Modelling global institutional networks

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Introduction

The world economy is facing new transitions concerning its accumulation regime and in strict dependency its regimes of institutions. As the theory of régulation proposes[1], every accumulation regime is changed endogenously caused and feeding back to economic crisis. These changes are often neglected by mainstream economic theory, usually not to be confronted with the consequences of its own impotence concerning the interpretation of the new circumstances. In the capitalist mode of production the increase of labour productivity to maximise entrepreneurial profits has become omnipresent. Today profit rates still are the ultima ratio on which all derived salaries of those who manage its working depend. In times of crisis it becomes evident that this regime tends to undermine its own fundamentals, that it produces unsustainable global inequality in economic, political, social dimensions as well as environmental disasters. In particular the capitalist mode of production proves more and more that it can no longer handle the problems it created by employing its own institutional settings, without creating other, even more severe problems. Nevertheless economists still work with an anti-historic picture of institutional change, ignoring cumulative processes of endogenously growing institutions.

Therefore we suggest looking more deeply into the evolution of institutions and possible social innovations – on all layers of aggregation, but in particular on the most neglected one: the global layer. The world economy is a globalised system now and it will face specific global problems in the future. David Held[2] for instance has impressively shown that we will probably need new global institutional settings to tackle upcoming problems. But how can we even think about such new institutional developments, when most economists at best have optimisation of transactions costs in mind, if they care of modelling institutions at all[3]. Institutions are developing frameworks of rule systems, their changes come as swarms of social innovations. In more quiet times they remain

[1] Compare Boyer, R. and Saillard, Y. (eds.) (2002).

[2] Compare Held, D. (2004).

[3] The last pair of Nobel Prize laureates demonstrates a slight departure from this tradition: Oliver Williamson, the godfather of transaction cost theory, *and* Elinor Ostrom, struggling to reconcile her seemingly non-economic aspirations with economic tools.

relatively stable and regulate the interactions of the social structures they are embedded in. The challenge for political economy hence is to produce a model of a pulsating system, which captures the diverging explosion of contradicting forces kept together by rigid institutional settings as well as the eventually occurring break of the old institutional setting if strains hit a limit. In this latter phase of radical social innovation modelling becomes particularly difficult since lower level institutional entities are forced to build the new rule set from scratch. In other words they use historical analogies and recently developed technological devices to compose new trial solutions. For a model-builder in political economy it is particularly hard to anticipate what the definite outcome of such a vaguely determined process could look like. At second glance the surprising, - and somewhat reconciling - fact is that the role of the model-builder and the role of the social innovators at work become congruent, even undistinguishable. Of course, scientists in political economy are not necessarily political entities deciding on a grand and novel global institutional framework – and vice versa. Nevertheless the subject of investigation, political economy, enforces a coalition of these roles[4].

In this paper we suggest a framework to model global institutional development, including global governance, in a network perspective along 3 specific concepts: ***agent-based modelling***, ***scale-freeness*** and ***nestedness***.

Agent based simulation seems to be the only game in town capable to transform the prosaic descriptions of large scale evolution in human societies into somewhat more formal descriptions. It has been the technological breakthrough of symbol manipulating machines more than 50 years ago, which made this advance possible. The same scientist who invented the computer, John von Neumann, also provided the booster detonation for the last exciting development in analytical techniques for political economics: game theory. Despite uncountable and supremely intelligent efforts to restrict game theory to the analytical study of equilibrium paths its innovative force inspiring evolutionary political economy via agent-based simulation seems to be unbroken. Indeed, recent developments seem to foreshadow a rather successful co-evolution of the two sub-disciplines.

The concept of scale-freeness started its career as an empirical discovery, as a property of distributions observed in samples generated by living entities of the same species. It clearly was a serious challenger to the all-time darling of physics, the normal distribution. While the latter – with all kinds of substantial refinements - still dominates theories of non-living matter, the search for the generating processes that produce scale-freeness in space and time should be one of the hottest topics in evolutionary political economy[5]. If this type of distribution is a footprint of a living system, then the discovery of generating processes could provide hints for the jump from non-living to living dynamics. Note that such a process again is best modelled as a computer program, and thus easily incorporated in agent-based simulation.

Finally nestedness has to be addressed. In principle the idea of nested structures has always been implicit in the social sciences. When Auguste Comte, still pupil of Saint-Simon at the time, conceptualized the new science as a kind of 'social mechanics' he clearly envisaged a social

[4] The classic 'philosopher kings' (!) of ancient Greece have thus anticipated what the dark ages of the last 135 years of mainstream economics tried to disguise. Only a handful of renegades, e.g. [Schumpeter, 1911], made attempts to break the spell of pseudo-seriousness, a spell propelled by the use of inadequate but complicated formalisms. It is remarkable that the intuition of these renegades usually did stem from close inspection of actually occurring processes in political economy.

[5] Herbert Simon was one of the first scientists to suggest such a process for Zipf's empirical law for city sizes in the early fifties, [Simon, 1955].

machinery consisting of interwoven parts of different size and heterogeneous functions. Smaller parts being nested in larger parts, the overall logic being accessible to the human mind – this indeed being the core of the intellectual project of the French Enlightenment. In modern mainstream economics this view degenerated into the disciplinary split between microeconomics and macroeconomics. Though the project to base macroeconomics on a rigidly formalized but misconceived microeconomic credo failed dramatically, the contemporary structure of economic research still reflects this obsolete dichotomy[6]. Clustering and nestedness certainly are not properties of living systems only; every solar system consists of planets with planets eventually having moons. What is unique in human networks is that its planets *consciously form* a solar system which then governs their individual behaviour. Nestedness in economics thus is characterized as a trend, a procedure, which drives entities at all levels to form larger entities[7]. The survival of the larger entity seems to transcend the shorter lifespan of the smaller entities, this being the central issue of the concept of a species. Interesting enough this evolution again proceeds in pulsations; every larger entity after some time is subject to sclerosis and lower level entities get a chance to reframe its structure. Unfortunately enough so far economists have contributed little to conceptualize this type of dynamics.

The framework sketched in this paper is to be understood as a step to improve his poverty of economic theory. In particular it indicates potential gains to model and to improve global governance via its archetypical concepts.

[6] In this respect evolutionary economics is the exception from the rule, since it puts strong emphasis on the importance of meso-levels and their links. Instead of building models of all phenomena by assuming smallest units (atoms) endowed with first principles (the 'economic principle') and then using deduction, evolutionary economics often starts with a network concept right away, enabling it to be much closer to empirically observed phenomena.

[7] Note that this again points at the importance to mimic procedures by the use of programs, to apply simulation and agent-based modeling.

1. Global governance – global institutions

Institutions are usually treated with the concept of transaction cost economics nowadays, which can be seen as a program to endogenize institutions into neoclassical models of growth for example. Here institutions emerge out of externalities and represent contracts among third parties such as firms, governments and society. These contracts then determine costs which can be traded on the market, as example given by ecological certificates. On a first look this conception seems quite obvious and adjudging, because it faces problems of common goods, property rights and externalities in an old school economic manner: 'Waste earth, but buy a certificate.' On a second look we have to admit that the idea of institutions as costs may let us think that we just need enough money to treat occurring problems with externalities and internalise them via the markets. In this respect we may say that for example an ecological externality, like mere dirt, is just a matter of market allocation. In belief of perfect markets such phenomena would be perfectly distributed among society. Then the problem arises either markets are perfect or not?

We want to argue in this paper that a globalised economy will produce global problems which will be of such complexity that mere markets will not manage to handle them in a fair and balanced way. Hence we have to imagine institutions differently. Recent developments on planet earth, like climate change, everlasting poverty, energy crisis and financial fall-down, have shown that markets are not general purpose machines, optimally allocating resources. Indeed markets are the most proper institutions humans developed, because they can exchange information very fast, unfortunately on the back of democratic principles. Markets are rule systems which change over time in the need of improvements due to new circumstances; that is a point policies mostly ignore. The mainstream economic view treats economic phenomena as a mechanistic closed system and gives policy suggestions in a similar manner. We wonder how global problems shall be tackled with such an odd and backward perspective. Globalisation made the world more interconnected and smaller, but complexity has grown very fast as well. We face an époque where global governance will get more and more important, due to the simple fact that mere nations don't have the power to solve global problems, they even can't estimate the consequences of their own policies on a global layer. Such an outlook suggests treating economics as an opened global system which should enhance its institutions in various directions. Economics needs a holistic naturalistic foundation, integrating the so-called social world with the natural world, and then the concept of an institution may regain blood in its veins. Modern institutional settings need to be self-organized and self-regulating on the one hand, though they have to care about regulative/governing tasks as well, in case of developing new rule systems. Facing such a double chimera needs a more complex concept of institutional development.

First of all institutions can't be treated as mere contracts, because it's the actors who build up an institution. They construct social realities[8]; of course institutions may deliberately emerge out of new socio-economic needs, nevertheless they are situated in agents' structures. Additionally institutions don't work as mechanic laws; they rather represent organic characteristics as individuals do. Hence in a naturalistic foundation of economics institutions would represent a whole linage or a species in an evolutionary interpretation and not just a single organism. In order to conceptualise global

[8] Compare Searle (1995).

governance via global institutional networks we also suggest using a new observational language, in tradition of evolutionary economics.

Modern evolutionary theory faces a struggle between micro- and macroevolutionary concepts, whereas the former usually works within the idea of population genetics and the latter with more developmentalist approaches.[9] This struggle can be compared with debates between orthodox and heterodox approaches in economics as well. The idea is rather simple; it's about history and adaptation. Sole micro approaches, independent from any scientific discipline, mostly argue that functional adaptation to the environment is the one and only justification for existence. Macro approaches argue that existence is a matter of development and history; hence structure and its constraints matter. We face an old dichotomy between functionalism and structuralism. This dichotomy is of great importance for the interpretation of institutions: Are they just adaptive vehicles in a struggle for existence or are they the cumulative outcomes of long historical processes?

Several institutionalists, such as Bourdieu (1984), Fine (2001), Hodgson (2004), Ostrom (2005), Searle (2005) for example, have continuously stressed the notion of agency versus structure in their work. It is the interconnection of these two most important concepts of social science at all, which drives institutional change. In order to integrate agency and structure it is necessary to reconceptualise the notion of the individual again. This special attempt of integration may be a first milestone towards bridging micro and macro approaches across the sciences. In this case we may follow evolutionary biologists such as Ghiselin (1974) and Gould (2002) who have stressed to use the term *individual* as a generalisation, contrary to the mainstream gene-centred perspective, advocated by Dawkins (1976) for example. That means in particular that an individual may be a unique *organism*, but can additionally stand for a species as well. Hence organisms refer to unique bodies, such as a human-being or a cow and individuals refer to a more general term of organized structures, such as species, lineages or organisms. Corning (2005, p. 187ff) took over the same idea but with different terminology, he uses *super-organisms* for higher level entities, as also Sober E. and Wilson D.S. (1999), Hölldobler B. And Wilson E.O. (2008) do. Gould (2002, p. 601) refers to this terminological discussion as too confusing and cites Hull (1976, p. 175) correspondingly:

> From the point of view of human perception, organisms are paradigm individuals. In fact biologists tend to use the terms 'organism' and 'individual' interchangeably. Thus biologists who wish to indicate the individualistic character of species are reduced to terming them 'superorganisms'. The same claim can be expressed less misleadingly by stating that both organisms and species are individuals.

Thus, we will refer to individuals as the general term as well. Why is this terminological discussion even important? In the modern synthesis of population genetics the idea came up that selection and adaptation is only working on micro-units, i.e. organisms. The more macro-evolutionary side of the discipline is nevertheless convinced that there is something like hierarchical selection going on. That means selection also works on lineages and species. This opens discussion, that even on the genetic level of inheritance, genes do not transfer genetic information alone in the process of inheritance.[10] These insights relax the mere gene-centred perspective of so-called Neo-Darwinism, elaborated by Dawkins (1976) for example. Bringing this discussion back to evolutionary economics it would on the one hand completely change the idea of a Generalized Darwinism, because its advocates trust on the

[9] Compare Gould (2002, p. 595ff).
[10] Compare Herrmann-Pillath (2007).

gene-centred perspective of population genetics for now, and on the other hand it opens new perspectives on institutions as holistic individuals.

A holistic concept of agency is necessary to understand the role of institutions in economics. Holism means that institutions can be neither reduced to mere contracts nor to its organismic agents, as the famous quote from Aristotle subsumes: 'The whole is more than the sum of its parts.' Another crucial issue of holistic institutionalism is that an institution cannot be treated within a setup of methodological individualism, because it can't be reduced to a unique *organism*, which can be simply distinguished via a certain discrete place and time of birth and death. Corning (2005) brings up the idea of synergy in order to ontologically state the assumption, that institutions are individuals. He refers to an individual[11] if it is as synergy-producing entity. In Corning's view human society faces a so-called *collective survival enterprise*. This notion is extremely important in the light of the Darwinian point of struggle for existence. Such holistic interpretations of evolution show that selection and adaptation work on various layers and that an evolutionary theory does not imply survival of the fittest *organism*, but rather of the fittest *individual*. In that respect it lies in humans' hands alone to treat planet earth as one integral individual, since everything in nature is connected, as again Aristotle showed via the metaphor of the *Great Chain of Being*.

This point additionally implies the possibility of group selection in cultural, socio-economic contexts, which was a major concern of Hayek (1973). Cultural group selection roughly means that cultural traits, which are on the one hand to the benefit of the whole group and which are on the other hand not assignable to a specific organism/human alone, are inherited via selection among groups of individuals. Group selection or hierarchical selection on the whole can help to explain specific developments of institutions. It can tell us why specific institutions emerge due to cultural constrains in different regions in the world. Culture can hear host as an institutional basin of attraction. Additionally we may use group selection as a heuristic device for the formation of specific institutional networks. It can be helpful in explaining historical processes of institutional development as well. Further we want to comment on two, for us important characteristics of group selection. First, Zywicki (2000) wisely argues, among others, that the possibility of group selection truly is a semantic question, hence the argument against group selection cannot be done in an *a priori* matter; it is rather a question of empirical provability. It is a semantic question, because if we look through holistic lenses we can always tackle the problem on two sides; on a higher macro level of one entity – the group – or on a lower micro level of several individuals. This game can be played infinitely. It rests as a question of empirical cover then, what fits better as an explanation, in each specific case. This point totally invites the notion of *nestedness* and *scalefreeness* as methodological vehicles in tradition of complex systems' studies. The second point on group selection can be made clear along Corning (2005, p.20):

> The current revival of group selection theory may perhaps be attributed, in considerable measure, to the growing recognition that it can also entail 'win-win' processes. Co-operating groups might provide mutual advantaged for their members, so that the net benefits to all participants outweigh the costs. In other words, co-operation is not equivalent to altruism and does not by definition require sacrifices, or genes of altruism. ... This, in essence, is what game theory models of co-operation tacitly postulate, (...) which is why game theory formulations are largely indifferent to the degree of relatedness, if any, between the co-operators. ... Moreover, game theory provides a window into a vastly larger galaxy of cooperative phenomena that, I submit, reduces the group selection controversy to a sideshow.

[11] Corning (2005, p. 201) uses superorganism instead of individual, it should be made clear via Gould's (2002, p. 595ff) argumentation why individual suits better.

This point stresses the notion that the discussion on altruistic or egoistic economic behaviour is probably of lower priority than the discussion on cooperation. Game theory as a theory observing cooperation opens a lot of opportunities. It is one thing to accept that institutions construct social realities, that they may stand alone as holistic individuals and probably have to build up networks on evolutionary graphs in a group selection manner in order to challenge global problems, but it still needs the notion of internal model building and strategy formation on the observer side. A game theoretic setting offers a formal model of a social situation, where two or more observers or players have to decide on their strategies. The point of game theory is that the outcome of the game may change endogenously if actors choose freely. If such games are played iteratively then cooperation gains influence; in the long run cooperation may beat out free-riding, as a strategy. Hence we argue that game theory gets its full power in an agent-based context. Agent-based modelling allows simulation of games over time and space with heterogeneous acting agents; therefore it can be easily used to model institutional change in various contexts.

Global governance becomes a huge complex human project. Consider the vast bureaucratic efforts to establish a global currency or even the idea of central banking as global governance[12], the efforts which have to be taken for global democracy[13] or the supply of green energy for all. Such projects can't be treated by a single central global authority, that's obvious. Insofar we insist on the idea of institutional networks as decentralised structures capable to treat ubiquitous problems. These networks carry a heterogeneous set of rule-systems, already developed and still developing by its own agents. In the last part of the paper we will present some concrete modelling techniques and possible applications to the idea of global governance with special focus on democracy design and global banking.

Conclusively we suggest modelling such global institutional networks via the following concepts, at home in the universe of complexity: agent-based modelling, scale-freeness and nestedness. It is very special that all three concepts share the above ascribed and assigned properties of institutions, such as holistic individuality, interconnectivity and internal particularity of heterogeneous cooperative agents. This can lead us to a full-fledged methodological approach to institutional economics along the lines of complexity and evolution.

2. Agent-based modelling

In our view agent-based modelling (or ABM for short) strikes a balance between the two methodological poles of formal mathematical modelling and verbal reasoning. The former methodology is adequate for simpler models, which allow for closed form solutions, but increasing complexity soon leaves numerical simulation as the last resort, thereby losing the elegance of generality while still maintaining the rigid straitjacket of functional relations. Verbal reasoning, on the other hand, a priori imposes no such limitations on the model building process. As Turchin (2003, p. 3) correctly emphasizes, verbal reasoning is "adequate for generating predictions in cases where assumed mechanisms act in a linear and additive fashion (as in trend extrapolation), but [it] can be very misleading when we deal with a system characterized by nonlinearities and lags."

[12] Compare Hall, R.B. (2008).
[13] Compare Held (2004).

In between these two methodological approaches lies ABM which on the one side requires the researcher to explicitly state his assumptions (usually in the form of source code or some meta-modelling language) while on the other hand it is less restraining than the language of mathematics. Especially for social sciences, which (with minor exceptions) usually lack the possibility of controlled experiments, ABM is additionally an attractive alternative for experimenting with hypothetical alternative worlds.

As Gilbert (2008) notes, ABM is a special form of computational social science. More specifically, "[a]gent-based models consist of agents that *interact* within an environment. Agents are either separate computer programs or, more commonly, distinct parts of a program that are used to represent *social actors* – individual people, organizations such as firms, or bodies such as nation-states. They are programmed to *react* to the computational *environment* in which they are located, where this environment is a model of the real environment in which the social actors operate" (Gilbert 2008, p.5, emphases added). While ABM is not necessarily related to computer models – witness Schelling's famous checkerboard model of urban segregation – representation as a computational model is the usual and also the most convenient approach for this class of models. We agree with Turchin (2003, p. 6) that ABM is a potent tool for the investigation of emergent properties of a society of individuals who are assumed to behave in a certain way.

The emphases in the quote above indicate what we believe to be the essential features of ABM, which give this methodology an advantage in explaining global institutional evolution. Specifically, it's the possibility of modelling local interaction between agents (be they individuals or composite actors), on the one hand reactively, in response to changes in the environment or on the other hand proactively, as the agents try to aim for some (exogenously given or endogenously formed) goal. As structures and patterns evolve on the macro-level they may further affect behaviour on the micro-level leading to a feedback cycle between what sociologists would call agency and structure. Add in heterogeneity with respect to agent attributes and it's easy to see that all this (at least in a combined fashion) is beyond the capabilities of mathematical modelling. At the same time, ABM exceeds verbal reasoning for all assumptions have to be stated clearly and their consequences are tested in the course of a simulation run (or a batch of runs).

Another big advantage is that once one has embraced/accepted the simulative approach, many limits/frontiers of pure mathematical modelling fall away. Since the general analytical solution of the model is no longer the point, everything that can be calculated for specific values may be part of the simulation. Many modelling simplifications have not been chosen because they capture the crucial elements of the (economic) process under scrutiny, but rather because analytical solutions wouldn't have been possible otherwise. So in contrast to method-driven modelling ("only model what you can solve"), agent-based modelling offers the chance to employ a more content/substance driven modelling approach ("model what really happens"). *This also enables the usage of (finite and sometimes scarce) space and time as dimensions of interest and importance.*

Since out-of-equilibrium behaviour (so essentially most human behaviour) is not easily captured by identical representative agents, the possibility to model and simulate the heterogeneity of agents is an important feature of agent-based modelling. Though ABM even need not stop at regarding the heterogeneous composition of a population regarding age, wealth, etc. like microsimulation does. It furthermore enables the modelled agents to endogenously behave different from each other in their interactions with other agents. This may be according to their heritage, general experiences, previous

encounters with specific agents, as well as their current state (age, health, wealth, etc.). Hardly anyone would disagree that these differences and partial similarities between individuals are the origin of the necessity for economic interactions.

Agent-based modelling has another advantage, which is important when studying the formation and sustainability of institutions, namely that the structure of interaction can be part of the model. Often the number of networked individuals is of far less relevance than how the network is structured. Agents-based models no longer need to pre-define static structures for their simulated social processes and institutions. Agent-based models can actually simulate the growth and evolution of social structures – for example by employing some form of space (spatial, economic, sociologic, etc.) which leads to local interactions.

Thus the results of different underlying conditions and the forces necessary for the formation of specific institutions can be identified. For the topic at hand, the most interesting part might be to test the sustainability of (e.g. formalized) institutions. This might be done by analyzing how agents accept (or don't accept) forced institutional changes.

The blessings of ABM, however, may at the same time be its weak side. Both, Cederman (1997) and Turchin (2003) agree that the possibility to keep adding interesting features to your model may often lead to overly complex models which are hard to understand. Additionally, we only begin to understand the subtleties of designing agent-based computational models and time and again, replications of so-called classics of ABM show that faulty assumptions or simply programming errors are the actual causes of some discovered interesting pattern. So, although progress at the validation and replication front of ABM is only piecewise and it is often times hard to tell whether a fascinating result is a surprising emergent property of the posited system or just caused by a programming bug, a careful and educated application of ABM proves to be the only game in town capable of advancing knowledge generation with respect to institutional evolution. So if a simulation model's assumptions, model structures, simulation parameters and results are documented well, it can lead to useful, credible and replicable insights[14], which could not easily be gained otherwise.

3. Scale-freeness

Scale-freeness is a concisely defined property of a network; it means that the degree distribution of the network (at least asymptotically) follows a power law. Since the degree of a node of the network is its number of links to other nodes, and the degree distribution thus is the distribution of shares of nodes with a degree k in the total number of nodes, this property of a network can be written compactly as

[1] $$P(k) = c \cdot k^{-\alpha}.$$

The functional form of [1] is called power law and it links in this specific form a distribution $P(k)$of properties of the nodes, e.g. conceptualized as their degree, to the values of this property. Parameter c is a constant and parameter α characterizes the strength of the link between the two

[14] In the ideal case the simulation model should be made available to the scientific community in a useful manner, e.g. completely run able on different operating systems, open-source, with well documented source code.

sides of the equation. In this more general view the expression $P(k)$ can be interpreted as the probability of a node having property k. Take logarithms and time derivatives to transforms [1] into its log-linear representation

[2] $$\frac{\ln P(k)}{P(k)} = -\alpha \cdot \frac{\ln k}{k} .$$

The instantaneous rates of change of the probability of the property and its value are thus proportional. As mentioned in the introduction, the particular interest in scale-freeness comes from the empirical observations of its occurrence in many living systems (compare table 1 taken from [Csermely, 2009, p. 16]).

Table 1: Range of exponents α

Name of distribution	Exponent
Atomic networks	
Occurrence of protein domains	1.6–2.5
Molecular networks	
Prokaryotic protein–protein interaction networks	2.6
Eukaryotic protein–protein interaction networks	2.1
Human protein–protein interaction network	1.7
Gene functional interactions	1.6–2
Yeast gene expression network	1.4–1.7
Escherichia coli metabolic network	1.7–2.2
Biological networks	
Food webs (ecological networks)	1
Social networks	
Scientific collaboration networks	1.2–2.5
Email messages	1.5–2
Zipf's law for size distribution of cities	2
Phone calls	2.1–2.3
Actors' appearance in various movies	2.3
Pareto's law for wealth distribution	2–3
Human sexual contact networks	3.2–3.4
Lotka's law of scientific productivity	2
Information networks	
WWW (in and out connections)	2.1–2.7
Word co-occurrence	2.7
Citations of scientific papers	3
Technological networks	
Software package parts	1.4–1.6
Internet	2.5
Digital electronic circuits	3
Power grids	4

Empirical evidence for the importance of scale-freeness and power laws thus rather is overwhelming. But as the samples investigated are just snapshots at certain points of time, what is even more intriguing is to find archetypical processes producing these distributions. Herbert Simon gave a first answer by looking at a class of functions of the form

[3] $$f(k) = A \cdot \int_0^\infty \lambda^{k-1} \cdot (1-\lambda)^\alpha \, d\lambda ,$$

which lead to the nowadays more familiar class of processes dubbed 'preferential attachment' or 'cumulative advantage'. Its economic interpretation is straight forward: It simply pictures cases where basically unlimited growth by adding additional units to a class in proportion to the actual size of the class occurs. This growth is therefore scale-free, but as Simon already saw, classes need to have a minimum size to start off. Carrying this argument one step further one might say that all that is needed is an environment with diverse conditions for potential entities (classes). If take-offs occur independently at different times at different places, then the initial conditions for a preferential attachment processes leading to snapshots with scale-free distributions are given. As England entered a global environment supporting industrial capitalism earlier than every other nation, it did accumulate faster than its followers[15]. As some firms after World War 2 met conditions which allowed them to establish themselves earlier preferential attachment - e.g. of consumers to their products – played its as an amplifier of heterogeneity[16].

A second more important generating process for scale-free distributions has been proposed by scientists working on protein structures. It works by the duplication of whole structures with slightly diverging mutations[17]. Growth by imperfect, eventually improved copying certainly is the second route taken by living systems. Again its algorithm can lead to scale-freeness. Examples from brain research via child learning to the often-cited *best practice traits* of firms abound.

Scale-freeness and in particular their generating algorithms are thus a new leitmotif for the formal description of growth on *all scales* of human societies. It is of utmost importance that this is adequate on ***all scales of human organization***, because this enables the model-builder to produce an archetypical model which in turn is applicable to all levels. It is appropriate to overcome the false dichotomy of the discipline mentioned in the introduction.

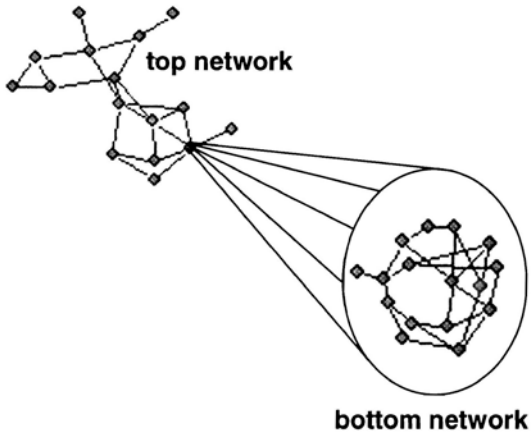
At the same time a consideration of exploding growth alone is insufficient for the understanding of the overall growth process. Its counterpart, the breakdown of sustainable environmental conditions as a consequence of the very success of growth has t be brought into the picture. As environmental conditions (constraints on natural resources, on socially bearable inequality, on military disequilibrium) make growth in the old regime infeasible, this obsolete regime – having lost its raison d'être – dies. But the many somewhat smaller entities which survive its demise, and still are struggling for new forms of cooperation, are probing to install new, more modest but aspiring relationships. They do so by working on a meta-structure (e.g. a global political entity) as well as working on the restructuring of their constituting lower constituents, which is necessary for the fit to the envisaged new meta-structure (e.g. the Lisbon Agenda for the EU, or the re-orientation of firms to go for change rather than growth). In times of crises the reshuffling of the nestedness of social entities, birth and death of institutions, suddenly becomes the most urgent task. This is the topic of the next chapter.

[15] An interesting paper exploring this point is [Malescio et al., 2000].
[16] Compare [Buldyrev et al., 2006a, 2006b].
[17] See [Vazquez et al, 2002], [Sole et al, 2002], or earlier in a different context [Kumar et al. 2000].

4. Nestedness

Nestedness usually is considered as an additional structuring device to make the handling of a complicated large network easier. Again the concise definitions come from pure network theorists. A top level network consists of nodes which themselves, at closer inspection, again are networks called bottom level networks (compare figure 1 taken from [Csermely, 2009, p. 33]). Handling of the top level with fewer nodes is easier than the handling of a network consisting of all nodes of all bottom level networks, in theory as well as in practice. Moreover bottom levels again may have even lower levels constituting each of their nodes; the idea can be generalized to many levels.

Graph 1: The basic idea of nestedness

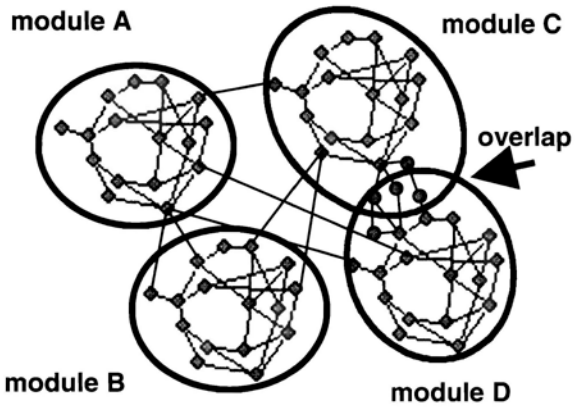


Though the intuition behind nestedness looks trivial and immediately reminds on the institutional structures (horizontal versus vertical) of institutional frameworks, the real crux is how the network summarized at the node of next higher level translates its working into the relationships to the other nodes at the higher level. This is not a trivial question, political economy – at least since Montesquieu - struggles with the question of the choice of good governance.

A formal enhancement to tackle these problems has been the introduction of so-called modules (compare figure 2 taken from [Csermely, 2009, p. 36]). Here the relationships between modules of a top network can be made more explicit by using direct links between low level nodes. It is even possible to blur the distinction between top level nodes by assuming overlaps.

But though matters are now made more explicit this advantage comes at a price: It is more difficult to determine for a given set of low level nodes what can count as a module in the first place. Again a concise definition must be chosen, a particularly common one requires nodes within a common module to have at least as many links within the module than links to nodes outside the module.

Graph 2: The basic idea modules



Like in the case of scale-freeness a lot of empirical research concentrated on the investigation of existing network structures at a given point in time and the implications of certain module definitions for the structure of higher level networks. But again the important aspect for the study of living systems - in particular also for political economy - is not comparative statics but dynamics: How does nestedness emerge? The formation of the European Union after the breakdown of the war structures in WW2 is a point in case as well as the emergence of global political entities starting with the global economic crisis right now.

As mentioned at the end of the last chapter the breakdown of an inadequate larger level network usually is the point of departure for emergence of a new large network. A kind of *destructive creation*, to paraphrase a famous expression of Schumpeter, takes place. The *vision* (Schumpeter again) of the new meta-system within the internal models of survivors works not only towards the top-level relationships, it also is forcing its lower level constituencies to reshape according to the new plan. It has to build adequate inner organs to stand the emerging challenges at the meta-level. If Latin America looks a bit lost in the after-crisis world, it nevertheless will be a survivor and an important contributor to the new global system – as documented in Brazil's first letter in the concept of BRIC states. Though it will place its mark at the top level it nevertheless will have to reshape simultaneously its internal structures to adjust to its own vision of global interplay. Emergence always works in both directions, upwards and downwards, though never symmetrically. The arrow of time points towards ever larger entities.

Another important point is the fact that the set of survivors usually is extremely heterogeneous. There seems to be no simple general issue that goes beyond Schumpeter's vague expression stating that out of old, slightly transformed elements observed in the past, new and surprising combinations are envisaged: novelty. Note also that the emergence of novelty in human society always occurs at two interdependent levels: In the internal models used by entities new nodes and programs emerge, and in the system of the primary metabolism ('reality') new entities and processes start to exist. Moreover both types of metamorphosis are mirrored by the vanishing of elements and procedures. Again this is addressed already by Schumpeter's notion of 'creative destruction, and since has been studied in detail for many cases – but a convincing archetypical model of novelty is still missing.

Perhaps in future research the study of the evolution of nestedness on lower scales can provide hints in that respect.

5. Synthesis

The question how to model institutional evolution today can be based on the works of a global scientific community in which extremely heterogeneous groups are not always aware of the respective advances of others, to say the least. Indeed it is hard to overcome differences in traditionally grown frameworks and professional jargon. Nevertheless to strive for more synthesis is currently scientifically more rewarding than working on decreasing returns within idiosyncratic sub-disciplines. One could start with an elementary overview.

A grouping of the approaches sketched in this paper has three elements:

(1) Methodological advances (e.g. agent-based modelling, game theory, etc.)
(2) Transdisciplinary studies of the current state of affairs in global political economy
(3) Study of the history of political economy to reveal long-run dynamics

Applying these three elements to consult global economic policy can roughly take on the following forms.

(1) The methods used should be able to[18] explain two different phases of evolution: exploding growth (like the famous 'Cambrium explosion' in biology), and the emergence of novelty when growth breaks down (metamorphosis). ABS techniques, algorithms producing scale-free distributions, and similar research are steps to explore the first phase. The study of the evolution of nestedness, of the emergence of institutions, and the like is trying to come to terms with the second phase. In example 2, further down, we briefly summarize an agent-based simulation exercise which throws new light on the concept of 'trust'.

(2) To identify which the relevant entities are building new institutions in the current crisis, it needs serious cross-disciplinary empirical research. Of course, this research must not remain in the arena of discovering 'interesting' singular issues but must be focussed on finding the strongest links between the strongest global players. In example 1 (below) a typical field for such research global banking, is provided.

(3) Having identified relevant (strongly heterogeneous) entities and their short-run interaction dynamics this image of the contemporary state of affairs has to be put into the long-run historical context. The rule is: the deeper the break that is expected, the longer back in history it is necessary to look. In a recent paper, one of the authors investigated the changing form of money, credit, capital, and the state in the long-run (Hanappi, 2009].

Some preliminary results of such a synthetic effort on the modest local basis, which the authors were able to reach, are stated below. These 15 suggestions have to be understood as a kind of interim report guiding our future efforts, and hopefully stimulating other researchers.

[18] Note that the contrast to the equilibrium dynamics method of mainstream economics could not be more radical.

i. The crisis has come to stay, it is not just one of the well-known cyclical downturns, which with the help of in-built stabilizers returns to a long-run growth path.

ii. There is a whole set of possible reasons for this L-shaped form of the current crisis. Their coincidence - which is not bad luck bad but due to them being interdependent – explains the particularly sudden and deep downturn. The most important underlying latent reason has been the fading out of sufficiently high profit rate expectations (linked to standard risk levels) with respect to investment in the real economy. This has depressed interest rates in the last decades and has driven capital towards stock exchanges.

iii. But, as explained in more detail in [Hanappi, 2009], winners in financial markets can only gain more than the low real growth rate of economies if they find the same amount of losers to trade with. In the long-run the difference between the sum total of extra-profits and extra-losses in stock exchanges cannot exceed gains achieved by real growth. Financial bubbles emerge because time enters explicitly into financial contracts and financial engineers have developed methods to delay market adjustments, methods which can disguise the just mentioned fact for some time. But the longer it is delayed, the deeper the fall.

iv. The candidates for triggering this latent cause into a manifest crisis are rather numerous and go beyond the rather anecdotal evidence of the fall of Lehmann Brothers. Candidates are the substantially increasing insecurity associated with the expected end of the Bush presidency, the expected fall in the exchange rate of the US dollar due to a sensitivity border expected to be hit in foreign exchange markets, the suddenly accelerating political emancipation of South American countries (linked via high oil prices in summer 2008), rapid and increasingly recognized deterioration of environmental conditions, and the like.

v. After the fall in autumn 2008 the underlying reasons have not been eliminated: There are no changes in possibilities for higher profit rate expectations in the real economy[19]; the US dollar only just started to fall (2 € per $ is still far away); stability in Latin America, Africa and the Near East has been dramatically decreasing; a change in global environmental policy is not in sight[20].

vi. The observable building-up of the next financial bubble thus should not be interpreted as a recovery from the crisis. It stems from the same causes as the bubble which just burst, and thus should be understood as a sign that these causes have not been eliminated. Given the available data we expect the next burst of the current bubble in early spring 2010.

vii. The big global crisis thus has only started yet. Roughly stated the sequence in OECD countries will be: (1) Massive unemployment starting in autumn to winter 2009/2010, households use up their savings lasting for 3 to 5 months to keep up consumption despite unemployment; (2) breakdown of demand starting in spring 2010; (3) swarming of bankruptcy of firms from summer 2010 till the end of the year; (4) severe political unrest and possibly destabilization of political regimes. Clearly there are similarities and differences to the interwar period calling for the long-run economic history analysis addressed above.

viii. It becomes mandatory to distinguish between short-run policy recipes to ameliorate the lot of households hit by the crisis, and long-run social innovations designed to eliminate the underlying reasons for the crisis.

[19] Effective demand, ruined by worldwide deteriorating income distributions, show no reversal of the trends initiated in the political roll-backs of the early Eighties.

[20] A frightening recent fact is the substantive increase of automobiles in China from 2007 to 2008. With the still high growth in China in 2009 there should be a further downturn in global environmental conditions.

ix. Far-sighted governments should link short-term measures (e.g. subsidies to businesses) with long-run commitments of the concerned social entities, commitments which can ease the necessary deep restructuring (e.g. environmental concerns, externalized social cost, etc).

x. The contours of the new arrangement necessary in the long-run (next 10 years) are already visible: Several global problems need a rather strong global political entity. They cannot be solved by the only entities acting global in the moment, the transnational companies and a few military clusters. Contrary to these current global players such a novel entity must not be private, but must have a well-designed democratic control structure enabling a countervailing power of decentralized social entities. As social entities become larger institutionalized control of bureaucracy becomes ever more important.

xi. Three mayor groups of global action to be directed by the novel entity stand out already: (1) abolishment of the current build-up of national military expenditure[21]; (2) interferences concerning the global income and wealth distributions between nations via interest rates and other measures; (3) environmental policy.

xii. The implementation problem will in the short-run force nation states to declare at least a partial moratorium to its public debt. In the EU this can only be done on a continental level and it will lead to a fundamental monetary reform.

xiii. This reform will have to take into account that real growth in the foreseeable future will tend to be zero. The name of the entrepreneurial game will be *change* instead of *growth*. The remuneration of entrepreneurial activity will have to take on (monetary) forms different from some extra-profit derived from exploitation plus old-style growth-oriented innovation. Again a novelty to be envisaged for the long-run.

xiv. The short-run national measures to keep employment higher by subsidizing part-time employment will develop into a permanent reduction of working hours with state subsidies fading out. The implied drop in household incomes will make direct employment by the state of larger parts of the working force mandatory. Indeed it is not a bad idea to use this directly employed workforce for the long awaited improvements of the infrastructure. Of course, the implications for the budget again point towards a moratorium and to the necessity of support of the global political entity.

xv. The visions sketched above need not materialize - we might as well experience the catastrophe of a global war. If it is possible to achieve a smooth transition to the next stage of human development, then this will also necessitate a profound cultural change. It will not be easy for OECD populations socialized with ‘growth’ and ‘private businesses’ as positively co notated fundamentals to accept ‘change’ and ‘political decision-making’ as substituting central concepts. Nevertheless the possible welfare enhancing effect might convince populations faster than economists expect.

These suggestions are in no way complete or at least empirically well founded – they are just reasonable and informed speculation. Some more ideas can be found in the two examples of our modelling exercises described below. Perhaps rather unusual for a research paper we thus conclude with the statement that the overwhelmingly larger part of the work we envisaged for it still waits to be completed. But unusual times require unusual interim reports.

[21] Given the dangerous political instability to be expected in the coming years a large military arsenal in a nation state is a particular threat. Unfortunately many states with a high probability to fall back to political Barbary have an extremely high military potential.

Example 1: Global Banking

Central banking is a very trustworthy process, as governance is on the whole. The only way to legitimate governance is by establishment and maintenance of social contracts. Now let's raise a simple question: Does the European currency union (Euro) represent a loss in trust in its national predecessors? In other words: Was the European decentralized financial system that bad that we needed a new currency and consequently a new central bank on a higher level? Or was there a need for a greater unification in order to compete with other financial global players, such as the US or China? These questions do all head up to a very essential notion: What does scalefreeness and nestedness mean in a concrete political economic environment? Why do we want to build up bigger entities over time? Are we afraid of losing competitiveness or is it a natural process, such as globalisation?

In case of banking we maybe better up with bigger united entities or coalitions/networks of banks, for the two reasons we stated above: trust and size. Banking is probably the most authentic trust indicator a society can face, hence it will depend on the governance of credit economics how stable[22] a society or political economy will be over time. The second argument on size involves globalisation processes such as internationalisation of corporations and interconnectedness on the production/real side of economics, such as wage competition or tax competition among countries, as well as interconnectedness on the financial side of economics. It shall be argued that the private sector got bigger and bigger in case of certain global players, i.e. huge multinational corporations, usually the winners of globalisation. Therefore there also emerges some need for counter weight on the public sector, which then has to be incorporated in political unions, such as the European Union or the Euro zone with the ECB. Banking has some additional characteristics compared to governmental issues. There is no democratic legitimisation of central banking at all, but there is some hidden/invisible social contract between creditors and debitors. Creditors and debitors are manifold in society, there are business banks, investment banks, private households, public households, central banks and many others, but there is probably no unit which exclusively lends or borrows money; it's always represented by both sides of the coin. This somehow independent special social contract on central banking plays a very crucial role in global political economy.

> Global financial governance – and particularly monetary governance – is argued in this book to be a system of rule based on systems of distributed authority networks among both public and private actors that are strongly dependent upon intersubjectively shared meanings. As it is a system with multiple sites of authority, it is a decentralized system of multilevel governance. Hall, R.B. (2008, p. 5)

As Hall, R.B. (2008) wisely argues, banking is primarily a social process. It has to redistribute debts and capital in a political economy. If a bank takes these concerns serious then it will earn trust. We argue that a bank has to establish social balancing functions in a very archetypical way. Now our concrete idea is to model the functions of banking in a social way, by that using the concept of nestedness and scalefreeness. In a research project, we conduct a social model of banking within a network approach. In this model we use the bank as a balancing unit for power relations in society. We consider an abstract network of different actors of creditors and debitors, where we assume that creditors are well equipped with economic capital and debitors with social capital. The idea is that

[22] By stable we mean the stability of macroeconomic fundamentals such as inflation, unemployment and so on, as well as societal factors such as trust, criminality, corruption and so on.

there has to be a process of capital redistribution in two ways: Creditors gain trust from debitors, in case of social capital, in return for economic capital – credits. This approach may lead us to a more contemporary concept of capital, where the social component gains more influence. The persistent economic crisis shows us that banks may only survive if society trusts in its redistributive role, this assumption will hold in the long run. The bank has to play the role of a meta player and coordinate or balance power relations of creditors and debitors, comparable to the state. The concept of nestedness allows us to start on an archetypical level of analysis. Once we establish the basic model we are able to scale/zoom it in both directions, towards a global layer or top-level network – in case of central banks or even world banks – and towards a regional layer or bottom-level network – in case of communal banks working in a more micro environment. The next step is to consider these networks as modules for themselves, this allows us to analyse the evolution of them. Time plays the most important role in a process of global banking. The current crisis can be interpreted as a sudden phase transition of network modularization, in the words of Csermely (2008, p. 35 ff.). Imagine a network of different, let's call them, bank-environment modules then these modules have to be linked as well, but not only on a horizontal level, as well as in a vertical scale dimension. Such links are also called weak links in the sense of Granovetter (1983), because they establish connections over broad ranges and are mostly unique. These weak links are system-retentive, but may also induce endogenous system-destructive shocks, if they break. If such weak links break or disconnect then the whole system may collapse due to immense spontaneous stress. This was the case as the credit links on the interbank sector got frozen, because of loss of trust. Afterwards, we want to argue, the whole system changed, it was not the same as before, because the structure of network modules between banks dissipated. Then structural change was induced in an evolutionary way. We have to admit that this model is totally work in progress, but it is able to sketch the evolution of crisis in trust via a rather simple idea.

The question of trust and its evolution in the context of institutional change is specifically treated in another model we conducted, independently from banking.

Example 2: Trust

In other contributions Radax, Wäckerle, Hanappi (2009) and Wäckerle, Radax, Rengs (2009) we show that trust or social capital, in a more abstract perspective, is the main force of institutional change. In an agent-based framework we conducted experiments where agents are able to build up institutions via certain leaders. These leaders enforce cooperation, which means in particular that agents are somehow protected if they join an institution; save in front of defection. Now leaders propose a fee in return for 'protecting' institutional members, if this fee exceeds the expected payoffs of a non-member status, agents will leave the institution and consequently institutions may break down if there are too less members. This process gains complex dynamics through endogenisation of trust. Trust is represented in the memory of an agent, which lists past encounters, either cooperative or defective ones of a Prisoner Dilemma's game. We could explicitly show that global trust (average of individual agents) influences the stability or age of institutions. If trust is high there is no need for enforced cooperation via leaders, if trust is low agents tend to favour institutions. Various runs of simulations have revealed three different scenarios or states. The first one represents a defective world with low global trust, where agents join institutions very fast. In this case institutions are very

stable and freeze the dynamics towards a static state of globally enforced trust. The second scenario offers rather the opposite. Agents start with a higher level of trust and tend to cooperate. Considering high payoffs without enforced institutions, agents won't join institutions, because the institutional fee is simply too high. The third case is probably the most interesting one. The dynamics involve a very high volatility of actions, institutional regimes occur in a kind of boom-bust cycle. These cycles always emerge if critical points of global trust are reached, in particular if cooperation regains a high level, agents will exit institutions and their overall stability decreases. Nevertheless the experiments have shown that trust can still decrease step-by-step, then institutions regain popularity again and agents will rejoin. A special case of this scenario is that institutions are somehow used as learning vehicles for cooperation. This results out of a more than less defective state of the world with low trust, where agents build up institutions very fast. Due to the fact that non-members can still play with members, the overall level of trust may increase in such a state, which increases expected non-member payoff. Then agents may leave their institutional enforced cooperative status in favour of non-member cooperation. Hence we thought about treating this as a learning effect.

Anyway this very simple agent-based model led us to very complex and volatile dynamics of institutional change.

As has been hinted at above, size is an important feature within the ever-changing global institutional networks. Change on a global level in the last 20 to 30 years was manyfold. With regard to the central players of this "game", the sole authority of nation-states started to erode with the rise of multinational corporations. By operating on a global scale these huge agglomerations of economic activity gained the capability to evade national regulatory policies and instigate races to the bottom with respect to corporate taxation, occupational health and safety measures and the like. Furthermore, these corporations increased their leverage on policy-making via ever-growing lobbying efforts. Not only do these lobbies try hard that legislature is passed in favour of big economic players, but they also increase their influence by directly proposing favourable bills. An even more dramatic entanglement and exertion of influence can be witnessed in campaigning for prominent political positions, most notably one of the most powerful positions, the US president, where campaigning is more or less strictly dependent on the donations from big corporations which in turn claim concessions regarding the following term of office. Clearly, we have arrived at a point where a number of big corporations have at least caught up with nation-states in terms of wealth, power and influence on politics.

This entanglement was surely rather beneficial to the corporations rather than to the nation-states and furthered their advantage even more. Confronted with these global players, the nation-states' capability to regulate only on a nation-wide scale soon turned out to be a rather toothless effort. Although political/economic blocs like the European Union could be seen as a step back for politics on a par with the economic sphere, these blocs suffer from the same problems with regard to the exertion of influence by lobbyists on the one hand and a number of democracy deficits and legitimacy problems on the other hand.

It took the emergence of a new actor on the world stage to provide (at least to some degree) a counterweight to these shifted balances of power. Increasingly dissatisfied with democratic deficits, grass roots movements gained momentum as exemplified by organized protests surrounding G8-

summits and the founding of the World Social Forum as a counter pole to the representation of multinationals in form of the World Economic Forum. Although lacking the organized force of their antagonists these movements provide at least some means of checks and balances to the unleashed power of the wealthy and powerful.

It is this emergence of new types of actors and the accompanying change in the power balance on the global level that traditional economics is not even capable of picturing but that at the same time prove to be the most decisive changes to be described and explained. And, more importantly, it is the approach proposed in this paper which we hope provides a first step away from the methodological poverty of the current orthodoxy and toward a better understanding of such structural dynamics.

Please note that we emphasize description and explanation of such processes rather than prediction. While prediction would be an aim worth pursuing, in the context of social and economic processes the record so far is rather depressing, at least with prediction understood as precise point prediction as is often suggested by the scientific rigor of formal methods. The difficulties with prediction in our domain can be best illustrated with a (rather casual) quote from the opus magnum of one of the leading thinkers of orthodoxy within International Relations:

> Few states die; many firms do. Who is likely to be around 100 years from now – the United States, the *Soviet Union*, France, Egypt, Thailand, and Uganda? Or Ford, IBM, Shell, Unilever, and Massey-Ferguson? I would bet on the states, perhaps even on Uganda. (Waltz 1979, p. 95, emphasis added)

Even a very educated guess from a highly respected expert is prone to immense prediction errors which points to the need to formulate more humble goals with respect to prediction efforts in the context of social and economic processes as compared to the achievable accuracy in natural sciences.

6. References

Bourdieu, P. (1984), *Distinctions: A social critique of the judgement of taste*.

Boyer, R. and Saillard, Y. (eds.) (2002), *Régulation Theory: The State of the Art*, Routledge.

Corning, P.A. (2005), *Holistic Darwinism*, University of Chicago Press.

Buldyrev et al (2006a), *A Generalized Preferential Attachment Model for Business Firms Growth Rates: I. Empirical Evidence*, Physical Review E, September 2006.

Buldyrev et al (2006b), *A Generalized Preferential Attachment Model for Business Firms Growth Rates: II. Mathematical Treatment*, Physical Review E, September 2006.

Csermely, P. (2009), *Weak Links: The universal key to the stability of networks and complex systems*, Springer.

Dawkins (1976), *The selfish gene*.

Fine, B. (2001), *Social capital versus social theory*, Rotuledge.

Gilbert, Nigel (2008), *Agent-Based Models*, Sage.

Ghiselin (1974), A radical solution to the species problem, *Systematic zoology*.

Gould, St.J. (2002), *The structure of evolutionary theory*, Belknap, Harvard.

Granovetter, M. (1983), The strength of weak ties: A network theory revisited, *Sociological Theory* Vol 1: 201-233.

Hall, R.B. (2008), *Central Banking as Global Governance*, Cambridge University Press.

Hanappi H. (2009), Money, Credit, Capital, and the State, invited paper at the Verein für Socialpolitik (Ausschuss evolutorische Ökonomik) forthcoming in JEE.

Hayek, F.A. (1973), *Law, Legislation and Liberty: Volume 1 – Rules and Order*, Chicago University Press.

Held, D. (2004), *Global Covenant: The Social Democratic Alternative to the Washington Consensus*, Polity Press.

Herrmann-Pillath, C. (2007), *The Concept of Information and the Problem of Holism Vs. Atomism in Biological and Economic Uses of Universal Darwinism*, Working Paper Series.

Hodgson, G. (2004), *The evolution of institutional economics*, Routledge.

Hölldobler B. And Wilson E.O. (2008), *The superorganism*, Norton & Company.

Hull, D. (1976), Are species really individuals?, *Systematic Biology*.

Kumar R. et al (2000), *Stochastic models for the web graph*, In Proceedings of the 41st Annual Symposium on Foundations of Computer Science (FOCS), pages 57–65, Redondo Beach, CA, USA. IEEE CS Press.

Malescio G. et al. (2000), *Hierarchical organization of cities and nations*, Physical Review E, February 2000..

Ostrom, E. (2005), *Understanding institutional diversity*, Princetone University Press.

Radax, Wäckerle, Hanappi (2009), *From Agents to large Actors and back: Formalized Story-Telling of Emergence and Exit in Political Economy*, HetEcon 2009.

Schumpeter, J.A. [1911], *Theorie der wirtschaftlichen Entwicklung*.

Searle, J. (1995), *The social construction of reality*, London.

Searle, J. (2005), What is an institution?, *Journal of institutional economics*, Cambridge University Press.

Simon H. (1955), *On a Class of Skew Distribution Functions,* Biometrika, Vol. 42, No. 3/4 (Dec., 1955), pp. 425-440.

Sober E. and Wilson D.S. (1999), *Unto others*, Harvard University Press.

Sole et al (2002), *A model of large-scale proteoeme evolution*, Advances in Complex Systems, 5, pp. 43-54.

Turchin, Peter (2003), *Historical Dynamics: Why States Rise and Fall*, Princeton University Press.

Vazquez et al (2002), *Modelling protein interaction networks*, Complexus, 1, pp. 38-44.

Wäckerle, Radax, Rengs (2009), *An agent-based approach to institutional change*, EAEPE 2009.

Zywicki (2000), *Was Hayek right about group selection after all?*, Review of Austrian Economics.