. In our view, the following paths offer considerable potential for socio-economists to engage in theory-construction of an inter- or trans-disciplinary nature. There are also many other new developments which we do not discuss for reasons of space. Exchange between natural science and social sciences could be much richer if they increasingly recognize that they are working on common problems.

Trans-Disciplinary Participation

Within the field of socio-economics, we should reflect on whether the range of our current interdisciplinary ambitions and targets is broad enough. Might we enhance our insights for a richer research program if we broadened our inter-disciplinary perspectives and attempted to understand how certain key issues like the integration of micro-meso-macro levels of analysis, binding theory, complementarity, and self-organization processes have been used by scientists in fields outside the broad domains of the social sciences? In our own scholarship, we are struck by the degree to which scientists in many fields—not just socio-economics—are wrestling with similar problems, a theme discussed at some length below.

Historically, a field such as socio-economics has reflected the fundamental tensions inherent in advancing modern science. On the one hand, increasing specialization and depth have developed as scientists have learned more and more about the world. Numerous new fields have emerged over the past 120 years. Indeed, there are several thousand disciplines, special fields, and sub-specialties. But at the same time that there has been increasing specialization, the borders among many specialties have been blurring. We have a need for greater depth about specific problems but we also need breadth which encompasses problems common to many fields. Of course, there is always the potential problem of premature hybridization of fields [Bunge, 2003, Chapter 17]. A successful marriage of different fields requires a modicum of maturity of various fields. However, whether fields are hybridizing, marrying, integrating, or co-merging is irrelevant to whether they can learn from recognizing that they are encountering similar problems. Insofar as they are addressing common problems, we believe they will benefit by mutual interactions.

Common Metaphors

As we interact with natural scientists about our research agenda for socio-economic theory building, we have an enhanced realization that many major advances in knowledge have historically occurred by individuals thinking metaphorically. We offer three recent examples, but we could easily suggest many more. In 1999, Günter Blobel was awarded the Nobel Prize in Physiology or Medicine for his work in cell biology which was built metaphorically on the idea of a postal system within human cells which sends and receives messages. In 2003, Peter Agre and Roderick MacKinnon received the Nobel Prize in Chemistry for demonstrating how materials are transferred across cell membranes by structures which resemble the architecture of water channels. And a few years earlier, John Walker in Cambridge (U.K.) received the Nobel Prize in Chemistry for demonstrating how movement within cells resembles the transport system in a modern economy. We are optimistic that if we strive to think in common metaphors and attempt to borrow insights from our colleagues, we are likely to have richer perspectives. But even though metaphorical thinking is an important tool in theory construction, we must always be conscious that "metaphors are never complete, precise, or literal mappings" [Hodgson, 1999:68]. Common metaphors like self-organization, self-assembly, emergence, order from chaos, life at the edge of chaos, path-dependency, bifurcations, punctuated equilibrium and many others are useful as tools for developing new insights. They can be a key vehicle by which ideas and models from one scientific discipline may be transferred to another. After a metaphor provides a new insight, we must then engage in rigorous and deep thinking in order to refine our new perspective [Brown, 2003; Mayntz, 1992; Maasen and Weingart, 2000]. In short, by engaging in metaphorical thinking and by attempting to understand how natural scientists have used concepts like self-organization or complementarity, we enhance our potential to apply these concepts to comprehend the social world [Amable, 2000].

Shared Methods and Models

We should be aware of a rising number of trans-disciplinary methods and models within the new knowledge base. It is important to note that the transfers of models and methods within the new perspective are not restricted to a one-way flow from biology or physics to socio-economic domains. As well, there are flows from the social sciences to natural science. The ideas of *The Theory of Games and Economic Behavior* by John von Neumann and Oskar Morgenstern [1944], originally conceived as a radical revolution for economic theory, rapidly diffused into the biological and other sciences [Lewontin, 1961; Burns and Gomolinska, 2000]. Mitman [1992] brilliantly demonstrated how entomologists borrowed models from social scientists who studied social cooperation and associations in order to understand the social behavior of insects. In recent decades, various complex models and/or methods have moved from their original domain to a wide spectrum of disciplinary fields both in the natural and the social sciences. Examples abound. For instance, Gerald Cory and others are working to integrate evolutionary neuroscience with social exchange and economics, trying to understand human sociality from the standpoint of physiology [Cory, 2003, 2006; Levine, 2006; Wilson, 2006; Lynne, 2006]. Entire new institutes and research programs have emerged which focus on problems of common interest to both natural and social scientists. One of the most visible organizations has been the Santa Fe Institute in New Mexico, involving some of the world's most prominent physicists, biologists, sociologists, economists, and anthropologists [Waldrop, 1992].

18.3 Examples of Socio-Economists and Natural Scientists Working on Common Problems

Scientists in different fields increasingly use common models, methods, and metaphors and they work on similar kinds of substantive problems. As researchers become more cognizant that they are working on similar types of problems, they enhance their potential for mutual learning. For illustrative purposes, we briefly discuss four general types of issues in which socio-economists are working with or parallel to their colleagues in other fields. These are (1) multi-level analysis, (2) the general binding problem, (3) the structure and dynamics of networks, and (4) power-law distributions.

1) Multi-Level Analysis

In most every field of science, one of the major concerns in recent decades has been to overcome the tendency to engage in micro-reductionism. From the seventeenth century to recent decades, micro-reductionism was the dominant scientific strategy for understanding reality. If reality resembled a machine, it followed that in order to understand the machine it made good sense to deconstruct it into its component parts. For such reductionists, reality was to be understood only at the level of parts—*e.g.*, protons, electrons, atoms, molecules in the natural sciences or individuals or collectives in the social sciences. In the social sciences, extreme micro-reductionism has often been characterized as methodological individualism [Hodgson, 1999].

However, wise investigators are reductionists only to obtain points of entry to complex systems. They are very much aware that parts or individuals are embedded in complex environments. As scientists in more recent years have become more sophisticated, they have engaged in a great deal of thought about causes and effects across different levels. Hence, in biology, a scientist may be a specialist in molecular biology but, at the same time, concerned with phenomena from subatomic particles to atoms as well as phenomena above the molecular level such as cell biology, systems biology, whole-organism biology, population biology, and even the global environment. Physical scientists also work at multiple levels, but many of the levels at which they work are different from those of interest to the biologist. But the logic of doing multi-level analysis and of moving beyond extreme reductionism is similar in both. Although most scientists become specialists at one level of analysis, E. O. Wilson of Harvard and Nobel laureate Gerald Edelman are examples of how good scientists attempt to understand how phenomena at one level are constrained by or interact with phenomena at other levels [Wilson, 1998; Edelman, 1974, 1987].

Similarly, the social sciences in recent years have been increasingly involved in multi-level analysis. In social science, as in the natural sciences, there are various multi-level investigations, some of which are illustrated in Table 18.2. The table presents two different approaches by social scientists using multi-level analysis—one pertains to spatial arrangements within political systems and the other encompasses both individuals and structures within entire social systems [see Table 18.2].

Most scientists, whether social scientists or natural scientists, center their research on only one level; very few systematically conduct research at multiple levels [for an exception, see Burns and Flam, 1987]. However, scholars working on one level have better opportunities for rich scholarship if they are sensitive to and communicate with scientists who work at other levels. In one sense, all levels are interacting with one another, and thus, there are clear benefits of relating one's specialized research to a larger system. In some respects, this is one of the goals of the field of socio-economics. For various examples in the field of socio-economics, see Boyer and Hollingsworth [1997] and Hollingsworth [1998].

2) General Binding Problem

One of the most common issues confronting scientists in many fields is what is known as "The General Binding Problem." The general binding problem is concerned with why different types of phenomena are attracted to each other, how strongly and for what duration they are attracted, and what consequences ensue. Over the decades, both natural and social scientists have addressed this problem.

In the field of socio-economics the general binding problem has been raised in recent years in the guise of complementarity. Colin Crouch, former President of the Society for the Advancement of Socio-Economics observed that recent socio-economists and natural scientists were wrestling with the general binding problem when he pointed out that a good bit of the literature on economic governance encompasses some of the same reasoning in which chemists and biologists have engaged when they have used the concept "complementarity" [Crouch, 2004; Crouch *et al.*, 2005]. Implicit—if not quite explicit—in Crouch's analysis was the view that socio-economists and natural scientists had shared views of complementarity, seeing it as an expression of the general binding problem. In Crouch's discussion, complementarity exists when two or more dissimilar actors/agents (*e.g.*, firms, institutions, macromolecules, etc.) are parts of a relationship due to underlying logic or rules, non-random in nature. This type of relationship exists in a configuration constantly threatened by instability because of both endogenous and exogenous forces. There is varying strength of the constituent parts of the configuration, and among the constituent parts, there is often mutual compensation for deficiencies: where one is weak, the other may be strong. Two key theoretical problems with this approach have been understanding what keeps the constituent parts of the configuration together, and how and why they come into being in the first place.

TABLE 18.2 **Examples of Multi-Level Analysis***

	Natural Sciences		**Social Sciences**	
	Physical Science	*Biological Science*	*Spatial Analysis*	*Structural Analysis*
	Cosmos, Galaxies, Stars	Environment	Global	Rules, Norms, Habits, Conventions, etc. (Institutions)
Feedback (↕)	Earth	Organisms	Transnational Regions (*e.g.*, European Union)	Institutional Arrangements (Markets, Hierarchies, States, etc.) and Institutional Sectors (Financial, Educational, Business, Research Systems, etc.)
	Subsystems of Earth	Tissues	Nation State	Organizations, Firms
	Molecules	Cells	Subnational Region	Small Groups, Families
	Atoms	Molecules	Local Level	Individuals
	Particles	Atoms		

*) It is assumed conceptually that each level influences all levels below it, and that there is feedback among all levels.

The individual from whom some theorists on socio-economic governance [Hollingsworth and Boyer, 1997] have derived considerable insight and inspiration has been the Caltech chemist and Nobel laureate Linus Pauling—certainly the most creative scientist to emerge in the U.S. and probably the most important chemist of the twentieth century. Just as some theorists of economic governance have long been interested in the logic by which a particular type of market coheres to or is associated with a particular type of state, associative system, etc., Pauling throughout much of his career addressed a comparable problem, trying to understand the logic with which atoms of particular molecules would bond to each other, why the bonding of particular molecules was either loosely or tightly coupled, and with what consequences. To repeat, some socio-economists and Pauling have been addressing the same theoretical kind of problem: Why are different phenomena attracted to each other, how strong and for what duration is the attraction, and with what consequences?

Perhaps Pauling's most significant contribution to chemistry was his theory of chemical bonds and complementarity. His approach to how bonding is expressed in terms of complementarity was first introduced into the chemistry literature in 1940 in a very significant paper which he co-authored with a young German physicist, Max Delbrück (later also a Caltech professor and recipient of a Nobel Prize for work in biology). Pauling and Delbrück wrote that "in order to achieve maximum stability, two molecules must have complementary surfaces, like die and coin" [Pauling and Delbrück, 1940]. The idea that atoms from dissimilar molecules would be attracted to each other became a key component of bonding and complementarity in modern chemistry and biology. Later, Delbrück became a mentor to James D. Watson, and it was the logic embedded in the Pauling-Delbrück 1940 paper about bonding and complementarity which provided the key insight for Crick and Watson to solve the structure of DNA. For Crick and Watson, understanding the bonding of differing base pairs was the key to solving the structure of DNA and of bringing about a revolution in biology [Watson, 1968; Crick, 1988].

For chemists, biologists, and many social scientists, bonding and complementarity among phenomena do not allow for similarity or identical properties. Historically, complementarity as used by scholars in most fields does not address phenomena having similarities. Bonding and complementarity theory generally involve interconnectivity of fundamentally different components. Throughout the twentieth century a critical puzzle for many scholars has been how mutually exclusive and dissimilar phenomena are attracted to each other. Indeed, the history of several academic fields could be written around the effort to solve this kind of puzzle. Certainly an important research project would be to understand for varying fields of science why phenomena with differences as well as similarities are attracted to each other.

One example of binding among mutually exclusive elements is found in the history of twentieth century immunology. In this field, scientists long suggested that antigens and antibodies were attracted to each other like a lock and a key. Indeed, it was in the antigen-antibody reactions that complementarity often received the most attention in twentieth century biology. Biologists long argued that an antigen and antibody were attracted to each other because there was a "complementarity" in the way that their shapes fit or complemented one another—in much the same way that a lock fits or complements the key for which it has been designed. The antigen in the metaphor was the lock and the antibody the key [Serafini, 1989:99–100; Hager, 1995:241–242].

At least four different Nobel Prizes across the twentieth century were awarded to scientists for addressing the problem of bonding and complementarity between antigens and antibodies [Paul Erlich in 1908, Macfarlane Burnet in 1960, Gerald Edelman in 1972, and Niels Jerne in 1984]. We have found Jerne's Nobel Prize winning work especially suggestive for socio-economists who address the problem of why particular governance structures are attracted to one another. Just as there is not a precise, one-to-one relationship between any particular type of state, market, or associative structure, so Jerne found that an antibody does not have to fit precisely to the antigen to have an "affinity." In short, "a key doesn't have to fit 100 percent to open a lock." The same key can fit multiple locks. [Söderqvist, 2003:177; Jerne, 1993]. Similarly only particular kinds of state structures are attracted to particular kinds of markets. In nature, there are no perfect fits between antigen and antibodies; in the social sciences we find that there is no perfect fit among different governance structures. But is there some underlying logic by which different governance structures are attracted to each other, or is the process by which governance structures fit together in particular societies only random and by chance?

The work of various scholars studying the socio-economics of capitalism includes analyses of why different institutional arrangements (*e.g.*, forms of governance) bond to each other [Amable, 2000; Boyer, 1990; Hollingsworth and Boyer, 1997; Hollingsworth and Gear, 2004; Hollingsworth, Müller and Hollingsworth, 2002; Hollingsworth, Schmitter and Streeck, 1994; Nelson, 1993; Whitley, 1998].

This work argues that there are a number of modes of governance for coordinating relationships among various economic actors (markets, types of hierarchies, networks, associations, state structures, communities, and clans). In essence, their work represents a strong plea for the recognition of the many types of governance arrangements—in short, an acknowledgement of the complexity of the bonding problem in economic governance—primarily because there are many types of each of the seven different modes of governance. Though each of these seven governance modes has its own distinctive logic, none exists in a pure or ideal form. Each is to be found only in some kind of combination relationship with other modes of governance. In other words, each governance mode may be mutually exclusive from the other, but they exist in relationship with each other in often-unstable configurations.

There are, similarly, many kinds of markets. Boyer [1997] rather brilliantly demonstrated that there are many types of markets, and hereafter it should be obvious that it makes no sense for anyone to suggest that an economy is coordinated by a "pure market," the "free market," etc. A "pure market" may exist in a Platonic sense but nowhere in the real world [Burns, 1990]. Similarly, Hage and Alter [1997] developed a typology of various types of networks. And it is hardly necessary to argue that there are many kinds of states [Weiss, 1998; Katzenstein, 1985; Hall, 1986]. Because each type of governance may exist in combination with many other types, the possible combinations of governance structures is very large. Nevertheless, the number of possible combinations is much smaller than those which computational biologists are facing [Kitano, 2002; Hood, 2003]. Because the problems faced by scholars in both fields are quite similar, we should be very attentive to the biologists' strategies for addressing the issues with which we are wrestling.

In addition to the complications arising from large numbers of possible combinations of governance arrangements, there are several critical theoretical issues about the binding of different governance arrangements for which we presently have poor answers in the social science community.

1) What is the logic by which one type of governance is *attracted* to another or repelled? Is there a logic by which one kind of market ends up in a configuration with a particular type of state, a particular kind of association system, etc.?[1] (Certainly, no one would imagine that a Soviet type state would exist configuratively with the kind of market system which one found in many industrial sectors in the U.S. during the middle of the twentieth century.)
2) What is the logic by which governance configurations are *tightly coupled* or bonded in some societies, while elsewhere they are *loosely coupled*? This problem relates to why there is variation in the coherence of governance structures, both within and across societies—a theme prominently discussed in some of the varieties of capitalism literature as well as in the literature on governance of different sectors in the same country [Campbell, Hollingsworth, Lindberg, 1991; Herrigel, 1996].
3) What is the logic for understanding governance structures at different *levels* of the social world? Boyer and Hollingsworth [1997] have emphasized that one of the most complex issues facing the social sciences is to understand the complementarities of governance structures at each level of the social world, how each level interacts with each other, and with what consequences.[2]

Even though scientists in different fields work on common problems and can derive insights from one another, scientific explanations are essentially specific to the phenomenon to be explained. As Bunge observes "there are no all-encompassing explanations because there are no one-size-fits-all mechanisms" [Bunge, 2003:22]. However, there seem to be a few common processes which socio-economics

1 It is not as though this is a neglected research problem in the social sciences. Wolfgang Streeck's [1992] work on the associations of workers and business interests is certainly noteworthy in this respect. This is also an important theme in many of the essays in Streeck and Yamamura [2001].

2 In one respect, this problem is very similar to the multi-level world (atoms, molecules, cells, organisms, ecosystems) which biologists are addressing [Montalenti, 1974]. However, when one is engaged in multi-level analysis, there is the problem of how the different levels are bound to each other.

shares with a number of other fields of science. For example, bonds are strongest among different entities in smaller systems. Thus physicists and chemists have demonstrated that bonds are very strong when nuclear forces give rise to small systems, whereas the bonds holding super-molecules in biology are much weaker. Similarly, in the socio-economic world, in small societies which are relatively homogeneous in ethnicity, religion, and forms of identity, the bonds holding the society together are relatively strong. On the other hand, societies which are larger and have a great deal of ethnic, religious, and linguistic diversity, the bonds holding the constituent parts of the society together are much weaker [Hollingsworth, 1982; Hanneman and Hollingsworth, 1984].

Focusing on how the constituent parts of societies emerge together, some scholars have long been concerned with the processes of nation and state building [Hollingsworth, 1971; Grew, 1978; Hollingsworth, 1978]. Economists have long been concerned with the processes of mergers and acquisitions of firms [Williamson, 1975, 1981, 1985]. Moreover, some socio-economists have written stimulating studies about the conditions under which capitalists and workers organize [Schmitter and Streeck, 1981; Streeck, 1991; Streeck and Schmitter, 1985; Offe and Wiesenthal, 1980].

Theorizing about how bonds hold phenomena together is only one side of the coin. The binding problem also concerns the process by which things come apart, and this concern cuts across many disciplines. Thus, physicists and chemists have long been fascinated with the process by which solids break down. Chemists for decades have used chromatography to separate compounds into constituent parts. One of the leading areas of biological research is research on the mechanisms of aging and death—the process by which parts of cells become dysfunctional and lead to cell death. In the social sciences, scholars have long been fascinated with the breakdown of empires and states—*e.g.*, the downfall of the Roman Empire, the collapse of the Austro-Hungarian Empire and the Ottoman Empire, the downfall of the British Empire, the disintegration of the Soviet Union, the breakup of Yugoslavia [Kennedy, 1987; Beissinger, 2002]. In sum, the binding problem involves understanding what binds constituent parts together as well as why they come apart. In the final analysis we must understand the nature of the bonds that hold a system together [Bunge, 2003]. To understand why societies come together or break apart requires a multi-level form of analysis—micro, meso, or macro research strategies which attempt to explain how individuals and institutions relate to one another [Hollingsworth, Müller, Hollingsworth, 2002].

3) The Structure of Complex Networks

In recent years, one of the most common subjects which has drawn the attention of physicists, biologists, computer scientists, and social scientists has been the study of complex networks. Of course networks are not new. They have long existed and are pervasive throughout nature and society. What is distinctive about the recent work is that a new science of networks has emerged. Whereas most of the older work on networks was essentially descriptive and static, the new science of networks is highly theoretical—though its practitioners do conduct a great deal of empirical analysis. The new science of networks engages in dynamic analysis, tends to observe phenomena in a continuous state of change, and attempts to analyze networks as evolving structures. The scholarship on networks reports that most networks are not developed by designers or engineers but have been unplanned, very decentralized, self-organizing, and emerged over long periods of time. Whether in the newer or older type of network analysis, networks by definition are essentially a collection of things (phenomena) connected to each other in some fashion [Watts, 2003].

In contrast to traditional reductionists and some early students of networks, the current group of network analysts tend to think that nothing happens in isolation. We live in a small world in which everything is linked to everything else [Barabási, 2002; Watts, 2003]. Among proponents of the new science of networks, the structure of networks is the key to understanding much of the world around us [Barabási, 2002]. To outsiders observing the new science of networks, it often appears that the difference between things not in networks and phenomena which are parts of networks is very subtle.

Networks are analyzed as part of a system, and in this respect the analysis methodologically is quite anti-reductionist. As network analysts have studied how complex networks evolve, they tend to conclude that they are self-organizing—that is they are not steered or directed by some external system. As a system, they emerge from a disordered collection of interacting parts. Self-organizing systems are viewed as processes and structures acting together with their environments [Ashby, 1960].

Those who study complex networks describe two types: the aristocratic type and the egalitarian type. Both networks have many different nodes, but the aristocratic type network has a few nodes which are connected to many other nodes. This type of network is characteristic of the world's aviation system. Globally, there are a few major hubs—such as the airports of Chicago O'Hare, London Heathrow, Frankfurt International—with each having links with hundreds of smaller airports, but each smaller airport is linked to relatively few other airports. Similarly, in the contemporary global banking system, there are a few major banks in New York, London, Frankfurt, and Tokyo which are linked to many other banks, while throughout the world there are thousands of small banks with few links to other banks. Alternatively, there are egalitarian type networks in which each node has only a few links to other nodes, but none has numerous links to others. In our world of rapid communication across the globe, it is the aristocratic type network which has been of greatest interest to social scientists who are engaged in the new science of networks [Watts, 1999, 2003, 2004; Sornette, 2003]—but the al Qaeda type network is the more egalitarian type of network and is also attracting increasing attention.

Some of the foundation of the new science of networks in the social sciences was prepared some years ago by Robert Merton's famous paper on "The Matthew Effect in Science" [Merton, 1968], Herbert Simon's celebrated work "The Gibrat Principle," [Simon and Bonini, 1958], and Derek John de Solla Price's argument about cumulative advantage in science [Price, 1965]. Merton in his essay on the Matthew Effect quoted from the Gospel of Matthew in the New Testament "For unto every one that hath shall be given, and he shall have abundance; but from him that hath not shall be taken away even that which he hath." Merton's argument was that rewards in science go to those who already have rewards, and they continue to receive more and more, while those who are unrecognized—even if deserving—remain unrecognized. In short, Merton's analysis was a variant on that of Pareto [1896] some years earlier: the rich tend to get richer, generally at the expense of the poor. Herbert Simon [1955], a future Nobel laureate, demonstrated that business firms grow in a more or less random fashion but their probability of growing is proportional to their current size. At about the same time that Simon was publishing his work, Simon Kuznets received a Nobel Prize in economics for demonstrating a similar principle about the distribution of income within countries. Price, in a famous paper which laid the foundation for the study of networks in the citation of scientific papers, was one of the first to demonstrate that the pattern of citing scientific papers has a network type structure. He pointed out that papers receive citations in proportion to the number they already have. He labeled this process "cumulative advantage" [Price, 1963, 1965, 1976; Newman, Barabási, Watts, 2006:17–18].

As the new science of networks has emerged, there has been considerable emphasis on two underlying principles: that of growth and preferential attachment. The principle that the rich get richer is the underlying driving force behind the evolution of many complex networks. If one node has many more links than any other node, it is far more likely to continue growing new links with other nodes. Such networks simply continue to evolve. The older nodes have distinct advantage over more recently established nodes. For example, urban geographers have observed that there is a systematic rank ordering of cities whereby large cities are more likely to attract new arrivals than small cities, thus exacerbating their differences in size. As Watts observes [2003:109] "small differences in ability of even purely random fluctuations can get locked in and lead to very large inequalities over time."

One of the most interesting results of the new science of complex networks is the finding that two micro-rules (growth and preferential attachment) appear to be both necessary and sufficient to generate highly ordered macro-behaviors across a variety of heterogeneous domains. In addressing the issues of growth and preferential attachment, there was no intention in the work of Merton, Simon, and Price to deny the importance of historical specificity in explaining the original success of a scientist's discovery or paper or the merits of a particular firm. Rather the idea is that regardless of the specific reasons for initial success, the success is more likely to continue reaping even more rewards than the less successful. The rich have many ways of getting richer, some deserved and others not, but as far as the resulting statistical distribution is concerned, the significant thing that matters is that they continue to prosper relative to others in the network [Watts, 2003:110–111].

Networks, whether aristocratic or egalitarian, are subject to change due to internal and external conditions. Internal network mechanisms may become overloaded, as nodes cannot integrate and exchange new information. External conditions may so change the environment for the network that it is overwhelmed and previous patterns of growth and preferential attachment cease to be relevant. Some of these changes, especially in aristocratic, small-world, networks may be so extreme that they destroy the nodes with the most attached links, especially if they are tightly linked to each other. This, of course, would mean that the shape of the network would be profoundly changed. Egalitarian networks are less subject to such extreme fluctuation.

Aristocratic, small world networks are in a sense more vulnerable, in that at some times they may experience what are known as "tipping points," which have very widespread ramifications. These are the points at which the collective organization of phenomena change, at which the system is reshaped. All change does not lead to "tipping points;" rather, "tipping points" are critical states of change in part related to the node relationships and their distribution [Gladwell, 2000]. An example of how change might or might not lead to a "tipping point" could relate to the failure of a financial institution. If a single bank is linked to only a few other banks, perhaps because of its small capitalization or its rural location, its failure will not resound throughout the network. But the failure of a large financial institution, with many network links, can induce so much turbulence in an extensive financial system that a whole network could fail. The failure of a large financial institution could represent a "tipping point," destroying the whole system. It is with these insights that analysts in the new science of networks are able to explain "crashes" in stock markets going all the back to the "tulip mania" in the seventeenth century, even the crashes that happen on the Internet, the contagion effects with fads in fashion, book publishing, the media, the spread of disease [Sornette, 2003; Pastor-Satorras and Vespignani, 2001, 2004].

4) Power-Law Distributions

Scientists long believed that most observations in the social and natural world followed a bell-shaped curve, alternatively known as a Gaussian curve. Observations, which were random, were distributed in a bell shaped pattern.

FIGURE 18.1 **Examples of Normal and Power-Law Distributions**

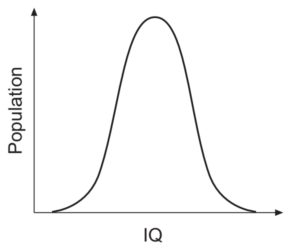


Figure 18.1.1
Normal Distribution

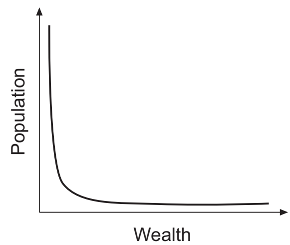


Figure 18.1.3
Power-Law Distribution

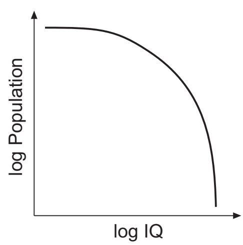


Figure 18.1.2
Normal Distribution on a log-log Plot

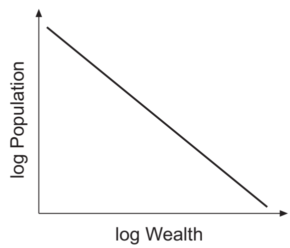


Figure 18.1.4
Power-Law Distribution on a log-log Plot

Most social scientists have long assumed that most things fall within a normal distribution. In a normal distribution, things have a well defined average. A bell shaped curve has a sharp peak, which rapidly tapers off on each side [see Figure 18.1.1]. This kind of curve is so widespread that scientists have often referred to it as a "normal distribution." Observations are assumed to be independent of each other. A common example of a bell shaped curve would be the distribution of the heights of males in a given population. If one measures the height of all adult males, one may arrange them in a histogram in terms of groups of four, five, six, or seven feet tall. Most males would be between five and six feet tall and there would be a peak value, with people scattered on either side of the peak. It is unimaginable that some might be ten or twenty times as tall. Clearly, many phenomena are best described with a bell shaped curve. Bell shaped distributions are so common that analysts in many social science fields do not even closely analyze their data in order to discern whether there might be "non-normal distributions." However, many analysts have long realized that distributions do not always follow a normal curve. Many distributions and patterns are non-linear, and there are many types of non-linear distributions. With the emergence of Science II, analysts across different disciplines began to observe that the characteristic distributions in self-organizing processes often have power-law distributions [Mandelbrot, 2004; Sornette 2000: 89ff]. Indeed, analysts in the new science of networks have discovered that power-law distributions are far more pervasive in the social and natural world than had previously been understood to be the case.

As we observe in Figure 18.1.3, power-law distributions do not have a peak at their average value. Rather, the distribution begins at its maximum value and then decreases all the way to zero. Moreover, power-law distributions are much steeper than the normal distribution, suggesting the likelihood of extreme cases in the upper value range of the variable in question as well as a clear asymmetry between a small number of high values and a large number of low values. Thus, in the examples in Figure 18.1.3, there are very few individuals with extreme wealth and only a few cities with very large populations, while most individuals have very little wealth and most urban areas are relatively small.

Analysts generally portray a power-law distribution similar to that provided in Figure 18.1.4. The key factor in a power-law distribution is a quantity generally referred to as an exponent which essentially describes how the distribution changes as a function of the underlying variable. A distinguishing feature of a power-law distribution is that when plotted on a double logarithmic scale, it appears as a straight line with a negative slope [see Figure 18.1.4]. This is very much in contrast to a normal distribution when plotted on a double logarithmic scale [Figure 18.1.2], which curves sharply downward with a "cutoff" value which is essentially zero. The power-law distribution has no such cutoff value [Watts, 2003:104–107; 2004:250].

Examples of power-law distributions are provided above—*e.g.*, the discussion of the "Pareto Law" whereby twenty percent of the population in capitalist societies tend to own eighty percent or more of the wealth. Similarly, urban geographers who study the rank ordering of cities point out that a few cities have very large populations, with eight to fifteen million inhabitants, while many others have only a few thousand. Again, this is a power-law-type distribution. Power-law distributions in networks, in contrast to, say, a normal or a Poisson distribution, are characterized by a small number of nodes with very many connections and a large number of nodes with few or no links.

Many disciplines in the natural and social sciences have discovered that there are vast amounts of reality in which things are distributed in a power-law distribution, and this has had a startling impact on the way that analysts in the new science of networks have begun to study phenomena. Network analysts have demonstrated that power-law distributions occur in many different kinds of phenomena other than distributions of city size, wealth, scientific citations, scientific rewards, but also in the severity of wars, the frequency of use of words in any human language, the number of papers scientists write, the number of hits on web pages, the sales of books and music recordings, cell metabolism, and a variety of other phenomena with phase transition in the natural world [Newman, Barabási, Watts, 2006; Sornette, 2000].

18.4 Concluding Observation

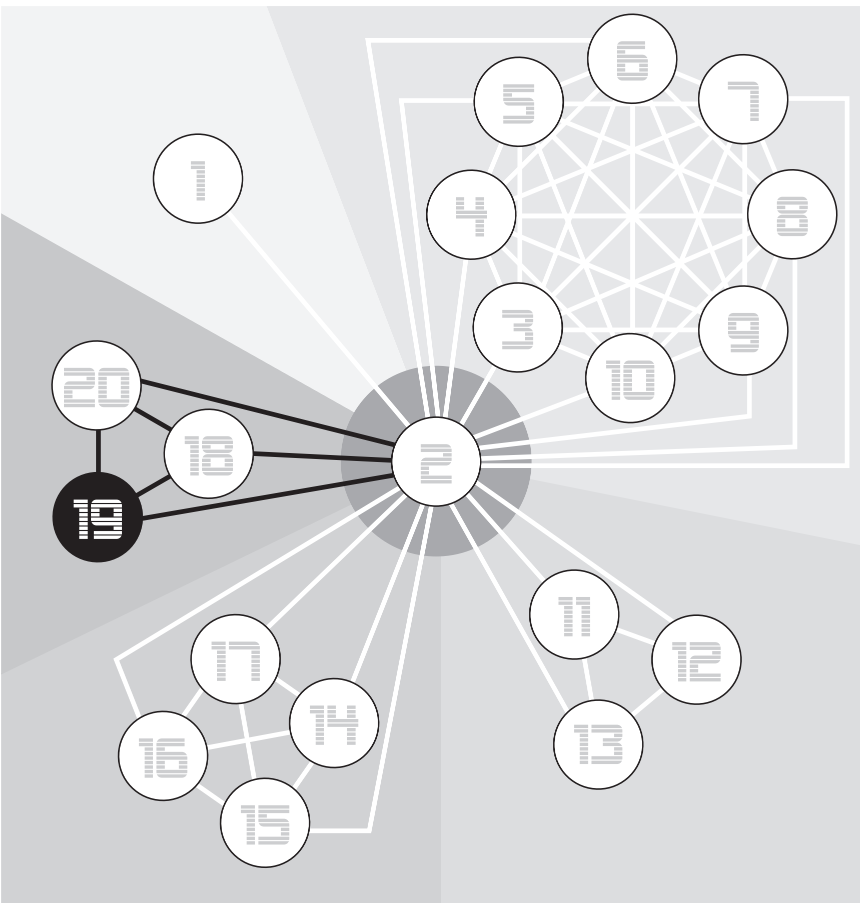
So far, our discussion of the search process in the new scientific knowledge base has brought to light several areas of research going on across many scientific domains, in particular common problems which have high relevance to socio-economics. We hope, returning to a terminology introduced at the beginning of this paper, that in the course of our explorations and searches no serious α-type error has been committed. Rather, we think that by introducing complex networks, their potential extensions as well as a specific socio-economic network agenda, we have helped to eliminate a potentially large β-type error. As we undertake active transfers of the ever-expanding stock of common problems, metaphors or methods and models used by natural and social scientists as part of our normal socio-economic research strategies, we should substantially advance our understanding of social reality. In this way we could contribute to diminishing the cultural divide between the natural sciences and the rest of the world which C.P. Snow and others have found so frustrating during the last half-century.[3]

3 C.P. Snow was a British physicist, novelist, and administrator who became a scientific advisor to the British government in World War II. He is well known for his book about science and literature, The Two Cultures and the Scientific Revolution [1959]. In it he argues that practitioners in each of the two fields know very little about the other and there is little communication among them. Over time, others have discussed how the increasing specialization within and between disciplines has posed serious problems in communication not only for the academic world but also for the development of effective and democratic governance [Hollingsworth, 1984].

19

Turning Science Transdisciplinary: Is it Possible for the New Concept of Cross-Disciplinary Cooperations to Enter Slovenian Science and Policy?

Franc Mali



19.1 Introduction

Transdisciplinarity is connected today with a new way of knowledge production that has transcended narrow disciplinary boundaries. It is also supposed that transdisciplinary research is more closely oriented with societal practices and applications. Indeed, the concept of transdisciplinarity in science and R&D policy has no long history. Nevertheless, it has recently become a crucial concept in science and policy discussions. The prestige of the term rests especially on the impression many scientists and policy decision-makers have that becoming transdisciplinary is 'the right thing to do.' The development of recent, post-academic science is characterized by a greater orientation towards transdisciplinarity in science. The whole philosophy underlying the European Research and Innovation Area emphasizes cross-disciplinary cooperation as well. It seems that the academic scientific community in Slovenia is not very strongly oriented to the new transdisciplinary discourse. There is also a lack of concrete policy action from the side of R&D policy makers to make a more radical shift from disciplinarity to transdisciplinarity.

In this article, I will primarily try to show certain obstacles that are preventing this paradigm shift. These obstacles will be observed on two levels: that internal to science, and that referring to R&D policy mechanisms. In the first part of the article, I will present the changing meaning of transdisciplinarity in science. Specifically, if the original meaning of transdisciplinarity, which was introduced in the 1970s and 1980s, connoted the presence of common axioms able to transcend narrow disciplinary worldviews through an overarching synthesis, the new concept of transdisciplinarity, which emerged in the first half of 1990s, has extended this meaning significantly. After showing this, I will call attention to the large, integrative potential of transdisciplinarity for modern scientific and technological development. Converging technologies represent a new phase in the development of transdisciplinarity in science. In the second part of my article, I will first explain some barriers that hinder the realization of the new transdisciplinarity in science and policy discourse in Slovenia. Then I will try to determine if the centers of excellence as new intermediary science organizations could play a role in shifting science and policy discourse from disciplinarity to transdisciplinarity.

19.2 Transdisciplinarity as a New Science and Policy Concept

The concept of transdisciplinarity was first introduced in 1970 by Eric Jantsch at the OECD conference in Nice, France. Jantch used the term "trans-disciplinarity" as the directed coordination of common disciplines and inter-disciplines in the complex scientific system based on a generalized axiomatic that is oriented to the common purpose [Jahn, 2008].

In Europe, the next important stage for the concept of transdisciplinarity was the scientific meeting at the "Bielefelder Zentrum für interdisziplinäre Forschung" at the end of 1970s. At this meeting of scientists and policy decision-makers, the links between the research practices of "disciplinarity," "interdisciplinarity" and "transdisciplinarity" were explained in great detail [Kocka, 1987]. Here, it should be added that the German philosopher and science theorist Jürgen Mittelstrass defined transdisciplinarity as a research practice that steps across disciplinary boundaries and addresses problems independently of disciplines [Mittelstrass, 1998:154].

The concept of transdisciplinarity expanded within science and science policy, especially in the 1990s. Tibor Braun and Andreas Schubert scientometrically analyzed the growth of the term in the titles of R&D policy papers covered by the Science Citation Index database during the 1980s and 1990s. The growth in this period was exponential with a doubling time of seven years [Braun and Schubert; 2003].

If the original meaning of transdisciplinarity, introduced by science theorists such as Peter Jantsch, Jürgen Mittelstrass and others, connoted common axioms that transcend the narrow scope of disciplinary worldviews through an overarching synthesis, the new concept of transdisciplinarity, which emerged in the first half of 1990s, is significantly more extensive. The new concept of transdisciplinarity has also put intersectoral links (not only interdisciplinary links) in the forefront. "The distinguishing feature of the new discourse has been the externality of complex problems and the participation of a wider range of stakeholders" [Klein, 2006:77]. In other words, the new concept of transdisciplinarity introduced various actors outside of science as an integral part of a new mode of knowledge production. Or, as Michael Guggenheim said, "The difference between disciplinary and transdisciplinary science is not the relevance of research results nor their applicability. The difference is that it is not only scientists who define research questions, theories and methods but also other stakeholders, who introduce other criteria for choosing methods and theories." [Guggenheim, 2006:412]

It seems that in the mid 1990s, the concept of 'Mode 2' knowledge production presented in the book *The New Production of Knowledge* [Gibbons *et al.*, 1994] became the symbolic banner for new viewpoints on transdisciplinarity.[1] The authors of *The New Production of Knowledge* [Mode 2] linked the classical concept of transdisciplinarity with two additional factors: problem-driven research and research in an applied context. According to them, both factors should contribute a new dimension to the concept of transdisciplinarity. "A transdisciplinary mode of research consists in continuous linking and relinking, in specific clustering and configuration of knowledge which is brought together on the temporary basis in a specific context of application. Thus, it is strongly oriented towards and driven by problem-solving" [Gibbons *et al.*, 1994:29].

After the introduction of the concept of transdisciplinarity within the frame of Mode 2, it has been possible to encounter a determined transdisciplinary research. All of them have emphasized certain categories, including complexity, uncertainty, tacit knowledge, etc.[2]

The category of integration has consistently played the central role. Matthias Bergmann and Engelbert Schramm explain,

> "Die Frage der Integration ist zentral für die Qualität trans-disziplinärer Forschung. Erst die Integration auf einer kognitiven, aber auch auf einer sozialen, kommunikativen, einer organisatorischen und möglicherweise auch auf einer technischen Ebene führt dazu, dass die transdisziplinäre Forschung gute Ergebnisse zu erzielen vermag" [Bergman and Schram, 2008:10].

Rogers Hollingsworth also says that science today is in the development phase, which requires the building of a common research core, consisting of shared theoretical frameworks plus a common stock of models and mechanisms that integrates a broad range of domains normally analyzed by different scientific disciplines [Hollingsworth, 2006]. For example, in an OECD study entitled *Interdisciplinarity in Science and Technology*, the category of integration is used to differentiate between three types of cross-disciplinary research:

1) multidisciplinary research is defined as research where the subject under study is approached from different angles using different perspectives, yet integration is not accomplished;
2) interdisciplinary research is defined as research leading to the creation of a theoretical, conceptual and methodological identity; more coherent and integrated results should thereby be obtained; and

1 The principle characteristics of the new production of knowledge (Mode 2) are not only the context of application, organizational heterogeneity, social accountability and new forms of quality control, but—first of all—transdisciplinarity.

2 For example, in his view of different definitions, Christian Pohl identified the following common characteristics for transdisciplinarity: it is problem-oriented, interdisciplinary, praxis-oriented, processual and participatory [Pohl, 2001].

3) transdisciplinary research is defined as research in which disciplines converge and where there is a mutual integration of disciplinary epistemologies [OECD, 1998].

In spite of the growing use and popularity of the term "transdisciplinarity" recently, there have been critical voices as well. The critics of transdisciplinarity are warning that there is still little known about how this new mode of research operates in practice. They say that the growing demand for cross-disciplinary links in science mostly reflect a nostalgia for an era when the unification of science appeared to be possible. For example, Dutch R&D policy analyst Arie Rip said that transdisciplinarity has become popular in recent times due to 'policy' reasons and not for 'epistemological' reasons [Rip, 2000]. The similar view has been expressed by German sociologist of science Peter Weingart. He said that transdisciplinarity is only some sort of normative template for a kind of politically correct science. For that reason, *"transdisziplinäre Vorhaben würden keine wirklich neuen Erkenntnisse produzieren"* [Weingart, 2001:341].

19.3 The Large Integrative Potential of Transdisciplinarity for Modern Scientific and Technological Development

In various discussions about transdisciplinarity in science, we still often encounter those who think that transdisciplinarity involves scientific work in which scientists of different backgrounds come together practically accidentally. Explaining transdisciplinarity in this way means accepting a meaning of transdisciplinarity that assumes weak forms of scientific integration. Such a 'soft' version of transdisciplinarity could be difficult for scientists and policy decision-makers who are committed to the Mode 2 research paradigm to accept. Only the 'hard' version of transdisciplinarity represents the tremendous integrative potential for recent scientific and technological progress. It seems that, in the future, basic scientific breakthroughs will depend more and more on the ability of researchers to cross disciplinary boundaries. Let us take the example of converging technologies.[3]

3 The first and most comprehensive presentation of the concept of converging technologies was given in the report entitled "Converging technologies for improving human performance: Nanotechnology, biotechnology, information technology and cognitive science" [Bainbridge and Roco, 2002]. The study was sponsored by the US National Science Foundation and the US Department of Commerce. As Steve Fuller [2008:12] notes, the original 2002 NSF report defines the phrase 'converging technologies.' Subsequently, a number of workshops and publications edited by William S. Bainbridge and Mihail C. Roco have advanced in the field of converging technologies.

Converging technologies (CTs) represent a new phase in the development of science and technology; they are the integration of nanotechnology, biotechnology, information and communication technology and the cognitive sciences. They are a (transdisciplinary) research field that is currently expanding rapidly. The notion of CTs could be described as a combination of scientific discoveries (genetics, nanoscience), techniques (informatics, gene splicing), and advances in allied tools (computing power, scanning tunneling microscopes, robotics) that greatly accelerates the basic science involved and the practical applications across a breathtaking range of subjects, from human health to materials science [Whitman 2006, Fisher *et al.*, 2006]. CTs represent a host of radically new possibilities that are opening up for modern societies. William Bainbridge and Michael Roco assert that the big difference between past and recent times concerning convergences in science and technology is the following: in the past, for many decades, small-scale convergences were taking place in science, while today, global convergences are radically changing the nature of science and technology. These changes have the greatest possible implications for the economy, society and culture at all levels: global, national, local. In fact, the recent processes of integration can be discerned in all fields of science.

In some circles of experts, the processes of the unification of science are practically praised in hyperbolic terms. Kurt Kurzweil is one of the most provocative advocates of the idea of singularity in science and in life. He assumes an evolutionary process in which the union of all entities of the world will arise. At this point of singularity, the knowledge and skills embedded in our brains will be combined with the vastly greater capacity, speed and knowledge-sharing ability of our own creations. Or, as he has said, "Just as a black hole in space dramatically alters the patterns of matter and energy accelerating toward its event horizon, the impending singularity in our future is increasingly transforming every institution and aspect of life" [Kurzweil, 2005:7].

It is also true that the European Union's experts who deal with the cognitive and social aspects of the new converging technologies are less optimistic [see, for example, Nordman *et al.*, 2004]. They warn that state-of-the-art research in some of the scientific fields included in converging technologies is quite distant from the research in some of the other fields. The gap is especially wide in the two human enhancement fields [Brain/Neuro and Physical Enhancement and in Synthetic Biology].

In spite of controversial assessments, we can say that we are living in the most exciting historical period of science, in which the various scientific fields are strongly interconnected and support each other. The cognitive and institutional convergences are radically changing the whole configuration of modern science and technology.

Sabine Maasen, Martin Lengwiler and Michael Guggenheim distinguish three types of contemporary institutional practices of transdisciplinary research [Maasen *et al.*, 2006]. According to these authors, the first type of institutional practice can be seen in the attempts of the university system to reform its disciplinary organization by strengthening ties with non-academic partners through means such as university-industry collaboration. The second type is visible in similar reforms in 'big science' research institutions. The third type of institutional practice of transdisciplinarity emerges from changes at the micro-organizational level of research projects, such as the growing internationalization of research projects. Unfortunately, in Slovenia—as I'll try to argue in the next chapters—there is no realization of any of the above-mentioned practices of transdisciplinary research.

19.4 Some Barriers that Hinder the Realization of the New Transdisciplinarity in Science and Policy Discourse in Slovenia

In spite of the periodic use of terms such as 'interdisciplinarity,' 'transdisciplinarity,' etc. in Slovenian R&D policy documents, there is a lack of concrete policy action to realize the new philosophy. The concept of transdisciplinarity has often been used in past R&D policy in Slovenia only as some sort of normative template in order to notify in a politically correct manner the acceptance of EU R&D guidelines (a declarative commitment to the ideas of the new European Research Area).[4]
To illustrate the gap between such declarations and practice in Slovenian R&D policy, it might be appropriate to refer to the situation in Western European countries in the beginning of 1960. As is mentioned by Arie Rip [2000], at that time the idea of 'big science' was very fashionable. It has been used to describe a form of scientific organization that did not correspond very closely with research practice.[5]

4 Especially after 2000, the new concept of transdisciplinarity that was invented in the context of the 'Mode 2' paradigm has often found its way into key EU R&D policy documents. For example, The Green Paper on the new European Research Area reconfirmed the importance of the free circulation of knowledge across Europe, as regards collaboration in the production of science and technology and in open access to scientific products, effective knowledge transfer between public research and industry as well as with the public at large [see, Green Paper, 2007].

5 The term 'big science' has been used by policy decision-makers, scientists, scientists of science to describe a series of changes in science that occurred in industrial nations in 1960s, when the production of scientific knowledge shifted from small group efforts to large-scale funded projects.

In Slovenia, various factors hinder the science and policy discourse in making a more radical shift to the new transdisciplinarity. I shall briefly present some of them.

1. The strong commitment of academic scientists to a disciplinary context.
Factors internal to the scientific community are often the most important hindrances to making a more radical paradigm shift. The prevalent academic culture inhibits researchers or research groups from withdrawing from the ivory tower of particular disciplines. There is not enough awareness among researchers that disciplinary boundaries are less and less relevant to the recent progress in science and technology. As has already been said, the modern concept of transdisciplinarity explicitly orients its production of knowledge not around narrow disciplinary definitions of problems but around other definitions, derived from the demands of customers and other societal stakeholders. These stakeholders can come from different social spheres: government agencies, private firms, NGOs or social movements.
A rather anachronistic understanding of the scientific autonomy still often prevails among scientists in Slovenia who work at academic institutions. Of course, after the political turn of early 1990, it was very important that the academic scientists looked to western models of scientific autonomy. But, there is an irony, which has been pointed out on occasion by American sociologist Henry Etzkowitz [1996]: academic scientists in all post-socialist Eastern and Central European countries [not only in Slovenia) have tried to replicate a concept of scientific autonomy whose base has already eroded in the West. Specifically, in the 1980s and 1990s in the West, demand increased for academic institutions (universities, public research institutes) to go beyond performing the traditional functions of cultural memory, education and research, and to contribute more directly to 'wealth creation.' It is also true that the traditional institutional organizational structures of the universities in Slovenia contribute to the narrow-mindedness of the academic staff and the lack of cross-disciplinary cooperation. It could be said: the world has problems, but universities have departments (even worse, sub-departments)! The research and teaching activities of the academic staff at Slovenian universities are too bound to the traditional department (disciplinary) organizational structures. This "ethnocentrism of academic disciplines" leads to an artificial compartmentalization and a separation of departments at the level of the faculties. Of course, there are also other reasons leading to this compartmentalization: more sophisticated concepts, theories and methods used in basic research [see for example: Hadorn *et al.*, 2008].
However, the recent progress of science and technology is no good if only the disciplinary specialists appearing in the role of supreme arbiter perform peer reviews, make decisions on how to allocate public money in science, etc. This

is because transdisciplinarity is a way of producing knowledge that cannot be fully controlled by disciplinary standards or by testing its functionality. As Mihael Guggenheim has said, “The switch to non-scientific mechanisms that ensure trans-disciplinary knowledge production involves a switch to procedural mechanisms… what is the stark contrast to the output-oriented mechanisms of only peer-review-based science” [Guggenheim, 2006:413]. To stay in the frame of narrow-minded thinking within disciplines does mean constantly risking splitting complex problems of reality into small disciplinary chunks.

2. The lack of R&D evaluation mechanisms needed to cross-disciplinary boundaries. Although the prevalent academic culture of the scientific community appears to be one of the most important barriers to realizing the new transdisciplinarity, the role of more organized R&D policy efforts cannot be ignored. It is impossible to expect that only spontaneous processes within the academic community will lead to the abolition of narrow-minded *Fachidiotismus* in science.

In spite of the self-organizing characteristics of modern science—if we use the terminology of modern social systems theory—R&D policy mechanisms imported from the outside are also important. In that sense, R&D policy decision-makers must also have some role in creating evaluation mechanisms. For example, the policy regulation of transdisciplinary research is strongly connected with the question of its quality control. Here, intermediary institutions operating in the area of national R&D policy can play very important roles. The intermediary institutions, such as research agencies or research councils, have relative autonomy from the state, which is especially important when negotiating between the interests of the different stakeholders involved in R&D policy issues. The new transdisciplinarity is precisely the type of knowledge production that cannot be controlled or steered only within the context of narrow science or governmental discourse, but it must also be assessed from outside the pure realm of science and politics, from a world in which social, economic, cultural, and other civic factors play important roles. Those who have analyzed R&D policy in developed countries have determined that these new types of intermediary organizations allow new interdependencies to be created and the role of the state (politics) with its specific steering models to become less dominant [see, for example, Braun, 1997; Maynetz *et al.*, 1998]. Making all decisions in research agencies (or research councils) ensures that external imperatives are integrated into the intellectual orientations at the level of actual research practice. To put it in other words, external demands and expectations are mediated in R&D activity.

In Slovenia, during the first phase of the political transition, intermediary R&D structures, such as research agencies, were not involved in decision-making. The Slovenian Agency for Scientific Research was not established before 2004.

The Technology Agency was also only formally established a few years ago, and because of the interference of political parties rotating through the positions of power over the last 19 years, it is still not fully operational.

It seems that because of its short period of operation, the Slovenian Agency for Scientific Research (in some sense, it is still in the early phase of its institutional development) has not entirely surmounted its initial deficiencies. One is a deficiency of developed mechanisms that can evaluate transdisciplinary research. Of course, since its founding, the Slovenian Agency for Scientific Research has introduced many innovative policy instruments to ensure the transparency of an R&D evaluation system. The use of modern information technologies and new approaches to collecting and processing output data provided grounds for the development of more transparent R&D evaluation systems. In that sense, the story of the R&D evaluation system at the Slovenian Agency for Scientific Research changed more radically after the use of COBISS and SICRIS as centralized and standardized bibliographical databases of research productivity in evaluation procedures, and after the inclusion of foreign experts in peer-review processes performed at the Slovenian Agency for Scientific Research.[6]

In any case, the gradual modernization and improvement of the R&D evaluation system at the Slovenian Agency for Scientific Research has certainly left important traces in the tendencies of scientists in Slovenia to be more research productive and to be oriented to an international arena. Notwithstanding, there is a lack of new approaches that can cope with the complexity of transdisciplinary research. Transdisciplinarity in science research needs to move beyond merely reliable disciplinary knowledge and towards more socially robust knowledge. Jakob Edler and Stefan Kuhlman [2008] speak of formative R&D evaluation procedures. In this type of evaluation

> "...angesichts der Notwendigkeit, heterogene Kontexte aufeinander zu beziehen, wird nicht mehr wichtig nur die Erfolgs- und Effeziensmessung—wie sie die klassische, summative Evaluation zum Ziel hat—sondern die Unterstützung aller beteiligten Akteure durch systematische Aktivitäten zur (Selbst)Reflexion und Adapation." [Edler and Kuhlman, 2008:204]

6 For example, in COBISS and SICRIS, all publications of all researchers are presented in a standardized manner. An extensive typology of publication documents is prescribed to classify scientific bibliographic items. For each bibliographic item by a scientist, a type (for example: original scientific article, review article, professional article, etc.) that is consistent with the established definition is determined [Seljak and Bosnjak, 2006]. In the evaluation procedures of Slovenian scientists, the following types of scientific publications are primarily considered: articles in international and domestic peer-reviewed research journals, monographs, (edited) books, or conference proceedings from abroad and at home. Other types of publications or reports ('grey literature'), usually written in a local language and not peer-reviewed, are less important.

Accordingly, the central elements of formative evaluation are self-learning processes and the participation of all stakeholders involved in R&D evaluation procedures. Jakob Edler and Stefan Kuhlman have determined the following characteristics of formative evaluation in science:

> "Evaluation wird als Verfahren der empirisch-analytisch aufbereiteten, strukturierten Präsentation und Konfrontation von (widerstreitenden) Akteurperspektiven konzipiert; dabei kann das gesamte Spektrum von Evaluationsmethoden zum Einsatz gebracht werden. Der Evaluator agiert als Facilitator, er unterstützt die Moderation der Auseinandersetzungen in Verhandlungssystemen. Der Evaluator agiert auch als Coach, indem er Komplexität greifbar macht und kontextübergreifende Dynamiken und Wechselwirkungen erläutert. Die Evaluation verläuft in der Regel begleitend, das heißt, dass die verschiedenen Funktionen des Evaluators im gesamten Interventionszyklus angewandt werden." [Edler and Kuhlman, 2008:215–16]

It seems that the R&D evaluation system in Slovenia is still too strongly bound to the traditional disciplinary setting. The small size of the scientific community in Slovenia makes things even worse. Slovenia is not only a very small country, but—if we use Thorsteinsdottir's term—it is even a "mini-country" [Thorsteinsdottir, 2000:434]. As has also often been noticed by other authors [see, for example, Schott, 1993], the small size of a country often negatively affects the R&D policy regulation. Thus, the small size of the scientific community does not necessarily lead to a high degree of transparency. On the contrary, with limited formal mechanisms for coordination, there is a risk that the whole system is poorly equipped to ensure more transparency and flexibility.

In Slovenia, external observers already determined in the mid-1990s that the R&D evaluation system is quite opaque [Phare, 1996]. They warned of the negative effects of 'scientific inbreeding,' of too much influence from day-to-day politics on bodies of evaluation experts and expert decision-makers, of the strong role of 'old-boy networks' in peer-review systems, etc. Today, many of these deficiencies have not been abolished. Some informal lobby groups in the scientific community still have tremendous influence on the R&D policy decision-making in Slovenia. And using the typology of Renate Mayntz, Uwe Stichwech and Peter Weingart [Mayntz *et al.*, 1998], these informal lobby groups are following a more "defensive conservative" than "offensive innovative" strategy to address the cross-disciplinary and cross-sectoral cooperation of scientists in Slovenia. These circumstances have certainly had many negative consequences for transdisciplinary research.

Can the Centers of Excellence Contribute Anything to the New Transdisciplinarity?

Could the research centers of excellence represent one of the new institutional forms in which scientific transdisciplinarity is more efficiently realized? Actually, the centers of excellence have emerged in Europe as new intermediary scientific structures.[7] They have been presented in the last 20 years in many different forms in various European countries. In the context of the new European Research Area strategy, centers of excellence are increasingly seen as an important mechanism for boosting cooperation between disciplines and also between sectors (academic science sector, business-enterprise sector, etc.). Centers of excellence receive support at many levels: the regional,[8] national and EU. They are normally funded by several partners, such as the industry, the state and the European Commission. Today, centers of excellence in Europe are increasingly organized along the following three lines: the concentration of R&D human resources, user orientation and cross-disciplinary links.

In Slovenia, centers of excellence did not emerge before 2004. After that they attracted more attention when Slovenia began to use financial means from the European Structural Fund (ESF). Until the establishment of the centers of excellence, the ESF has not been a major source of R&D financing in Slovenia. The centers of excellence in Slovenia mostly emerged as a consortium of partners from the academic scientific field and the business-enterprise sector that had complementary knowledge and skills and much previous experience with cooperation. In Slovenia, in the period from 2004 to 2008, nine research centers of excellence have been active: the center of excellence for biotechnology with pharmacy, for environmental technologies, for advanced metallic materials, for materials for next-generation electronics and other emerging technologies, for supercritical fluids, for the comprehensive management of the fragile natural and cultural landscape of the Slovenian Karst region, for information

7 In Europe, the first centers of excellence were designed on the basis of the United States National Science Foundation's (US NSF) Engineering Research Center program. The US NSF's Engineering Research Centers "discover new industry-relevant knowledge at the intersections of the traditional disciplines and transfer that knowledge to industry, while preparing a new generation of engineering leaders who are capable of leading in industry by engaging successfully in team-based, cross-disciplinary engineering to advance technology" [Parker 1997:46].

8 A typical case is Finland. In Finland, the creation of the centers of excellence at the regional level has been promoted through different governmental policy measures, including the European Structural Fund. Here, the relatively extensive network of universities and polytechnics across the whole country has enabled a more regional orientation of the centers of excellence. Notwithstanding, even in Finland these institutions are overly concentrated in a few of the larger urban areas [Miettinen, 2002].

and communication technologies, for nanosciences and nanotechnology, for functional genomics and biotechnology for health.

Did the centers of excellence in Slovenia, within the short period of their operation, contribute to a more transdisciplinary research culture?

On the grounds of our analysis,[9] it is possible to conclude that the newly established centers of excellence in Slovenia have had a positive role in the shift of R&D policy discourse towards inter- and transdisciplinary problem areas that are particularly important for the business-enterprise sector.

All activities at the centers of excellence have been strongly connected with problem-driven research. As has been already noted, this is an important source for transdisciplinarity in science.

Nevertheless, the centers of excellence in Slovenia are still far from triggering a more radical shift to a modern transdisciplinarity. Last but not least, there is a lack of cooperation between the centers. As mentioned above, recent science can progress if the scientific fields recognize their connections with each other. If in the past, small-scale convergences took place in science, then today, global convergences are radically changing the nature of science.

In that sense, it would be difficult to say that the centers of excellence in Slovenia have already progressed to a position of converging institutions. According to Ingrid Ott and Christian Papilloud [2007], converging institutions can be described as the kind of institution that maintains an open structure of communication and interaction as much as possible. They actively apply new emerging sciences as well as in dealing with the related public fears and risks that the new emerging sciences could drive.

A large deficiency in the functioning of centers of excellence in Slovenia in the period from 2004 to 2008 is also that quality control was too dominated by the state administration. Of course, the state is the key stakeholder that formally determines the legal and institutional framework for the functioning of such intermediary science structures. Notwithstanding, state control was quite static and inflexible. The centers of excellence spent much time and energy on administrative issues, such as preparing public calls to tender, selecting and negotiating with project applicants, signing contracts according to complicated procedures (particularly for projects with consortium agreements), and reporting and claiming funds through even more complex means. All of this resulted in a lack of time for addressing more content-based issues.

9 The content of annual, self-evaluation reports prepared by the centers of excellence were analyzed, and extensive interviews with leaders of the centers of excellence were conducted [see more: Mali and Jelnikar, 2008].

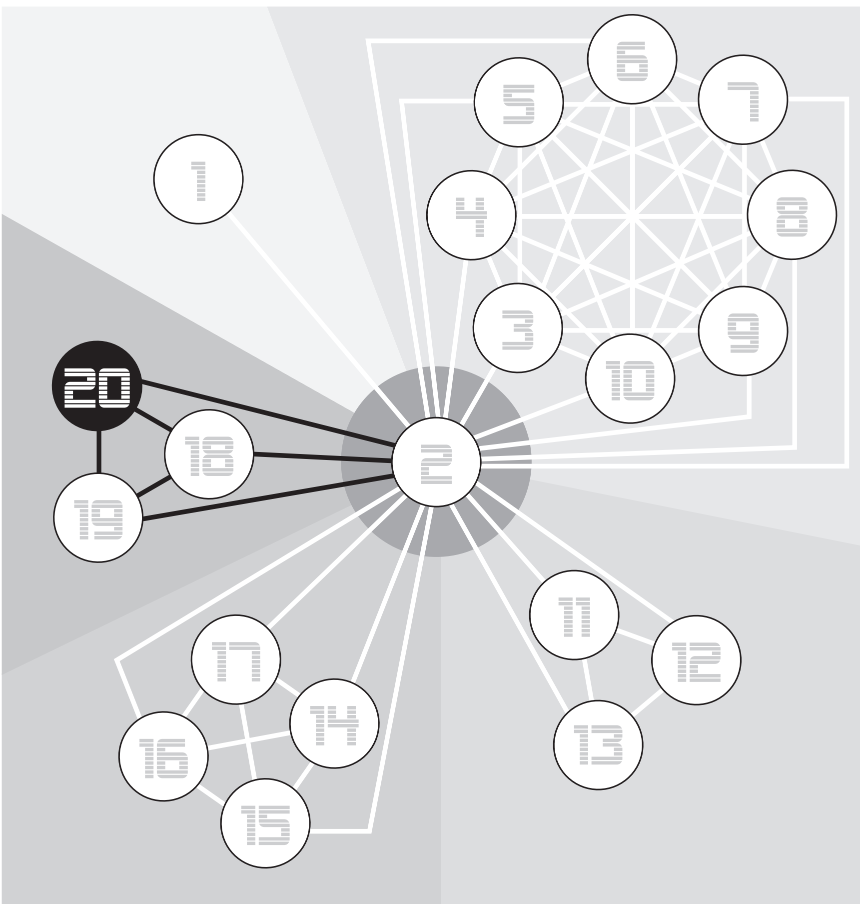
19.5 Conclusion

At the end of my discussion, I would like to say that I agree with those who claim that the necessary demand for a paradigm shift from disciplinarity to transdisciplinarity must not become a new form of theoretical orthodoxy. However, we cannot oversimplify matters. All types of scientific knowledge production (disciplinarity, interdisciplinarity, multidisciplinarity) will also retain their epistemological and social importance in future scientific and technological development. Nevertheless, we must consider that the new transdisicplinarity is radically changing the recent nature of science and technology.

In Slovenia, various factors hinder science and policy discourse in making a more radical shift to transdisciplinarity. In spite of the periodic use of the terms "interdisciplinarity," "transdisciplinarity," etc. in Slovenian R&D policy documents, there is often a lack of concrete policy action, which is needed to realize the new philosophy in practice. Although there are a lot of obstacles in this paradigm change, it would be wrong to say that there are no the positive examples of cross-disciplinary and cross-sectoral cooperation in Slovenia. These positive examples have not been presented on this occasion. Instead, the focus of my discussion has been primarily oriented towards the weak points in science and policy discourse.

20 Approaches to Interdisciplinary Collaborative Research

Simona Tancig | Urban Kordeš



20.1 Introduction

In recent decades, the cognitive complexity and demanding nature of issues dealt with in modern societies has increased; problems are often ambiguous, unstructured and ill-defined, causing a need for flexible and adaptable problem solving strategies and frameworks by expert teams (composed of professionals or researchers from multiple fields).

One possible answer to such complex issues could be the development of an interdisciplinary collaboration work culture and teams of various experts, including researchers and professionals from different disciplines who combine the perspectives of various fields. They should be able to perceive highly specific aspects of a problem that might be overlooked from the vantage point of a single perspective.

Since different perspectives and multiple ideas can trigger and facilitate fruitful discussions and enable creativity in problem solving, multi- and interdisciplinary groups may be preferred in academic education and research settings [Tancig, 2009].

Using metaphors, analogies, shared concepts, abstractions, insights, models and methods that are transferable across various scientific fields can help develop common ground for conversations in multi- and interdisciplinary collaborative groups.

Interdisciplinary, collaborative learning and problem solving extend the range of possibilities in developing competencies.

Collaborative learning can help develop high-order cognitive skills, interpersonal or social skills, values, and attitudes relevant for successful problem solving in today's complex and diverse society [Tancig, 2007]. Learning occurs socially as a collaborative construction of knowledge.

Collaborative learning puts into practice the major conclusions from advanced cognitive theories, research and methodologies. A social constructivist perspective is applied to collaborative learning by focusing on the group process, without excluding individual processes, with particular emphasis on how the processes of cognition and communication can be conceived as situated, dialogic, distributed and emergent.

20.2 Theoretical and Practical Issues of Multi-, Inter-, Trans- and Cross-Disciplinarity

Taxonomy of Interdisciplinarity-related Terms

Multidisciplinarity
"Multidisciplinarity" is normally considered to be a simple addition of at least two discipline-specific views. Each discipline yields discipline-specific results and there is no agent that would integrate the various individual results. A multidisciplinary work is carried out by experts from different disciplines and professions who are engaged in working together as "equal stakeholders in addressing a common challenge" [Interdisciplinarity, 2009]. A multidisciplinary approach is efficient in the areas where the challenge can be decomposed into subparts and then addressed via the distributed knowledge in the community or project team —in other words, where analysis and reduction are possible. Many extremely complex issues can be translated into a multidisciplinary problem (or even into a series of mono-disciplinary ones) after initially being efficiently dealt with in a more holistic matter (if the solution was carefully analyzed and algorithmized later). Over time, multidisciplinary work does not typically lead to an increase or decrease in the number of disciplines or expert fields.

Interdisciplinarity
The term "interdisciplinarity" usually describes organized inquiry aiming at knowledge-production and/or problem solving where participating experts tend to gain perspective from a higher order viewpoint (that is, they try to see their disciplinary-limited views as part of wider picture). "Interdisciplinary" normally describes a work-in-progress, meaning a state of collaboration where stable consensus and definitions are not yet established. Typically, successful interdisciplinary work can lead to the formation of a new field. Aspects of interdisciplinary challenges cannot be addressed simply by a series of specialized interventions, that is, with existing distributed knowledge. So, even in cases where the main goal of an interdisciplinary work is a very specific, practical problem, it is almost as a rule accompanied by the evolution of new knowledge.

Transdisciplinarity
As we progress along our scale of synergy, the terms introduced become less defined. "Transdisciplinarity," for example, is used quite often but in quite different contexts, so it does not yet have a fixed meaning.
It is either seen "as the act of taking theories and methods which exist independently of several disciplines and applying them to organize and understand

different areas or fields" [Ausburg, 2006]. Or—and more often—transdisciplinarity is seen as a sort of advanced interdisciplinarity where boundaries between disciplines are dissolved and a common toolbox and vocabulary are found. Both definitions agree that mono-disciplinary rules and methods are used for the purpose of achieving new insights or for expanding the discipline's resources. Ideally, in a transdisciplinary team, the common knowledge of individuals and the distributed knowledge of the collective are identical for the purpose of addressing a common challenge. Some uses of the term also suggest taking into account different aspects of knowledge: from propositional, dispositional knowledge and also knowledge "how."

Cross-Disciplinarity

"Cross-disciplinarity" describes more radical cooperation. Wikipedia [2009] describes it as "the act of crossing disciplinary boundaries to explain one subject in the terms of another, foreign subject or method. Common examples of cross-disciplinary approaches are studies of the physics of music or the politics of literature." It is often regarded as ultra-interdisciplinarity, and its results are seen as mostly of metaphorical value.

Broadly speaking, the above-mentioned progression from multi- to cross-disciplinarity can be regarded as a continuum. We do not believe that there are well defined borders between levels, and it also appears that a direct jump from one end of this continuum to another (multi- to cross-disciplinarity) is virtually impossible—a team must evolve through all phases. This is so because of the importance of non-propositional forms of knowledge in the process of team integration—forms that can only be gained hermeneutically (that is, through action).

The main shift then occurs when we move from disciplinary-oriented problem solving to cooperation resulting in a higher order view.

In the following exposé, we will mostly use the term "interdisciplinarity" (unless otherwise noted). By this, we will not try to point to some particular point in the above-mentioned continuum, but will describe the shift from separate disciplines to higher-order integration (or an attempt of this). We will use "interdisciplinarity" as a term describing experts attempting to cooperate in order to achieve a synergic view or solution of an issue that is too complex to be tackled from a single disciplinary perspective alone.

It is clear that we are not talking about a simple adding of pieces of knowledge but of collaborations that have the potential to produce higher order insights. Just connecting two "neighboring" disciplines, like engineering and physics or sociology and philosophy, is not what interdisciplinarity is about. Such endeavors do not have to deal with any of the problems mentioned in this text; neither do they have the potential to produce higher-order knowledge. Multidisciplinarity works just as well in those areas and the above-mentioned shift is unnecessary. Some authors speak of a *radical* interdisciplinarity to differentiate from the inflation of "interdisciplinary" projects that has been occurring recently. The radical interdisciplinary communities are those that cooperate across "distantly related" research areas, meaning they have to traverse the epistemological gap between "soft" and "hard" sciences. According to a study by the Danish Agency for Science, Technology and Innovation [2008], "Only few research and educational communities concentrate on radical interdisciplinary fields. Even though many research communities and educations have come far in cooperation across disciplinary boundaries, there are in fact very few that seriously cross these boundaries. About ten percent of the research communities, research council grants and higher education programs are characterized by the type of strong interdisciplinary research and education where there is cooperation across the 'soft' and 'hard' disciplines." The report concludes that current interdisciplinary cooperation is characterized by cooperation across fields which lie close to those within which they are already working.

It therefore seems that despite the popularity of the term and despite the high innovative value of such endeavors, a true interdisciplinarity is hard to find. Below, we will explore problems that accompany interdisciplinary attempts, but before that, it is important that we identify the most common problems that call for a true (or radical) interdisciplinary approach.

Types of Problems where Interdisciplinarity is Unavoidable

The most common factor that triggers interdisciplinary inquiry is complexity. By that we do not mean computational difficulty (like multibody problems in physics) but the realization that many expert fields have something to say about the phenomena we are investigating. When we refer to a certain problem as "complex," it is often the case that we have already found a new viewpoint from which it becomes obvious that the problem cannot fully be dealt with through any of the existing disciplinary toolboxes.

Modern science has already acknowledged many such areas as inevitable challenges for its future development. Two of the most prominent examples are environmental science and cognitive science—both spanning the scientific divide between the social and natural sciences.

Perhaps the example of cognitive science is the most telling, since this area has developed from cybernetics. And it is exactly the development of cybernetics and system science [in the 1940s and 1950s] that set the foundations for interdisciplinary research. One of founders of the cybernetics movement, Margaret Mead, said in one of her addresses to the American Society of Cybernetics, "I specifically want to consider the significance of the set of cross-disciplinary ideas which we first called 'feed-back' and then called 'teleological mechanisms' and then called 'cybernetics'—a form of cross-disciplinary thought which made it possible for members of many disciplines to communicate with each other easily in a language which all could understand."

Cybernetics and system science are probably the first research projects that were developed to create an interdisciplinary field. They contain a spectrum of concepts and solutions of various, highly complex systems—they do not try to create idealized systems; one of their main guidelines is "cultivating the complexity." Two other typical features of the so-called system solutions are the consideration of the interaction of various parameters and, in particular, an integral approach to the problem.

Cognitive Science

From cybernetics, many extremely successful research areas developed, and cognitive science, which evolved in the 1950s, is only one. The basic scientific disciplines that cognitive science includes are neurology, psychology, computer sciences, linguistics and philosophy. The research field encroached upon various human activities, such as recognizing auditory and visual patterns, remembering, learning, language command, decision making and solving problems, which are classified as cognitive processes. Nowadays, the research topics have been extended even further—cognitive sciences address various mental processes, among others also emotions and social actions—while the range of scientific disciplines has also been broadened to include physics, chemistry, biology, anthropology, sociology and cultural sciences.

The basic question of cognitive sciences was (and still is) how to integrate these diverse approaches, for each scientific discipline deals with these issues from its own perspective and uses its own technical language and specific methods. The holy grail of cognitive science is the mind-body problem which some philosophers also call "the hard problem." The problem of the relationship between physical and mental phenomena can easily be translated into a methodological problem of how knowledge from both sides of the disciplinary divide can be merged.

It is interesting enough that by establishing an adequate method of connecting results from the different disciplines of the cognitive sciences, most of the pressing problems (including "the hard problem") would solve themselves. So, if the interdisciplinary connection between the natural sciences (dealing with neurophysiological processes) and the humanities (dealing with experience) were realized, the ensuing methodological achievement would have far reaching consequences.

It is quite clear by now that such interconnection should be achieved on a higher, integral (interdisciplinary) level. Only on this level is it possible to produce answers to such difficult question as, for example, the questions of mind and consciousness. Lately, an express need has grown in the cognitive sciences for a synthesis of the increasingly vast but unconnected knowledge of all disciplines involved. In general, the need for interdisciplinarity is more and more present in many scientific fields, such as ecology, sustainable development, genetic research.

As another example, one could mention the management of catastrophic events, which is one of the well-known interdisciplinary education programs at University of Copenhagen.

There are other, less paradigmatic examples of interdisciplinary problems.

Sometimes, for example, interdisciplinary assessment is needed where the problem at hand does not respond to a "more of the same" approach. Connecting different views can, however, bring the necessary solution. An example of this could be the work of Leonard Duhl in Oakland—a well documented case where he helped improve the city's health indicators only by creating a powerful interdisciplinary network of shareholders.[1]

Main Problems of Interdisciplinary Work

The above overview of examples of interdisciplinary projects has already outlined some "hard" problems that such attempts encounter. When a simple addition of mono-disciplinary insights does not work, one has to expect the following major challenges.

Interdisciplinarity as an Epistemological Issue

Especially when crossing the soft and hard disciplinary boundaries, we encounter the essential problem that is many times overlooked: how can different, even opposing, epistemologies be bridged?

As seen in the example of cognitive science, when trying to reach across the disciplinary barrier, one keeps bumping into the unsurpassable boundaries dividing the different systems of thought, different languages and finally—different epistemologies. Each side of this "epistemological abyss" has its basic (axiomatic) position, on which it has set the foundations for its system of thought. A given question can appear to be fundamental in one of the systems, while in the other one the answer can be seen as resulting from the chosen conceptual network.

1 For details, see the WHO archives.

Just like in building mathematical systems, we proceed from a fistful of selected axioms. The procedures for reaching our epistemological conclusions are, of course, not as clear as mathematical frameworks. Hermeneutics teaches us that we are, at any time, unable to fully articulate the tradition and the entire context on which our system of thought is based. But we can at least try to approach as much as possible the articulation and awareness of our premises on which we build our understanding of the whole phenomena.

We believe that in the awareness of our differences and hermeneutic dialogue lies the solution to a problem of bridging the epistemological abyss. The hermeneutic approach (characteristic of constructivism) allows for a spiral approach to reaching agreement in a dialogue or operative knowledge [Kordes and Jericek, 2001]. This last notion implies the situation when we are perhaps unable to construct a complete definition of a given notion, but we are able to handle it and use it in a meaningful way (*i.e.* capability of action).

According to Rorty [1991], there is a strong consensus concerning a certain part of our world that we can take it as objective and thus can afford to be "epistemological" in that area—meaning, we can assume that other parties will understand us there. But outside of it we must act "hermeneutically." We can afford to act epistemologically in the areas where we understand completely what is going on (*i.e.* where we have already agreed upon a discourse), while we must act hermeneutically where we do not understand what is going on and are sincere enough to admit that to ourselves.

Rorty further says that the difference between hermeneutic and epistemological discourse is that the hermeneutic does not ascribe the possibility of reaching consent to the existence of a common underlying ground or matrix but to the discussion itself—while the discussion goes on, there is hope that the participants will somehow reach consent.

Once trust is achieved, the search for agreement, which is the essential component in communication, as we have emphasized many times before, can begin. In philosophical discussions, it is most important to agree on epistemological assumptions. If that is accomplished, we can turn from a hermeneutic to an epistemological position [according to Rorty]. But to accomplish that we need a dialogue that calls for the awareness of there being two (or more) involved in the dialogue. We cannot address everyone from nowhere. We must first make sure that our epistemological assumptions are in line; only then can we start exploring the network of meanings woven around these assumptions.

Interdisciplinarity as an Organizational Issue

Now that we have tackled the more abstract issue of interdisciplinary work, let us turn our attention to more concrete issues. Organizing interdisciplinary projects is a huge endeavor and the person planning to start it should take into account the following points (in addition to the above-mentioned epistemological consideration):

i) *Interdisciplinary work is not the main issue for anyone*
So far, purely interdisciplinary experts are very rare, so teams will be comprised of experts from different fields. Unless it is a well funded project that can buy 100% of its research potential, all of the experts will be dedicated to their own particular fields, so they will be taking on work in an interdisciplinary environment more as an interesting addition or hobby, which will inevitably result in problems of prioritizing their schedules. Anyone who has attempted to organize an interdisciplinary team knows how difficult the seemingly simple task of preparing a work schedule can be.
Experience also shows that interdisciplinary work normally does not lead to immediate results that can help development within the disciplines themselves, which is then an additional turnoff for top experts. Normally, only highly interested and broad-minded researchers remain within the interdisciplinary team long enough to gather enough trust, common ground, common language and common concepts (in that order) to allow a synergy to emerge.
This important detail is also mostly overlooked by funding agencies. They are (recently) welcoming interdisciplinary projects, but still measuring them by standards valid for mono-disciplinary work.

ii) *Top-down approaches rarely work*
In connection to point i), one has to mention the organization of any joint effort. Because of the drawbacks mentioned above, the problem investigated must be of shared interest. Top-down approaches almost never work (and even if they do, such projects are expensive and teams face many dropouts). The best projects are created around a common issue (which is viewed from different angles), so that a community of experts emerges where each participant sees the project as his or her own challenge.

iii) *What is the research problem, actually?*
This is the issue of common language. We dealt with it partially in the epistemological section, so here let us only mention that even if we seem to agree on the problem, this still does not mean that we are talking about the same thing. Again, the cognitive sciences can provide us with a great example. Almost everyone within this field would agree that the purpose of research is to build a body of knowledge about cognitive phenomena. Yet, when one investigates different understandings of this statement, one sees an unbelievably colorful palette of ideas: from clinical practicalities to globally philosophic hopes. Building common mental models is therefore of utmost importance.

The next issue we should mention is purely methodological, but it directly translates to another one: *interdisciplinary work is viewed as a communicative task*. An interdisciplinary team has to know how to do its job. The team must be trained and skilled, requiring less propositional knowledge. This is the point where we proceed into the next part of the paper, the point where we ask the crucial question: how can people from different disciplines, with different scientific languages, using different methodologies etc., work together and produce high-quality results? This is the case to consider the intricacies of collaborative work, collaborative learning and collaborative knowledge construction.

20.3 Collaborative Learning and Problem Solving

The Conceptualization of Collaborative Learning

The Definition of Collaborative Learning

Collaborative learning is an emerging multidisciplinary field in the learning sciences and cognitive sciences. Researchers from cognitive psychology, communication science, sociology, anthropology and computer science, among others, collaborate to study processes and outcomes of collaborative learning.

Collaborative learning addresses several major concerns related to improving learning and problem solving for students, professionals and researchers across different disciplines. Collaborative learning continues to attract interest because engagement in productive teamwork is a prerequisite in many professions.

Other terms for collaborative learning activities are also used: team learning, group learning and cooperative learning. Some authors use the terms cooperative and collaborative interchangeably. Others, however, insist on a clear, epistemological distinction between the two. For instance, Bruffee [1995], Dillenbourg [1999], Roschelle and Teasley [1995] advocate that learning in cooperative groups is done individually and, subsequently, a collection of individual results is presented as the group's work. In collaborative work, it is assumed that knowledge is socially produced, that it is "something people construct by talking together and reaching agreement" [Bruffee, 1993:3].

Thus Dillenbourg [1999:8] states, "In cooperation, partners split the work, solve sub-tasks individually and then assemble the partial results into the final output. In collaboration, partners do the work 'together'." According to Roschelle and Teasley [1995:70], "Collaboration is a process by which individuals negotiate and share meanings relevant to the problem solving task at hand... Collaboration is a coordinated synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem."

The main feature of collaboration is group interaction, like negotiation and social sharing of group meanings.

Metaphors of Collaborative Learning—Acquisition, Participation, Creation

Collaborative learning puts into practice conclusions from advanced cognitive theories, research and methodologies. A social constructivist perspective is applied to collaborative learning by focusing on the group process, without excluding individual processes, with a particular emphasis on how the processes of cognition and communication can be conceived as situated, dialogic, distributed and emergent. Thus, metaphors of collaborative learning reflect the main paradigmatic changes in learning sciences and cognitive sciences related to learning and knowledge.

Lipponen, Hakkaraienen and Paavola [2004] distinguish between acquisition, participation and knowledge-creation metaphors. The first two metaphors are derived from the work of Sfard [1998], who has defined them [Table 20.1]. The third metaphor is based on the ideas of Bereiter [2002] and Engestroem [1987].

The acquisition metaphor identifies learning as individual knowledge attainment or the accumulation of knowledge and concepts by reception or active construction. The participation metaphor, in contrast, focuses on the ongoing learning activities that involve becoming a member of a particular community that has its own language and norms. In other words, the focus is on the shared knowledge, negotiation, intersubjective meaning making, distributed cognition and interaction.

TABLE 20.1 **The Comparison Between Acquisition and Participation Metaphors**

Attributes	Acquisition metaphor	Participation metaphor
Goal of learning	Individual enrichment	Community building
Learning	Acquisition of something	Becoming a participant
Student	Recipient (consumer), (re-)constructor	Peripheral participant, apprentice
Teacher	Provider, facilitator, mediator	Expert participant, preserver of practice/discourse
Knowledge, concept	Property, possession, commodity (individual, public)	Aspect of practice/discourse activity
Knowing	Having, possessing	Belonging, participating, communicating

[Adapted from Sfard, 2008]

The knowledge-creation metaphor means that shared knowledge and social practices are transformed, created or advanced through collaboration.

The relationship between the acquisition and participation metaphors can also be considered as an epistemological distinction between a final (static), Cartesian concept of knowledge and a Heideggerian, changeable and fluid (dynamic) view of knowledge.

This epistemological dichotomy strongly influences methodological approaches to investigating collaborative knowledge: outcome-oriented studies are focused on individual and group learning, while process-oriented studies focus on interaction, alignment, organization of collaboration, etc.

Socio-Cultural and Situative Perspectives of Collaboration

Bredo [1994] characterizes symbol processing and a situated view of the mind in terms of three dualisms: language vs. reality, mind vs. body, and individual vs. society [Table 20.2].

According to the information-processing view, the learner can be either a passive processor of information or an active one in constructing knowledge from experiences.

In the symbol-processing view, symbols are like mirrors of reality, and these representations are transmitted to or acquired by learners. Thinking is seen as an individual process that is separate from the actions that the body takes.

TABLE 20.2 **Ideas about Knowledge as Depicted by Symbol-Processing and Situated Cognition**

Dualism	**Symbol-Processing**	**Situated Cognition**
Language and reality	Objective reality	Knowledge is not a mirror of reality
Mind and body	Knowledge in the head	Knowledge is related to action
Individual and society	Knowledge as individual property	Knowledge is social

[Aadapted from McCormick and Murphy, 2008]

In contrast, according to the situated view, all three dualisms become complementary and unified.

Theoreticians have concentrated on the social aspect of knowledge construction, which holds learning as a process of participation and emphasizes the role of others in constructing and sharing meaning, and advocates a socio-cultural approach. Bredo [1994] has labeled this approach, together with social-constructivist positions, as a situated one.

Vygotsky [1978] argues that we cannot study thinking independently from the social and cultural context in which it takes place. Socio-constructivist views of learning acknowledge the cultural value given to different educational outcomes and also focus on the interplay between the individual and the group that leads to cognitive growth and cultural affiliation [Bruner, 1996:153]. *Zone of proximal development* (ZoPD) is a term invented by Vygotsky and refers to the understanding that lies just beyond the current knowledge and ability: what we can learn with the help of others but not on our own at the given time. ZoPD is defined as the distance between the actual developmental level of a student as determined by independent problem solving and the level of potential development as determined through problem solving in collaboration with other, more capable peers [Vygotsky, 1978]. According to Vygotsky, individual learners have different developmental capabilities in collaborative situations than when they are learning or reasoning alone.

A socio-cultural approach, building on the Vygotskian framework, emphasizes how participants collaborate and build on each other's ideas to construct a new understanding.

A Piagetian constructivist approach focuses on the individual internalization of knowledge and also on the interaction between peers as a prerequisite for the knowledge construction that occurs through cognitive conflicts.

Greeno [2006] defines situational perspective as a synthesis of two research programs: cognitive sciences and interactional studies. Both emerged in opposition to behaviorism. The former is an interdisciplinary science, traditionally focused mainly on the cognition of individuals and less on their interactions. The latter focuses on a group of individuals engaged in a joint cognitive action with the tools and materials available in their environment. Each of the approaches has strongly influenced the development of contemporary learning sciences.

Thus, a situative approach, including mental informational structures in interactional analysis, brings together concepts and methods of cognitive and interactional studies. A situative perspective assumes that knowledge is not a static mental structure in a person's head. Knowing is a process involving a person, other people, tools and activities in the social and physical environment.

Situative studies concentrate on learning by an activity system, a complex social organization of learners, teaching materials, tools, software and the physical environment [Greeno, 2006].

In the framework of activity theory, Engestroem [1987; 2001] has developed the concept of an "activity system" as a group of people whose orientation to the object of their activity is mediated by rules, a division of labor and cultural artifacts. Engestroem's [2005] often cited analysis of the activity system highlights relationships not only between the participants, the focus of the activity, the goals, motives and tools in use, but also between the wider community, social rules, norms and values.

The implications of situated cognition also extend to the physical and social context of learning.

The socio-cultural approach has become very influential in learning sciences and cognitive sciences because all intelligent behavior has been realized predominantly in complex social and physical environments. Thus, artificial intelligence research, for instance, has begun to emphasize distributed cognition; cognitive psychology has begun to study collaboration, teamwork, group dynamics and the role of the social context in cognitive development; education research studies classroom collaboration, face-to-face or computer supported learning (CSCL), collaborative discourse, and interactions in student groups or project teams [Sawyer, 2006].

Understanding Collaborative Processes

Distributed Cognition

Hutchins [1991] has pointed out in his studies that cognition is distributed across people as they collaborate with each other and work with the tools designed to aid them in cognitive work, such as data gathering, planning and reasoning, and problem solving. The idea is that cognition is not only individual but is also distributed across individuals in a group, other people, and cultural tools and institutions. Especially with such mental tools as language, cognition is distributed not only across individuals and material objects but also across ideas and communication with other people [Rogoff, 2008]. Some cultural tools, like computers, literature, workbooks and diagrams, are particularly designed to foster collaboration and interaction in thinking among people participating at a distance in a shared activity [Bruffee, 1993; Crook, 1994]. Nowadays, computers have such an important cultural role as a cognitive tool that they can be considered as interactive partners themselves [Schrage, 1990].

Distributed cognition refers to cognition, understanding it as the interaction among the participants and the tools in the context of an activity. In the context of a workplace, rethinking the meaning of expertise is needed. In many cases, expert knowledge among professionals is less a matter of what each individual knows and more their joint ability to produce a right decision. In other words, expertise is a social affair [Schrage, 1990].

In a situative perspective of collaborative learning and thinking, the focus is on understanding cognition as the interaction among participants and tools in the context of an activity. Therefore, the situative approach studies distributed cognition (thinking, reasoning, problem solving, etc.) in a collaborative group or a community.

Understanding collaborative learning requires making sense of the conversation the participants engage in and the tools that mediate their learning [Hmelo-Silver, 2003]. Group thinking and reasoning are reflected in a collaborative discourse, which provides evidence of the interaction and semiotic structures (structure of information) that are being generated and used in an activity.

In contrast to an individual's cognitive approach where the individual's mental activity is analyzed, in the situative perspective, we can obtain with conversational or discursive analyses insights into the ways participants in a conversation mutually construct meaning and shared knowledge through a process of negotiation.

Collaborative discourse results in the emergence of new representations and shared knowledge. In a group's discussions, both the overall group dynamics and the individual's collaborative learning emerges from the group's conversation. For a complete understanding of collaborative interactions, both discourse and communication as externally visible, distributed emergent knowledge and participants' thoughts and actions are needed [Sawyer, 2006]. In other words, the emphasis is on both representations: individual (mental) ones and socially distributed ones in practice.

Meaning Making, Negotiation Meaning

According to Wenger [2008:31], "Practice is, first and foremost, a process by which we can experience the world and our engagement with it as meaningful... Practice is about meaning as an experience of everyday life." He maintains that:

- meaning is located in a process of negotiating meaning
- the negotiation of meaning involves the interaction of two constituent processes: participation and reification
- participation and reification form a duality that is fundamental to the human experience of meaning and thus to the nature of practice.

Group activity has to be negotiated and actively constructed. Collaboration is primarily conceptualized as a process of shared meaning-making [Stahl, Koschmann and Suthers, 2006]. In general, the concept of negotiation of meaning characterizes the process by which we experience the world and our engagement in it as meaningful. "... negotiation constantly changes the situations to which it gives meaning and affects all participants. In this process, negotiating meaning entails both interpretation and action." [Wenger, 2008:33]

According to the distributed conceptualization of the learning process, an interpersonal meaning is created through participating in a social activity.

In face-to-face and computer-supported collaboration, commonly shared knowledge increasingly facilitates communication and interaction among researchers in various scientific fields, who are, through interdisciplinary interactions, collaboratively developing shared knowledge by negotiating common ground.

Learning Community and Community of Practice

In the cultural-historical activity theory, agency, knowing and learning are not properties of individuals but can be understood as situated and distributed "engagement in changing processes of human activity." [Lave, 1993:12] In learning communities, each participant is involved in a collective agency.

The goal of the learning community is to advance collective knowledge of the community, and in that way to support an individual participant in learning [Scardamalia and Bereiter, 2006]. The learning community approach is based on knowledge sharing, discussing, talking, and working together on a project. Thus, learning means learning to participate in a community. The whole approach is aimed at ensuring a culture of learning in which everyone is involved in collective learning. That means that the learning process is viewed not as a transmission of knowledge from a knowledgeable individual but as an authentic cultural activity, a participation in a community of learning. From this perspective, learning to be part of a community is not just an acquisition of concepts but also a matter of behavior, values and identity [McCormick and Scrimshaw, 2008].

A community of practice refers to the creation of a learning environment in which the participants actively communicate and engage the skills involved in an expertise [Wenger, 1998]. Such communities are characterized by common intention, personal investment and mutual dependency. Collaboration in a community can be stimulated by common projects and shared experiences. The participants are engaged in the development of understanding and knowledge-building through problem identification, research and discourse.

Communities of practice exhibit practices which include subject-matter content of discourse, items that count as knowledge in the group's domain, meaning of concepts and principles, application of methods and other activities. In other words, participating in a community includes understanding conventions and practices that are significant in the community's discourse about activities [Greeno, 1995].

A collaborative group or community can be viewed as a network of interacting components at various levels. Multilevel modeling (analysis) can reveal different kinds of levels and their mutual interactions with each other.

Multilevel modeling deals with hierarchical nesting, interdependency and unit-of-analysis problems. De Wever *et al.* [2007] have demonstrated how multilevel analysis can be applied to data obtained by content analysis of a collaborative discussion group (CSCL). In their study, they report on the effect of assigning roles to students in the knowledge construction process and on learning in asynchronous discussion groups. Their results show that summarizing contributions, focusing on theory in contributions, moderating content, and summarizing the results of work contribute to significantly higher levels of knowledge construction.

Alignment

Collaborative learning and problem solving are based on a concept of alignment (as distinct from agreement) which generally means "to put in line." Alignment refers to arranging a group of scattered element so that they function as a whole by orienting them all to a common awareness of each other, their purpose, and their current reality [Senge *et al.*, 2000].

Alignment develops when participants of a collaborative group feel involved in their joint engagement (activity). Alignment in a group or community is based on an ability to see and respect each other, on positive interdependence, on individual accountability and on establishing some common mental models.

The effectiveness of a collaborative group depends, to a large extent, on coordination or alignment among various components of an activity system —participants, materials and technical tools in the environment, cognitive structures (prior knowledge, mental models), and the practice of the participants in the subject matter domain of their activities [Greeno, 2006].

Participants in a collaborative environment usually spend a lot of effort coordinating their ongoing interactions, because an activity is usually not planned in advance, but has to be negotiated and actively constructed by participants.
The coordination or alignment among individuals depends on the mutual understanding of communicative intentions as well as the coordination of action; understanding the conventions and practices that are important in group's or community's discourse about its activities; participants' shared social practices, and the way in which individuals participate in an activity [Greeno, 2006].

Challenges and Possibilities

Computer-Supported Collaborative Learning (CSCL)

Computer-supported collaborative learning has been emerging with the rapid development of information communication technologies.
Computer support for collaboration is the main issue for the CSCL approach to e-learning. Students' collaboration in learning and problem solving is supported, and scaffolding with networked computers is provided. CSCL can take the form of face-to-face collaboration or online communication. CSCL environment technology can make the difference in both how and what the participants learn under the right conditions [O'Donnell, 2006].
Contrary to popular belief, computers, though ubiquitous in higher-education institutions and environments, have not substantially changed the traditional, centuries-old educational practices [Bruffee, 1999]. They are great helpers and facilitators, number crunchers and text processors, presenters and demonstrators, but they are not improving the essential nature of traditional teaching and learning.
In order to achieve a qualitative leap in the relationship between computers and education, it would be necessary to think about computers in a nontraditional way and find new means of utilizing the former to advance the latter. The first inklings of this new era might be perceived in the advent of networked computers where the constant interaction or conversation among them can be compared to a conversation in an educational group, which is not about conveying information but about collaborative learning.
Traditional thinking about computers can be categorized into three groups [Bruffee, 1999]:

a) *Objectivist*: computers are storing information extracted from (mirroring) the external world. In order to better educate, computers should allow access to ever-increasing amounts of increasingly refined data and their relations.

b) *Subjectivist*: computers should assist the imaginative, conceptualizing and synthesizing skills of the human mind by furnishing it with increasingly elaborate ways of combining, synthesizing and presenting stored information.
c) *Elisionist*: drawn from the tenet of socioculturalists in education that the individual learner cannot be meaningfully separated from the social and cultural context of learning, elisionists emphasize the need for sophisticated computers that enable students to "interact" with them through accessing a massive, integrated database.

Computer-supported collaborative learning CSCL can be observed [Koschmann, 1996] as the last phase in the historical sequence of using computers in education:

a) *Computer-assisted instruction*: a typical behaviorist approach of the 1960s in which learning is equated with the memorization of facts. These systems were based on drilling and practicing logical sequences of elemental facts presented to students.
b) *Intelligent tutoring systems*: based on the cognitive science of the 1970s, the underlying assumption was that these systems must use computer models of a student's understanding based on representation and processing knowledge. Corresponding actions were then taken by computers based on the student's right or wrong answers.
c) *Logo as Latin*: Logo programming language from 1980s was used a tool stimulating students to build their knowledge themselves. This constructivist approach was based on the programming constructs the students were using in building their own programs.
d) *CSCL*: the current phase of using computers in education draws from social constructivist and dialogical theories and strives to bring together students in small groups and in learning communities in order that they learn collaboratively by constructing shared knowledge.

It is instructive to compare both authors' perspectives regarding underlying assumptions and characteristics for the different usage of computers in education. The correspondence and overlapping of concepts from these two perspectives is summarized in the following Table 20.3.

CSCL is usually supported with specially designed technology, and its software is in some cases based on artificial-intelligence techniques. CSCL environments are often used in various educational and research settings.

CSCL is based on epistemological assumptions of various study fields: socially oriented learning theories, social constructivism, socio-cognitive theories [Garton, 1992], practice theory [Lave and Wenger, 1991], situativity [Greeno, 2006], ecological theories, and dialogical theories [Hicks, 1996]. Thus the focus is on social phenomena, like meaning negotiation, meaning construction, interpersonal interaction, distributed cognition, etc.

TABLE 20.3 **Relations (Overlapping) between Two Perspectives on Using Computers in Education**

Bruffee [**1999**] **Koschman** [**1996**]	**Objectivist**		**Subjectivist**	**Elisionist**
	Data	Relations		
Computer-assisted instruction	x	(x)		
Intelligent tutoring systems		x	x	
Logo	x	x	x	
Computer-supported collaborative learning				x

According to Koschmann [2002:20], CSCL is a "field centrally concerned with meaning and practice of meaning-making in the context of joint activity, and the ways in which these practices are mediated through designed artifacts."
The technology of CSCL environments supports collaborative learning and problem solving by providing [Goldman-Segall and Maxwell, 2003] the following:

- shared contexts
- opportunities for participants to compare different perspectives as they participate in various communities
- opportunities to use, create and share information
- a communication medium.

CSCL provides a dynamically evolving context for interaction and is very effective in solving open-ended (ill-defined) problems, in which information can be discussed from multiple perspectives and problems can be solved in many different ways.
Veerman and Veldhuis-Diermanse [2006] have been studying collaborative learning through computer-mediated communications (CMC) systems in academic education as a process of knowledge construction. Their findings are related to some of the main factors in the educational context: the roles of the student, peer-student, tutor or moderator, the characteristics of the learning task, and features of the CMC system used. They offer a list of practical tips for using educational technology effectively in collaborative learning situations, with an emphasis on the construction of knowledge:

- Open-ended tasks should be used, as they offer opportunities for multiple perspectives, discussions and problem solving in many different ways.
- Task structures for regulating organizational and planning issues should be used, especially when these issues are not related to the content of the tasks and learning goals.
- Groups of students should be heterogeneous and the students should be assigned different discussion roles, if possible.
- Students' assumptions and expectations should be checked beforehand. Guidelines about participation, collaboration and communication should be provided.
- User-friendly and transparent CMC systems should be exploited. Students, tutors and moderators should be provided with sufficient time and exercises to become familiar with the system.
- Clear discussion threads should be organized. Different content aspects (discussion themes, technical issues, planning aspects, and social issues) should be separated.
- Asynchronous CMC systems should be preferred, especially for larger groups of students, as they allow students more time to think, search for information, elaborate and explain ideas, and reflect on each other's contributions.
- Synchronous CMC systems should be used only for small groups (2–3 participants), especially for non-structured interactions. Students have less time to search for information, produce extended explanations, evaluate information thoroughly, ask elaborated questions, etc.

Bosworth [1994] proposed a taxonomy of collaborative skills: interpersonal skills, inquiry skills, conflict resolution skills, and synthesis and presentation skills.
Skills are needed for a productive collaboration, articulating and sharing ideas, listening to others, offering explanations and arguing. Collaborative argumentation is one of the most important modes of participation where the participants need to think critically and argue in order to learn. According to the dialogue theory [Walton, 2000], in arguing to learn, students are not primarily trying to convince each other but are engaged in cooperative explanation of solutions [Walton, 1989; Nonnon, 1996]. In the dialogue theory [Walton, 2000], an argument is seen as a move made in a dialogue in which two parties attempt to think and reason together. An argument for learning should be evaluated according to its collaborative value as a contribution to the conversation [Grice, 1975].
Baker [2004] identified four learning mechanisms associated with effective arguing for learning:

- making knowledge explicit
- conceptual change—transformation of misconception

- co-elaboration of new knowledge
- increasing articulation (questions, statements, ...).

Programs are constructed for improving collaborative skills and scaffolding collaborative argumentation, which can help to develop social awareness, more general collaborative ability, deep understanding, and the ability to learn to think critically.

Rhizome Metaphor of Online, Collaborative Knowledge Construction

Cormier [2008] proposed the rhizome metaphor for collaborative knowledge construction supported with new information and communication technologies. He argued that neither social constructivist nor connectivist pedagogies, which are focused on the process of negotiating knowledge, are sufficient for representing the nature of the learning process in the online world, and he therefore offered the rhizome metaphor for a more "flexible conception of knowledge for the information age." According to Deleuze and Gauttari [2004], who at the beginning of 1980s first used this term, which otherwise originally referred to a botanical rhizome (myzel), the concept is appropriate for theory and research that take into account multiple, non-hierarchical entry and exit points in data representation and interpretation. A rhizome works with horizontal and trans-species connection; for example, two different species interact to form a multiplicity (*i.e.*, a unity that is in itself multiple). "A rhizomatic plant has no center and no boundary; it is made up of a number of semi-independent nodes, each of which is capable of growing and spreading on its own, bound only by the limits of its habitat" [Cormier, 2008].

Similarly, members of an online community have the capacity to make new connections with other nodes in the network, and in doing so, they broaden the knowledge of the community. Such a rhizomatic community has the power to collaboratively build and create knowledge on the basis of participation and negotiation on websites. For instance, wikis offer a participatory medium that allows for communal negotiation of knowledge [Cormier, 2008]. New information and communication technologies enable participatory social learning environments for a discursive rhizomatic approach to knowledge discovery; *i.e.*, collaborative communities (students, professionals, researchers, etc.), on the one side, explore already established knowledge canons, and on the other, negotiate what qualifies as knowledge. Collaboratively constructed knowledge is more likely to be current than traditional, expert-assessing ways or publications.

Multi-/Interdisciplinary Collaborative Problem Solving

Our knowledge in the global society is constantly challenged by an increasing complexity, unpredictability and diversity from the world we live in. Thus, we are faced with many common problems, which are most frequently ill-defined, open-ended and very complex, and therefore require collaborative engagement of scientists and professionals across various domains to discuss, elaborate, explain, and evaluate solutions from multiple perspectives.

Complex problems are thought to require the integration of knowledge from different disciplines [Rotmans, 1998]. Hence, the team's diversity has to have a positive effect on the team's performance, and numerous situations are calling for multidisciplinary and interdisciplinary teams with a wide range of knowledge and expertise.

However, to benefit from interdisciplinarity, the collaborative team members need to be able to build an effective group process. The quality of the team's work depends on the group process, sharing knowledge with one another, understanding one another, elaborating one another's ideas, engaging in critical discussions, etc.

As Bruffee [1999:26–27] points out, "In general, heterogeneous decision-making groups work best because ... differences tend to encourage the mutual challenging and canceling of unshared biases and presuppositions ... Groups that are ... too homogeneous tend to agree too soon ... There is not enough articulated disagreement or resistance to consensus to invigorate the conversation ..." But he also emphasizes, "On the other hand, members of decision groups that are too heterogeneous may have no basis for arriving at a consensus—or no means for doing so: they find that they can't 'come to terms' because they 'don't speak the same language'."

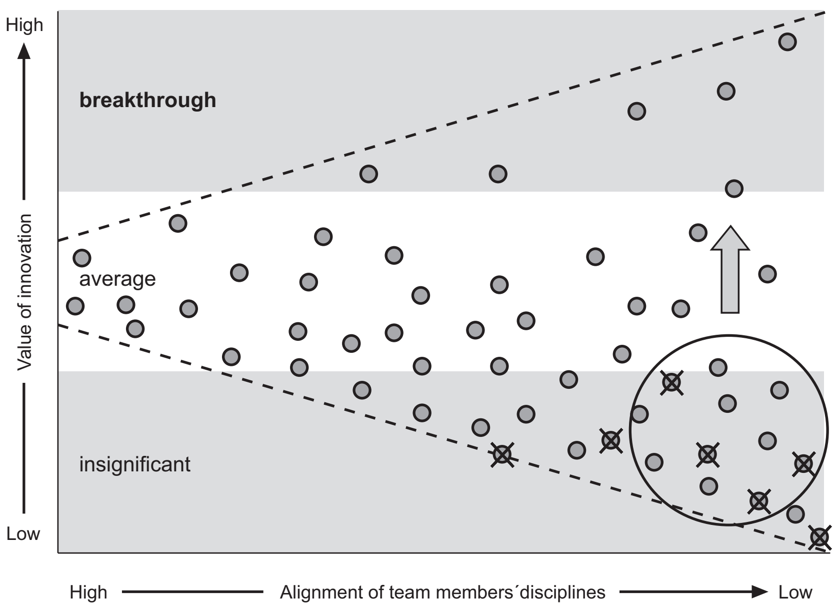
That means [Bromme, 2000] that multidisciplinary teams need to develop enough common ground (shared cognitive frame of reference). A collaborative environment is very suitable for fulfilling such a task, and ICT tools can be useful for supporting the negotiation of common ground in multidisciplinary teams.

Another important issue of multidisciplinary teams is the relationship between the similarity of team members' disciplines and their creativity (quantity and quality of their innovations). Fleming [2004] analyzed more than 17,000 patents in his research of this relationship. He found that "When a creative team is made up of people from very similar disciplines, the average value of its innovations will be high, but it will be unlikely to achieve a breakthrough." In contrast, "A group of people from very diverse disciplines is more likely to achieve breakthroughs —but will also produce many more low-value innovations." [Fleming, 2004:22] This can be seen in the following diagram.

Fleming's research also suggests that multidisciplinary team members with deep expertise in their respective disciplines (deep teams) produce fewer low-value innovations than team members with broad but shallow expertise (shallow teams), regardless of diversity of the team's disciplines.

The quality of innovations is most probably not dependent only on the discussed factors but also on the team's group processes [Fay, Borrill, Amir *et al.*, 2006]. Multidisciplinary teams produce innovations of greater quality when effective group processes take place, such as the team reflecting on its own effectiveness, every member of the team being listened to, etc.).

FIGURE 20.1 **Breakthroughs vs. Failures in a Collaborative Working Environment**



[Adapted from Fleming, 2004]

Bibliography

Adams, J. (1995), *Risk*. London: Routledge.

Adams, F., Aizawa, K. (2010), *The Bounds of Cognition*. Chichester: Wiley-Blackwell.

Aldhous, P. (2006), "Synthetic biologists reject controversial guidelines." *New Scientist*. Available at http://www.newscientist.com/article/dn9211-synthetic-biologists-reject-controversial-guidelines.html

Alvarez, L.W., Alvarez, W., Asaro, F., Michel, H.V. (1980), "Extraterrestrial cause for the Cretaceous–Tertiary extinction." *Science*, Vol. 208 (4448), 1095–1108.

Amable, B. (2000), "Institutional Complementarity and Diversity of Social Systems of Innovation and Production." *RIPE 7* (4), 645–687.

Ambrose, S.H. (1998), "Late Pleistocene human population bottlenecks, volcanic winter, and differentiation of modern humans." *Journal of Human Evolution*, Vol. 34, No. 6, 623–651.

Anderson, P.W. (1972), "More is Different. Broken Symmetry and the Nature of the Hierarchical Structure of Science", in: *Science 4047,* Vol. 177, 393 –396.

Anderson, P.W., Arrow, K.J., Pines, D. (1988) (eds.), "The Economy as an Evolving Complex System." *The Proceedings of the Evolutionary Paths of the Global Economy Workshop*, held September, 1987 in Santa Fe, New Mexico. Redwood City: Addison-Wesley.

Andorno, R. (2004), "The Precautionary Principle: A New Legal Standard for a Technological Age." *Journal of International Biotechnology Law*, Vol. 1, 11–19.

Anissimov, M. (2009a), "Contained Biodisaster for Risk Analysis." *Accelerating Future*. Available at http://www.acceleratingfuture.com/michael/blog/2009/04/contained-biodisaster-for-risk-analysis

Anissimov, M. (2009b), Personal communication.

Annigeri, S., Mittal, A.K., Jain, A.K. (1996), "Uncoupled frequency ratio in asymmetric buildings." *Earthquake Engineering and Structural Dynamics,* Vol. 25, No. 8, 871–881.

Applied Technology Council (1996), "Seismic evaluation and retrofit of concrete buildings." *Report ATC-40*, Redwood City, California.

Arens, N.C. (2008), "Press-pulse: A general theory of mass extinction?" *Paleobiology*, Vol. 34, 456.

ARSO (2008a), Alerts on extreme weather events for Slovenia. http://www.arso.gov.si/vreme/opozorila

ARSO (2008b), Earthquake related information for Slovenia. http://www.arso.gov.si/potresi/potresna%20nevarnost

Arthur, W.B. (2009), *The Nature of Technology. What It Is and How It Evolves*. New York: Allen Lane.

Arthur, W.B., Durlauf, S.N., Lane, D.A. (1997) (eds.), "The Economy as an Evolving Complex System II." *Proceedings Volume XXVII, Santa Fe Institute Studies in the Sciences of Complexity*. Reading, MA: Addison-Wesley.

Ashby, W.R. (1957), *An Introduction to Cybernetics*. London: Chapman&Hall.

Ashby, W.R. (1960), *Design for a Brain: The Origin of Adaptive Behaviour* (2nd ed.). New York: Wiley&Sons.

Ashby, W.R. (1970), *Einführung in die Kybernetik*. Frankfurt: Suhrkamp (orig. 1956).

Ashby, W.R. (1981), *Mechanisms of Intelligence: Ross Ashby's Writings on Cybernetics*, ed. by R. Conant. Seaside: Intersystems Publications.

Auerbach, F. (1913), "Das Gesetz der Bevölkerungskonzentration." *Petermanns Geographische Mitteilungen*, No. 59, 74–6.

Augoustinos, M.I.W. (2001), *Social Cognition. An Integrated Introduction*. London: SAGE Publications.

Ausburg, T. (2006), *Becoming interdisciplinary: An introduction to interdisciplinary studies*. New York: Kendall-Hunt Publishing.

Ayres, R.U. (2006), "Did the Fifth K-Wave Beginn in 1990–92? Has it been Aborted by Globalization?," in: T.C. Devezas op.cit., 57–71.

Bailey, R. (2007), "Synthesizing Bioterror." *Reason Magazine*. Available at http://reason.com/archives/2007/10/30/synthesizing-bioterror

Bainbridge, W.S., Roco, M.C. (2002), "National Science Foundation. Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science" [on line]. Retrieved May 12, 2009 (http://www.wtec.org/Converging Technologies).

Bainbridge, W.S., Roco, M.C. (2005) (eds.), *Managing Nano-Bio-Info-Cogno innovations: Converging Technologies in Society*. Dordrecht: Springer.

Bainbridge, W.S., Roco, M.C. (2006) (eds.), *Progress in Convergence: Technologies for Human Wellbeing.* New York: New York Academy of Sciences.

Bairoch, P. (1995), *Economics and World History: Myths and Paradoxes*. Chicago: University of Chicago Press.

Bak, P. (1996), *How Nature Works. The Science of Self-Organized Criticality*. New York: Springer.

Baker, M.J. (1994), "Recherches sur l'élaboration de connaissance dans le dialogue [Research on knowledge elaboration in dialogues] Synthèse pour l'habilitation a diriger les recherches." Université Nancy 2.

Ball, P. (2004), *Critical Mass: How One Thing Leads to Another*. New York: Farrar, Straus&Giroux.

Banks, S. (2001), *Ethics and values in social work*. London: Macmillan BASW.

Banse, G. (1996), *Riskoforschung zwischen Disziplinarität und Interdisziplinarität. Von der Illusion der Sicherheit zum Umgang mit Unsicherheit.* Berlin: edition sigma.

Barabási, A.L. (2002), *Linked: How Everything Is Connected to Everything Else and What It Means for Business, Science, and Everyday Life*. New York: Plume Books.

Barabási, A.L. (2002), *Linked: The New Science of Networks*. Cambridge, MA: Perseus.

Barabási, A.L. (2010), *Bursts. The Hidden Pattern behind Everything We Do.* New York: Dutton Books.

Barabási, A.L., Albert, R. (1999), "Emergence of Scaling in Random Networks." *Science*, Vol. 286, 509–512.

Baraldi, C., Corsi, G., Eposito, E. (1997), *GLU: Glossar zu Niklas Luhmanns Theorie sozialer Systeme.* Frankfurt am Main: Suhrkamp.

Barbat, A.H., Rodellar, J., Ryan, E.P., Molinares, N. (1995), "Active control of nonlinear base-isolated buildings." *Journal of Engineering Mechanics*, Vol. 121, No. 6, 676–685.

Barenblatt, G.I. (2003), *Scaling.* Cambridge: Cambridge University Press.

Batty, M. (2006), "Hierarchy in City Systems," in: D. Pumain (ed.), *Hierarchy in Natural and Social Sciences*. *Methodos Series Vol. 3*. Dordrecht: Springer Verlag.

Beck, U. (1986), *Risikogesellschaft. Auf dem Weg in eine andere Moderne.* Frankfurt am Main: Suhrkamp.

Beck, U. (1992), *Risk Society: Towards a new Modernity*. London: Sage Publications.

Beck, U. (1997), *Was ist Globalisierung? Irrtümer des Globalismus – Antworten auf Globalisierung.* Frankfurt am Main: Suhrkamp.

Beck, U. (1998a) (ed.), *Perspektiven der Weltgesellschaft.* Frankfurt am Main: Suhrkamp.

Beck, U. (1998b) (ed.), *Politik der Globalisierung*. Frankfurt am Main: Suhrkamp.

Beck, U. (2000), *World Risk Society*. Cambridge: Polity Press.

Beck, U. (2002), *Macht und Gegenmacht im globalen Zeitalter. Neue weltpolitische Ökonomie*. Frankfurt am Main: Suhrkamp.

Beck, U. (2007), *Weltrisikogesellschaft. Auf der Suche nach der verlorenen Sicherheit*. Frankfurt am Main: Suhrkamp.

Beckert, B. *et al.* (2008), *CONTECS*, available at http://www.contecs.fraunhofer.de/

Beckert, B., Blümel, C., Friedewald, M., Thielmann, A. (2008), "Converging technologies and their impact on the social sciences and humanities (CONTECS)." Appendix A: R&D Trends in Converging Technologies. Available at http://www.contecs.fraunhofer.de/images/files/contecs_report_appendix_a.pdf

Beckmann, M. (1958), "City Hierarchies and the Distribution of City Size." *Economic Development and Cultural Change*, Vol. 6, 243–248.

Beinhocker, E.D. (2006), *The Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics.* Boston: Harvard Business School Press.

Beissinger, M.R. (2002), *Nationalist Mobilization and the Collapse of the Soviet State.* Cambridge: Cambridge University Press.

Bell, D. (1979a), *Die nachindustrielle Gesellschaft*. Reinbek: Rowohlt.

Bell, D. (1979b), *Die Zukunft der westlichen Welt. Kultur und Technologie im Widerstreit.* Frankfurt am Main: Fischer.

Benton, M.J. (2003), *When Life Nearly Died: The Greatest Mass Extinction of All Time.* London: Thames and Hudson.

Bereiter, C. (2002), *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.

Beresford, P. (2005), "Theory and practice of user involvement in research," in: L. Lowes, I. Hulatt, *Involving Service Users in Health and Social Care Research*. Abingdon: Routledge, 6–17.

Bergmann, M., Schramm, E. (2008), "Innovation durch Integration," in: M. Bergmann, E. Schramm (eds.), *Transdisziplinäre Forschung. Integrative Forschungsprozesse verstehen und bewerten.* Frankfurt am Main/New York: Campus Verlag, 7–21.

Bernstein, P.L. (1996), *Against the Gods. The Remarkable Story of Risk*. New York: John Wiley&Sons.

Bhattacharya, U., Yu, X. (2008a), "The Causes and Consequences of Recent Financial Market Bubbles: An Introduction." *The Review of Financial Studies* Vol. 21, 3–10.

Bhattacharya, U., Yu, X. (2008b), *The Review of Financial Studies – Special issue*, Vol. 21.

Blundell-Wignall, A., Atkinson, P., Lee, S.H. (2008), "The Current Financial Crisis: Causes and Policy Issues." *Financial Market Trends*, OECD. http://www.oecd.org/dataoecd/47/26/41942872.pdf

BMASK (2008), "Beschreibung der Würfel der AMS-BMASK Arbeitsmarktdatenbank (AM-DB), Bundesministerium für Arbeit, Soziales und Konsumentenschutz." Wien: BMASK.

Bonß, W. (1995), *Vom Risiko. Unsicherheit und Ungewißheit in der Moderne.* Hamburg: Hamburger Edition.

Borden, W. (1992), "Narrative Perspective in Psychosocial Intervention Following Adverse Life Events." *Social Work*, Vol. 37, 2.

Bostrom, N. (2002), "Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards." *Journal of Evolution and Technology*, Vol. 9, No. 1, 1–30.

Bostrom, N., Cirkovic, M. (2008) (eds.), *Global Catastrophic Risks*. Oxford University Press. Oxford.

Bosworth, K. (1994), "Developing collaborative skills in college students," in: K. Bosworth, J.S. Hamilton (eds.), *Collaborative learning: Underlying processes and effective techniques*. San Francisco, CA: Jossey-Bass, 25–32.

Boutin, P. (2006), "Biowar for Dummies." Available at http://research.lifeboat.com/biowar.htm

Boyer, R. (1990), *The Regulation School: A Critical Introduction*. New York: Columbia University Press.

Boyer, R. (1997), "The Variety and Unequal Performance of Really Existing Markets: Farewell to Doctor Pangloss?," in J. R. Hollingsworth, R. Boyer, (eds.), *Contemporary Capitalism: The Embeddedness of Institutions.* Cambridge and New York: Cambridge University Press, 55–93.

Boyer, R., Saillard, Y. (2002) (eds.), *Regulation Theory. The State of the Art*. London: Routledge.

Boyer, R., Hollingsworth, J.R. (1997), "From National Embeddedness to Spatial and Institutional Nestedness," in: J. R. Hollingsworth, R. Boyer, (eds.), *Contemporary Capitalism: The Embeddedness of Institutions.* Cambridge and New York: Cambridge University Press, 433–484.

Braun, D. (1997), *Die politische Steuerung der Wissenschaft*. Frankfurt am Main/New York: Campus Verlag.

Braun, T., Schubert, A. (2003), "A quantitative view on the coming of age of interdisciplinarity in science 1980–1999." *Scientometrics,* Vol. 58, No. 1, 183–189.

Bredo, E. (1994), "Reconstructing educational psychology: Situated cognition and Deweyian pragmatism." *Educational Psychologist*, Vol. 29, No.1, 23–35.

Bromme, R. (2000), "Beyond one's own perspective: The psychology of cognitive interdisciplinarity," in: P. Weingart, N. Stehr (eds.), *Practicing interdisciplinarity.* Toronto, Canada: University of Toronto Press, 115–133.

Brown, T.L. (2003), *Making Truth: Metaphor in Science*. Urbana, IL and Chicago: University of Illinois Press.

Bruffee, K.A. (1993), *Collaborative learning: Higher education, interdependence, and the authority of knowledge*. Baltimore, MD: John Hopkins University Press.

Bruffee, K.A. (1995), "Sharing our toys: Cooperative learning versus collaborative learning." *Change*, Vol. 28, No.1, 12–18.

Bruffee, K.A. (1999), *Collaborative learning: Higher education, interdependence, and the authority of knowledge* (2nd edition). Baltimore, MD: John Hopkins University Press.

Bruner, J. (1991), "The Narrative Construction of Reality." *Critical Inquiry*, Autumn, Vol. 18, 1–21.

Bruner, J. (1996), *The culture of education*. Cambridge, MA: Harvard University Press.

Brunnermeier, M.K. (2007), "Bubbles," in: L. Blume, S. Durlaug (eds.), *The New Palgrave Dictionary of Economics*. Oxford: Oxford University Press.

Buchanan, M. (2002), *Nexus: Small Worlds and the Groundbreaking Science of Networks.* New York: Norton.

Bude, H. (2008), *Die Ausgeschlossenen. Das Ende vom Traum einer gerechten Gesellschaft*. München: Carl Hanser Verlag.

Bunge, M.A. (1978), *Treatise on Basic Philosophy. Ontology I: The Furniture of the World*. Dordrecht: Reidel.

Bunge, M.A. (1979), *Treatise on Basic Philosophy. Ontology II: A World of Systems.* Dordrecht: Reidel.

Bunge, M.A. (1983a), *Treatise on Basic Philosophy. Epistemology and Methodology I: Exploring the World.* Dordrecht: Reidel.

Bunge, M.A. (1983b), *Treatise on Basic Philosophy. Epistemology and Methodology II: Understanding the World.* Dordrecht: Reidel.

Bunge, M.A. (2003), *Emergence and Convergence: Qualitative Novelty and the Unity of Knowledge*. Toronto: University of Toronto Press.

Burkart, K. (2009), "Boy discovers microbe that eats plastic." *Mother Nature Network*. Available at: http://www.mnn.com/technology/research-innovations/blogs/boy-discovers-microbe-that-eats-plastic

Burns, T.R. (1990), "Models of Social and Market Exchange: Toward a Sociological Theory of Games and Social Behavior," in: C. Calhoun, M.W. Meyer, W.R. Scott, (eds.), *Structures of Power and Constraint: Papers in Honor of Peter M. Blau*. Cambridge: Cambridge University Press, 129–165.

Burns, T.R., Flam, H. (1987), T*he Shaping of Social Organization*. Beverly Hills, CA: Sage.

Burns, T.R., Gomolinska, A. (2000), "The Theory of Socially Embedded Games: The Mathematics of Social Relationships, Rule Complexes, and Action Modalities." *Quality and Quantity: International Journal of Methodology* Vol. 34, 379–406.

Calvin, W.H. (1998), *The Cerebral Code. Thinking a Thought in the Mosaics of Mind*. Cambridge: The MIT Press.

Campbell, J.L., Hollingsworth, J.R., Lindberg, L. (1991) (eds.), *The Governance of the American Economy.* Cambridge and New York: Cambridge University Press.

Caplan, P. (2000) (ed.), *Risk Revisited.* London: Pluto Press.

Carr, E.H. (1990), *What is History?* London: Penguin.

Cascio, J. (2006), "The Open Future: The Reversibility Principle." *Worldchanging.* Available at http://www.worldchanging.com/archives/004174.html

Castells, M. (1996), *The Information Age. Economy, Society and Culture. Vol. I: The Rise of the Network Society.* Oxford: Blackwell Publishers.

Castells, M. (1997), *The Information Age. Economy, Society and Culture, Vol. II: The Power of Identity*. Oxford: Blackwell Publishers.

Castells, M. (1998), *The Information Age. Economy, Society and Culture, Vol. III: End of Millennium.* Oxford: Blackwell Publishers.

Castells, M. (2000), *The Rise of the Network Society*, (second edition). Oxford: Blackwell Publishers.

Casti, J.L. (1986), "Metaphors for Manufacturing: What Could it be Like to be a Manufacturing System?", in: *Technological Forecasting and Social Change,* Vol. 29, 241–270.

Casti, J.L. (1988), "Linear Metabolism-Repair Systems", in: *International Journal of General Systems,* Vol. 14, 143–167.

Casti, J.L. (1989a), *Alternate Realities. Mathematical Models of Nature and Man*. New York: John Wiley&Sons.

Casti, J.L. (1989b), "(M,R) Systems as a Framework for Modelling Structural Change in a Global Industry", in: *Journal of Social and Biological Structures,* Vol. 12, 17–31.

Casti, J.L. (1989c), "Newton, Aristotle and the Modelling of Living Systems," in: J.L. Casti, A. Karlqvist (eds.), *From Newton to Aristotle*. New York: Basic Books, 47–89.

Casti, J.L. (1992), *Reality Rules*, 2 vol. New York: Basic Books.

Casti, J.L. (1994), *Complexification. Explaining a Paradoxical World through the Science of Surprise*. New York: Harper Collins Publishers.

Casti, J.L. (2010), *Mood Matters: From Rising Skirt Lengths to the Collapse of World Powers.* Berlin: Springer.

CEN (2005), European Committee for Standardization, EN-1998-1-Eurocode 8: Design of structures for earthquake resistance. Part 1: General rules, seismic actions and rules for buildings.

Center for Responsible Nanotechnology (2008a), "Benefits of Molecular Manufacturing." Available at http://crnano.org/benefits.htm

Center for Responsible Nanotechnology (2008b), "Dangers of Molecular Manufacturing." Available at http://crnano.org/dangers.htm

Chaitin, G.J. (1987), *Algorithmic Information Theory*. New York and Cambridge: Cambridge University Press.

Chancellor, E. (2000), *Devil Take the Hindmost*. New York: Plume, 386.

Chandler, A.D. (1990), *Scale and Scope: The Dynamics of Industrial Capitalism*. Cambridge, MA: Harvard University Press.

Ching, F.D.K. (2007), *Architecture: Form, Space, and Order* (3rd edition). Hoboken, New Jersey: John Wiley&Sons, Inc.

Chopra, P., Kamma, A. (2006), "Engineering life through Synthetic Biology." *Silico Biology*, Vol. 6, 401–410.

Clark, A. (1998), *Being There. Putting Brain, Body, and World Together.* Cambridge: The MIT Press.

Clark, A. (2001), *Mindware. An Introduction to the Philosophy of Cognitive Science.* New York: Oxford University Press.

Clark, A. (2008), *Supersizing the Mind: Embodiment, Action, and Cognitive Extension.* Oxford: Oxford University Press.

Collyer, S.C., Malecki, G.S. (1998), "Tactical Decision Making Under Stress: History and Overview," in: J.A. Cannon-Bowers, E. Salas (eds.), *Making Decisions Under Stress.* Washington: APA, 3–15.

Cooper, G. (2008), *The Origin of Financial Crisis. Central Banks, Credit Bubbles and the Efficient Market Fallacy.* Petersfield: Harriman House.

Cormier, D. (2008), "Rhizomatic education: Community as curriculum." *Journal of Online Education*, Vol. 4, No. 5, June/July.

Cory, G.A. (2003), *The Consilient Brain: The Bioneurological Basis of Economics, Society, and Politics*. Dordrecht: Kluwer Academic/Plenum Publishers.

Cory, G.A. (2006), "A Behavioral Model of the Dual Motive Approach to Behavioral Economics and Social Exchange." *The Journal of Socio-Economics* 35(4, August), 592–612.

Courtillota, V.E., Renneb, P.R. (2003), "Sur l'âge des trapps basaltiques." *Comptes Rendus Geoscience*, Vol. 335, No.1, 113–140.

Coveney, P., Highfield, R. (1995), *Frontiers of Complexity. The Search for Order in a Chaotic World*. New York: Fawcett Columbine.

Cowan, G.A., Pines, D., Meltzer, D. (1999) (eds.), *Complexity. Metaphors, Models, and Reality.* Cambridge: Perseus Books.

Crick, F.C. (1988), *What Mad Pursuit: A Personal View of Scientific Discovery.* New York: Basic Books.

Crook, C. (1994), *Computers and the collaborative experience of learning.* London: Routledge.

Crouch, C. (2004), "Complementarity and Innovation." Paper prepared for Workshop on Complementarity at Max Plank Institute for Study of Societies, Cologne, Germany, March 26–27.

Crouch, C. (2005), *Capitalist Diversity and Change: Recombinant Governance and Institutional Entrepreneurs.* New York: Oxford University Press.

Crouch, C, Streeck, W., Boyer, R., Amable, B., Hall, P.A., Jackson, G. (2005), "Dialogue on 'Institutional Complementarity and Political Economy.'" *Socio-Economic Review*, Vol. 3, No. 2, 359–382.

Crutzen, P.J., Stoermer, E.F. (2000), "The 'Anthropocene.'" *Global Change Newsletter*, 41, 17–18.

CSI Computer & Structures Inc. (2008), SAP 2000: "Linear and nonlinear static and dynamic analysis and design of three-dimensional structures." Berkeley, California: Computer & Structures, Inc.

Curry, L. (1964), "The random spatial economy." *Association of American Geographers,* Vol. 7, 138–146.

Cvetkovich, G., Lofstedt, R.E. (1999) (eds.), *Social Trust and the Management of Risk.* London: Earthscan.

Dallek, R. (1997), "Johnson, Project Apollo, and the Politics of Space Program Planning," in: R.D. Launius, H.E. McCurdy (eds.), *Spaceflight and the Myth of Presidential Leadership*. Urbana/Chicago: University of Illinois Press, 68–91.

Danish Agency for Science, Technology and Innovation (2008), Thinking across disciplines: Interdisciplinarity in research and education.

De Wever, B., Van Keer, H., Schellens, T., Valcke, M. (2007), "Applying multilevel modeling to content analysis data: Methodological issues in the study of role assignment in asynchronous discussions groups." *Learning and Instruction,* Vol. 17, No. 4, 436–447.

Deleueze, G., Guatarri, F. (2004), *A thousand plateaus: Capitalism and schizophrenia.* London, New York: Continuum. [Book originally published 1980 in French.]

Dembo, R.S., Freeman, A. (1998), *The Rules of Risk.* New York: John Wiley&Sons.

Dervin, B., Foreman-Wernet, L., Lauterbach, E. (2003) (eds.), *Sense-making Methodology Reader: Selected Writings of Brenda Dervin*. Cresskill, NJ: Hampton Press.

Dessler, A., Parson, E.A. (2010), *The Science and Politics of Global Climate Change* (second edition). Cambridge: Cambridge University Press.

Devezas, T.C. (2006) (ed.), *Kondratieff Waves, Warfare and World Security*. Amsterdam: IOS Press.

Diamond, J. (2005), *Kollaps. Warum Gesellschaften überleben oder untergehen.* Frankfurt am Main: S. Fischer.

Dillenbourg, P. (1999), "What do you mean by 'collaborative learning?,'" in: P. Dillenbourg (ed.), *Collaborative learning: Cognitive and computational approaches*. Amsterdam: Pergamon, Elsevier Science, 1–16.

Dilthey, W. (1881), *Einleitung in die Geisteswissenschaften: Versuch einer Grundlegung für das Studium der Gesellschaft und der Geschichte*. Leipzig: Duncker & Humblot.

Dörre, K., Lesenich, S., Rosa, H. (2009), *Soziologie – Kapitalismus – Kritik. Eine Debatte*. Frankfurt am Main: Suhrkamp.

Dolšek, M., Fajfar, P. (2008), "The effect of masonry infills on the seismic response of a four-storey reinforced concrete frame – a deterministic assessment." *Engineering Structures,* Vol. 30, No. 7, 1991–2001.

Dosi, G. (1982), "Technological paradigms and technological trajectories. A suggested interpretation of the determinants and directions of technical change." *Research Policy. A journal devoted to research policy, research management and planning*, Vol. 11, 147–162.

Douglas, M. (1992), *Risk and Blame. Essays in Cultural Theory.* London: Routledge.

Dowd, K. (2006), *Measuring Market Risk* (second edition), Chichester: John Wiley&Sons.

Drabek, T. (1986), *Human System Responses to Disaster: An Inventory of Sociological Findings.* New York: Springer-Verlag.

Drexler, E.K. (1992), *Nanosystems: Molecular Machinery, Manufacturing, and Computation.* London: Wiley&Sons.

Drucker, P.F. (1993), *Die postkapitalistische Gesellschaft.* Düsseldorf: Econ-Verlag.

Durham, W.H. (1991), *Coevolution. Genes, Culture, and Human Diversity.* Stanford: Stanford University Press.

Dynes, R.R. (1974), *Organized Behavior in Disaster*. Newark: DRC.

Edelman, G.M. (1974), "The Problem of Molecular Recognition by a Selective System," in: F.J. Ayala, Th. Dobzhansky, *Studies in the Philosophy of Biology: Reduction and Related Problems*. London: Macmillan, 45–56.

Edelman, G.M. (1987), *Neural Darwinism: The Theory of Neuronal Group Selection*. New York: Basic Books.

Edelman, G.M. (1988), *Topobiology: An Introduction to Molecular Embryology.* New York: Basic Books.

Edelman, G.M. (1989), *The Remembered Present. A Biological Theory of Consciousness*. New York: Basic Books.

Edelman, G.M. (1992), *Bright Air, Brilliant Fire. On the Matter of the Mind*. New York: Basic Books.

Edelman, G.M., Tononi, G. (2000) (eds.), *A Universe of Consciousness. How Matter Becomes Imagination*. New York: Basic Books.

Edelman, G.M., Changeux, J.P. (2001) (eds.), *Brain*. New Brunswick: Transaction Publishers.

Edelman, G.M., Gally, J.A. (2001), "Degeneracy and Complexity in Biological Systems." *Proceedings of the National Academy of Sciences USA 98*(24), 13763–13768.

Edelman, P.D., McFarland, D.C., Mironov, V.A., Matheny, J.G. (2005), "In Vitro Cultured Meat Production." *Tissue Engineering,* Vol. 11, Nos. 5–6), 659–662.

Edler, J., Kuhlman, S. (2008), "Formative Evaluation in reflexiver Forschungspolitik," in: M. Bergmann, E. Schramm (eds.), *Transdisziplinäre Forschung. Integrative Forschungsprozesse verstehen und bewerten.* Frankfurt am Main, New York: Campus Verlag, 203–231.

Eggert, H., Kauschke, W. (2002), *Structural Bearings.* Berlin: Ernst&Sohn Verlag.

Embrechts, P., Klüppelberg, C., Mikosch, T. (1996), *Modelling Extremal Events for Finance and Insurance.* Berlin: Springer-Verlag.

Engestroem, Y. (1987), *Learning by expanding: An activity-theoretical approach to developmental research.* Helsinki, Finland: Orienta-Konsultit Oy.

Engestroem, Y. (2001), "Expansive learning at work: Toward an activity theoretical reconceptualisation." *Journal of Education and Work*, Vol. 14, No.1, 133–156.

Engestroem, Y. (2005, orig. publ. 1991), "Non scolae sed vitae discimus: Toward overcoming the encapsulaton of school learning," in: H. Daniels (ed.), *An introduction to Vygotsky* (2nd ed.), Abingdon, Oxon: Routledge, 157–176.

Ertel, I.D., Morse, M.L. (1969–1978) (eds.), *The Apollo Spacecraft. A Chronology*, 4 Vols. Washington: National Aeronautics And Space Administration.

Esposito, E. (1996), "Observing Interpretation: A Sociological View of Hermeneutics." *MLN 3,* (German Issue), 593–619.

Etzioni, A. (1988), *The Moral Dimension: Toward a New Economics.* New York: Free Press.

Etzkowitz, H. (1996), "Losing our bearings: the science policy crisis in post-Cold War Eastern Europe, former Soviet Union and USA." *Science and Public Policy,* Vol. 23, No. 1, 13–26.

Eurofund (2010), Flexicurity, http://www.eurofound.europa.eu/areas/industrial-relations/dictionary/definitions/FLEXICURITY.htm

Fajfar, P. (2000), "A nonlinear analysis method for performance-based seismic design." *Earthquake Spectra,* Vol. 16, No. 3, 573–592.

Fajfar, P., Marušić, D., Peruš, I. (2005), "Torsional effects in the pushover-based seismic analysis of buildings." *Journal of Earthquake Engineering*, Vol. 9, No. 6, 831–854.

Fastovsky, D.E., Sheehan, P.M. (2005), "The extinction of the dinosaurs in North America." *Geological Society of America Today,* Vol. 15, No. 3, 4–10.

Fay, D., Borrill, C., Amir, Z., Haward, R., West, M.A. (2006), "Getting the most out of multidisciplinary teams: A multi-sample study of team innovation in health care." *Journal of Occupational and Organizational Psychology,* Vol. 79, No.4, 553–567.

Feldman, M.W. (1988), "Evolutionary Theory of Genotypes and Phenotypes: Towards a Mathematical Synthesis," in: D. Pines (ed.), *Emerging Syntheses in Science*. Redwood City: Addison Wesley, 43–52.

Felgentreff, C., Glade, T. (2007) (eds.), *Naturrisiken und Sozialkatastrophen*. Heidelberg: Spektrum Akademischer Verlag.

Fischer, K., Reiner, C., Staritz, C. (2010) (eds.), *Globale Güterketten: Weltweite Arbeitsteilung und ungleiche Entwicklung.* Wien: Promedia Verlag.

Fischhoff, B., Lichtenstein, S., Slovic, P., Derby, S.L., Keeny, R. (1981), *Acceptable Risk.* Cambridge: Cambridge University Press.

Fisher, E., Mahajan, R., Mitcham, C. (2006), "Midstream Modulation of Technology: Governance from Within." *Bulletin of Science, Technology&Society,* Vol. 26, 485–96.

Fiske, S.T., Taylor, S.E. (1991), *Social Cognition (*second edition). New York: McGraw-Hill, Inc.

Flaker, V. (2003), *Oris metod socialnega dela: uvod v katalog nalog centrov za socialno delo*. Ljubljana: Skupnost centrov za socialno delo Slovenije.

Flaker, V. (2006), "Social work as a science of doing: In the praise of a minor profession," in: V. Flaker, T. Schmid (eds.), *Von der Idee zur Forschungsarbeit: Forschen in Sozialarbeit und Sozialwissenschaft.* Vienna: Böhlau, 55–78.

Flaker, V., Cuder, M., Nagode, M., Podbevšek, K., Podgornik, N., Rode, N., Škerjanc, J., Zidar, R. (2007), "Vzpostavljanje osebnih paketov storitev. Poročilo o pilotskem projektu ‚Individualiziranje financiranja storitev socialnega varstva." Fakulteta za socialno delo Univerze v Ljubljani.

Fleming, L. (2004), "Perfecting Cross-Pollination." *Harvard Business Review,* Vol. 82, No. 9, 22–24.

Florida, R. (2002), *The Rise of the Creative Class. And How It's Transforming Work, Leisure, Community and Everyday Life*. New York: Basic Books.

Florida, R. (2005), *Cities and the Creative Class.* New York: Routledge.

Foerster, H. v. (2003), *Understanding Understanding. Essays on Cybernetics and Cognition*. New York: Springer.

Foerster, H.v., Mora, P.M., Amiot, L.W. (1961), "Population Density and Growth," in: *Science 133*, 1931–1937.

Foerster, H.v., Müller, K.H. (2003), "Action without Utility. An Immodest Proposal for the Cognitive Foundation of Behavior," in: *Cybernetics and Human Knowing 3–4*, Vol. 10, 27–50.

Frampton, K. (1995), (edited by Cava, J.), “Studies in tectonic culture: The poetics of construction in nineteenth and twentieth century architecture.” Cambridge: Massachusetts institute of technology, The MIT Press.

Freeman, C. (1974), *The Economics of Industrial Innovation*. Harmondsworth: Penguin.

Freeman, C. (1983) (ed.), *Long Waves in the World Economy.* London: Butterworths.

Freeman, C. (1987), *Technology and Economic Performance. Lessons from Japan*. London: Frances Pinter.

Freeman, C., Clark, J., Soete, L. (1982), *Unemployment and Technical Innovation. A Study of Long Waves and Economic Development.* London: Frances Pinter.

Freeman, C., Soete, L. (1994), *Work for All or Mass Unemployment. Computerised Technical Change into the 21st Century.* London: Frances Pinter.

Freeman, C., Soete, L. (1997), *The Economics of Industrial Innovation*, (third edition). London: Frances Pinter.

Freire, P. (1996), *Pedagogy of the oppressed.* Harmondsworth: Penguin books.

Freitas R.A. Jr., Merkle, R.C. (2004), *Kinematic Self-Replicating Machines.* Georgetown, TX: Landes Bioscience.

French, A.P., Kennedy, P.J. (1985) (eds.), *Niels Bohr: A Centenary Volume.* Cambridge: Harvard University Press.

Friedman, E. (1982) (ed.) , *Ascent and Decline in the World-System*. Beverly Hills: Sage Publications.

Froebel, F., Heinrichs, J., Kreye, O. (1977), *Die neue internationale Arbeitsteilung*. Reinbek: Rowohlt.

Froebel, F., Heinrichs, J., Kreye, O. (1981) (eds.), *Krisen in der kapitalistischen Weltökonomie*. Reinbek: Rowohlt.

Froebel, F., Heinrichs, J., Kreye, O. (1986), *Umbruch in der Weltwirtschaft. Die globale Strategie: Verbilligung der Arbeitskraft / Flexibilisierung der Arbeit / Neue Technologien.* Reinbek: Rowohlt.

Fukuyama, F. (2002), *Our Posthuman Future: Consequences of the Biotechnology Revolution*. New York: Farrar, Straus and Giroux.

Fuller, R.B. (1963), “Preview of Building” (transcript of a lecture given on April 1, 1949, at the University of Michigan, Ann Arbor, Mid-Century Conference on Housing), *Ideas and Integrities: A Spontaneous Autobiographical Disclosure*, edited by R.W. Marks. Englewood Cliffs, NJ: Prentice-Hall, 199–224.

Fuller, S.R. (2008), "Research Trajectories and Institutional Settings of New Converging Technologies. Knowledge NBIC." *Knowledge Politics and New Converging Technologies: A Social Science Perspective.* CIT6 No. 028334 [online]. Retrieved May 15, 2009 (http://www.converging-technologies.org/outputs.html).

Fuller, S.R., Aldag, R.J. (1997), "Challenging the Mindguards: Moving Small Group Analysis beyond Groupthink," in: P. 't Hart, E. Stern, B. Sundelius (eds.), *Beyond Groupthink.* Ann Arbor: The University of Michigan Press, 55–93.

Galbraith, J.K. (1997), *The Great Crash 1929*. Boston: Houghton Mifflin, 206.

Galbraith, J.K. (1998), *Die solidarische Gesellschaft. Plädoyer für eine moderne soziale Marktwirtschaft*. Hamburg: Hoffmann und Campe.

Garber, P. M. (1989), "Tulipmania." *Journal of Political Economy*, Vol. 97/3, 535–560.

Garber, P. M. (2000), *Famous First Bubbles*. Cambridge (MA), London: The MIT Press, 163.

Gardner, D. (2009), *Risk. The Science and Politics of Fear*. London: Virgin Books.

Garreau, J. (2005), *Radical Evolution: The Promise and Peril of Enhancing Our Minds, Our Bodies—and What It Means to Be Human*. New York: Doubleday&Company.

Garton, A.F. (1992), *Social interaction and the development of language and cognition*. Hove: LEA Publishers.

Gershuny, J. (1983), *Social Innovation and the Division of Labour*. Oxford: Oxford University Press.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M. (1994), *The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies*. London: Sage Publications.

Giddens, A. (1984), *The Constitution of Society: Outline of the Theory of Structuration.* Berkeley: University of California Press.

Giddens, A. (1991), *Modernity and Self-Identity. Self and Society in the Late Modern Age*. Cambridge: Polity Press.

Giddens, A. (2000), *The Third Way and Its Critics*. Cambridge: Polity Press.

Giddens, A. (2009), *Politics of Climate Change*. Cambridge: Polity Press.

Gibrat, R. (1931), *Les Inégalités Économiques.* Paris: Recueil Sirey.

Gigerenzer, G. (2000), *Adaptive Thinking.* Oxford: Oxford University Press.

Gigerenzer, G. (2002), *Reckoning with Risk.* London: Allen Lane The Penguin Press.

Gigerenzer, G., Selten, R. (2001), "Rethinking Rationality," in: G. Gigerenzer, R. Selten (eds.), *Bounded Rationality: The Adaptive Toolbox.* Cambridge: MIT, 1–12.

Gilbert, C. (1998), "Studying Disaster," in: E.L. Quarantelli (ed.), *What is a Disaster?* London: Routledge, 11–18.

Gillespie, D. F. (1991), "Coordinating Community Resources," in: T.E. Drabek, G.J. Hoetmer (ed.), *Emergency Management: Principles and Practice for Local Government.* Washington, DC.: International City Management Assocication, 55–78.

Gisler, M., Sornette, D. (2009), "Exuberant Innovations: The Apollo Program." *Society,* Vol. 46, 55–68.

Gisler, M., Sornette, D., Woodard, R. (2010), "Exuberant innovation: The Human Genome Project." *Submitted* to *Research Policy*.

Gladwell, M. (2000), *The Tipping Point: How Little Things Can Make a Big Difference.* Boston: Little, Brown.

Glanville, R. (1990), "The Self and the Other. The Purpose of Distinction," in: R. Trappl (ed.), *Cybernetics and Systems '90. The Proceedings of the European Meeting on Cybernetics and Systems Research.* Singapore: World Scientific; this text has been quoted from the pdf-File at http://www.univie.ac.at/ constructivism/ people/glanville/cv.html #publications, 1–8

Glanville, R. (2009), *The Black Box Vol III. 39 Steps.* Vienna: edition echoraum.

Goffman, E. (1974), *Frame Analysis: An Essay on the Organization of Experience.* New York, NY: Harper&Row.

Goldgar, A. (2007), *Tulipmania. Money, honor, and knowledge in the Dutch golden age*. Chicago: University of Chicago Press.

Goldman-Segall, R., Maxwell, J. (2003), "Computers, the Internet, and new media for learning," in: W.M. Reynolds, G.E. Miller (eds.), *Handbook of psychology: Educational psychology*, Vol. 7, 397–427, New York: John Wiley&Sons.

Goldstein, A. (2006), "I, Nanobot." Available at https://lifeboat.com/ex/i.nanobot

Golnaraghi, M. (2008), "WMO Natural Disaster Prevention and Mitigation Programme, 1980–2005." (www.knmi.nl/samenw/geoss/wmo/CIMO-XIV/ppt/07(2)_Golnaraghi.ppt).

Goodwin, B. (1995), *How the Leopard Changed Its Spots. The Evolution of Complexity.* New York: Charles Scribner's Sons.

Graham, J.D., Wiener, J.B. (1995) (eds.), *Risk versus Risk. Tradeoffs in Protecting Health and the Environment.* Cambridge: Harvard University Press.

Graham-Rowe, D. (2006), "Better bugs for oil spills." *MIT Technology Review*. Available at http://www.technologyreview.com/read_article.aspx?id=17230&ch=biotech&pg=1.

Grebenc, V. (2006), "Needs assessment in community: What communities can tell us," in: V. Flaker, T. Schmid (eds.), *Von der Idee zur Forschungsarbeit: Forschen in Sozialarbeit und Sozialwissenschaft.* Vienna: Böhlau, 167–189.

Green Paper (2007), "The European Research Area: New Perspectives." Brussels, 4.4.2007, COM(2007) 161 final.

Greeno, J.G. (1995), "Understanding concepts in activity," in: C.A. Weaver III, S. Mannes, C.R. Fletcher (eds.), *Discourse comprehension: Essays in honor of Walter Kintsch*. Hillsdale, NJ: Lawrence Erlbaum Associates, 65–96.

Greeno, J.G. (2006), "Learning in activity," in: R.K. Sawyer (ed.), *The Cambridge handbook of the learning sciences.* Cambridge, England: Cambridge University Press, 79–96.

Grew, R. (1978) (ed.)*, Crises of Political Development in Europe and the United States*. Studies in Political Development 9. Princeton, NJ: Princeton University Press.

Grice, H.P. (1975), "Logic and conversation," in: P. Cole, J.I. Morgan (eds.), *Syntax and semantics 3: Speech acts.* London: Academic Press, 41–58.

Gross, D. (2007), *Pop! Why Bubbles Are Great For The Economy.* New York: Collins, 232.

Guerin-Pace, F. (1995), "Rank-Size Distribution and the Process of Urban Growth." *Urban Studies,* Vol. 32, No.3, 551–562.

Guggenheim, M. (2006), "Undisciplined research: the proceduralisation of quality control in transdisciplinary projects." *Science and Public Policy,* Vol. 33, No. 6, 411–421.

Gunderson, L.H., Holling, C.S. (2002) (eds.), *Panarchy. Understanding Transformations in Human and Natural Systems.* Washington: Island Press.

Gunderson, L.H., Allen, C.R., Holling, C.S. (2010) (eds.), *Foundations of Ecological Resilience*. Washington: Island Press.

Haag, G. (1989), *Dynamic Decision Theory: Application to Urban and Regional Topics*. Dordrecht: Kluwer Academic Publishers.

Haag, G. (1994), "The Rank-Size Distribution of Settlements as a Dynamic Multifractal Phenomenon." *Chaos, Solitons and Fractals*, Vol. 4, No.4, 519–534.

Haag, G., Weidlich, W. (1984), "A Stochastic Theory of Interregional Migration." *Geographical Analysis*, Vol. 16, 331–357.

Haag, G., Munz, M., Pumain, D., Sanders, L., Saint-Julien, Th. (1992), "Interurban migration and the dynamics of a system of cities: Part 1. The stochastic framework with an application to the French urban system." *Environment and Planning A,* 24, 181–198.

Haag, G., Müller, K.H. (1992a), "Employment and Education as Non-Linear Network Populations, Part I: Theory, Categorization and Methodology," in: G. Haag, U. Mueller, K.G. Troitzsch (eds.), *Economic Evolution and Demographic Change. Formal Models in Social Sciences.* Heidelberg: Springer-Verlag, 349–376.

Haag, G., Müller, K.H. (1992b), "Employment and Education as Non-Linear Network Populations, Part II: Model Structures, Estimations, and Scenarios," in: G. Haag, U. Mueller, K.G. Troitzsch (eds.), *Economic Evolution and Demographic Change. Formal Models in Social Sciences.* Heidelberg: Springer-Verlag, 377–409.

Haag, G., Max, H. (1995), "Rank-Size Distribution of Settlement Systems: A stable attractor in urban growth." *Papers in Regional Science*, Vol.74, No.3, 243–258.

Habermas, J. (1968), *Erkenntnis und Interesse*. Frankfurt am Main: Suhrkamp.

Habermas, J. (1981), *Theorie kommunikativen Handelns*. 2 Vol. Frankfurt am Main: Suhrkamp.

Habermas, J. (1984), *Vorstudien und Ergänzungen zur Theorie des kommunikativen Handelns*. Frankfurt am Main: Suhrkamp.

Hage, J., Alter, C. (1997), "A Typology of Interorganizational Relationships and Networks," in: J.R. Hollingsworth, R. Boyer, (eds.), *Contemporary Capitalism: The Embeddedness of Institutions*. Cambridge and New York: Cambridge University Press, 94–126.

Hager, T. (1995), *Force of Nature: The Life of Linus Pauling*. New York: Simon& Schuster.

Haken, H. (1977), *Synergetics. An Introduction – Nonequilibrium Phase Transitions and Self-Organization in Physics, Chemistry and Biology*. Berlin: Springer.

Haken, H. (1980) (ed.), *Dynamics of Synergetic Systems*. Berlin: Springer.

Haken, H. (1982), *Synergetik. Eine Einführung*. Berlin: Springer.

Haken, H. (1983), *Advanced Synergetics. Instability Hierarchies of Self-Organizing Systems and Devices*. Berlin: Springer.

Hall, P.A. (1986), *Governing the Economy: The Politics of State Intervention in Britain and France*. New York: Oxford University Press.

Hanneman, R., Hollingsworth, J.R. (1984), "Modeling and Simulation in Historical Inquiry." *Historical Methods* 17 (Summer), 150–163.

Hanson, R. (1998), "The Great Filter—Are We Almost Past It?" Available at http://hanson.gmu.edu/greatfilter.html.

Harrell, E.B., Zakour, M.J. (2000), "Including Informal Organizations in Disaster Planning: Development of a Range-of-Type Measure." *Tulane Studies in Social Welfare*, Vol. 21, 61–83.

Hausman, D.M. (2001), "Explanation and Diagnosis in Economics." *Revue Internationale De Philosophie*, Vol. 55, 311–26. http://philosophy.wisc.edu/hausman/papers/Explanation-and-Diagnosis.pdf

Heath, R. (1998), *Crisis Management for managers and executives*. London: Financial Times Management.

Hebb, D. O. (1949), *The Organization of Behavior*. New York: John Wiley& Sons.

Hecht, J. (2002), "Methane prime suspect for greatest mass extinction." *New Scientist*. Available at http://www.newscientist.com/article.ns?id=dn2088

Hedström. P., Swedberg, R. (1998) (eds.), *Social Mechanisms. An Analytical Approach to Social Theory*. Cambridge: Cambridge University Press.

Hegel, G.W.F. (1956), *The Philosophy of History*. New York: Dover Publications.

Hempel, C.G. (1965), *Aspects of Scientific Explanation and other Essays in the Philosophy of Science*. New York: Free Press.

Henley, C.L. (1993), "Statics of a 'self-organized' percolation model." *Physical Review Letters,* Vol. 71, Issue 17, October 25, 2741–2744.

Herath, S., Lešnik, B. (2008), "The many faces of Internally Displaced Persons: Implications for the development of social work in Sri Lanka," in: S. Ramon (ed.), *Social Work in the Context of Political Conflict*. Birmingham: Venture Press.

Herath, S.M.K. (2008), "Skrb za stare na Šrilanki: Perspektiva spola." *Socialno delo*, Vol. 47, 3–6, 163–176.

Herper, M. (2006), Regenesis. Forbes.com. Available at http://www.forbes.com/2006/04/15/synthetic-biology-evolution_cx_mh_06blank_0418life.html

Herrigel, G. (1996), *Industrial Constructions: The Sources of German Industrial Power.* Cambridge and New York: Cambridge University Press.

Hicks, D. (1996), "Contextual inquiries: A discourse-oriented study of classroom learning," in: D. Hicks (ed.), *Discourse, learning and schooling.* New York: Cambridge University Press,104–141.

Hirsch, G., Hoffman-Riem, H., Biber-Klemm, S., Joye, D., Pohl, C.,Wiesmann, U., Zemp, E. (2008) (eds.), *Handbook of Transdisciplinary Research*. Dordrecht: Springer Verlag.

Hmelo-Silver, C.E. (2003), "Analyzing collaborative knowledge construction: Multiple methods for integrated understanding." *Computers and Education,* Vol. 41, No. 4, 397–420.

Hmelo-Silver, C.E., Bromme, R. (2007), "Coding discussions and discussing coding: Research on collaborative learning in computer-supported environments." *Learning and Instruction*, Vol. 17, No., 460–464.

Hodgson, G.M. (1999), *Evolution and Institutions: On Evolutionary Economics and the Evolution of Economics.* Cheltenham, UK: Edward Elgar Publishing Ltd.

Hoffmann, W.G. (1965), *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts*. Berlin: de Gruyter.

Hofstadter, D.R (1982), *Gödel-Escher-Bach. An Eternal Golden Braid* (4th edition), Harmondsworth: Penguin.

Holland, J.H. (1986), "Escaping Brittleness: The Possibilities of General-Purpose Learning Algorithms Applied to Parallel Rule-Based Systems," in: R.S. Michalski *et al.* (1986) (eds.), *Machine Learning. An Artificial Intelligence Approach*, Vol. II. Los Altos: Morgan Kaufmann Publishers, 593–623.

Holland, J.H. (1988), "The Global Economy as an Adaptive Process," in: P.W. Anderson, K.J. Arrow, D. Pines (1988) (eds.), *The Economy as an Evolving Complex System. The Proceedings of the Evolutionary Paths of the Global Economy Workshop, Held September, 1987 in Santa Fe, New Mexico*. Redwood City: Addison-Wesley, 117–124.

Holland, J.H. (1992), *Adaptation in Natural and Artificial Systems. An Introductory Analysis with Applications to Biology, Control, and Artificial Intelligence.* Cambridge: MIT Press.

Holland, J.H. (1995), *Hidden Order. How Adaptation Builds Complexity*. Reading: Addison-Wesley.

Holland, J.H. (1998), *Emergence. From Chaos to Order*. Reading: Perseus Books.

Holland, J.H., Holyoak, K.J., Nisbett, R.E., Thagard, P.R. (1989), *Induction. Processes of Inference, Learning, and Discovery.* Cambridge: The MIT Press.

Holling, C.S. (1978) (ed.), *Adaptive Environmental Assessment and Management*. Cakdwell: The Blackburn Press.

Hollingsworth, J.R. (1971) (ed.), *Nation and State Building in America: Comparative Historical Perspectives.* Boston: Little, Brown and Company.

Hollingsworth, J.R. (1978), "The United States," in: R. Grew (ed.), *Crises of Political Development in Europe and the United States.* Studies in Political Development 9. Princeton, NJ: Princeton University Press, 163–195.

Hollingsworth, J.R. (1982), "The Political-Structural Basis for Economic Performance." *The Annals of the American Academy of Political and Social Science* 459 (January), 28–45.

Hollingsworth, J.R. (1998) "New Perspectives on the Spatial Dimensions of Economic Coordination: Tensions between Globalization and Social Systems of Production." *Review of International Political Economy*, Vol. 5 (3, Autumn), 482–507.

Hollingsworth, J.R. (2004), "Institutionalizing Excellence in Biomedical Research: The Case of Rockefeller University," in: D.H. Stapleton (ed.), *Creating a Tradition of Biomedical Research: The Rockefeller University Centennial History Conference.* New York: Rockefeller University Press, 17–63.

Hollingsworth, J.R. (2006), "Advancing Our Understanding of Capitalism with Niels Bohr's Thinking about Complementarity," in: G. Wood, Ph. James (eds.), *Institutions, Production and Working Life*. Oxford: Oxford University Press, 62–82.

Hollingsworth, J.R. (2006), *Fostering Scientific Excellence. Organizations, Institutions, and Major Discoveries in Biomedical Science.* New York: Cambridge University Press.

Hollingsworth, J.R., Hollingsworth, E.J. (2000a), "Major Discoveries and Biomedical Research Organizations: Perspectives on Interdisciplinarity, Nurturing Leadership, and Integrated Structure and Cultures," in: P. Weingart, N. Stehr (eds.), *Practising Interdisciplinarity.* Toronto: University of Toronto Press, 215–244.

Hollingsworth, J. R., Hollingsworth, E. J. (2000b), "Radikale Innovationen und Forschungsorganisation: Eine Annäherung", in: *Österreichische Zeitschrift für Geschichtswissenschaften* 1, 31–6.

Hollingsworth, J.R., Schmitter, P., Streeck, W. (1994) (eds.), *Governing Capitalist Economies: Performance and Control of Economic Sector*s. New York: Oxford University Press.

Hollingsworth, J.R., Boyer, R. (1997) (eds.), *Contemporary Capitalism: The Em-beddedness of Institutions.* Cambridge and New York: Cambridge University Press.

Hollingsworth, J.R., Hollingsworth, E.J. (2000), "Major Discoveries and Biomedical Research Organizations: Perspectives on Interdisciplinarity, Nurturing Leadership, and Integrated Structure and Cultures," in: P. Weingart, N. Stehr (eds.), *Practising Interdisciplinarity.* Toronto: University of Toronto Press, 215–244.

Hollingsworth, J.R., Müller, K.H., Hollingsworth, E.J. (2002), *Advancing Socio-Economics: An Institutionalist Perspective.* Lanham, MD: Rowman& Littlefield Publishers.

Hollingsworth, J.R., Müller, K.H., Svetlik, I., Toš, N. (2007), "A Proposal for the Establishment of a New Type of Research Institute for the Twenty-First Century." Unpublished manuscript. Ljubljana: University of Ljubljana.

Hollingsworth, J.R., Hage,J., Hollingsworth, E.J. (2007), *Fostering Scientific Excellence: Organizations, Institutions, and Major Discoveries in Biomedical Science.* New York: Cambridge University Press, (forthcoming).

Hollingsworth, J.R., Müller, K.H. (2008), "Transforming Socio-Economics with a New Epistemology." *Socio-Economic Review* Vol. 3, No. 6, 395–426.

Hollingsworth, J.R., Müller, K.H., Hollingsworth, E.J. (2008), "The End of the Science Superpowers." *Nature* 454, 412–413.

Hollingsworth, J.R., Müller, K.H., Hollingsworth, E.J., Gear, D.M. (2008), "Socio-economics and a New Scientific Paradigm," in: H. Flam, M. Carson (eds.), *Rule Systems Theory. Applications and Explorations*. Frankfurt am Main: Peter Lang Verlag, 39–56.

Hood, L. (2003), "Systems Biology: Integrating Technology, Biology, and Computation." *Mechanisms of Ageing and Development*, Vol. 124, 9–16.

Hopkins, T.K., Wallerstein, I. (1980) (eds.), *Processes of the World System*. Beverly Hills: Sage Publications.

Horn, R.E. (2001), "What we know—and what we don't know—about ecological risks of genetically engineered plants." Available at http://www.macrovu.com/image/GMimg/infoMrlUnknwnsInGMv7.pdf

http://bbf.openwetware.org. BioBricks Foundation (2009).

http://gspp.berkeley.edu/iths/Maurer%20et%20al._April%203.pdf

http://www.hydrate.tesaf.unipd.it/Movies/MovieSlo2.htm (The event of Sept. 18, 2007 in Slovenia: movies)

http://www.kew.org/science-conservation/conservation-climate-change/millennium-seed-bank/index.htm. (2009). Kew's Millennium Seed Bank Partnership.

http://www.nytimes.com/2005/10/17/opinion/17kurzweiljoy.html?_r=1

Hughes, J.J. (2007), "Global Technology Regulation and Potentially-Apocalyptic Technological Threats," in: F. Allhoff, P. Lin, J. Moor, J. Weckert (eds.), *Nanoethics: The Ethical and Social Implications of Nanotechnology*. London: Wiley-Interscience.

Hughes, J.J. (2008), "Millenial tendencies in responses to apocalyptic threats," in: N. Bostrom, M. Ćirković (eds.), *Global Catastrophic Risks*. Oxford: Oxford University Press, 73–86.

Hutchins, E. (1991), "The social organization of distributed cognition," in: L.B. Resnik, J.M. Levine, S.D. Teasley (eds.), *Perspectives on socially shared cognition*. Washington, DC: American Psychological Association.

Ibrahim, R.A. (2008), "Recent advances in nonlinear passive vibration isolators." *Journal of Sound and Vibration*, Vol. 314, No. 3–5, 371–452.

ILO (2008a), ILO warns of cuts in real wages for millions of workers in 2009 – Declines follow decade in which wages failed to keep pace with economic growth. Press release, 25 November 2008, ILO News. http://www.ilo.org/global/About_the_ILO/Media_and_public_information/Press_releases/lang--en/WCMS_100783/index.htm

ILO (2008b), World of Work Report 2008—Global income inequality gap is vast and growing. Press release, 16 October 2008, ILO News. http://www.ilo.org/global/About_the_ILO/Media_and_public_information/Press_releases/lang--en/WCMS_099406/index.htm

ILO (2009a), ILO and the global job crisis. http://www.ilo.org/global/Themes/lang--en/WCMS_101130/index.htm

ILO (2009b), Unemployment, working poor and vulnerable employment to increase dramatically due to global economic crisis. Press release, 28 January 2009, ILO News. http://www.ilo.org/global/About_the_ILO/Media_and_public_information/Press_releases/lang--en/WCMS_101462/index.htm

IMF (2009), Lessons from the Crisis: IMF Urges Rethink Of How To Manage Global Systemic Risk. IMF Survey Magazine: Policy. IMF Survey online, March 6, 2009. http://www.imf.org/external/pubs/ft/survey/so/2009/POL030609A.htm

Institute of Policy Studies (2007), Report on Disaster Management Policy and Practice in Sri Lanka: Sharing Lessons among Government, Civil Society and Private Sector/ Institute of Policy Studies and Oxfam America. Colombo: Institute of Policy Studies.

Interdisciplinarity (2009, September 20), in Wikipedia, The Free Encyclopedia. Retrieved 06:00, September 20, 2009, from http://en.wikipedia.org/w/index.php?title=Interdisciplinarity&oldid=315050235

Inselberg, A. (2009), *Parallel Coordinates. Visual Multidimensional Geometry and Its Applications*. Dordrecht: Springer.

Isaković, T., Fischinger, M., Zevnik, J. (2006), "Response of structures isolated with elastomeric bearings subjected to low-intensity earthquakes." *International Journal for Engineering Modelling*, Vol. 19, Nos. 1–4, 55–61.

Jackson, J. (2006), "Fatal Attraction: Living with Earthquakes, the Growth of Villages into megacities, and Earthquake Vulnerability in the Modern World." *Philosophical Transactions of the Royal Society* A. 364, 1911–1925.

Jahn, T. (2008), "Transdisziplinarität in der Forschungspraxis," in: M. Bergmann, E. Schramm (eds.), *Transdisziplinäre Forschung. Integrative Forschungsprozesse verstehen und bewerten.* Frankfurt am Main, New York: Campus Verlag, 21–37.

Jangid, R.S., Datta, T.K. (1994), "Nonlinear response of torsionally coupled base isolated structure." *Journal of Structural Engineering,* Vol. 120, No. 1, 1–22.

Janis, I.L. (1971), "Groupthink." *Psychology Today*, Vol. 5 (November), 43–46, 74–76.

Jantsch, E. (1972), *Technological Planning and Social Futures.* London: Frances Pinter.

Jensen, H.J. (1998), *Self-Organized Criticality. Emergent Complex Behavior in Physical and Biological Systems.* Cambridge: Cambridge University Press.

Jeraj, J. (1998), *Preparedness of population in Ljubljana municipality area to disaster.* Ljubljana: Faculty for Social Work.

Jeraj, J. (2008), "Slovenian Earthquake – 31st August 1998." *Journal of the Institute of Emergency Management*, UK, Issue 5, March 2002.

Jerne, N.K. (1993), "The Generative Grammar of the Immune System." *Nobel Lectures: Physiology or Medicine 1981–1990.* Singapore: World Scientific Publishing Co, 211–225.

Jones, R.A.L. (2004), *Soft Machines: Nanotechnology and Life.* Oxford: Oxford University Press.

Jones, R.A.L. (2005), "Six challenges for molecular nanotechnology." *Soft Machines.* Available at http://www.softmachines.org/wordpress/?p=175

Joseph, B.W. (2005), "Interview with Paolo Virno" responses translated by Alessia Ricciardi, *Grey Room* Vol. 21, Fall 26–37 [http://mitpress.mit.edu/journals/pdf/GR21_026-037_Joseph.pdf] and [http://info.interactivist.net/print.pl?sid=06/01/17/2225239]

Joy, B. (2002), "Why the future doesn't need us." *Wired.* Available at http://www.wired.com/wired/archive/8.04/joy_pr.html

Kaizoji, T., Sornette, D. (2009), "Market Bubbles and Crashes." *Encyclopedia of Quantitative Finance* (Wiley), in press. (http://arXiv.org/abs/0812.2449)

Karatani, K. (2003), *Transcritique: On Kant and Marx, translated from Japanese by Sabu Kohso.* Cambridge, MA: MIT Press.

Kasperson, R., Jhaveri, N., Kasperson, J.X. (2004), "Stigma and the Social Amplification of Risk: Toward a Framework of Analysis," in: J. Flynn, P. Slovic, H. Kunreuther (eds.), *Risk, Media and Stigma.* London: Earthscan, 9–27.

Katzenstein, P.J. (1985), *Small States in World Markets: Industrial Policy in Europe.* Ithaca, NY and London: Cornell University Press.

Kauffman, L. (1987), "Self-Reference and Recursive Forms." *Journal of Social and Biological Structures* Vol. 10, 53–72.

Kauffman, L. (2005), "EigenForm." *Kybernetes,* Vol. 1/2, No. 34, 121–150.

Kauffman, L. (2009), "Reflexivity and Eigenform: The Shape of Process." *Constructivist Foundations* Vol. 4, No. 3, 121–137.

Kauffman, S.A. (1992), *Origins of Order: Self-organization and Selection in Evolution.* Oxford: Oxford University Press.

Kauffman, S.A. (1995), *At Home in the Universe. The Search for the Laws of Self-Organization and Complexity.* New York: Oxford University Press.

Kauffman, S.A. (2000), *Investigations.* Oxford: Oxford University Press.

Keim, B. (2009), "How to Defend Earth Against an Asteroid Strike." *Wired.* Available at http://www.wired.com/wiredscience/2009/03/planetdefense/

Kelly, J.M. (1997), *Earthquake-Resistant Design with Rubber.* (2nd edition), London: Springer-Verlag.

Kelly, T.E., Robinson, B.W.H., Skinner, R.I. (2007), "Seismic isolation for designers and structural engineers." (Electronic book in PDF format). Wellington: Holmes Consulting Group and Robinson Seismic Ltd.

Kennedy, P. (1987), *The Rise and Fall of the Great Powers: Economic Change and Military Conflict from 1500 to 2000.* New York: Random House.

Khodakovskaya, M., Dervishi, E., Mahmood, M., Xu, Y., Li, Z., Watanabe, F., Biris, A.S. (2009), "Carbon Nanotubes Are Able To Penetrate Plant Seed Coat and Dramatically Affect Seed Germination and Plant Growth." *ACS Nano*. Available at http://pubs.acs.org/doi/abs/10.1021/nn900887m

Kilar, V., Fajfar, P. (2001), "On the applicability of pushover analysis to the seismic performance evaluation of asymmetric buildings." *European Earthquake Engineering*, Vol. 15, No. 1, 20–31.

Kilar, V., Koren, D. (2008), "Effectiveness of base isolation system for simple RC frame buildings," in: Y.M. Xie, I., Patnaikuni (eds.), 4th *International Structural Engineering and Construction Conference, ISEC-4,* Melbourne, Australia. "Innovations in structural engineering and construction: proceedings of the Fourth International structural engineering and construction conference (ISEC-4), Melbourne, Australia, 26–28 September, 2007, (Balkema – Proceedings and monographs in engineering, water and earth sciences). London: Taylor&Francis, 969–975.

Kilar, V., Koren, D. (2009a), "Seismic behaviour of asymmetric base isolated structures with various distributions of isolators." *Engineering Structures,* Vol. 31, No. 4, 910–921.

Kilar, V., Koren, D. (2009b), "Usage of simplified N2 method for analysis of base isolated structures," in: M. Papadrakakis, N.D. Lagaros, M. Fragiadakis (eds.), *2nd International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering* (COMPDYN 2009–ECCOMAS Thematic Conference), Rhodes, Greece, June 22–24.

Kilar, V., Koren, D. (2009c), "Simplified inelastic seismic analysis of base isolated structures using the N2 method." *Earthquake Engineering and Structural Dynamics*, (in press), DOI: 10.1002/eqe.978

Kindleberger, C.P. (2000), Review of Peter M. Garbers, "Famous First Bubbles: The Fundamentals of Early Manias." EH.Net, H-Net Reviews (August), URL: http://www.h-net.org/reviews/showrev.php?id=4432

Kindleberger, C.P. (2005) (5th edition), *Manias, Panics, and Crashes: a History of Financial Crises*. New York: John Wiley&Sons, 355.

Kitano, H. (2002), "Computational Systems Biology." *Nature* 420 (November 14), 206–210.

Klein, G. (1999), *Sources of Power: How People Make Decisions*. Cambridge: The MIT Press.

Klein, J. (1990), *Interdisciplinarity: History, theory, and tractice.* Detroit: Wayne State University.

Klein, T. J. (2006), "Afterword: the emergent literature on interdisciplinary and transdisciplinary reserach evaluation." *Research Evaluation*, Vol. 15, No. 1, 75–80.

Kloepfer, I. (2008), *Aufstand der Unterschicht.* Hamburg: Hoffmann und Campe.

Knorr-Cetina, K. (1999), *Epistemic Cultures: How the Sciences Make Knowledge.* Cambridge: Harvard University Press.

Kocka, J. (1987) (ed.), *Interdisziplinaritaet. Praxis – Herausforderung – Ideologie.* Frankfurt am Main: Suhrkamp.

Kondratieff, N.D. (1928), "Die Preisdynamik der industriellen und landwirtschaftlichen Waren. Zum Problem der relativen Dynamik und Konjunktur." *Archiv für Sozialwissenschaft und Sozialpolitik,* Vol. 60, 12.

Kordes, U., Jericek, H. (2001), "Komunikacija kot spiralno približevanje" (Communication as a Spiral Approach). *Socialno delo,* Vol. 40, No. 5, 275–289.

Koschmann, T. (1996), "Paradigm shifts and instructional technology," in: T. Koschmann (ed.), *CSCL: Theory and practice of an emerging paradigm.* Mahwah, NJ: Lawrence Erlbaum Associates, 1–23.

Koschmann, T. (2002), "Dewey's contribution to the foundations of CSCL research," in: G. Stahl (ed.), *Computer support for collaborative learning: Foundations for a CSCL community. Proceedings of CSCL 2002.* Boulder, CO: Lawrence Erlbaum Associates, 17–22.

Krugman, P. (2009), *The Return of Depression Economics and the Crisis of 2008.* New York: W.W. Norton.

Kurzweil, R. (2005), *Singularity is Near. When Humans Transcend Biology.* New York: Penguin Group.

Kurzweil, R. Joy, B. (2005), "Recipe for Disaster." *New York Times*, October 17.

Laughlin, R.B. (2005), *A Different Universe. Reinventing Physics from the Bottom Down.* New York: Basic Books.

Lave, J. (1993), "The practice of learning," in: S. Chaikliln, J. Lave (eds.), *Understanding practice: Perspectives on activity and context.* Cambridge, England: Cambridge University Press, 3–32.

Lave, J., Wenger, E. (1991), *Situated learning: Legitimate peripheral participation.* Cambridge, England: Cambridge University Press.

Lawson, T. (2003), *Reorienting Economics (Economics as Social Theory).* London: Routledge.

Lawton, J.H., May, R.M. (1995), *Extinction Rates*. Oxford: Oxford University Press.

Leggewie, K., Welzer, H. (2009), *Das Ende der Welt, wie wir sie kannten. Klima, Zukunft und die Chancen der Demokratie.* Frankfurt am Main: S.Fischer.

Lefebvre, V. (1982), *Algebra of Conscience: A Comparative Analysis of Western and Soviet Ethical Systems.* Dordrecht: Reidel.

Lefebvre, V. (2001), *Algebra of Conscience. Revised Edition with a Second Part and a New Foreword by Anatol Rapoport.* Dordrecht: Kluwer.

Lerbinger, O. (1997), *The Crisis Manager.* Mahwah: LEA.

Levine, D.S. (2006), "Neural Modeling of the Dual Motive Theory of Economics." *The Journal of Socio-Economics, Vol.* 35, (4, August), 613–625.

Lewin, R. (1993), *Complexity: Life at the Edge of Chaos.* Phoenix: Orion Books.

Lewontin, R.C. (1961), "Evolution and the Theory of Games." *Journal of Theoretical Biology,* Vol.1, 382–403.

Lewontin, R.C. (2000), *The Triple Helix: Gene, Organism, and Environment.* Cambridge: Harvard University Press.

Lewontin, R.C., Oyama, S. (2000), *The Ontogeny of Information: Developmental Systems and Evolution* (second edition). Durham: Duke University Press.

Li, H.N., Li, G. (2007), "Simplified method for pushover curves of asymmetric structure with displacement-dependent passive energy dissipation devices." *Advances in Structural Engineering*, Vol. 10, No. 5, 537–549.

Lifeboat Foundation (2009a.), "LF Bioshield Report." Available at http://lifeboat.com/ex/bio.shield

Lifeboat Foundation (2009b), "LF A-Prize." Available at https://lifeboat.com/ex/a-prize

Linden, E. (2006), *The winds of change: climate, weather, and the destruction of civilizations*. New York: Simon&Schuster.

Lipponen, L., Hakkarainen, K., Paavola, S. (2004), "Practices and orientations of CSCL," in: P. Dillenbourg (Series ed.), J.W. Strijbos, P.A. Kirschner, R.L. Martens (Vol. eds.), *What we know about CSCL: And implementing it in higher education*. Boston, MA: Kluwer Academic Publishers, 31–50.

Löfgren, L. (1961), *Kinematic and Tesselation Models of Self-Repair*. TR 8. Contract NONR 1834(21). University of Illinois:Electrical Engineering Research Laboratory Engineering Experiment Station.

Lu, L.Y., Lin, G.L., Kuo, T.C. (2008), "Stiffness controllable isolation system for near-fault seismic isolation." *Engineering Structures*, Vol. 30, No. 3, 747–765.

Luhmann, N. (1984), *Soziale Systeme. Grundriß einer allgemeinen Theorie*. Frankfurt am Main: Suhrkamp.

Luhmann, N. (1997), *Die Gesellschaft der Gesellschaft,* (2 Bände.) Frankfurt am Main: Suhrkamp.

Lynne, G.D. (2006), "Toward a Dual Motive Metaeconomic Theory." *The Journal of Socio-Economics*, Vol. 35 (4, August), 634–651.

Maasen, S., Weingart, P. (2000), *Metaphors and the Dynamics of Knowledge.* London: Routledge.

Maasen, S., Lengwiler, M., Guggenheim, M. (2006), "Practices of transdisciplinary research: closer encounters of science and society." *Science and Public Policy*, Vol. 33, No. 6, 394–398.

Macrae, N. (1992), *John von Neumann: The Scientific Genius Who Pioneered the Modern Computer, Game Theory, Nuclear Deterrence, and Much More.* New York: Pantheon Books.

MacKenzie, D., Muniesa, F., Siu, L. (2007) (eds.), *Do Economists Make Markets? On the Performativity of Economics*. Princeton: Princeton University Press.

Magliulo, G., Maddaloni, G., Cosenza, E. (2007), "Comparison between nonlinear dynamic analysis performed according to EC8 and elastic and nonlinear static analyses." *Engineering Structures,* Vol. 29, No. 11, 2893–2900.

Mali, F., Jelnikar, B. (2008), "Intermediarne strukture v Sloveniji in njihova vloga pri prenosu znanja z akademskega področja znanosti v gospodarstvo." *Teorija in praksa,* Vol. 45, 93–112.

Mandelbrot, B.B. (2004), *The (Mis)Behaviour of Markets. A Fractal View of Risk, Ruin and Reward*. London: Profile Books.

Mansfield, E. (1995), "Academic Research Underlying Industrial Innovations: Sources, Characteristics, and Financing." *Review of Economics and Statistics* Vol. 77, 55–65.

Margulis, L. (1981), *Early Life*. Boston: Jones & Bartlett.

Margulis, L. (1993), *Symbiosis in Cell Evolution* (second edition). New York: W.H. Freeman.

Margulis, L. (1998), *Symbiotic Planet. A New Look at Evolution.* New York: Basic Books.

Marx, K. (1964), *Das Kapital, Band III: Der Gesamtprozess der kapitalistischen Produktion.* Berlin: Dietz.

Mason, B. (2009), "NASA Falling Short of Asteroid Detection Goals." *Wired*. Available at http://www.wired.com/wiredscience/2009/08/neoreport/

Maturana, H.R. (1985), *Erkennen: Die Organisation und Verkörperung von Wirklichkeit*, second edition. Braunschweig: Friedrich Vieweg&Sohn.

Maturana, H.R. (1998), *Biologie der Realität*. Frankfurt: Suhrkamp.

Maturana, H.R., Varela, F.J. (1998), *The Tree of Knowledge. The Biological Roots of Human Understanding*. Boston: Shambhala.

Maurer, S.M., Lucas, K.V., Terrell, S. (2006), *From Understanding to Action: Community-Based Options for Improving Safety and Security in Synthetic Biology*. Berkeley CA: University of California.

Mavronicola, E.A., Komodromos, P. (2009), "On the suitability of proposed equivalent linear elastic models for multi-story seismically isolated buildings," in: M. Papadrakakis, N.D. Lagaros, M. Fragiadakis (eds.), *2nd International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering* (COMPDYN 2009 – ECCOMAS Thematic Conference), Rhodes, Greece, June 22–24.

Mayhew, P.J., Jenkins, G.B., Benton, T.G. (2008), "A long-term association between global temperature and biodiversity, origination and extinction in the fossil record." *Proceedings of the Royal Society B: Biological Sciences,* Vol. 275 (1630), 47–53.

Maynard-Smith, J. (1974), *Models in Ecology.* Cambridge: Cambridge University Press.

Maynard-Smith, J. (1982a), *Evolution and the Theory of Games.* Cambridge: Cambridge University Press.

Maynard-Smith, J. (1982b) (ed.), *Evolution Now. A Century after Darwin.* London: Macmillan.

Maynard-Smith, J. (1989), *Evolutionary Genetics.* Oxford: Oxford University Press.

Maynard-Smith, J., Szathmáry, E. (1996), *Evolution. Prozesse, Mechanismen, Modelle.* Heidelberg: Spektrum Akademischer Verlag.

Mayntz, R. (1992), "The Influence of Natural Science Theories on Contemporary Social Science," in: M. Dierkes, B. Biervert (eds.), *European Social Science in Transition: An Assessment and Outlook.* Frankfurt am Main and Boulder, CO: Campus Verlag and Westview Press, 27–79.

Mayntz, R., Schimak, U., Weingart, P. (1995) (eds.), *Transformation mittel- und ost-europaeischen Wissenschaftssysteme.* Opladen: Leske und Budrich Verlag.

Mayr, E. (1991), *One Long Argument: Charles Darwin and the Genesis of Modern Evolutionary Thought.* Cambridge, MA: Harvard University Press.

McComb, W.D. (2004), *Renormalization Methods. A Guide for Beginners.* Oxford: Oxford University Press.

McCormick, R., Murphy, P. (2008), "Curriculum: The case for a focus on learning," in: P. Murphy, K. Hall (eds.), *Learning and practice: Agency and identities.* London: SAGE Publications Ltd, 3–18.

McCormick, R., Scrimshaw, P. (2008), "Information and communications technology, knowledge and pedagogy," in: P. Murphy, R. McCormick (eds.), *Knowledge and practice: Representations and identities.* London: SAGE Publications Ltd, 86–103.

McElroy, M.B. (2003), "Global Warming, Global Threat." *The Modern Scholar.*

McKibben, B. (2004), *Enough: Staying Human in an Engineered Age.* New York: Holt Paperbacks.

Mensch, G. (1977), *Das technologische Patt. Innovationen überwinden die Depression*. Frankfurt am Main: Fischer.

Merton, R.K. (1968), "The Matthew Effect in Science." *Science* 159 (3810, January 5), 56–63.

Merton, R.K. (1985), *Entwicklung und Wandel von Forschungsinteressen. Aufsätze zur Wissenschaftssoziologie.* Frankfurt am Main: Suhrkamp.

Meteoalarm (2008), "Alerting Europe for extreme Weather." (http://www.meteoalarm.eu/)

Middlebrook, P.N. (1980), *Social Psychology & Modern Life*. New York: Alfred A. Knopf.

Midgley, J. (1981), P*rofessional Imperialism: Social Work in the Third World.* London: Heinemann.

Miettinen, R. (2002), N*ational Innovation System. Scientific Concept or Political Rhetoric.* Helsinki: Edita Prima Ltd.

Minahan, A., Pincus, A. (1977), "Conceptual Framework for Social Work Practice." *Social Work*, Vol. 22, No. 5, 347–352.

Minsky, H.P. (1982), *Can "It" Happen Again?: Essays on Instability and Finance.* Armonk: M.E. Sharpe.

Minsky, H.P. (2008), *Stabilizing an Unstable Economy*. Quebec: McGraw-Hill.

Mitman, G.A. (1992), *The State of Nature: Ecology, Community, and American Social Thought, 1900–1950.* Chicago: University of Chicago Press.

Mittelstrass, J. (1998), "Die Stunde der Interdisziplinaritaet?," in: J. Kocka, (ed.), *Interdisziplinaritaet. Praxis – Herausforderung – Ideologie.* Frankfurt am Main: Suhrkamp, 152–518.

Montalenti, G. (1974), "From Aristotle to Democritus via Darwin," in: F.J. Ayala, T. Dobzhansky, *Studies in the Philosophy of Biology: Reduction and Related Problems.* London: Macmillan, 3–19.

More, M. (2005), "The Proactionary Principle." *The Innovation Roadmap*, Vol. 2, No. 1, 1–4.

Morris, J. (1993), *Independent Lives? Community Care and Disabled People.* Basingstoke: Macmillan.

Müller, K.H. (1995), „Zement und Gesellschaft. Modernisierungsskizzen aus dem Geist Karl Polanyis", in: K.R. Leube, A. Pribersky (eds.), *Krise und Exodus. Österreichische Sozialwissenschaften in Mitteleuropa*. Wien: WUV-Universitätsverlag, 146–190.

Müller, K.H. (1999), *Marktentfaltung und Wissensintegration. Doppelbewegungen in der Moderne.* Frankfurt am Main/New York: Campus Verlag.

Müller, K.H. (2002), *Wissenschaftliche Institute in Österreich. Schlüsselfaktoren für Innovationsgrade und Forschungsperformanzen.* Vienna: Wisdom.

Müller, K.H. (2007), "The BCL – an Unfinished Revolution of an Unfinished Revolution," in: A. Müller, K.H. Müller (eds.), *An Unfinished Revolution,* op.cit., 407–466.

Müller, K.H. (2008), *The New Science of Cybernetics. The Evolution of Living Research Designs, Vol. I: Methodology*. Vienna: edition echoraum.

Müller, K.H. (2010), *The New Science of Cybernetics. The Evolution of Living Research Designs, Vol. II: Theory*. Vienna: edition echoraum (to be published).

Müller, A., Müller, K.H. (2007) (eds.), *An Unfinished Revolution? Heinz von Foerster and the Biological Computer Laboratory (BCL), 1958–1976.* Vienna: edition echoraum.

Mulhall, D. (2002), *Our Molecular Future: How Nanotechnology, Robotics, Genetics and Artificial Intelligence Will Transform Our World.* Amherst, New York: Prometheus Books.

Naeim, F., Kelly, J.M. (1999), *Design of Seismic Isolated Structures: From Theory to Practice.* New York: John Wiley&Sons, Inc.

Nancy, J.L. (2001), *L'"il y a" du rapport sexuel.* Paris: Galilée.

National Research Council (2006) (ed.), *Facing Hazards and Disasters. Understanding Human Dimensions.* Washington: The National Academies Press.

Naumoski, N.D. (1998), Program SYNTH: Generation of artificial accelerograms compatible with target spectrum.

Nelson, R.R. (1993) (ed.), *National Innovation Systems: A Comparative Analysis.* Oxford: Oxford University Press.

Nelson, R.R. (2005), *Technology, Institutions, and Economic Growth*. Cambridge, Massachusetts / London, England: Harvard University Press, 306.

Neumann, J.v. (1964), "The Theory of Automata: Construction, Reproduction and Homogeneity," in: A. Burks (ed.), *John von Neumann's Collected Works.* Urbana: University of Illinois Press, 1–49.

Neumann, J.v. (1966), *Theory of Self-Reproducing Automata.* Completed and edited by Arthur W. Burks. Champaign-Urbana, IL: University of Illinois Press.

Neumann, J.v., Morgenstern, O. (1944), *The Theory of Games and Economic Behavior. Princeton.* NJ: Princeton University Press.

Newman, M. (2005), "Power Laws, Pareto Distributions and Zipf's Law." *Contemporary Physics*, Vol. 46, 323–351.

Newman, M., Barabási, A.L., Watts, D. (2006) (eds.), *The Structure and Dynamics of Networks.* Princeton: Princeton University Press.

Nicolis, G., Prigogine, I. (1977), *Self-Organization in Nonequilibrium Systems: From Dissipative Structures to Order through Fluctuations.* New York: John Wiley.

Nicolis, G., Prigogine, I. (1989), *Exploring Complexity.* New York: W.H. Freeman.

Nietzsche, F. (1968), *Werke, Kritische Gesamtausgabe, herausgegeben von Giorgio Colli und Mazzino Montinari, Abteilung 6, Band 2, Jenseits von Gut und Böse – Zur Genealogie der Moral (1886–1887)*. Berlin: Walter de Gruyter.

NISD (2005), *Bachelor of Social Work: Prospectus.* Colombo: National Institute of Social Development.

NISD (2008), *Master of Social Work: Prospectus*. Colombo: National Institute of Social Development.

Noe, A. (2006), *Action in Perception.* Cambridge: The MIT Press.

Nonnon, E. (1996), "Activités argumentatives et élaboration de connaissance nouvelles: Les dialogue comme espace d'exploration." *Langue Française,* Vol. 112, 67–87.

Nordman, A. (2004) (ed.), "Converging Technologies. Shaping the Future of European Societies." *Report of High Level Expert Group Foresighting the New Technology Wave*, Brussells.

Norris, F.H. (1992), "Epidemiology of trauma: Frequency and impact of different potentially traumatic events on different demographic groups." *Journal of Consulting and Clinical Psychology,* Vol. 60, 409–418.

Nouri, A., Chyba, C.F. (2008), "Biotechnology and biosecurity," in: N. Bostrom, M. Ćirković (eds.), *Global Catastrophic Risks.* Oxford: Oxford University Press, 450–481.

Nowotny, H. (2005), *Unersättliche Neugier. Innovation in einer fragilen Zukunft.* Berlin: Kadmos.

Nowotny, H., Scott, P., Gibbons, M. (2001), *Re-Thinking Science. Knowledge and the Public in an Age of Uncertainty.* Cambridge: Polity Press.

O'Donnell, A.M. (2006), "Introduction: Learning with technology," in: A.M. O'Donnell, C.E. Hmelo-Silver, G. Erkens (eds.), *Collaborative reasoning, learning and technology*. Mahwah, NJ: Lawrence Erlbaum Associates, 1–14.

O'Hara, M. (2008), "Bubbles: Some Perspectives (and Loose Talk) from History." *The Review of Financial Studies* Vol. 21, 11–17.

O'Sullivan, M. (2005), "Typologies, Ideologies and Realities of Capitalism." *Socio-Economic Review,* Vol. 3(3), 547–558.

OECD (1998), Interdisciplinarity in Science and Technology. Directorate for Science, Technology and Industry. Paris: OECD.

OECD (2009a), Frequently Asked Questions – Impact of crisis on employment. Background Paper. http://www.oecd.org/faq/0,3433,en_2649_201185_42061569_1_1_1_1,00.html

OECD (2009b), Tackling the crisis – a strategic response. Labour and Employment Ministerial Meeting, September 2009. http://www.oecd.org/document/27/0,3343,en_2649_201185_41973851_1_1_1_1,00.html

OECD (2009c), OECD Quarterly National Accounts – Fourth Quarter 2008. http://www.oecd.org/document/63/0,3343,en_2649_33715_42182975_1_1_1_1,00.html

OECD (2009d), Tackling the financial and economic crisis. Labour and Employment Ministerial Meeting, September 2009. http://www.oecd.org/document/24/0,3343,en_2649_201185_41707672_1_1_1_1,00.html

Offe, C., Wiesenthal, H. (1980), "Two Logics of Collective Action: Theoretical Notes on Social Class and Organizational Form." *Political Power and Social Theory* Vol. 1, 67–115, Greenwich, CT: JAI Press.

Ogle, R. (2008), *Smart World. Breakthrough Creativity and the New Science of Ideas.* London: Marshall Cavendish and Cyan Communication.

Oliver, M. (1996) (ed.), *Social Work, Disabled People and Disabling Environments*. London: Jessica King.

Ong, N.P., Bhatt, R.N. (2001) (eds.), *More is Different. Fifty Years of Condensed Matter Physics*. Princeton: Princeton University Press.

Orasanu, J., Connolly, T. (1995), "The Reinvention of Decision Making," in: G.A. Klein, J. Orasanu, R. Calderwood, C.E. Zsambok (eds.), *Decision Making in Action: Models and Methods.* Norwood: Ablex Publishing Corporation, 3–20.

Ott, I., Papilloud, C. (2007), "Converging Institutions: Shaping Relationships between Nanotechnologies, Economy, and Society." *Bulletin of Science, Technology & Society*, Vol. 27, No. 6, 455–466.

Oyama, S. (2000), *Evolution's Eye. A Systems View of the Biology-Culture Divide.* Durham: Duke University Press.

Page, S.E. (2009), *Understanding Complexity.* Chantilly VA: The Teaching Company.

Pareto, V. (1896), *Cours d'Economie Politique.* Geneva: Droz.

Parker, L. (1997), The Engineering Research Centres (ERC) Programme: "An Assessment of Benefits and Outcomes." Arlington, Virginia: National Science Foundation (http://www.nsf.gov/pubs/1998/nsf9840/nsf9840.pdf)

Parrot, W.G. (1995), "Groupthink," in: A.S.R. Manstead, M. Hewstone (eds.). *The Blackwell Encyclopedia of Social Psychology.* Oxford: Blackwell, 282–284.

Parsons, T. (1951), *The Social System*. Glencoe, Ill.: The Free Press.

Parsons, T. (1964), "Evolutionary Universals in Society." *American Sociological Review,* Vol. 19, 339–357.

Parsons, T. (1994), *Aktor, Situation und normative Muster. Ein Essay zur Theorie sozialen Handelns.* Frankfurt am Main: Suhrkamp.

Pastor-Satorras, R., Vespignani, A. (2001), "Epidemic Spreading in Scale-free Networks." *Physical Review Letters,* Vol. 86, 3200.

Pastor-Satorras, R., Vespignani, A. (2004), *Evolution and Structure of the Internet: A Statistical Physics Approach.* Cambridge: Cambridge University Press.

Pauling, L., Delbrück, M. (1940), "The Nature of the Intermolecular Forces Operative in Biological Processes." *Science* 92 (July 26), 77–79.

Payne, M. (2008), *Modern Social Work Theory*. New York: Palgrave Macmillian.

Perez, C. (2002), *Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages*. Cheltenham/Northampton: Edward Elgar, 198.

Perez, C. (2009), "The special nature and consequences of major technology bubbles." CERF Working Paper. Judge Business School, Cambridge University (forthcoming).

Perrings, C., Mäler, K.G., Folke, C., Holling, C.S., Jansson, B.O. (1995) (eds.), *Biodiversity Loss. Economic and Ecological Issues.* Cambrigde: Cambridge University Press.

Pettinga, J.D., Pampanin, S., Christopoulos, C., Priestley, M.J.N. (2007), "Developments in the prediction and mitigation of residual deformations due to seismic demand, including asymmetric structural response." *Research Report No. ROSE-2007/01.* Pavia, Italy: IUSS Press.

Pfeifer, R., Bongard, J. (2007), *How the Body Shapes the Way We Think. A New View of Intelligence*. Cambridge: The MIT Press.

Phare Report (1996), "A Science and Technology Strategy for Slovenia." Ljubljana: Ministry for Science and Technology of Republic of Slovenia.

Phoenix, C. (2008), "Molecular Manufacturing: What, How and Why?" Center for Responsible Nanotechnology. Available at http://wise-nano.org/w/Doing_MM.

Pidgeon, N., Kasperson, R.E., Slovic, P. (2003) (eds.), *The Social Amplification of Risk.* Cambridge: Cambridge University Press.

Pilkington, E. (2007), "I am creating artificial life, declares US gene pioneer." *The Guardian*, October 6. Available at http://www.guardian.co.uk/science/2007/oct/06/genetics.climatechange

Pimm, S.L., Russell, G.J., Gittleman, J.L., Brooks, T.M. (1995), "The Future of Biodiversity." *Science*, Vol. 269, 347–350.

Pines, D. (1988) (ed.), *Emerging Syntheses in Science.* Redwood City, CA: Addison-Wesley.

Pohl, C. (2001), "How to bridge between natural and social sciences? An analysis of three approaches to transdisciplinarity from the Swiss and German field of environmental research." *Natures, Sciences, Societies,* Vol.9, 37–46.

Polič, M., Milovanovič, T., Bauman, A., Umek, P., (1988), "Psihološki vidiki nesreč: zemeljski plaz v Zagorju leta 1987" (Psychological aspects of disasters: Landslide in Zagorje 1987). *Ujma*, 2, 29–33.

Polič, M., Bauman, A., Rajh, V., Ušeničnik, B., (1990), "Psihološki vidiki nesreč: neurje v Halozah leta 1989" (Psychological aspects of disasters: Storm in Haloze 1989). *Ujma*, 4, 31–37.

Polič, M., Rajh, S., Ušeničnik B., (1991), Dogajanje med poplavami leta 1990 v očeh prizadetih prebivalcev (Events during floods in 1990 in the eyes of victims). *Ujma*, 5, 5, 114–120.

Popper, K.R (1965), *Conjectures and Refutations. The Growth of Scientific Knowledge.* New York: Harper&Row.

Popper, K.R. (1972), *Objective Knowledge. An Evolutionary Approach.* Oxford: Oxford University Press.

Posner, R.A. (2009), *A Failure of Capitalism. The Crisis of '08 and the Descent into Depression.* Cambridge: Harvard University Press.

Prechter, R.R. (1999), *The Wave Principle of Human Social Behavior and the New Science of Socionomics*. Gainesville: New Classics Library.

Prechter, R.R. (2003), *Pioneering Studies in Socionomics.* Gainesville: New Classics Library.

Prechter, R.R. (2009), *Conquer the Crash: You Can Survive and Prosper in a Deflationary Depression,* second edition. New York: John Wiley&Sons.

Pred, A.R. (1966), *The Spatial Dynamics of U.S. Urban-Industrial Growth, 1800–1914. Interpretative and Theoretical Essays*. Cambridge: The MIT Press.

Pred, A.R. (1973), *Urban Growth and the Circulation of Information: The United States System of Cities, 1790–1840.* Cambridge: Harvard University Press.

Pred, A.R. (1980), *Urban Growth and City-Systems in the United States, 1840–1860.* Cambridge: Harvard University Press.

Price, D. (1963), *Little Science, Big Science*. New York: Columbia University Press.

Price, D., Solla, J. de (1963), *Little Science, Big Science.* New York: Columbia University Press.

Price, D., Solla, J. de (1965), "Networks of Scientific Papers." *Science,* Vol. 149 (3683, July 30), 510–515.

Price, D., Solla, J.de (1976), "A General Theory of Bibliometric and Other Cumulative Advantage Processes." *Journal of the American Society for Information Science,* Vol. 27, 292–306.

Priestley, M.J.N., Calvi, G.M., Kowalsky, M.J. (2007), *Displacement-based Seismic Design of Structures.* Pavia, Italy: IUSS Press.

Prigogine, I., Stengers, I. (1984), *Order Out of Chaos: Man's New Dialogue with Nature.* New York: Bantam Books.

Prigogine, I., Nicolis, G. (1989), *Exploring Complexity.* New York: W.H. Freeman.

Prigogine, I., Stengers, I. (1997), *The End of Certainty: Time, Chaos, and the New Laws of Nature.* New York: Free Press.

Productive Nanosystems Work Group (2007), "Productive Nanosystem: A Technology Roadmap." Available at http://www.foresight.org/roadmaps/Nanotech_Roadmap_2007_main.pdf

Pumain, D. (1982), *La Dynamique des Villes.* Paris: Economica.
Pumain, D. (2006) (ed.), *Hierarchy in Natural and Social Sciences, Methodos Series.* Vol. 3, Dotrecht: Springer.
Pumain, D., Haag, G. (1994), "Spatial patterns of urban systems and multifractality, in Evolution of Natural Structures." 3rd Internat. Symposium of the Sonderforschungsbereich 230, Univ. Stuttgart, 4–7, Heft 9, 243–252.
Purvis, J.R. (1994), "Crisis Management," in: V.S. Ramachandran (ed.), *Encyclopedia of Human Behavior,* Vol. 2., San Diego: Academic Press, 23–29.
Quandt, R.E. (1964), "Statistical discrimination among alternative hypothesis and some economic regularities." *Journal of Regional Science*, Vol. 2, 1–23.
Quarantelli, E.L. (1970), "Property Norms and Looting: Their Patterns in Community Crisis." *Phylon*, Vol. 31, 168–82.
Quarantelli, E.L. (1973), "Human Behavior in Disaster." *Proceedings of the Conference to Survive Disaster*. Chicago: Research Institute, 53–74.
Quarantelli, E.L. (1982) "What is a disaster? An agent specific or an all disaster spectrum approach to socio-behavioral aspects of earthquakes," in: B. Jones, M. Tomaževič (eds.), *Social and Economic Aspects of Earthquakes.* Ithaca NY: Program in Regional and Urban Studies, Cornell University.
Quarantelli, E.L. (1985), "An Assessment of Conflicting Views on Mental Health: The Consequences of Traumatic Events," in: C.F. Figley (ed.), *Trauma and Its Wake.* Vol. I., New York: Brunner/Mazel, 173–215.
Quarantelli, E.L. (1991), *Different types of Disasters and Planning Implications.* Newark: DRC.
Quarantelli, E.L. (1998), "Introduction: The basic question, its importance, and how it is addressed in this volume," in: E. Quarantelli (ed.), *What is a Disaster?* London: Routledge.
Quarantelli, E.L. (1998) (ed.), *What is a Disaster? Perspectives on the Question*. London: Routledge.
Rakovec, J., Vertačnik, G. (2008), – in M. Brilly, J. Rakovec, M. Kobold, A. Širca, D. Goršak, G. Vertačnik, M. Primožič, A. Horvat, 2007: Medsebojni vpliv infrastrukturnih in energetskih ureditev na spodnji Savi v času izrednih hidroloških dogodkov—model Save—Izračun verjetne visoke vode "PMF": končno poročilo (Interrelations of infrastructure and energetic arrangements on the lower Sava during extreme hydrologic events—model for Sava—Calculation of Probable Maximum Floods "PMF"—Final report), Ljubljana: Univerza v Ljubljani, Fakulteta za gradbeništvo in geodezijo, Katedra za splošno hidrotehniko, 75.
Raup, D.M., Sepkoski, J. (1982), "Mass extinctions in the marine fossil record." *Science*, Vol. 215, 1501–1503.

Raynal, G., Diderot, D. (1988), *Die Geschichten beider Indien*. Nördlingen: Franz Greno.

Reason, J. (1994), *Menschliches Versagen. Psychologische Risikofaktoren und moderne Technologien*. Heidelberg: Spektrum Akademischer Verlag.

Repovs, G., Polič, M., Kranjcec, R. (2004), "Fire at the Gorenje Factory on Sept.3, 2000," in: A. Brändström, M. Malesic (eds.), *Crisis management in Slovenia: comparative perspectives.* (A publication of the Crisis Management Europe Research Program, 26). Stockholm: Swedish National Defence College, 177–200.

Rescher, N. (1978), *Scientific Progress: A Philosophical Essay on the Economics of Research in Natural Science*. Oxford: Blackwell.

Rescher, N. (1982), *Wissenschaftlicher Fortschritt: Eine Studie über die Ökonomie der Forschung.* Berlin: de Gruyter.

Rescher, N. (1998), *Complexity. A Philosophical Overview.* New Brunswick, NJ: Transaction Publishers.

Resnick, S.I. (2007), *Heavy-Tail Phenomena. Probabilistic and Statistical Modeling.* New York: Springer.

Riddel, A. (2006), "Tweaking Genes in the Basement." Wired. Available at http://www.wired.com/medtech/health/news/2006/07/71276

Rieke, F. *et al.* (1999), *Spikes. Exploring the Neural Code.* Cambridge: The MIT Press.

Rihtar, F., Zupančič-Strojan, T. (1996), *Spaces of Urban City* (*Prostor mesta*). (2nd edition) (in Slovenian). Ljubljana: University of Ljubljana, Faculty of Architecture.

Rip, A. (2000), "Fashions, Lock-ins and the Heterogeneity of Knowledge Production," in: M. Jacob, T. Hellstroem (eds.), *The Future of Knowledge Production in Academy*, Buckingham: Open University Press, 28–40.

Robbins, P., Aydede, M. (2008) (eds.), *The Cambridge Handbook of Situated Cognition.* Cambridge: Cambridge University Press.

Robson, B. (1973), *Urban Growth, An Approach.* Paris: Methuen.

Roco, M.C., Bainbridge, W.S. (2003) (eds.), *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science.* Springer. Dodrecht.

Roco, M.C., Montemagno, C.D. (2004) (eds.), *The CoEvolution of Human Potential and Converging Technologies.* New York: New York Academy of Sciences.

Rode, N. (2005), *Socialno delo kot posrednik med življenjskim svetom in sistemom. Doktorska disertacija.* Ljubljana: UL-Fakulteta za družbene vede.

Rodriguez, H., Quarantelli, E.L., Dynes, R.R. (2007) (eds.), *Handbook of Disaster Research*. New York: Springer.

Roehner, B., Wiese, K.E. (1982), "A Dynamic Generalisation of Zipf's rank-size rule." *Environment and Planning*, Vol.14, 1449–1467.

Rogoff, B. (2008), "Thinking with the tools and institutions of culture," in: P. Murphy, K. Hall (eds.), *Learning and practice: Agency and identities.* London: SAGE Publications Ltd., 49–70.

Rho, R.M., Sankar, R., Strafstrom, C.E. (2010) (eds.), *Epilepsy. Mechanisms, Models and Translational Perspectives.* Boca Raton: CRC Press.

Ronan, R., Johnston, D.M. (2005), *Promoting Community Resilience in Disasters: The Role for Schools, Youth, and Families*. New York: Springer.

Rorty, R. (1991), *Philosophical papers. Vol. 2, Essays on Heidegger and others.* Cambridge, England: Cambridge University Press.

Roschelle, J., Teasley, S. (1995), "The construction of shared knowledge in collaborative problem solving," in: C. O'Malley (ed.), *Computer-supported collaborative learning.* Berlin, Germany: Springer Verlag, 69–197.

Rosen, M.R. (1991), *Life Itself.* New York: Columbia University Press.

Rosenberg, N. (1974), "Science, Invention and Economic Growth." *Economic Journal,* Vol. 84/333, 90–108.

Rosenberg, N. (1994), *Exploring the Black Box: Technology, Economics, and History.* Cambridge: Cambridge University Press.

Rosenthal, U., 't Hart, P., Charles, M. (1989), "The World of Crises and Crisis Management," in: U. Rosenthal, M. Charles, P. 't Hart (eds.), *Coping with Crises.* Springfield: Charles C. Thomas, 3–33.

Ross, S. (2005), *Neoclassical Finance*. Princeton, NJ: Princeton Univ. Press, 102.

Rostow, W.W. (1978), *The World Economy. History & Prospect.* Austin: University of Texas Press.

Rotmans, J. (1998), "Methods of IA: The challenges and opportunities ahead. Challenges and opportunities for Integrated Assessment." *Environmental Modeling and Assessment*, Vol. 3, No. 3 (Special Issue), 155–179.

Rozental, S. (1967) (ed.), *Niels Bohr: His Life and Work as Seen by His Friends and Colleagues.* Amsterdam: North-Holland.

Ryan, K.L., Chopra, A.K. (2006), "Estimating bearing response in symmetric and asymmetric-plan isolated buildings with rocking and torsion." *Earthquake Engineering and Structural Dynamics,* Vol. 35, No.8, 1009–1036.

Sagan, C. (1997), *The Demon-Haunted World: Science as a Candle in the Dark.* New York: Ballantine Books.

Saleebey, D. (1997) (ed.), *The strengths perspective in social work practice.* New York: Longman.

Samali, B., Wu, Y.M., Li, J. (2003), "Shake table tests on a mass eccentric model with base isolation." *Earthquake Engineering and Structural Dynamics,* Vol. 32, No. 9, 1353–1372.

Sanderson, K. (2007), "Oil-eating bacteria make light work of heavy fuel." Nature. Available at http://www.nature.com/news/2007/071212/full/news.2007.375.html

Sanderson, K. (2009), "Synthetic biology gets ethical." *Nature*. Available at http://www.nature.com/news/2009/090512/full/news.2009.464.html

Savulescu, J. (2001), "Procreative beneficence: why we should select the best children." *Bioethics*, Vol. 15, Nos. 5–6, 413–426.

Sawyer, R.K. (2006), "Analyzing collaborative discourse," in: R.K. Sawyer (ed.), *The Cambridge handbook of the learning sciences.* Cambridge, England: Cambridge University Press, 187–204.

Scardamalia, M., Bereiter, K. (2006), "Knowledge building theory, pedagogy, and technology," in: R.K. Sawyer (ed.), *The Cambridge handbook of the learning sciences.* Cambridge, England: Cambridge University Press, 97–115.

Schafer, M., Crichlow, S. (1996), "Antecedents of Groupthink." *Journal of Conflict Resolution*, Vol. 40, No. 3, 415–435.

Scheffer, M., Westley, F., Brock, W.A., Holmgren,M. (2002), "Dynamic Interaction of Societies and Ecosystems – Linking Theories from Ecology, Economy, and Sociology", in: L.H. Gunderson, C.S. Holling, op.cit., 195–239.

Schelter, B., Timmer, J., Schulze-Bonhage, A. (2008) (eds.), *Seizure Prediction in Epilepsy. From Basic Mechanisms to Clinical Applications*. Weinheim: Wiley VCH Verlag.

Schirber, M. (2009), "Did Comet Crashes Help Spark Earth Life?" *SPACE.com*. Available at http://www.space.com/scienceastronomy/090924-AM-chiral-comet.html

Schmid, M. (2006), *Die Logik mechanismischer Erklärungen*. Wiesbaden: VS Verlag für Sozialwissenschaften.

Schmidt, M., Florian, M., Hillebrandt, F. (2006) (eds.), *Reflexive soziale Mechanismen. Von soziologischen Erklärungen zu sozionischen Modellen.* Wiesbaden: VS Verlag für Sozialwissenschaften.

Schmitter, P.C., Streeck, W. (1981), "The Organization of Business Interests: A Research Design to Study the Associative Action of Business in the Advanced Industrial Societies of Western Europe." Discussion Paper IIM/LMP 81–13: Wissenschaftszentrum Berlin.

Schock, M., Tan, T., Lehmann, B. (2009), Lecture: Issues in Disaster response. Schock M.: Disaster Response & Role of Behavioral Health. Powerpoint presentation, slide 3. Oren Gateway, Augsburg College, Minneapolis St.Paul, Minnesota, June 12, 2009.

Schott, T. (1993), "World Science: Globalization of Institutions and Participation." *Science, Technology & Human Values*, Vol. 18, No. 2, 196–208.

Schrage, M. (1990), *Shared minds.* New York: Random House.

Schumpeter, J.A. (1934), *The Theory of Economic Development. (*1983 edition). London: Transaction Publishers.

Schumpeter, J.A. (1952), *Theorie der wirtschaftlichen Entwicklung. Eine Untersuchung über Unternehmergewinn, Kapital, Kredit, Zins und den Konjunkturzyklus* (fifth edition). Berlin: de Gruyter.

Schumpeter, J.A. (1961), *Konjunkturzyklen. Eine theoretische, historische und statistische Analyse des kapitalistischen Prozesses.* 2 Vol. Göttingen: Vandenhoeck &Ruprecht.

Schumpeter, J.A. (1975), *Kapitalismus, Sozialismus und Demokratie*, (fourth edition). München: UTB.

Schumpeter, J.A. (1989), *Business Cycles. A Theoretical, Historical and Statistical Analysis of the Capitalist Process*. New York: McGraw-Hill.

Seljak, T., Bošnjak, A. (2006), "Researchers' bibliographies in COBISS.SI." *Information Services and Use,* Vol. 26, No. 4, 303–308.

Senge, P., Cambron-McCabe, N., Lucas, T., Smith, B., Dutton, J., Kleinrer, A. (2000), *Schools that learn—A fifth discipline fieldbook for educators, parents, and everyone who care about education.* New York: Doubleday.

Serafini, A. (1989), *Linus Pauling: A Man and His Science*. New York: Paragon House.

Sfard, A. (1998), "On two metaphors for learning and the dangers of choosing just one." *Educational Researcher,* Vol. 27, No. 2, 4–13.

Sfard, A. (2008), "On two metaphors for learning and the dangers of choosing just one," in: P. Murphy, R. McCormick (eds.), *Knowledge and practice: Representations and identities.* London: SAGE Publications Ltd., 30–45.

Shefrin, H. (2000), *Beyond Greed and Fear: Understanding Behavioral Finance and the Psychology of Investing*. Boston (MA): Harvard Business School Press.

Sherraden, M.S., Fox, E. (1997), "The Great Flood of 1993: Response and Recovery in Five Communities." *Journal of Community Practice*, Vol. 4, No. 3, 23–45.

Shiller, R.J. (2000), *Irrational Exuberance*. Princeton (NJ): Princeton University Press.

Shleifer, A. (2000), *Inefficient Markets: An Introduction to Behavioral Finance*. Oxford: Oxford University Press.

Shock, M. (2009), "Disaster Response & Role of Behavioral Health." Lecture on June 12, 2009 at Augsburg College, Minneapolis-St.Paul Minnesota, USA.

Siebert, H. (1997), "Labor Market Rigidities: At the Root of Unemployment in Europe." *Journal of Economic Perspectives,* Vol. 11, No. 3, 37–54.

Sime, J.D. (1980), "The Concept of Panic," in: D. Canter (ed.), *Fires and Human Behavior*. Chichester: Wiley&Sons, 63–81.

Simon, H.A. (1955), "On a Class of Skew Distribution Functions." *Biometrika,* Vol. 42, 425–440.

Simon, H.A. (1991), *Models of My Life.* New York: Basic Books.

Simon, H.A., Bonini, Ch.P. (1958), "The Size Distribution of Business Firms." *American Economic Review, Vol.* 48, 607–617.

Singer, E. (2009), "Startup That Builds Biological Parts." *MIT Technology Review.* Available at http://www.technologyreview.com/biomedicine/23567

Škerjanc, J. (2004), Poročilo o delu Tabora 2004. Ministrstvo za obrambo in Ministrstvo za delo, družino in socialne zadeve.

Škerjanc, J. (2006), Individualno načrtovanje z udejanjanjem ciljev. Pomen uporabniške perspective pri zagotavljanju socialnovarstvene storitve. Ljubljana: Center RS za poklicno izobraževanje.

Skidelsky, R., Westerling Wigström, C. (2010) (eds.), *The Economic Crisis and the State of Economics*. New York: Palgrave Macmillan.

Skinner, R.I., Robinson, W.H., McVerry, G.H. (1993), *An Introduction to Seismic Isolation.* Chichester, England: John Wiley&Sons.

Slovic, P. (1993), "Perception of Environmental hazards: Psychological perspectives," in: T. Garling, R. Golledge (eds.), *Behavior and Environment: Psychological and Geographical Approaches*. Holland: Elsevier, 223–248.

Slovic, P. (2000), *The Perception of Risk*. London: Earthscan.

Snow, C.P. (1959), *The Two Cultures and the Scientific Revolution.* New York: Cambridge University Press.

Söderqvist, T. (2003), (trans. by David Mel Paul) *Science as Autobiography: The Troubled Life of Niels Jerne.* New Haven: Yale University Press.

Solomou, S. (1990), *Phases of Economic Growth, 1850–1873. Kondratieff Waves and Kuznets Swings.* Cambridge: Cambridge University Press.

Soltesz, I., Staley, K. (2008) (eds.), *Computational Neuroscience in Epileps.* Amsterdam: Elsevier.

Sornette, D. (2003a), "Critical market crashes." *Physics Reports* C 378 (1), 1–98.

Sornette, D. (2003b), *Why Stock Markets Crash: Critical Events in Complex Financial Systems*. Princeton (NJ): Princeton University Press, 421.

Sornette, D. (2005), "Endogenous versus exogenous origins of crises. Extreme Events in Nature and Society," in: S. Albeverio, V. Jentsch, H. Kantz (eds.), *Series: The Frontiers Collection*. Heidelberg: Springer.

Sornette, D. (2006), *Critical Phenomena in Natural Sciences: Chaos, Fractals, Selforganization and Disorder: Concepts and Tools*. Berlin: Springer.

Sornette, D. (2008), "Nurturing Breakthroughs: Lessons from Complexity Theory." *Journal of Economic Interaction and Coordination,* Vol. 3, 165–181.

Sornette, D. (2010), "Prediction," in: I. Osorio, M.G. Frei, H. Zaveri, S. Arthurs (eds.), *Epilepsy: The Intersection of Neurosciences, Mathematics, and Engineering.* Boca Raton: CRC Press (in preparation).

Sornette, D., Deschatres, F., Gilbert, T., Ageon, Y. (2004), "Endogenous Versus Exogenous Shocks in Complex Networks: an Empirical Test Using Book Sale Ranking." *Phys. Rev. Letts.* Vol. 93 (22), 228701

Sornette, D., Davis, A.B., Ide, K., Vixie, K.R., Pisarenko, V., Kamm, J.R. (2007), "Algorithm for Model Validation: Theory and Applications." *Proc. Nat. Acad. Sci.* USA 104 (16), 6562–6567.

Sornette, D., Davis, A.B., Kamm, J.R., Die, K. (2008), "A General Strategy for Physics-Based Model Validation Illustrated with Earthquake Phenomenology, Atmospheric Radiative Transfer, and Computational Fluid Dynamics." *Book series: Lecture Notes in Computational Science and Engineering*, Vol. 62, *Book Series: Computational Methods in Transport: Verification and Validation*, F. Graziani, D. Swesty (eds.), New York: Springer, 19–73. (http://arxiv.org/abs/0710.0317)

Sornette, D., Woodard ,R., Zhou, W.X. (2009), "The 2006–2008 Oil Bubble: evidence of speculation and prediction." *Physica* A 388, 1571–1576.

Soros, G. (1994a), *The Alchemy of Finance. Reading the Mind of the Market*, (second edition), New York: JohnWiley&Sons.

Soros, G. (1994b), "Theory of Reflexivity." *MIT Speech* (retrieved January 10, 2010, http://www.sharpeinvesting.com/2007/08/george-soros-theory-of-reflexivity-mit-speech.html)

Soros, G. (1998), *Die Krise des globalen Kapitalismus. Offene Gesellschaft in Gefahr.* Berlin: Alexander Fest Verlag.

Soros, G. (2001), *Die offene Gesellschaft. Für eine Reform des globalen Kapitalismus.* Berlin: Alexander Fest Verlag.

Soros, G. (2007), *The Age of Fallibility.* New York: Phoenix.

Soros, G. (2008), *The New Paradigm for Financial Markets. The Credit Crisis of 2008 and What It Means*. New York: Public Affairs.

Soros, G. (2009), *The Crash of 2008 and What It Means. The New Paradigm for Financial Markets.* New York: Public Affairs.

Soros, G. (2010), *The Soros Lectures: At the Central European University.* New York: Public Affairs.

Spencer-Brown, G. (1997), *Laws of Form. Gesetze der Form*. Lübeck: Bohmeier Verlag (orig. 1969).

Spree, R. (1977), *Die Wachstumszyklen der deutschen Wirtschaft von 1840 bis 1880*. Berlin: Duncker & Humblot.

Stahl, G., Koschmann, T., Suthers, D.D. (2006), "Computer-Supported Collaborative Learning," in: R.K. Sawyer (ed.), *The Cambridge handbook of the learning sciences.* Cambridge, England: Cambridge University Press, 409–426.

Stallings, R.A. (1978), "The Structural Patterns of Four Types of Organizations in Disaster," in: E.L. Quarantelli (ed.), *Disasters*. London: Sage, 87–103.

Stark, B. (2009), *Sustainable Global Governance. The Singular Challenge of the Twenty-first Century.* RISC-Research Paper No .5 Ljubljana-Vienna: WISDOM.

Steffen, A. (2009), "Save the Holocene!" *Worldchanging*. Available at http://www.worldchanging.com/archives/009704.html

Stein, D.L. (1989), "Lectures in the Sciences of Complexity." *The Proceedings of the 1988 Complex Systems Summer School, Held June-July 1988 in Santa Fe, New Mexico*. Redwood City: Addison-Wesley.

Stern, E. (2001), *Crisis Decisionmaking: A Cognitive Institutional Approach*. Stockholm: Försvarhögskolan.

Stiglitz, J.E. (2008a), "Commentary: How to prevent the next Wall Street crisis." *CNNPolitics.com*., September 17. http://edition.cnn.com/2008/POLITICS/09/17/stiglitz.crisis/

Stiglitz, J.E. (2008b), "The fruit of hypocrisy." *Guardian.co.uk*, 16 September. http://www.guardian.co.uk/commentisfree/2008/sep/16/economics.wallstreet

Stiglitz, J.E. (2009a), "Capitalist Fools." *Vanity Fair*, January. http://www.vanityfair.com/magazine/2009/01/stiglitz200901

Stiglitz, J.E. (2009b), "Obama's Ersatz Capitalism." *The New Yourk Times*, March 31. http://www.nytimes.com/2009/04/01/opinion/01stiglitz.html?_r=2

Stiglitz, J.E. (2009c), "Developing Countries and the Global Crisis." *Project Syndicate*, April 2009. http://www.project-syndicate.org/commentary/stiglitz111

Streeck, W. (1991), "Interest Heterogeneity and Organizing Capacity: Two Logics of Collective Action?," in: R.M. Czada, A. Windhoff-Héritier, (eds.), *Political Choice: Institutions, Rules and the Limits of Rationality*. Boulder, CO: Westview Press, 161–198.

Streeck, W., Schmitter, P.C. (1985) (eds.), *Private Interest Government: Beyond Market and State*. London: SAGE publications, Ltd.

Stross Hall, J. (2005), *Nanofuture: What's Next for Nanotechnology.* New York: Prometheus Books.

Structural Engineers Association of Northern California (SEAONC) (1986), "Tentative Seismic Isolation Design Requirements." San Francisco, California.

Sundet, P., Mermelstein, J. (1996), "Predictors of Rural Community Survival after Natural Disaster: Implications for Social Work Practice." *Journal of Social Service Research*, Vol. 22, No.1/2, 57–70.

Suppe, F. (1977) (ed.), *The Structure of Scientific Theories*, (second edition). Chicago: University of Chicago Press.

Tancig, S. (2007), "Postgraduate supervisory model: A constructivist, experiential and collaborative approach." *Postgraduate supervision: State of the art and the artists, Conference programme and abstracts, 23–26 April 2007*. Stellen-bosch, South Africa: Center for Higher and Adult Education, No. 78.

Tancig, S. (2009), "The role of collaborative learning in postgraduate supervision and some methodological challenges for collaborative learning research." *Postgraduate supervision conference, Conference programme and abstracts, 27–30 April*. Stellenbosch, South Africa: Center for Higher and Adult Education, No. 61.

Tanner, L.H., Lucas, S.G., Chapman, M.G. (2004), "Assessing the record and causes of Late Triassic extinctions." *Earth-Science Reviews,* Vol. 65 (1–2), 103–139.

Tena-Colunga, A. (2003), "Seismic design of base-isolated structures using capacity spectra." *Journal of Earthquake Engineering,* Vol. 6, No. 4, 553–586, 2002. Erratum in: *Journal of Earthquake Engineering*, Vol. 7, No. 3, 511.

Tena-Colunga, A., Escamilla-Cruz, J.L. (2007), "Torsional amplifications in asymmetric base-isolated structures." *Engineering Structures,* Vol. 29, 2, 237–247.

The Fertility Institutes (2009), "100% Sex Selection, Family Balancing and Genetic Embryo Screening." Available at http://www.gender-selection.com/?gclid=CO 241JaH-JgCFRxNagodVX7DnA

The World Bank Group (2009), "Financial Crisis". http://www.worldbank.org/html/extdr/financialcrisis/

Thom, R. (1989), *Structural Stability and Morphogenesis. An Outline of a General Theory of Models.* Redwood City, CA: Addison Wesley.

Thompson. J.N. (1994), *The Coevolutionary Process.* Chicago: University of Chicago Press.

Thorsteindottir, H. (2000), "Public sector research in small countries: does size matter?" *Science and Public Policy,* Vol. 27, No. 6, 433–42.

Thurow, L.C. (1996), *The Future of Capitalism. How Today´s Economic Forces Shape Tomorrow's World.* New York: William Morrow and Company.

Thurow, L.C. (1999), *Building Wealth. The New Rules for Individuals, Companies, and Nations in a Knowledge-Based Economy.* New York: HarperCollins Publishers.

Thurow, L. C. (2005), *Fortune Favors the Bold: What We Must Do to Build a New and Lasting Global Prosperity.* New York: CollinsHarper.

Tononi, G., Sporns, O., Edelman, G.M. (1999), "Measures of Degeneracy and Redundancy in Biological Networks." *Proceedings of the National Academy of Sciences USA 96,* 3257–3262.

Trayhurn, P. (2003), "Nutritional genomics-'Nutrigenomics,'" *British Journal of Nutrition*, Vol. 89, 1–2.

UJMA, Revija za vprašanja varstva pred naravnimi in drugimi nesrečami (*Journal of natural and other disasters defence*), http://www.sos112.si/slo/page.php?src=li11.htm

Umpleby, S.A. (1987), "Some Policy Implications of Lefebvre's Theory of Ethical Cognition." Paper Presented at a Special European Meeting of the American Society for Cybernetics, St. Gallen, Switzerland.

Umpleby, S.A. (1987a), "World Population: Still Ahead of Schedule," in: *Science, No. 4822*, Vol. 237, 1555–1556.

Umpleby, S.A. (1987b), "Some Policy Implications of Lefebvre's Theory of Ethical Cognition," Paper Presented at a Special European Meeting of the American Society for Cybernetics, St. Gallen, Switzerland.

Umpleby, S.A., Negev, E. (2009), "A Reflexive View of a Transdisciplinary Field: The Case of Cybernetics." Paper Presented at the 4th Heinz von Foerster Conference, Vienna.

United Nations News (2004), "UN: Population to double in flood prone areas." Retrieved 30th August 2009 (www.unmideast.com/)

Valente, M. (2003), "Oil-Eating Bacteria for Antarctica." *IPS*. Available at http://ipsnews.net/news.asp?idnews=21652

Varela, F.J. (1975), "A Calculus for Self-Reference." *Inernational Journal of General Systems* Vol. 2, 5–24.

Varela, F.J. (1976a), "Not one, not two: Position paper for the mind-body conference", *Co-Evolution Quarterly* 3: 62–67.

Varela, F.J. (1976b), *The Arithmetic of Closure*, unpublished manuscript.

Varela, F.J. (1979), *Principles of Biological Autonomy.* New York: Elsevier/North Holland.

Varela, F. J., Goguen, J. (1977), "The Arithmetic of Closure", in: R. Trappl (ed.), Progress in Cybernetics and Systems Research, Vol. 3, Wiley Hemisphere: New York, 48–63 (reprinted also 1978 in the Journal of Cybernetics, Vol. 8, 291–324)

Velis, D.N. (2008), "Thoughts about Seizure prediction from the Perspective of a Clinical Neurophysiologist," in: B. Schelter, J. Timmer, A. Schulze-Bonhage (eds.), *Seizure Prediction*, op. cit., 317–323.

Vodeb, G. (2004), "Metodologija ustvarjanja smisla kot teoretska zasnova študija uporabnikov." *Knjižnica Ljubljana,* Vol. 48,1–2.

Vogel, S. (2007), "Anwendung und Kalibrierung eines Entscheidungsmodells mit Gedächtniseffekt." Diplomarbeit, Inst. F. Theo. Physik, Univ. Stuttgart.

Vogel, V., Baird, B. (2003), "Nanobiotechnology: Report of the National Nanotechnology Initiative Workshop." Available at http://www.nano.gov/nni_nanobiotechnology_rpt.pdf

Völz, H. (1994), *Information verstehen. Facetten eines neuen Zugangs zur Welt.* Braunschweig: FR. Vieweg&Sohn.

Vygotsky, L.S. (1978), *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Vynnycky, E., White, R.G. (2010), *An Introduction to Infectious Disease Modelling.* Oxford: Oxford University Press.

Wadsworth, Y. (1998), "What is Participatory Action Research?" *Action Research International paper 2.* Retrieved 10th September 2009 (http://www.uq.net.au/action_research/ari/p-ywadsworth98.html).

Waldrop, M.M. (1992) *Complexity: The Emerging Science at the Edge of Order and Chaos.* New York: Simon&Schuster.

Wallerstein, I. (1974), *The Modern World System I. Capitalist Agriculture and the Origins of the European World Economy in the Sixteenth Century.* New York: Academic Press.

Wallerstein, I. (1979), *The Capitalist World-Economy.* Cambridge: Cambridge University Press.

Wallerstein, I. (1980), *The Modern World System II. Mercantilism and the Consolidation of the European World Economy*. New York: Academic Press.

Wallerstein, I. (1984), *The Politics of the World Economy. The States, the Movements and the Civilizations.* Cambridge: Cambridge University Press.

Wallerstein, I. (1989), *The Modern World-System, vol. III: The Second Great Expansion of the Capitalist World-Economy, 1730–1840's.* San Diego: Academic Press.

Wallerstein, I. (2004), "The Scholarly Mainstream and Reality: Are We at a Turning Point," in: ibid. (ed.), *The Modern World System in the Longue Durée*. Boulder: Paradigm Publishers, 219–228.

Wallerstein, I. (2004), *The Uncertainties of Knowledge.* Philadelphia, PA: Temple University Press.

Walton, D.N. (1989), *Question-reply argumentation.* New York: Greenwood Press.

Walton, D.N. (2000), "The place of dialogue theory in logic, computer science and communication studies." *Synthese,* Vol. 123, No. 3, 327–346.

Watson, J.D. (1968), *The Double Helix*. New York: Atheneum.

Watts, D.J. (1999), *Small Worlds: The Dynamics of Networks Between Order and Randomness.* Princeton, NJ: Princeton University Press.

Watts, D.J. (2003), *Six Degrees: The Science of a Connected Age.* New York: Norton.

Watts, D.J. (2004), "The 'New' Science of Networks." *Annual Review of Sociology,* Vol. 30, 243–270.

Weber, M. (1905), *Die protestantische Ethik und der 'Geist' des Kapitalismus* (The Protestant Ethic and the Spirit of Capitalism, transl. 1930). London: Allen&Unwin.

Weber, M. (1949), *The Methodology of the Social Sciences*. New York: Free Press.

Weber, M. (1951), *The Religion of China: Confucianism and Taoism*. Glencoe, Ill.: Free Press; New York: Macmillan.

Weber, M. (1978), *Economy and Society: An Outline of Interpretive Sociology*. Berkeley: University of California Press.

Weidlich, W. (2000), *Sociodynamics: A Systematic Approach to Mathematical Modelling in the Social Science*. London: Taylor&Francis.

Weidlich, W., Haag, G. (1983), *Concepts and Models of a Quantitative Sociology, The Dynamics of Interacting Populations*. Springer-Series Synergetics, Vol. 14, Berlin, Heidelberg, New York: Springer.

Weidlich, W., Haag, G. (1987) (ed.), "A Dynamic Phase Transition Model for Spatial Agglomeration Processes." *Journal of Regional Science*, Vol. 27, No. 4, 529–569.

Weidlich, W., Haag, G. (1988) (eds.), *Interregional Migration. Dynamic Theory and Comparative Analysis.* Berlin: Springer.

Weingart, P. (2001), *Die Stunde der Wahrheit? Zum Verhältnis der Wissenschaft zu Politik, Wirtschaft und Medien in der Wissensgesellschaft*. Weilerswist: Velbrück Wissenschaft.

Weiss, L. (1998), *The Myth of the Powerless State*. Ithaca, NY and London: Cornell University Press.

Welzer, H. (2002), *Das kommunikative Gedächtnis: Eine Theorie der Erinnerung.* München: Verlag C. H. Beck.

Wenger, E. (1998), *Communities of practice: Learning, meaning and identity*. New York: Cambridge University Press.

Wenger, E. (2008), "Meaning," in: P. Murphy, K. Hall (eds.), *Learning and practice: Agency and identitities*. London: SAGE Publications Ltd., 431–446.

Whalen, J. (2009), "In Attics and Closets, 'Biohackers' Discover Their Inner Frankenstein." *The Wall Street Journal.* Available at http://online.wsj.com/article/SB124207326903607931.html

White, E.N. (1996), *Stock market crashes and speculative manias*. Cheltenham: Elgar.

White, E.N., Rappoport, P. (1995), "The New York stock market in the 1920s and 1930s: Did stock prices move together too much?," in: M. Bordo, R. Sylla (eds.), *Anglo-American Financial Systems: Institutions and Markets in the Twentieth Century*. New York: Irwin Professional Publishers, 299–316.

White, H.C. (2002), *Markets from Networks. Socioeconomic Models of Production*. Princeton: Princeton University Press.

White, R.W. (1977), "Dynamic Central Place Theory." *Geographical Analysis,* Vol. 10, 226–243.
Whitehead, A.N. (1911), *An Introduction to Mathematics.* London: Williams and Norgate.
Whitley, R. (1998), "Internationalization and Varieties of Capitalism: The Limited Effects of Cross-National Coordination of Economic Activities on the Nature of Business Systems." *Review of International Political Economy,* Vol. 5, No. 3, 445–481.
Whitman, J. (2006), "Governance Challenges of Technological Systems Convergence." *Bulletin of Science, Technology & Society*, Vol. 26, No. 5, 398–409.
Williams, T. (2008), "Algae and Bacteria Oil." *GreenMuze*. Available at: http://www.greenmuze.com/blogs/eco-geek/655-algae-and-bacteria-oil.html.
Williamson, O. (1975), *Markets and Hierarchies: Analysis and Antitrust Implications.* New York: Free Press.
Williamson, O. (1981), "The Economics of Organization: The Transaction Cost Approach." *American Journal of Sociology*. Vol. 87, 548–577.
Williamson, O. (1985), *The Economic Institutions of Capitalism.* New York: Free Press.
Wilson, D.R. (2006), "The Evolutionary Neuroscience of Human Reciprocal Sociality: A Basic Outline for Economics." *The Journal of Socio-Economics,* Vol. 35 (4, August), 626–633.
Wilson, E.O. (1998), *Consilience: The Unity of Knowledge.* New York: Alfred A. Knopf.
Wisner, B., Blaikie, P., Cannon, T., Daws, I. (2004), *At Risk. Natural Hazards, People's Vulnerability and Disasters* (second edition). London: Routledge.
WMO (2007), "Elements for life." A Publication for the International Conference on Secure and Sustainable Living." Madrid, March.
WMO, "Severe Weather Information Centre. Official observations." *Official Warnings*: http://severe.worldweather.org/
Wong, D., Fotheringham, A.S. (1990), "Urban Systems, Fractal Dimension, Rank-Size, and rural to urban Migration." *Geografiska Annaler,* 72 B, 89–99.
Žagar, M. (2007), Personal communication.
Žagar, M. (2008), "Analiza vzrokov in numerično modeliranje močnih padavin 18. septembra" (Analysis of causes and numerical modelling of heavy precipitation on 18 September 2007). *Ujma* (Ljublj.), 22, 101–104.
Zakour, M.J. (1996), "Geographic and Social Distance during Emergencies: A Path Model of Interorganizational Links." *Social Work Research*, Vol. 20, 1.
Zakour, M.J. (2009), "Social Work and Disaster," Retrieved 30th August. Http://training.fema.gov/EMIWeb/downloads/edu/Socialworkanddisasters4.doc)

Zaviršek, D. (2006), "Ethnographic research as the source of critical knowledge in social work and other caring professions," in: V. Flaker, T. Schmid (eds.), *Von der Idee zur Forschungsarbeit: Forschen in Sozialarbeit und Sozialwissenschaft*. Vienna: Böhlau Verlag, 125–144.

Zhao, J.X., Zhang, J. (2007), "Inelastic demand spectra of bi-linear models for capacity spectrum method and response of simple structures under near-source records." *Journal of Earthquake Engineering*, Vol. 11, No. 4, 631–652.

Zipf, G.K. (1949), *Human Behavior and the Principle of Least Effort*. Cambridge, MA: Addison-Wesley.

Zsambok, C.E., Klein, G. (1997) (eds.), *Naturalistic Decision Making*. Mahwah: LEA.

Zuo, X.B., Li, A.I., Chen, Q.F. (2008), "Design and analysis of a superelastic SMA damper." *Journal of Intelligent Material Systems and Structures*, Vol. 19, No. 6, 631–639.

Zupančič, T. (2008), "Architectural-urban reasons influencing the design of irregular building structures." (Arhitekturno-urbanistični dejavniki za projektiranje iregularnih zasnov stavb); (in Slovenian). *AR, Architecture, Research*, 2008/1, 99.

Authors

David M. Gear is a Senior Research Scientist in the social sciences at the University of Wisconsin Madison. His main publications and professional activities have involved socio- economies, institutions, creativity in science, and the history, philosophy, and sociology of science.

Monika Gisler (monikabgisler@gmail.com) has been a senior scientist at ETH Zurich, since 2000 at the Swiss Seismological Service, Department of Earth Sciences, ETH Zürich (Prof. Dr. D. Giardini), and since 2007 at the Chair for Entrepreneurial Risks, Department of Management, Technology, and Economics, ETH Zurich (Prof. Dr. D. Sornette). Her publications include books and papers on Historical Seismology, 18th century Science history, and most recently the topic of Social Bubbles.

Günter Haag (haag@stasa.de), professor, is director of the Steinbeis Transfer Centre Applied System Analysis; managing director of the Steinbeis Applied System Analysis GmbH, and trustee of the Wiener Institute for Social Science Documentation and Methodology (WISDOM).

Ellen Jane Hollingsworth (hollingsjr@aol.com); as a member of the University of Wisconsin Department of Sociology and previously, the Institute for Research on Poverty, is the author, coauthor, or editor of six books and many articles on the delivery of social services in the United States and Europe. Her studies of service systems for people with severe mental illness and for people with other disadvantages have usually been framed with a socioeconomics perspective. Her other work has been concerned with administration of welfare and health programs, modes for delivering social services to the needy, and administrative/legal constraints on public employees and clients. Her recent studies have centered on research institutions, organizations, and scientific laboratories, particularly in Britain.

J. Rogers Hollingsworth (hollingsjr@aol.com); since 1964, he has been a faculty member at the University of Wisconsin (Madison) where he has held the following appointments: professor in the Departments of Sociology, History, the Industrial Relations Research Institute, affiliated faculty member in the Department of History of Medicine, and chairperson of the Graduate Program in Comparative History (presently emeritus); visiting professor at the University of Ljubljana, September 2008: Co-coordinator of the trans-Atlantic program on RISC (Rare Incidents with Serious Consequences).

Lučka Kajfež-Bogataj (lucka.kajfez.bogataj@bf.uni-lj.si) is a professor of climatology at the Biotechnical Faculty since 1997. She is/was involved in and leading several national and international scientific projects related to climatology; publicised many scientific publications. Her background are mainly climate change (she served as vice-chair of the WG 2 Fourth Assessment of the IPCC) and climate system. She is currently a member of GCOS – Global Climate Observation System committee at WMO. She has references also in agrometeorological applications, mainly related to water balance and crop models and was engaged in several EU COST actions. Since 2006 she is Chairman of WG3 for EC-COST 734 Project Impacts of Climate Change and Variability on European Agriculture. Currenty she is the project leader in EuroGEOSS (WP5), a large scale project in the 7th FP of the EC.

Vojko Kilar (vojko.kilar@fa.uni-lj.si), structural engineer, is associate professor at the Faculty of Architecture, University of Ljubljana. He is author of several books covering topics related to static and earthquake-resistant design in architecture. His research work is primarily related to the field of earthquake engineering and earthquake-resistant structures in architecture. He is author of more than 50 scientific papers in international reviews, books and conference proceedings. As a practical designer or structural advisor, he has cooperated in the design of a number of buildings in Slovenia.

David Koren (david.koren@fa.uni-lj.si), structural engineer, is a PhD student at the Faculty of Architecture, University of Ljubljana. His research work is concentrated on structures in architecture, seismic isolation, structural asymmetry, seismic analysis and modeling of structures. He is now finishing his PhD dissertation, which focuses on the usage of seismic isolation in order to reduce the unfavorable seismic behavior of asymmetric structures and on the simplified methods for nonlinear analysis of base-isolated building structures.

Urban Kordeš (urban.kordes@guest.arnes.si) graduated in mathematical physics at the University of Ljubljana, Slovenia. He defended his master thesis and doctoral dissertation in philosophy and cognitive science. He is assistant professor of methodology at the Faculty of Education of the Ljubljana University. He is currently president of the Slovenian society for cognitive sciences. Main research areas: cognitive science, theory and approaches to interdisciplinary collaboration, first-person inquiry and dialogue.

Vili Lamovšek (Vili.Lamovsek@fsd.uni-lj.si) is a social worker. He graduated from the Faculty of Social Work at the University of Ljubljana, Slovenia. He is currently employed as the coordinator for community mental care at Center of Social Work in Ljubljana. He also works part-time as research fellow and assistant lecturer at the Faculty of Social Work. His main areas of interest are coordination of care, especially for people affected by natural and other disasters. He has rich experiences of voluntary work in affected areas.

Bogdan Lešnik (Bogdan.Lesnik@fsd.uni-lj.si) is an associate professor at the Faculty of Social Work, University of Ljubljana, and currently the dean of the Faculty. He has led research on post-tsunami relief operations in Sri Lanka and has established long-term cooperation between University of Ljubljana and University of Colombo. His fields of interest include psychoanalysis and group analysis.

Adrian Lucas (lucas.switzerland@gmail.com) studied Natural Sciences in Cambridge, and has worked as a hydrologist, derivatives structurer, and software business developer. Alongside his writing project *The Organizing of Promises*, his current interest is propagating an open source environment for printed electronics, thus enabling a future of mass-distributed personal printers for on-demand printing of polymer-based functional devices, including lights and photovoltaics.

Franc Mali (franc.mali@fdv.uni-lj.si) is professor for sociology of science and epistemology at the Faculty of Social Sciences, University of Ljubljana. He is head of the Center for Social Studies of Science at the Faculty of Social Sciences, University of Ljubljana. His recent research is concentrated on the social and ethical regulation of modern technologies, the role of scientific intermediary structures in modern societies, science and technology indicators for R&D policy.

Karl H. Müller (Mueller@wisdom.at), works as a social scientist, is head of WISDOM and president of the Heinz von Foerster Society. Among his books are Marktentfaltung und Wissensintegration [1999], Knowledge, Second-order Cybernetics, Society. The New Alchemy of the Information Age [2007] and The New Science of Cybernetics. The Evolution of Living Research Designs, [2008]. He has co-edited Heinz von Foerster, Der Anfang von Himmel und Erde hat keinen Namen [1997] and Advancing Socio-Economics [2002] (with J. Rogers Hollingsworth and E. J. Hollingsworth). His research interests include second-order cybernetics, complexity theory and evolutionary designs.

Marko Polič (marko.polic@ff.uni-lj.si) is professor of general and environmental psychology at the Department of Psychology, Faculty of Arts, University of Ljubljana. He is active in the fields of environmental psychology, psychological aspects of disasters, and traffic psychology and has been engaged in a number of international and Slovenian research projects.

Toni Pustovrh (tony.pustovrh@gmail.com) is a doctoral student of political and social sciences at the Faculty of Social Sciences, University of Ljubljana. His areas of research and interest include the ethical, legal and societal aspects of emerging technologies, human enhancement, biopolitics, science and technology policy, complexity science and evolutionary psychology.

Jože Rakovec (joze.rakovec@fmf.uni-lj.si) is full professor of meteorology and head of the Chair of Meteorology at the Faculty of Mathematics and Physics, University of Ljubljana. His research covers modeling of meteorological and environmental processes, mainly in meso-scale. He teaches in different faculties at the University of Ljubljana; in the interdisciplinary doctoral program in environmental protection, he is field coordinator for natural sciences. He has represented Slovenia in various international organizations and forums (CAS of WMO, COST etc.) and is a member of advisory boards for two international meteorological journals.

Nino Rode Ph.D. (Nino.Rode@fsd.uni-lj.si) is assistant lecturer at the Faculty of Social Work at University of Ljubljana, Slovenia. His main areas of interest are methodology of research in social work and methodology of evaluation research.

Michael F. Schreiber (michael.schreiber@wisdom.at) Computer artist, researcher and teacher, starting between Marketing, organization development and cybernetics at WU.ac.at; then software engineering and prototyping at Wolfram.com. Author of more than 300 interactive Mathematica programs featuring mathematical concepts, empirical contexts and creative applications of simple programs. Lecturing and coaching at Wolfram Research New Kind of Science Summer Schools in USA and Italy. Exhibitions and live performances of frequency modulated media. Currently lecturer at the department of analytical economics WU.ac.at and senior researcher at WISDOM.at

Jelka Škerjanc Ph.D. (Jelka.Skerjanc@fsd.uni-lj.si) is assistant lecturer and researcher at the Faculty for Social Work in Ljubljana. She has had a long career as a social worker in institutions for disabled people and has contributed to developing community-based social services in Slovenia. Her main area of research focuses on the power and control that social-service users have over the social services they receive. She is involved in designing new profiles in social work and new approaches in social work practice. As a lecturer and supervisor, she has contributed to developing social work courses at the University of Kiev, Ukraine and Tbilisi State University in Georgia. She coordinated the three-month-long, social work volunteer project to support residents affected by the earthquake in Bovec area in July 2004, and she delivered the results of the project to the Ministry of Defense and Ministry of Labor, Family and Social Affairs, Tabor 2004.

Didier Sornette (dsornette@ethz.ch) (b. 1957, Paris), professor on the Chair of Entrepreneurial Risks Department of Management, Technology and Economics (D-MTEC) ETH Zürich; director of the Financial Crisis Observatory; co-founder of the Competence Center for Coping with Crises in Socio-Economic Systems; member of the Swiss Finance Institute; professor of physics associated with the Department of Physics (D-PHYS), ETH Zurich; professor of geophysics associated with the Department of Earth Sciences (D-ERWD), ETH Zürich.

Peter Štrukelj (peter.strukelj@gmail.com) holds a Master Degree in Economics at the Faculty of Economics (University of Ljubljana, Slovenia) with the thesis *Mathematization and modeling in orthodox and heterodox economic theory*. He also holds a Diploma in International Relations at the Faculty of Social Sciences (University of Ljubljana, Slovenia). He currently works as a young researcher and assistant professor—a PhD candidate in Management of Technologies—at the Faculty of Management Koper (University of Primorska, Slovenia). His main fields of study are economics, theory of science and management of technologies.

Ivan Svetlik is currently Minister of Labour, Family and Social Affairs. He was born on September 4, 1950 in Srednja Kanomlja in the Municipality of Idrija. After undergraduate and postgraduate studies in sociology at the Faculty of Social Sciences of the University of Ljubljana he spent further study stays in England and Sweden, where he studied active employment policy. In 1983 he obtained his doctoral degree with his thesis on “Sociological Conceptualisation of Unemployment.” From 1974 until his nomination for Minister, he was employed at the Faculty of Social Sciences of the University of Ljubljana. He is a full professor for human resources and social area, and was appointed Head of the Centre for Organization and Human Resource Research. He investigated and lectured on the topics of work and employment, human resources management, education, quality of life and social policy. From 2005, he also worked at the Rectorate of the University of Ljubljana as Vice-Rector for the areas of quality and students. He is the author of more than 200 scientific and professional publications, mainly in the areas of education, employment, social policy and human resources (Kakovost življenja v Sloveniji, The Profile of the Voluntary Sector in Eastern Central European Countries, Management kadrovskih virov, Politika zaposlovanja, HRM's Contribution to Hard Work, The European Union and HRM: impact on present and future members, etc.). Ivan Svetlik is married and has two children.

Simona Tancig (simona.tancig@guest.arnes.si) is associate professor of developmental psychology at the Faculty of Education, University of Ljubljana, Slovenia. In The Netherlands she completed specialist studies in supervision. In Boston (USA) she pursued advanced studies in psychology. Her basic research interests are in cognition, metacognition, self-regulation, self-efficiency, collaborative learning, expert knowledge, and cognitive science.

Niko Toš (niko.tos@fdv.uni.lj.si) is Professor of Sociology, University of Ljubljana, former Dean and Director of the Institute of Social Sciences in the Faculty of Social Sciences; he was the founder [1966] and continues to be the Head of the Public Opinion and Mass Communication Research Centre, and he acts as the Slovenian representative in cross-national, empirical projects (ISSP, WVS, EVS, CSES, ESS). He was President of the Slovenian [1965–1973] and Yugoslav Sociological Association [1981–1985]. His specializations include: the methodology of social sciences, social stratification, international migrations, democracy, voting behavior and electoral systems, and values.

Stuart Umpleby (umpleby@gmail.com) (b. 1944, USA), cybernetician of management, organizations and society. professor of management science at the George Washington University; PhD at the University of Illinois with Heinz von Foerster as supervisor; former president of the American Society of Cybernetics; many papers on cybernetics and systems thinking, among them "Cybernetics of Conceptual Systems" [1994], "Knowledge Management from the Perspective of Systems Theory and Cybernetics" [2000], "The Design of Intellectual Movements" [2002], "A History of the Cybernetics Movement in the United States" [2005].

Mojca Urek (mojca.urek@fsd.uni-lj.si) is senior lecturer at the Faculty of Social Work, University of Ljubljana, Slovenia. She has undertaken research on community mental health, on the narrative approaches in social work, gender issues in social work and on social work in natural and other disasters.

Romana Zidar, MA (romana.zidar@fsd.uni-lj.si) is assistant lecturer and researcher at the Faculty of Social Work in Ljubljana. Her areas of interest are leadership and management and organizational practices in nonprofit organizations, community organizing, nonprofit marketing, social economy and social entrepreneurship.

Index

H

M

N

O

P

Q

R

S

T

U

V

W

Y

Z

Between 2007 and 2009 the University of Ljubljana initiated a trans-disciplinary research program on rare events with strong societal repercussions and effects, which has been labeled as RISC-program (Rare Incidents, Strong Consequences). In this process, the university established a small unit that sought to act as a catalyst for promoting trans-disciplinary research on rare events across a wide variety of domains both inside and outside the social sciences.
The RISC-unit organized a series of talks, lectures, workshops and research activities, which highlighted the current knowledge frontiers on rare events as well as the available policy recommendations and best practices in reducing hazards and disasters related to rare events. From its overall goals, these RISC-activities were intended as a model for a new type of trans-disciplinary knowledge production that draws together expertise in the social, physical, biological and technical sciences to address urgent societal problems.
The present volume summarizes the advances of these RISC-activities and points to the high relevance of the new RISC-based perspective on societal problems both at present and in the future.