# Policy Implications of Economic Complexity and Complexity Economics

Elsner, Wolfram

iino – Institute of Institutional and Innovation Economics, University of Bremen, Faculty of Business Studies and Economics

26 March 2015

**Policy Implications of Economic Complexity.**

Towards a systemic, long-run, strong, adaptive, and interactive policy conception[1]

Wolfram Elsner[2]

Revised, December 11, 2015

**Abstract:** Complexity economics has developed into a promising cutting-edge research program for a more realistic economics in the last three or four decades. Also some convergent micro- and macro-foundations across heterodox schools have been attained with it. With some time lag, boosted by the financial crisis 2008ff., a surge to explore economic complexity's (EC) policy implications emerged. It demonstrated flaws of "neoliberal" policy prescriptions mostly derived from the neoclassical mainstream and its relatively simple and teleological equilibrium models. However, most of the complexity-policy literature still remains rather general. Therefore, policy implications of EC are reinvestigated here. EC usually is specified by "Complex Adaptive (Economic) Systems" [CA(E)S], characterized by mechanisms, dynamic and statistical properties such as capacities of "self-organization" of their components (agents), structural "emergence", and some statistical distributions in their topologies and movements. For agent-based systems, some underlying "intentionality" of agents, under bounded rationality, includes improving their benefits and reducing the perceived complexity of their decision situations, in an evolutionary process of a population. This includes emergent social institutions. Thus, EC has manifold affinities with long-standing issues of economic heterodoxies, such as uncertainty or path-dependent and idiosyncratic process. We envisage a subset of CA(E)S, with heterogeneous agents interacting, in the "evolution-of-cooperation" tradition. We exemplarily derive some more specific policy orientations, in a "framework" approach, embedded in a modern "meritorics", that we call Interactive Policy.
(223 words)

**JEL codes:** B4, B5, C72, D02, H4, P41.

**Keywords:** complex adaptive systems; self-organization; emergence; social-dilemma games/evolution of cooperation; economic policy; futurity/time horizons; networks; interactive/institutional policy; meritorics; negotiated economy.

---

[1] Paper given at the ASSA/ASE Meetings, Boston, Jan. 2015, Session on "Policy Options in an Age of Uncertainty" (invited paper) and at the EAEPE annual conference Genoa, Sept. 2015. The author is grateful to the discussants there and to Magda Fontana, Hardy Hanappi, Torsten Heinrich, Claudius Graebner, Henning Schwardt, Lin Gao, and Fred Jennings for comments.

[2] University of Bremen, Faculty of Business Studies and Economics, iino – Institute of Institutional and Innovation Economics; welsner@uni-bremen.de.

## 1. Introduction: Simplistic vs complex economics and policies

The neoclassically-based "mainstream" policy conception – propagated less in research than in mass education, mass media, and the policy-advice business (e.g., Zuidhof 2014) – is a fundamentally *normative* prescription system rather than a set of recommendations, with a consideration of alternative options, diverse pathways and horizons, and estimations of actual political action spaces. But its normativism usually is not overt, but it is crypto-normative, particularly in its "neoliberal" attitude of "T-i-n-a" ("There-is-no-alternative!"), geared towards a *state planning for "more market"* (op. cit.).[3]

Its (tacit) message: "There-is-only-one-unique-and-optimal-state-in-the-universe", connected to one unique "market" economy, not only is unrealistic and crypto-normative, it is derived from a *simplistic* approach to economics, as, e.g., John Foster had nicely developed (Foster 2005, 2006). It follows a mathematically tractable, *deterministic* model with its simplification of a representative agent and its resulting *teleological* attitude of a unique equilibrium. Its historical message: "The market economy is the optimum, the culmination and end of human history" mistakenly mimics early 19th-century *static analytical* equation models of physics. The *stochastic* version of its physical analogy basically refers to alleged *random* motions (the famous Brownian motion), which justifies *normal distributions* and "rational expectations" of mean values. Such perspective, outmoded in modern physics, was the notorious basis of *financial "market" models*, today considered a cornerstone of the financial crisis 2008ff., as complex systems behave qualitatively different (e.g., Lux, Marchesi 1999; Tang, Chen 2015).

---

[3] This is neither "neo" (new) nor can, with its practical consequences of de-regulating "big power", intended or not, be "liberal" for the common man in any reasonable sense. Of course, we do not simply identify analytical neoclassical economics with political neoliberalism.

Thus, such simplistic economics still needs to be imposed on society and *politics* in a teleological vein and with a *coercive* attitude. [4], [5] It also is *methodologically* untenable.[6] It cannot provide an appropriate understanding of evolving process, emerging structure, institutionalization of coordination and cooperation, of collectivity, commonality, or broader and longer than myopic rationality, or of a proactive, learning, and adapting policy conception based on participation and democracy – as everything is evaluated against an abstract static "optimal" construct.

Logically, then, with the slightest alteration of the assumptions for a general equilibrium, the available next *Second Best* state would require more violations of "optimality conditions", as was already elaborated in the 1950s (Lipsey, Lancaster 1956/7). But if the "optimum" is not attained, there has *no piecemeal policy* ever been defined to re-approach it, as there is *no process orientation* "off optimum". Simple ways to the "optimum" through "more market", ignoring complex structure and process, is what the (neoliberal) mainstream has suggested since four decades.

A much needed approach towards political control of a complex economy and its *nonlinear*, *path-dependent*, and *idiosyncratic* dynamic has never been elaborated for practical policy by the mainstream. The political-economic power play of simple and quick "solutions", the rough-and-ready *de-regulation cum privatization*, based on supply-side myths of markets and money, has been ever more reinforced, rather. And, as was foreseeable, this has skyrocketed the *degeneration*

[4] Note, however (as, e.g., Fontana, Terna 2015 point out), that the idea that economies can be controlled in mechanic ways was not exclusively neoclassical, but lingered also in some non-mainstream approaches, until they pioneered into economic complexity, and re-read their classics (e.g., Smith, Marx, Keynes).
[5] For a more detailed display of the ruling out of complexity by neoclassical economics, e.g., Fontana 2010; van den Berg 2015.
[6] For a thorough methodological and epistemological critique of neoclassical crypto-normativism, immunization strategies, and unlimited "ad-hocery", e.g., Kapeller 2013.

*of "markets"* into unprecedented *oligopolization and "power-ization"*, and into multi-layered *global hierarchical hub&spoke networks*, under control now of a few dozen core financial-industrial groups (Vitali et al. 2011). This has made the powerful more powerful and the rich richer, and rendered politics and policies their dependent servants. And it has been too alluring for many leading economists to stay with the powerful and rich.

Manifold theoretical constructions have contributed to such relatively simple economic-policy paradigm. In public-choice theory, for instance, *Arrow's voting paradox* ("impossibility theorem") has long been (mis-)interpreted against any feasibility of collective and longer-run rationality and any collectively-rational, ameliorating policy in general, stressing *state failure* instead. This interpretation ignored complex structures and processes with their, among others, endogenous preference change, as was elaborated namely by A. Sen (1970/1984).

*Hayekian* fallacies also impeded the elaboration of complex and qualified policies beyond privatization, "marketization", de-regulation, and dismantling of the welfare state. First, though, in a complexity and evolutionary perspective, Hayek did recognize some complex *self-organization* capacity in "market" systems. This however remained in a teleological vein, as it was considered, with its random distribution of information among agents, to generate a natural *spontaneous order*, being relatively optimal (as compared to state intervention with its allegedly dominating state failure). The assumption for the *distribution of information* in a "market" was such that some "wisdom of the crowd" would become effective. Second, an extreme version of an *unpredictability* of any policy impacts under such complexity warranted the Hayekian attitude of intervention *abstinence*, if beyond just *planning for the market* (e.g., Bloch, Metcalfe 2011; Durlauf 2012, 62ff.). [7]

But the *self-organization* capacities of what are called *complex adaptive (economic) systems* [CA(E)S] cannot redudantize policy, since they typically generate *no ("optimal", "natural") spontaneous order*. They rather are related to so-called "*dissipative* structures", i.e., *open* metabolic systems with interacting components that generate "structure" in *non-optimal*, *non-equilibrium* processes, with often *abrupt transitions between order and disorder*. Self-organized order, even if relatively stable, is relative and often transient, dependent on system parameters and endogenous dynamics. Order and disorder, stability and volatility may alternate in regular or (apparently) irregular ways (e.g., Fontana 2010; Room 2011). Thus, as recently stated by Colander and Kupers,

> "… seeing the social system as a complex evolutionary system is quite different from seeing it as a self-steering system requiring the government to play no role, as seems to be suggested by unsophisticated market advocates" (Colander, Kupers 2014, 5).

Particularly, for decentralized spontaneous economic ("market") systems, with their incentive structure in favor of a *myopic* (short-term maximizing, hyper-rational, or individualistic) culture (e.g., Rappaport, Bogle 2011; Aspara et al. 2014), we do know about dominating mechanisms generating *fallacies of aggregation* or *negative unintended consequences* that undermine clear-cut positive relations between "self-organization" and "optimality" or "naturalness". For instance, *lock-in* on inferior system states and other *positive-feedback cumulative* processes may mirror

[7] For recent arguments for strict policy abstinence in the Hayekian vein, see, e.g., Gaus 2007, and particularly against policies reacting to the financial crisis, e.g., Lewin 2014.

technological conditions, such as *increasing returns* in production or *network externalities* in use, incomplete, imperfect, or asymmetric *information*, or *power*-related *ceremonial* degenerations of institutions.[8]

*Real-world* CA(E)S are based, among others, on *metabolic openness* towards the social and natural subsystems, increasing their own complexity at the expense of an increased metabolism with them and increasing entropy of the entire ecolo-socio-economic system. And, namely *capitalist* “market” economies, according to famous ecological and institutionalist economists (N. Georgescu-Roegen, K.W. Kapp), are formally “designed” for reinforced institutionalized *exploitation* of the social and natural systems. This all prevents considering CA(E)S “self-policing”, “self-sustaining”, and “self-equilibrating” in any “natural” or spontaneous manner.

*Complexity Economics* (CE)[9] actually suggests that self-organization processes in complex systems, if reflected by equilibria (fixed points) or attractors, usually generate *multiple equilibria* and often attractors that are not stable but transient. Specifically under conditions of individualistic (hyper-)rationality, some *problem-solving* self-organization, e.g., some informal instrumental *institutional emergence*, may be extremely (1) *time-consuming* to be learned and (2) *fragile* (prone to backslide), if not (3) *blocked* at all.

Also, well-known (and empirically relevant) *scale-invariant* system properties, such as *power law distributions* (e.g., of agents, their sizes or centralities across network topologies, or of the

[8] In a Veblenian perspective, ceremonially warranted institutions reflect a dominating value of invidious distinction and of aspired differential power and status.
[9] Note that there exist many definitions and measures of complexity, based, e.g., on how difficult a CA(E)S is to be described or created (for an overview of definitions, e.g., Lloyd 2001). So we better do not confine ourselves to a particular one but focus on describing particular complexity dimensions in section 2.

sizes of certain critical events), often reproducible by mathematically quite simple interrelations among agents, but also any relatively stable emerged structure, are no indication of any optimality.

In all, the requirement of some policy intervention vis-á-vis CA(E)S is strongly warranted from a CE perspective, not least because of the manifold problematic mechanism and shortcomings of decentralized agent-based systems in myopic cultures, be they located in the micro-level *structures* (e.g., information and incentive problems), in the *processes* (interaction and self-organization mechanisms) or at the *"macro"- or systemic outcome* level with its emergent properties (such as heavy-tail power-law distributions, which may imply problematic power positions impeding, in turn, a superior systemic path) that feed back to the micro level. Such policy, if properly conceptualized and instrumentally endowed, might *improve incentive structures* and cultures, stabilize and improve the system's path and its emerging properties. And it will not just be any rampant interventionism, and thus no Hayekian *"road to serfdom"*. On the contrary, properly complex policies would in fact *avoid cumulatively increasing ad-hoc interventions*, as seems to be the current praxis under neoliberal alleged minimal intervention.

"Stagflation" and increasing distributional conflict were, according to the neoliberal narratives of the 1970s and 1980s, the results of *"Keynesian" welfare-state interventions*. Those specters, however, were mostly just a reflection of a distortedly *perceived over-complexity* of those real-world problems on the part of a (partly unwilling, partly incapable) political, parliamentary, party, governmental, and administrative system, closely allied with the big corporative economy. Thus, a new *complex-adaptive-(economic)-policy* [CA(E)P] paradigm will have to include a new conception of its *democratic legitimation*, the *capabilities of the public agent*, and new proper instrumentation. Note that more adaptive policies, systematically interacting with the interaction system of the private agents, somehow may become more *endogenous* to the entire system.

Since the *financial crisis* 2008ff., it has become obvious to an increasing number of economists and practitioners that we need *different micro- and macroeconomic models* than those based on well-informed hyper-rational behavior, "smooth" stochastic process generating normal distributions, and predetermined equilibrium. This also applies to the (allegedly more real-world and more policy relevant, compared to conventional GET) *dynamic stochastic general equilibrium* (DSGE) models, which largely remain equilibrium-based and teleological: They still measure policy impacts by comparisons between pre-and post-policy equilibria (or equilibrium paths), where structures are held constant and changes, including policy measures, remain exogenous. Adaptations to new phenomena still largely occur through arbitrary "ad-hocery". [10]

Models that theorize new microfoundations, considering many heterogeneous agents in recurring direct interactions and dynamic populations, are known as *agent-based models* (ABM), which typically are no longer analytically but only stochastically computable, and with non-normally distributed stochastics so. Computer simulations, rather than analytically tractable and solvable equation-based models, only can do the job then.[11] They involve a *new policy paradigm*, where also the relation between the system and policy measures will be dynamic, evolving, and non-linear, i.e., structurally *variable*, with the system's development. Again, policy insofar becomes somewhat more endogenous.

---

[10] We cannot delve deeper into this here. For a critique of DSGE models from a CA(E)S perspective, e.g., Colander et al. 2008.

[11] For more detail on formal methods used in CE compared to the mainstream, e.g., Fontana 2010.

While discontent with the state of economics has grown, *CE* has developed into a promising overarching economic research program in the last three decades. [12] With its characteristics as indicated, it has manifold affinities with long-standing *issues of economic heterodoxies*, such as uncertainty and bounded rationality, path-dependent and idiosyncratic process, dynamics, non-linearity, structural change, evolution, and emergence, complex agency, institutionalization, or lock-in. In this process, also some convergent micro- and macro-foundations across heterodox schools could be attained.[13] However, as should be expected, positive *policy implications* of CE have become a major theme only recently,[14] naturally occurring with some time lag vis-à-vis its basic explaining paradigm only, and particularly boosted by the *financial crisis* (e.g., OECD 2009; Geyer, Rihani 2010; Room 2011; Beinhocker 2012; Durlauf 2012; Fontana 2012; Wilson, Gowdy 2013; Colander, Kupers 2014; Fontana, Terna 2015). However, most of this literature still is rather general and has not sufficiently developed policy implications derivable from specified models yet.[15]

Therefore, this paper will use the example of some *subset of complexity approaches*, i.e., those with an explicit micro-foundation or agent base, particularly using *evolutionary-institutionally interpreted game-theoretic* (GT) arguing[16] in the evolution-of-cooperation tradition (e.g., Axelrod 1984/2006; Elsner 2012), in order to derive some more specific set of policy orientations.

[12] See, e.g., Waldrop 1992; Velupillai 2005; Foster 2005, 2006; Garnsey, McGlade 2006; Miller, Page 2007; Beinhocker 2007; Fontana 2010; Kirman 2011; Colander, Holt, Rosser 2011; Aoki et al. (Eds.) 2012; Arthur 2013. For a "complexity-based view" of the firm, e.g., Bloch, Metcalfe 2011; Navarro-Meneses 2015. For an overview of complexity sciences in general, e.g., Mitchell 2009.
[13] E.g., Elsner 2013.
[14] With rare exemptions, e.g., Durlauf 1997; Salzano, Colander (Eds.) 2007.
[15] Again, with few exemptions, e.g., Durlauf 2012, 57ff.; Fontana, Terna 2015. However, Durlauf considers CE largely consistent with the neoclassical mainstream. In contrast, e.g., Fontana 2010, 593f., considers CE a full-fledged paradigm shift.
[16] Similarly, e.g., Colander, Kupers 2014, 150ff.

With this, we will disregard, for instance, complex dynamic *macro-models*. We distinguish rather between CA(E)S that are "adaptive as a system" and those that are "composed of agents that employ adaptive strategies" (Wilson 2014, 3). While macroeconomic systems are of the first type, microeconomic approaches are of the second. Within the second, we refer to those CA(E)S that have "large numbers of components, often called agents that interact and adapt or learn" (Holland 2006, 1), or what Weaver (1948) had called "systems with organized complexity", i.e., with some self-organization and non-normal distributions rather than pure random interaction.[17] We assume that our subfield exemplarily and sufficiently mirrors important basic mechanisms, resulting properties, and critical factors of all CA(E)S. In this more specific area, we may delve somewhat deeper into specific policy implications.

In the *evolutionary and institutionalist* traditions, related policy conceptions were developed well before the financial crisis (e.g., Axelrod 1984/2006; Elsner 2001; Witt 2003; Hayden 2006). Even long before that, evolutionary institutionalists even had combined the long-standing *instrumentalist/pragmatist* philosophy and its policy approach (e.g., Dewey 1930; Commons 1934) with a systemic policy conception. We will refer to its *social-valuation* conception below in the context of some modern "*meritorics*".

This paper proceeds as follows: Section 2 briefly reviews that subset of CA(E)S, its microfoundations, mechanisms, and system properties. Section 3 reviews some general orientations of a CA(E)P received from the previous literature. Section 4 will assume an evolutionary game-theoretic (EGT) perspective and refer to the older Axelrodian "evolution-of-

[17] We will, thus, not only disregard those CA(E)S that deal with aggregates only but also those that, if they have individual agents, deal with more or less representative ones, not explicitly modeled as interacting. We are aware that interesting subsets of CA(E)S thus are not considered, such as, e.g., dynamic evolutionary macro models based on Post-Keynesianism, Minsky, or Goodwin, or models of macroeconomic (systemic) risk, financial interaction and contagion.

cooperation" approach and its policy implications. Section 5 will generalize this and discuss more policy implications that may be derived from game theory (GT) in an evolutionary and institutional interpretation, considering populations and network topologies. Section 6 will combine that perspective with the instrumentalist approach of social valuation to some modern meritorics and a conception of an Interactive/Institutional Policy. Section 7 concludes.

## 2. Mechanisms and properties of CA(E)S – A brief review

For the subset of economic-complexity approaches that we focus on, we will follow a simple distinction for modeling among *antecedences* ("given" structures", mechanisms), *consequences* and *outcomes* (process, emergent structure, system properties), and continuing *feedback* (circular cumulative causation, differential replication, endogenized structure).

***Initially "given" structures***

In the particular class of CA(E)S that has a population of interacting agents in "organized complexity", a network topology, with games played on network graphs, and that apply EGT in an evolutionary-institutional interpretation, model structures include, as a baseline:

(1) *Individual decision structures*: *Multiple* and (potentially) *heterogeneous* agents (i.e., with different behavioral options to be interactively learned and habituated), being directly interdependent and recurrently *interacting* in different, more or less *"intricate" interdependence structures* of social (multi-personal) interaction problems. The most-used formal language for this is provided by GT. So we may think here of different well-known

*coordination*, *anti-coordination*, non- or *dis-coordination* (e.g., zero-sum), and *social-dilemma* problems, and of some other problems and incentive structures that are used in lab experiments. Different behavioral options fundamentally generate (initial) strong strategic *uncertainty*, and open the logical space and time frame for learning different *social rules* and *institutions*.[18] These potentially emerge under recurrence, proper trigger strategies, and reinforcement learning, particularly when interactions are *indefinitely repeated*, in a culturally acquired *time horizon* that extends the agents' earlier practical planning horizons (formally considered an infinite repetition in prisoners' dilemma supergames – PD-SGs, as e.g., Axelrod 1984/2006 had established on the basis of EGT). Certain institutional structure, beyond some basic "rules of the game", may also be considered initially given.

(2) *Network structures*: Those interdependence structures also may be defined on different network topologies, i.e., structures of a *population* with different social or geographical *distances* and proximities (reference groups, "neighborhoods"), often with some local clustering and some long-distance relations, related *differential probabilities to interact*, and critical consequences for individual decisions and differential performance, for diffusion, segregation,[19] systemic risk and stability etc. (e.g., Jun, Sethi 2007; Acemoglu et al. 2012; Hu et al. 2015).[20] Network structures typically are not "complete", i.e., with full *connectivity* (where each agent interacts with each other with some probability in any given time period), but display different patterns of local neighborhoods. Different interaction

[18] Note that, as "coordination" and "cooperation" as solutions, so do the solution tools "social rules" and "social institutions" refer to coordination games and dilemma games, resp. (for the definitions, e.g., Schotter 1981; Elsner 2012).

[19] Note that one of the first complex systems with (unexpected) emergent structure was Schelling's (1971) segregation model.

[20] For social network analysis as a part of CE, e.g., Room 2011; Ormerod 2012; Richards 2012. Of course, not all CA(E)S models do employ network theory. And network theory is, of course, not confined to networks of agents, or to games on networks, although this appears as a particularly dynamic research area (e.g., Jackson, Zenou 2015).

*densities* across network structures and differential densities within networks are critical for diffusion and other individual and systemic outcomes. “Neighborhoods”, or relevant interaction “*arenas*”, may also be *overlapping* and *staged* systems, where one agent may interact in different arenas, which may overlap in many respects (same agents in different social roles, different relevant “goods” with overlapping and staged *reach* etc.). Finally, if agents may die out, get born, learn and change strategies, move within the topology in reaction to relative performance, or differentially replicate in response to their relative success, network structure becomes *endogenous*.

(3) *Institutional structures and ”rules of the game”*: Note again that such “initially given” structures are assumptions in a modeling and simulation methodology. Behavioral options (strategies), interdependence (game) structures, and network structures really never are unquestioned preset “givens” but always evolved results of preceding process. Just as “rules of a game” need to be carefully considered part of what we want to explain, they are of *methodological character*, which requires specific consideration in complex modeling. [21]

***Process and emergent structure***

(1) *Continuing interaction, nonlinear aggregation, and structural emergence*: Modeling and computing an ongoing dynamics of the interrelations of the components of a model – be it a complex dynamic macro model, a strategy-centered EGT approach, or an explicit multi-agent-based model –, continuing interaction among the system components, mostly with some behavioral micro-consideration even in macro-models, typically generates nonlinear

[21] Acemoglu et al. (2015) similarly distinguish among “interaction functions”, linking an agent’s state to a summary measure of the states of all other agents (a game structure), a “network specification”, establishing those summary measures as a function of other agents’ states, and an “aggregation function”, determining how agent-level states collectively determine macro-outcomes.

aggregation functions (Acemoglu et al. 2015), as compared to ("linear") static summing up of quantitative properties of representative agents. In agent-based systems, agents typically will *adapt* to each other, their relevant neighborhoods, and/or the global condition of the system. This logically implies that some emergent structure cannot be reduced in turn to the individual behaviors of the components – a well-known property of structural emergence.[22]

(2) *Emergent system properties*: Emergent formal structures of CA(E)S show, among others, that the *boundaries between micro and macro* properties will blur as, e.g., agents react both to their neighbors (or peers) and to global information (the status of the system). Also, distributional information (distributional statistics) of a system may be considered both micro and macro properties. When it comes to process and emergent structure, the *limits of analytical tractability, determinacy, and prediction* are quickly touched, while *stochastic* analysis finds itself between ("macro") network structure and its ("micro") link level (e.g., Jackson et al. 2015; Acemoglu et al. 2015). This again reflects the nonlinearities of relational structures, interactions, complex feedback and aggregation, and the phenomenon of emergence (e.g., Fontana 2010, 591f.).

(3) *Path dependence and non-ergodicity*: Finally, CA(E)S, with their reacting and interacting components and, thus recursivity, behave in path-dependent ways, as is well-known. Such processes are extremely sensitive to initial conditions, and thus "history matters". *Indefinite recurrence* and *sequentiality* of interactions typically generate an "*open-ended*" process (both *indefinite* in time and *unpredictable* in substance) over *historical time*. Such process

[22] Also known as morphogenesis or autopoiesis. The capacity of emergence is usually considered the distinctive property of complexity science, sometimes also coined "generative science" (e.g., Fontana 2010, 592; Harper, Lewis 2012).

then typically is not only cumulative, and thus path-dependent and irreversible, but at instances also very *idiosyncratic* (i.e., at so-called phase transitions, unpredictable or "chaotic", and very vulnerable to small changes of conditions). They are thus *non-ergodic* in the sense that the distribution of states they do assume over time is not identical with the distribution of the potential states they basically *could* assume. This relates to the fact that such systems are "*sensitively dependent*" on initial conditions, the "history matters" property.

(4) *Self-organization and power-law distributions*: Recognizable indications of some emergent order (and related equilibrium, even if transient) usually are expressions of some self-organization capacity of the agents. Of particular interest are processes that generate some distributions invariant under different scaling, the phenomenon of *self-similarity*, with *repeating patterns* at different scales (also called fractals). In very many *real-world* decentralized socio-economic topologies, usually based on historically emerged, deep-rooted and dominating individualist cultures, agents are very different in terms of *power and status*, which is reflected in network topologies by the relative number and quality of relations an agent has, i.e., her *centralities*. Distributions of, e.g., *degrees* of centrality and different *qualitative positions* of agents (e.g., a "gatekeeper" position for a local cluster) are usually considered for network analysis. For many *real-world* systems, in diverse scientific disciplines, such as income, firm size, or spatial settlement systems, letter and word systems in languages, or brain structure, empirical research (since Pareto explored for income distributions) has shown that some self-organization capacity – driven, e.g., by aspirations of individual improvement, common and collective problem-solving, and of reducing the complexity of individual decision situations – often leads to certain *size*

*distributions* (power, centrality) among agents and certain *size distributions of critical events*, re-approaching certain system “attractors”. Typically, in such systems many components (agents) have few relations and few have many. Thus, typically for CA(E)S, sizes are distributed in a way that, if we match size classes and numbers of nodes in those size classes and scale both logarithmically, we yield linearly falling graphs with an identical curve property at all scales (scale-invariance), so called power-law distributions. Their implications are considerable: Contrasting Gaussian normal distributions, power-law distributions usually have *no mean*, around which empirical distributions and critical events (and thus “rational” expectations) might center and expectations might even out and stabilize. In fact, they have “*fat tails*”. Thus, in case of critical phase transitions, where systems re-approach a certain attractor, *big critical events* do appear considerably more often than to be expected in mainstream models of random (“normal”) distributions. The fundamental flaws of mainstream financial-market models have become obvious against this background (e.g., Lux, Marchesi 1999), as the financial crisis could not be anticipated in mainstream models (e.g., Tang, Chen 2015). Under such *self-organized criticality*[23], abrupt transitions of a wide range of intensities do occur. Note again that such “self-organization”, for instance under conditions of myopic individualist (financial) “markets”, may relate to *herd behavior* and *social dilemmas* rather than to any “rationality/optimality”.

(5) *Endogenous scale-free and small-world networks*: Considering changing network structure, real-world networks that display such power-law distributions of nodes and critical dynamics (scale-free networks; e.g., Barabási, Albert 1999), typically also display combinations of local clusters and long-distance relations. So-called small-world networks

[23] This recognition stems from the famous sand-pile model of the power-law size distribution of avalanches, when sand is continually dribbled onto a pile (Bak et al. 1987).

(e.g., Watts, Strogatz 1998), for instance, display some scale-free distribution and show some clustering, enabling *local problem-solving* through institutionalization (coordination, cooperation, thus some stability) and at the same time a relatively *low mean path-length* between any two agents, ensuring relatively quick and effective long-distance exchange, diffusion and learning (a non-coordination, non-conformism, and *flexibility* dimension).[24] Scale-free and small-world properties seem to exist in variations in many networks in all areas. Designed socio-economic systems, such as logistics, settlement, IT, or security architectures, try to deliberately *design* them. Note again that power-law based emergent properties have little to do with optimality, as very large nodes, e.g., most powerful agents, may cause problems for *network stability* or system *resilience*.[25]

(6) *Social dilemmas, unintended negative consequences, lock-in, ceremonial dominance, and collective action capacities*: CA(E)S with intricate game structures on networks usually display *mixed interests* (partially consistent, partially conflicting) and entail lasting tensions among agents, as reflected in different anti- and non-coordination as well as dilemma problems. And even in relatively simple coordination problems, with Pareto-different solutions, a *collective incapacity* to ensure longer-run optimal solutions exists, for reasons of technical (Arthur 1989) and/or institutional (David 1985) *lock-in*. This is indicative of contradictions between individualistic and collective rationalities and solutions and the absence of (mechanisms to generate some) collective rationality. For some coordination

[24] Problem-solving clustering may or may not coincide with homophily, conformism, or segregation, which might impede longer-run network effectivity and success (e.g., Jackson et al. 2015). Thus the ubiquitous and notorious stability-flexibility and related efficacy-flexibility trade-offs are often a question of degree and timely adaptation of institutions (e.g., Hallsworth 2012, 45f.; Jarman et al. 2015).

[25] System resilience is closely related to CAS, as resilience is a system property that does not meaningfully apply to simple systems. Thus, the policy implications for building resilience are similar to those of complexity: Besides maintaining diversity, it is about caring for effective connectivity, for diminishing positive feedback (to slow cumulation down), participation, or polycentric, cluster- and network-based governance with some redundancy (e.g., Biggs et al. (Eds.) 2015).

problems, Schelling's (1960) idea of *focal points* has provided some way out – which also has some policy relevance (below). However, in other more intricate structures such as social dilemmas, unintended negative consequences of individualistic behavior appear to be pervasive, and *fallacies of aggregation* a resulting feature in dominating myopic "market" cultures. Below, we will start with simple deterministic 2x2 PD-SGs played in a population, in an EGT view, and will start to derive policy implications. But proper analysis of resulting processes with *many* strategies, and even *endogenous strategies*, is feasible only through computer *simulations* (e.g., Lindgren 1997). Finally, institutional lock-in appears to be equivalent with a *domination of ceremonial value* in a *Veblenian* sense, i.e., a dominance of invidious distinction and aspirations of differential status and power, entailing a *ceremonial degeneration* of originally instrumental institutions (e.g., Bush 1987; Elsner 2012; Heinrich, Schwardt 2013). If, however, strategies could be interactively learned, adopted, and habituated as *instrumental solutions* for coordination or dilemma problems, emergent structure would take the form of *problem-solving* institutional emergence. In systems with intentionally deliberating and anticipating agents, rule-and institution-based coordination and cooperation do also function as *complexity reduction* for agents. In both ways (ceremonial or instrumental), institutions relate to some *homeostasis* (or "equifinality", sometimes also considered "hysteresis"), holding some variable values within limits and, thus, ensuring some *continuity* and *stabilization* (e.g., Gilles et al. 2015). In terms of policy, hysteresis may even include some *evasion* of policy measures. *CA(E)P*, thus, will need to be attuned in proper interaction with the interaction processes of the private and shift the system towards more instrumental behavior.

(7) *Individual agent capacities, intentionality, and institutionalization*: EGT-based evolution-of-cooperation approaches as well as ABM assume or explicitly model many two-person games (or many *n*-person games) in a population, often with an embedding narrative that makes required *agency capacities* explicit, beyond short-run maximization (as in conventional GT). Agents typically must culturally acquire a *longer-run perspective* and some capacity of *preferential mixing* (partner selection) and *establishing and terminating relations* (e.g., moving into empty positions of networks in order to find themselves new neighborhoods or peers). Given *bounded rationality* as the realistic assumption in multi-agent-multi-strategy environments, agents must be considered both searching (experimenting, adapting) and endowed with some intentionality, to improve their benefits and solve related intricate problems. Such intentionality under relatively limited cognitive capacity would primarily include *reducing the perceived complexity* of their decision situations. This is where the emergence of *social rules* and *institutions* comes in. De-regulated "markets", in fact, tend to reinforce (individually perceived) *over-complexity* and its systemic costs (e.g., Helbing 2013; Jones 2014; Battiston et al. 2015), with overly high *turbulence* (volatility), and transparency and stability may quickly become too small. Individual "knowability" or calculability of the systems' dynamics and of a good individual choice therein then become highly restricted, given human brains' capacities.[26] Thus, for policy, we will have to deal with proper *complexity reduction* of individual decision situations – without having any hope, though, to be able, or even to wish, to reduce the system complexity so far that global "perfect information" and "certainty" would result.

[26] In a formal perspective, as is well known, already quite simple mathematical structures may generate very complex dynamics (e.g., May 1976; Durlauf 2012, 57ff.).

***Differential performance and replication, and positive feedback: Circular cumulative causation, evolution, and endogenized network structure***

(1) *Differential replication, attractors, and orbits*: Agents or strategies in a population with repeated (random or preferential) pairwise (or *n*-person) encounters will, typically after many *interactions* within a *round* (e.g., a supergame), and after many rounds at the end of an artificial *generation*, have performed differently (Axelrod 1984/2006; Lindgren 1997). A replicator mechanism generating differential "offspring" according to differential performance (also to be considered learning or imitation vis-à-vis some reference standard: the population average, the absolutely best, some neighborhood average etc.) will typically provide a next logical generation with a *changed ecology*, i.e., a different strategy composition. With continuing replication, then, we may consider an *evolutionary* process. Replication processes under certain conditions (parameter constellations), then, may converge to some out of *multiple possible equilibria*. This may be a strict fixed point or an *attractor* that draws the system into itself from some vicinity in its state space. Analysis of dynamical systems then may show that an equilibrium is *stable* or not. If situations are instable (thus transitory or even periodic), the system might perform cyclical (periodic) or even non-periodic orbits (e.g., Room 2011, Chpt.9). Under not too turbulent parameter changes, what can be expected from CA(E)S, are *behavioral patterns* (e.g., ibid., Chpt.10). However, CA(E)S may undergo so-called phase transitions anytime, during which certain properties and resulting motions of the system *discontinuously change*, a result of a (often continuous and only marginal) change of some external condition (parameter). This happens at so-called tipping points, where diverse further paths may exist and the system's motion cannot be (fully) predicted ("deterministic chaos"). Under self-organized criticality, as indicated, CA(E)S may have an attractor, such that their macroscopic behavior displays

phase transitions towards that attractor and the size distribution of such critical changes has a scale-invariance characteristic (scale-free or power-law distribution).

(2) *Dynamic populations and size-dependent fitness*: However, evolutionary optimality, in the sense of a *survival of the fittest*, across social environments and time, will typically not occur. Related *selection* for such result would require structurally stable and, through this, relatively transparent and "apprehendable" environments, where a selection mechanism has enough time to meliorate the system. However, this is typically not the environment of complex dynamic human populations. For instance, when "fitness" and population shares of strategies are subject to *cumulative first-mover* advantages and differential *power* acquisition, or to *limits of growth*, or *dependent on population shares* already achieved before, situations of a *survival of the first*, *survival of the fattest*, or a *survival of all* (with possibly different shares of each) may occur – all of them situations of non-optimality (e.g., Nowak 2006).

(3) *Circular upward and downward causation*: Full-fledged evolution of CA(E)S is, of course, not just bottom-up structural emergence, but also *reconstitutive downward causation* (e.g., Hodgson 2002) from emerged structure onto the behavior of the components (shaping and re-shaping, e.g., incentive structures, behavioral options, and evolving behavioral patterns, including reactions to the system's global state). Circular cumulative upward and downward mechanisms have been basic understandings of the economy in evolutionary institutionalism from Veblen through Myrdal till today and are theoretical and methodological modules of CE.

(4) *Endogenous network structures*: Finally, as indicated, if in an agent-based model agents, after some "generation" ends with differential performances, may exit or enter accordingly, establish or terminate links or move on a topology into some preferred neighborhood, the network structure will be "endogenous".

With full-fledged evolutionary process, related structures, mechanisms, and resulting properties of CA(E)S, we are finally

> "… maturing to a point at which policy implications are emerging … Moving forward, it is our hope and expectation that .. (this – W.E.) will greatly aid in the understanding of policies …" (Jackson et al. 2015, 41).

## 3. Some general policy orientations for complex economies from previous literature

### *"Everything's political"[27]: "Revising the concept of regulation"*

Against that background, it is the manifold non-optimalities of complex-systems' mechanisms and processes, not properly reflected by the theory of "market failure" (e.g., Fontana 2012, 232f.), which opens the space for a proactive and systemic policy strategy. The "*pervasiveness of unintended consequences*"[28] (Wilson 2014, 12) in CA(E)S with dominant individualistic cultures and power relations particularly justifies a role for a proactive policy.

[27] The more extreme citation from that 1996 song of the band Skunk Anansie would have been: "Yes, it's fucking political!" They were presumably not in modern complexity science, though.

[28] Notably negative unintended consequences rather than the positive ones assumed in the "invisible-hand" metaphor of the Scottish Enlightenment.

Basically, complexity and evolution suggest a different conception of "regulation" than the mainstream has established. As socio-biologist *D.S. Wilson* argues, for a neoclassical and neoliberal economist, "regulation is something imposed by governments, and self-organizing processes such as the market are regarded as an absence of regulation", while for a socio-biologist,

> "all of the metabolic processes that keep organisms alive and all of the social processes that coordinate … [social animals – W.E.] are regulated ... The concept of regulation in economics and public policy needs to be brought closer to the biological concept of regulation. The idea of no regulation should be regarded as patently absurd but determining the right kind of regulation and the role of formal government in regulatory processes are still central topics of inquiry" (Wilson 2014, 11).

Thus, again, self-organizing capacities of CA(E)S are in no way running counter to a proactive role of policy. Rather, it is

> "clear that unmanaged cultural evolutionary processes are not going to solve the problems … at the scale and in the time that is required, which means that we must become 'wise managers of evolutionary processes' …" (ibid.).

Then, "the selection of self-organizing regulatory processes" (ibid., p.12) becomes a major policy task.

***But policy system partly endogenous***

As indicated, public policy is (1) *itself a complex system* with its own relative structural, procedural, and performative strengths and weaknesses, interacting with the CA(E)S, and (2) will thus have to be considered at least partly endogenous to the system under scrutiny. This, however, does not imply that the policy system cannot itself assume a higher degree of complexity as required to affect the CA(E)S. It may keep itself *sufficiently "exogenous"* if it properly develops its different constitutional mechanism: ideally, a unique, uniform, transparent, and *centralized and public* discourse and decision-making, well-informed of the complexity of the target system (and of its own complexity). This may be attained in face of its *multi-layered* structure, which needs to be turned into an advantage of proactive influence. With its unique and uniform discourse, some *collective rationality*, compared to individualistic rationalities in the target system, should become effective, and "moving the economy from an undesirable basin of attraction to a more desirable one" (Colander, Kupers 2014, 53), thus, should become feasible.

For an *evolutionary-institutional* approach, e.g., Hayden (2006) developed a *Social-Fabric-Matrix* approach to policy analysis to investigate the dynamic network structure among agents, institutions, and value systems, including policy agents and measures, with sequential input-output relations as directed graphs. This has often been applied to policy-relevant systems and demonstrably helps making transparent and pursuing policy actions throughout the socio-economic system, of which they are endogenous then in transparent ways.[29]

### *A higher complexity for the control system*

An early insight from information theory and cybernetics was that the complexity of a control system needs to be at least as high as the complexity of the targeted system, so-called *Ashby's*

[29] For evolutionary-policy approaches also, e.g., Radzicki 2009; Pelikan 2003; Witt 2003.

*Law* (Ashby 1956), where “only variety can absorb variety”. In other words, in order to shift a controlled system into an aimed-at area of outcome values (e.g., a “superior attractor”), while dealing with sometimes unpredictable adaptations of the system, including evasion, the control system must be able to assume at least as many possible states, or have at least as many degrees of freedom, as the controlled one.

In this way, CA(E)P needs to be itself complex, *system- and process-oriented*, with a *long-run learning* and *adaptation* perspective – “policy as a collective learning process” (Witt 2003, 81f.). It needs to stick to its clarified and legitimized *objectives*, while being prepared to assume many different states itself.

This seems to be impossible with a *neoliberal minimalist state* – ideally confined to a legal and court system, to tax and financial operations, and to police and military action, but de-qualified and run-down otherwise (in its capacities of democratic goal clarification, long-term planning, learning and adaptation, regulative frame-setting, and pursuing a holistic approach towards economy, society, and the natural commons). A political system with little current participation, based on an oligopolistic/duopolistic party system with the-winner-takes-it-all incentives and myopia until the next elections, will not be able (or willing) to develop such an approach.

***“Reducing complexity” of individual decision-making***

Regarding complexity and its reduction, we have to distinguish between the complexity of the system and of the decision situation of individual agents. In fact, the system may remain highly complex, when individual decision situations become less complex.

With respect to *system complexity*, many have warned recently against an increasing instability and uncontrollability under increasing complexity of the globalized and financialized networked system (e.g., Helbing 2013; Mirowski 2013) and argued that, to make such a system manageable, a "fundamental redesign" (Helbing) is needed. One of the standard devices since the beginning of CE in this respect has been careful *modularization design* (Simon 1962). Modularization (or "clusterization") should go together with proper *module coupling* (e.g., in small-world structures). The latter may include some overlap and some *hierarchization* among modules, according to the reach of relevant functions (reach of relevant "goods"). But maintaining the system's resilience, at the same time, requires *diversification* (and thus complexity) remaining large enough.

Also, given CA(E)S' nonlinear and often discontinuous behaviors, reducing the system's complexity and volatility may be *more or less successful at different phases* of the system. CA(E)S may be more or less robust or sensitive vis-à-vis policy measures in different times and phases. If the system is in a "basin of attraction", even if an inferior one, policy interventions may have little effect.

With respect to the decision situation of individual agents, emerged collectivities (*platforms*) of interacting "*intentional*" agents may have generated, carry, and apply social rules and institutions, as a tool of successful, problem-solving self-organization and of complexity reduction of their decision situations (e.g., Bloch, Metcalfe, 2011, 85f.; Gilles et al. 2015). Policy support for such institutional emergence then would help reducing the *perceived (over-) complexity* and (over-) turbulence of their individual and common/collective decision situations, by matching the agents' cognitive capacities and supporting farsightedness and innovation. Supported institutional emergence then may *de-block*, *accelerate* and *stabilize* rules and institutions with their mutually consistent expectations and, thus, common and collective action, and enable and empower agents.

A basic idea involved in such public support in favor of transparency, stability, and proper time for learning seems to be some (tacit) *contrât social* (J.J. Rousseau), a collective self-commitment (for some defined time) to collective decisions to be taken or taken earlier (whether right or wrong), and the corresponding public *assurance* (Sen 1967) of individuals that all are part of the social contract. This may exclude some behavioral options and limit "flexibility", but will also limit turbulence, thus increasing *efficacy* through *stability*, supporting *transparency* and empowerment in critical phases (also, e.g., Houser et al.2014). Therefore, introducing some *collective rationality and commitment* may help the system to settle in aspired value areas.

***The role of computation and simulations***

What has been said on the modeling of CA(E)S has of course a bearing on the qualification of CA(E)P. While calculation requirements are higher for CA(E)S than for simple systems, considerable *analytical intractability*, *indeterminacy* and *unpredictability* of CA(E)S processes remain. As computer calculations basically consist of simple *regular mathematical operations*, system complexity will quickly translate into *computational complexity*, measured, for instance, in *calculation time*, which might become infinite in extreme cases. But proper modeling and calibrations of *simulations* will indeed help detecting mechanisms, critical factors, and system-behavior patterns.

But cause and effect between the *control and target systems* will no longer be simple, unidirectional, and structurally constant but interdependent and *structurally changing*. For instance, a reversal of an earlier policy will usually not generate proportionate reverse effects on the target system. Nor must the *strengths of effects* of identical measures be the same over time. The ability of *forecasting*, therefore, will be generally reduced and context-dependent. Thus, although *formal methods* will be *more demanding* (dynamical-system analysis, system dynamics, Social Network Analysis, ABM, and computer simulations), forecasting "to the point" and *technocratic hopes* of easy and quick "*manageability*" (point intervention) will be infeasible. What we can expect to identify, though, is recognition of *patterns*, and explaining puzzles that mainstream's "normal science" cannot.

Policy interventions, therefore, have been said to necessarily remain *"nonalgorithmic"* in many instances (Velupillai 2007, also: 2005). Policy recommendations of CE, V. Velupillai argued, will be less certain, more "*inductive*", and more acting on the long-run temporal dimension. More degrees of freedom and some *undecidability*, then, require a basic "change in the worldview that is currently dominant in policy circles" (Velupillai 2007, 275).

The problems of intractability, incalculability, relative indeterminacy and more difficult predictability render policy measures and impacts not always exactly computable. Thus, "nonalgorithmic" action will be needed to move the system into an aspired (superior) basin of attraction with aimed-at outcome values. But all this does by no means absolve politics from the requirement of assuming a *proactive role* in the sense of a CA(E)P (e.g., Durlauf 2012, 62ff.), or making the best of its "algorithmic" underpinnings. [30]

[30] Notably, a debate on new opportunities of calculation-based political planning, given modern computer-system capacities, seems to emerge from Marxian perspectives; e.g., Whitmore 2014; Cockshott 2015. On the other hand, Kauffman et al. 2015, in a biology-inspired neo-Schumpeterian and Austrian stance towards CA(E)S, conclude that "unprestatable" and non-algorithmic system change prevents clear-cut policies at all (similar, as mentioned, e.g., Gaus 2007; Lewin 2014).

***Further "Complexity Hints for Economic Policy" and the "Art of Public Policy"***

Salzano and Colander (Eds., 2007) pioneered on policy implications of economic complexity. In their volume, one group of authors, Gallegati et al. (2007) showed that system stabilization under *power-law* structures (see above) of *firm sizes* has to control "*idiosyncratic volatility*" caused by volatility in the highest classes of firm sizes (similarly, e.g., Mantilla 2015). They conclude to pursue an apparently traditional policy orientation: a *reduction of high firm centralities* and concentration by reducing certain overly strong legal protections of size and power (namely of intellectual property rights).

CA(E)P tackling relative indeterminacy reminds of what was already implied in the *Theory of the Second Best* above and also justifies Colander's and Kupers' (2014) dictum of a complexity-based "art of public policy".

Such policy orientations from the previous literature are, with few examples, quite basic and not specified to certain complexes of measures and tools. Thus, we will have a closer look, in the following, into a notorious little non-complex and basic formalism of a PD-SG, embedded in narratives of a population and networks ("evolution of cooperation"), aspiring to advance some more specific CA(E)P orientations, tools and measures.

## 4. A simple example for specific frame-setting for institutional emergence in prisoners'-dilemma supergames

This simple example already holds some exemplary policy relevance. We refer to Axelrod's (1984/2006) older EGT-based approach to the *evolution-of-cooperation* in repeated PDs, a simple formal reflection of his 1980s complex multi-strategy simulations, which have triggered a surge in the use of PD-SGs and simulations ever since (e.g., Lindgren 1997; Kendall et al. 2007).[31] Note that only an evolutionary interpretation will render the particular policy implications of a static analytical approach (as given below) relevant as a starting point for more specific CE policy implications and more consistent with structural emergence and idiosyncratic process within complexity theory than with mainstream interpretations. We will try to show that even such a relatively simple approach provides relevant first insights that then extend into policy implications from more complex network- and agent-based approaches (see section 5).

***Axelrod's simple formalism and first policy implications***

The well-known starting point is the PD normal form:

$$\begin{matrix} a, a & d, b \\ b, d & c, c \end{matrix}$$

with $b>a>c>d$ and $a > (d + b)/2$.

The approach to the superiority, in the sense of EGT [non-invadability, or evolutionary stability (ES)], of cooperation in a population with randomly matched agents playing many 2x2-PD-SGs

[31] Too often, however, the PD is just taken for granted. We have elaborated on both the ubiquity and everyday relevance of social-dilemma structures elsewhere (e.g., Elsner, Heinrich 2009).

applies one of the usual ES-conditions of EGT, comparing defectors' (*ALL-D*) yield against tit-for-tat-cooperators (*TFT*) with what cooperators attain playing against their kind[32]:

$$P_{TFT/TFT} = a + \delta a + \delta^2 a + \ldots$$

$$= \frac{a}{1-\delta};$$

$$P_{ALL\text{-}D/TFT} = b + \delta c + \delta^2 c + \ldots$$

$$= \frac{c}{1-\delta} + b - c.$$

The ES criterion used is, whether an existing population of cooperators cannot (or can) be invaded by defectors and thus be an ES strategy (or not):

$$P_{TFT/TFT} >!\ P_{ALL\text{-}D/TFT},$$

$$\text{thus } a/(1-\delta) >!\ c/(1-\delta) + b - c$$

$$\delta >!\ (b-a)/(b-c).$$

The result is a logical condition for SGs for *cooperation* to prevail in a population.[33]

Such cooperation not only is infeasible under one-shot rationality, it would not be an ES strategy in the regular EGT. But it may attain ES status in a SG with proper *expectations* (the discount

[32] TFT, as known, starts cooperating and then does what the other agent did last interaction. It is the simplest cooperative strategy in a PD-SG that does reflect some sequence of interactions (with one period memory), is responsive and, thus, not always strictly dominated (like *ALL-C* is). Note that TFT is considered incumbent, while All-D invading.

[33] The more interesting question Axelrod had also addressed is, in the more general population approach, what the minimum critical mass (or share) of TFT cooperators would be that can survive and expand in a defector population.

factor $\delta$, equivalent with the expectation of meeting the same again next interaction). In a sequential interaction process, this would require *social learning* and *cultural acquisition* of a related longer-run perspective. Then the *habituation* of cooperation as a *social institution* may emerge, as agents must "irrationally" *sacrifice* their short-run maximum (their sacrifice then would be *b-a*) (e.g., Sen's rational fools; Sen 1977; also, e.g., Schotter 1981). An institution thus is a social rule plus an *endogenous sanction* (exerted through the credible threat of a trigger strategy, such as *TFT*, to defect as well upon defection and in this way punish the defector). This then may prevent opportunism and keep agents from chasing after their short-run maximum, trying to free-ride or exploit others. As it cannot be attained by "hyper-rational" myopic maximization, it must become habituated and pursued "*semi-consciously*", i.e. pursued as long as there is no reason to expect that the next interaction partner will intend to exploit.

A major theoretical question for complex modeling, then, is the actual *emergence* of such *longer-run rationality* (formally, as above, a long-run maximization calculation, reflected by a current-capital value of the infinite geometric series of payoffs, the so-called *single-shot* solution). The longer time horizon then would by indicated by a high $\delta$ (a high perceived probability that the interaction with the same will continue and a low time preference), equivalent to the probability, in any particular interaction, to meet the same interaction partner again (or one otherwise informed about the agent's earlier behavior, or a cooperative one, as experienced, on average, in a population).

The single-shot payoffs, when the PD is solved, will transform the PD into a less intricate *coordination game* (with two Pareto-different Nash equilibria).[34] And a general management and *policy* perspective for the Pareto-superior solution was already presented by *A*. *Sen* (1967). In a context of an independent and endogenous national development strategy and related collective saving effort of a population to build a national capital and investment base, he introduced into a coordination-game structure the idea of a *public assurance* that all other agents will also contribute (e.g., will forego current consumption and increase saving for building a national capital stock to make the next generation, and not only own offspring, benefit), thus termed "assurance" game. Such public assurance would be equivalent with an informal *contrât social*, or a *general-trust* building, providing a Schellingian focal point in favor of the Pareto-superior coordination.

But, of course, in any sequential interaction, an existing dilemma structure still will continue to exist, with its dominating incentive to defect. As long as agents are uncertain and myopic, playing series of one-shots, the direction and outcome of a resulting process will not be problem-solving. A *"self-organized"* superior, *instrumental solution* may remain *completely blocked* and the system caught in the one-shot Nash logic. Should however an institutional solution emerge, it may be very *time-consuming*. Finally, an actually emerged institution also may be *endogenously fragile* and prone to backslide and a later breakdown, depending on the evolution of population shares of cooperators and defectors, among others, i.e., the particular systemic path. Thus, there is much reason and space for a *more systemic policy support* of the process of self-organization and emergence than the idea of public "assurance" would suggest.

[34] A prototypical complex simulation model is W.B. Arthur's technology choice, where the cumulation towards one of the possible Nash equilibria (coordination) was attained by increasing returns in production (or network externalities in use) (Arthur 1989).

As first shown by Axelrod, a more both systemic and specific policy support is feasible indeed on the basis of such a simple analytic exercise. [35] It points to two *complexes of policy measures*:

(1) Gradually improving the *incentive (payoff) structure* in favor of cooperation, e.g., *rewarding cooperation*, weakening the social dilemma, making the structure less intricate and difficult to solve, without necessarily dissolving the PD structure as such, may increase the probability of an *emergence of a superior, instrumental solution* (or systemic attractor) in an evolutionary population process (formally reducing the right-hand side of the above inequality).

(2) Promoting the *recognition of interdependence* ("recognized interdependence", an older institutionalist issue, BTW; e.g., Bush 1999) and, particularly, the awareness of the *common future*, enlarging the *time horizon* in a social learning process („enlarging the shadow of the future" – Axelrod), may have the same effect. Formally it renders the inequality above more likely to hold from its left side, i.e., a longer-run calculation and culturally acquired perspective to emerge as some enlightened self-interest, supporting a culture of reciprocity. This has also been an older institutionalist issue, for instance, extensively dealt with as *futurity* by Commons (1934) (see also, e.g., Jennings 2005; Hayden 2006). [36]

[35] We do, of course, not assume that we can identify normal-form games in reality and derive clear-cut behavioral and policy conclusions from them. But we assume that we can identify certain basic incentive and game structures and attenuate those that imply high intricacy and turbulence for agents.

[36] Past experience and futurity may be reflected by intergenerational games that stress both memory and future expectations and thus increase capacities to cooperate (e.g., Fukadai, Inukai 2015; for overlapping games, also, e.g., Heinrich, Schwardt 2013).

Axelrod gave *policy examples* for the latter, less obvious issue, such as generating, and involving agents in, series of *common projects (games) that overlap over time* so that agents always have a perspective to "*meet again*" (increasing the value of $\delta$). Note again that this must not be the identical agent. Given agency capacities of *monitoring* or *reputation-chain* building and usage, this must just be a "knowing" agent, who is informed about the agent's earlier behavior.

We have elaborated on the two complexes of tools and provided a real-world case study earlier (Elsner 2001; similarly, e.g., Richards 2012). Among others, we showed how *regional networking* on identifiable common and collective issues may serve the second complex. We also demonstrated how the first complex may be addressed through *non-pecuniary payoffs* (such as, e.g., selective early provision of critical information), while, on the other hand, supporting cooperation through pecuniary subsidies (so that, in the extreme, the particular PD structure is abolished) may be fiscally too costly and thus practically infeasible for the public agent. Therefore, such gradual approach can also be considered a *cheaper and leaner* policy as compared to a full public production of public goods ("on behalf" of a "failing market"), or a full subsidization of cooperative behavior to make cooperation the individualistically dominant behavior (similarly, e.g., McCain 2009, 85ff.; Colander, Kupers 2014, 280).

***A designer's perspective***

Such policy support of collective problem-solving, again, would formally focus on increasing *expectations* "to meet" ($\delta\uparrow$) and/or on weakening the fierceness of the dilemma ($b\downarrow$, $a\uparrow$), so that the single-shot condition above will more likely hold. This can be illustrated with the inequality above:

$$\delta\uparrow >! \ [(b\downarrow - a\uparrow)\downarrow / (b\downarrow - c\downarrow\downarrow)\uparrow]\downarrow .$$

We may qualify this, setting the inequality condition as an equation, to illustrate derivatives after the policy-relevant variables, changing the minimum $\delta$ into $\delta_{crit.}$:

$$\delta_{crit.} = (b-a)/(b-c) = 1-[(a-c)/(b-c)] = (b-a)^1(b-c)^{-1},$$

with the marginal conditions:

$$\frac{\partial\delta_{crit.}}{\partial(b-a)} = 1/(b-c) > 0 \qquad (1)$$

$$\frac{\partial\delta_{crit.}}{\partial(b-c)} = -(b-a)/(b-c)^2 < 0 \qquad (2)$$

and particularly for the individual incentive variables:

$$\frac{\partial\delta_{crit.}}{\partial b} = (a-c)/(b-c)^2 > 0 \qquad (3)$$

$$\frac{\partial\delta_{crit.}}{\partial a} = 1/(c-b) < 0 \qquad (4)$$

$$\frac{\partial\delta_{crit.}}{\partial c} = (b-a)/(b-c)^2 > 0 . \qquad (5)$$

This little exercise somewhat clarifies the policy implications re. the incentive structure:

Ad equ. (1): *Reduce the "costs of collective cooperation"*, (*b*-*a*), so that the requirement, in terms of the required *length of the individual time horizon* ($\delta_{crit.}$) for the dilemma to be solved through a calculated long-run superiority of collective cooperation, softens as well. The probability that the dilemma will be solved by the agents will then increase c.p., as the single-shot condition will be easier met. The requirement for $\delta_{crit.}$ for a solution then could even be somewhat reduced, c.p., and the problem still solved. Similarly, ad (2): *Increase the "costs of common defection"*, (*b*-*c*), i.e., increase the *frustration* (the endogenous mutual punishment) for defecting agents. Further, and more obviously, for the individual payoffs, e.g., ad (3): *Reduce the temptation to defect*, (*b*); ad (4): *increase the reward of collective cooperation*, (*a*); and, ad (5): *reduce c* (and if *b* is reduced as well: reduce *c* even more than *b*, in order to meet condition (2)).

Do all this in order to make the institution of cooperation increasingly superior in an evolutionary process in the population, supporting agents in a process of learning to solve social dilemmas. The fierceness of the social dilemma may be *gradually* attenuated, futurity gradually strengthened, and the inequality condition gradually made more feasible, to favor the collective-good production in a process within a population. Public support for the system's intended adaptation, thus, is largely a gradual issue. These gradual changes may, in an evolutionary process, *de-block* individualistic lock-in (the one-shot Nash equilibrium) or *accelerate* and *stabilize* the process of institutional emergence.

Completely eliminating the dilemma structure as such would not only be rather costly for the public agent but also just a "static" solution (therefore theoretically trivial as well), rather than learned and habituated in a process. Rather, private *agents need to be held liable for their individual interests in the collective solution* (as indicated by the payoffs *a*), and should correspondingly *contribute*. And their contribution should be intrinsically learned and informally emerge in an adaptive process among themselves – rather than being imposed (or provided in lieu of them) by the public agent (on behalf of a "failed market").

The single-shot solution may be elaborated for *population size* and/or *cooperators' share* relevant for respective cognitive capacities to generate proper expectations "to meet (again)". Total *maximum population size*, *minimum critical share of cooperators*, and even a *maximum carrier-group size* of the institution might be determined (e.g., Elsner, Heinrich 2009). Size, thus, will be another critical factor for the probability of structural emergence.[37]

## 5. More policy implications from the complex "deep structure" of the economy: GT and network considerations in an evolutionary-institutional policy perspective

***"Framework" approach***

The simple example above reflects a more general principle of CA(E)P, inferable from a broader set of GT, network-based and agent-based analyses: While the "market", if not properly regulated, is subject to system(at)ic failure, self-degeneration, and self-annihilation, the public agent, if properly qualified, might be able to generate and implement basics of a long-run individual and collective rationality, a better collective-action capacity, and some control of the decentralized private interaction systems in order to mitigate systemic failure. However, there is no reason for assuming for the public agent, even for a sophisticated, calculating, and qualified one, "to know everything" or "to know better" in all contexts and dynamics of the socio-economic system. This sometimes may require, as mentioned, just *enforcing a general commitment* for some time to collective decisions taken earlier. But some very quickly and unpredictably changing behaviors of the CA(E)S will also require the policy agent to

[37] For an overview of the size dimension in economics in general, e.g., Elsner, Heinrich, Schwardt 2015, Chpt. 14.

systematically *make use also of the "knowledge of the target system"* (not at all, of course, of "markets" alone). This implies some *reduced policy vision*, as mentioned, which we now can qualify as a policy orientation towards some *specific frame-setting*, while *letting the system and its agents do their part and adapt*.[38]

Such framework approach, using an *interactive relation* between diverse bodies of knowledge and action, has also been advocated, but somewhat misleadingly called an "activist laissez-faire policy", by Colander and Kupers (2014, 214ff.), also called "political stewardship" by others (e.g., Beinhocker 2012; Hallsworth 2012; Colander, Kupers 2014, 240ff.). It appears consistent with what Colander, Kupers (2014, 186ff., 195ff.) called a "norm influencing role for government (…) designed to influence the rules and tone of the social game" (p.186). Then government may indeed become "a means through which individuals solve collective problems" (ibid.).

***Analytical components***

At the same time, policy needs to be prepared to *learn from the complex system's path and reactions* – an "agile decision-making in a turbulent world" (Room 2011), which will be more demanding for the policy system than what we know from the currently dominating "global" "market-order" policy approach. CA(E)P rather includes the task of identifying and *analyzing* the *components*, *mechanisms*, and *critical factors* that generate the visible complex processes and system motions. These are the prime components, mechanisms, and factors as discussed so far:

[38] This seems to resemble mainstream perspectives on a framework policy of the "ordo-"liberal kind. However, it will turn out that it has little to do with just pushing the "market" as a framework structure, but will go beyond that, being both broader and more specific.

(1) *awareness of interdependence* among private agents (improving "recognized interdependence");

(2) *incentive structures*, their kind and their quantitative strength (type and degree of "intricacy" of games; gradually improving them from "fierce" to less "fierce", "intricate" to "less intricate"), leaving agents to adapt accordingly;[39]

(3) *futurity* (improving private agents' time horizons and future expectations of coordination/cooperation behavior of other agents, supporting the cultural acquisition of longer time horizons;

(4) *interaction arenas* (designing their *sizes and network structures*, taken as initially given and endogenously changing, in this way supporting endogenously emerging *platforms* of carriers of rules and institutions);

(5) the *collective goods* to be "produced" (and natural and social *commons* to be reproduced) in those arenas/networks by way of rule-based coordination or institutionalized cooperation (identifying their reaches, overlaps, and layered structure);

(6) the particular *deficiencies of the decentralized private social provision* processes of those good and commons (identifying them in terms of complete *blockage*, high *time* requirement or great *fragility*);

(7) social and *political objectives* (identifying the particular *public interest* in those collective goods and commons, to be clarified in a proper participative process);

(8) the *private interests* in those solutions (goods and commons) (identifying payoffs private agents get for the solutions, in order for the public agent to call the private in to contribute accordingly); and

(9) the relevant intervention areas or *target areas*, and complexes of *tools and measures*.

---

[39] This relates to the general economic "design" approach, as applied to games and institutional emergence by Hurwicz himself (e.g., Hurwicz 1987).

***Further policy orientations, target areas, tools, and measures***

We will briefly discuss some of these components as political target/intervention areas. Elaborating on them, further policy orientations, tools, and measures may be derived, which however, do overlap. But favorable results must be expected to depend on systemic constellations of those components anyway.

(1) *Improving incentive structures, assuring, and supporting focuses*, helping agents to converge on *superior coordination options*: In solved and transformed PD-SGs, i.e., coordination structures with Pareto-different NEs, a public assurance may work to *create a focus* for the Pareto-superior coordination (Sen 1967; Calvert 1995; Arthur 1989; McCain 2009).

(2) *Caring for appropriate inner network structures, for local clustering and global exchange of experience*: Generally, it has been argued that

> "(T)he more knowledge we have of how people are connected on the relevant network (…) the more chance a policy has of succeeding" (Ormerod 2012, 37).

For instance, supporting *small-world* properties, while avoiding too much *centrality* and power for few agents, would make power-law distributions more even and less volatile (and their graphs steeper); or, put reversely: When regulating connectivity structures, and in particular when reducing centrality degrees, the small-world property may not be suspended.[40] The policy implication would be to support a balance of *"meso"-sized clustering* and neighborhood, and some far-reaching, *"global" interconnections*. A large literature of network analyses, done particularly against the background of the financial crisis 2008ff., has related all *scale-free* networks with highly uneven size/power structures to systemic *volatility*, fluctuations, and vulnerability. This suggests to *regulate connectivity structures*, particularly reducing high-level power positions, in an effort to *stabilize* networks and increase their *resilience* (as above: Gallegati et al. 2007; also, e.g., Acemoglu et al. 2012; Glasserman, Young 2015).

(3) *Designing appropriate systems of interaction arenas* and supporting emergent *cooperation platforms* of proper *sizes*, *overlaps*, and *hierarchy levels*: Such structures will have to depend on the overlapping and layered *reaches* of the basic collective goods and commons; e.g., supporting local, regional, national, and global collective goods and commons through "structural" (industrial, regional, environmental, developmental …) policies; shaping proper "*meso*" arena and network sizes to meet individual cognitive capacities and thus increase private solution capacities (e.g., Binmore 2011, 189ff.; Loasby 2012; Charness, Yang 2014; also Elsner 2001).[41]

(4) *Promoting decomposability and reducing complexity*: In approaches that consider relevant-population size, meso-size of arenas, platforms, groups, or networks, with their greater average proximity, neighborhoods, interaction density, and probabilities "to meet" (related to some *decomposition*, "*delinkage*", *modularization*, or *clustering*), may reduce the complexity of individual decision situations and thus play a favorable role for emerging

---

[40] Also, small-world networks may have endogenous tendencies to either homogenize and reduce bridging ties, and/or fragment and lose cluster structures (e.g., Gulati et al. 2012). Structuring policies would thus have to care for maintaining problem-solving small-world properties in any case.

[41] This obviously refers to H. Simon's older insight, mentioned above, that "building systems" requires some decomposability into smaller systems. According to Loasby (2012), this is to be based on some selective connectivity (such as neighborhoods, peers, or partner selection). Mirowski (2013) elaborates on reducing over-complexity and volatility in the speculation sector and calls it delinkage.

coordination and cooperation. Many analytical, empirical, and simulation approaches have argued that *smaller groups* improve "recognized interdependence", futurity, and the *quality of individual and common and collective decision-making* in realistic environments (e.g., Fainmesser, Goldberg 2011; Richards 2012; Mirowski 2013; Elsner, Schwardt 2013, 2014; Kao, Couzin 2014). This particularly applies when agents may *move on networks* and make location choices (e.g., Berninghaus et al. 2013).

(5) *Reducing volatility, turbulence, and disembedding mobility*: Reducing perceived over-complexity of individual decision situations also may favor private collective problem-solving in consistence with public objectives (i.e., not at the expense of third agents). This relates to increasing *transparency* and oversight, reducing volatility and turbulence for the individuals, in order to *provide time frames required to learn, adapt, and stabilize expectations and interrelations* (e.g., Houser et al. 2014; Acemoglu et al. 2015). A surprising and often counter-intuitive implication – running counter mainly established neoliberal convictions, but making sense within an evolutionary-institutional GT perspective – is that such *social-capital* building requires the reduction of current levels of *enforced and dis-embedding mobility*, as a dimension of a perceived overly high degree of complexity and turbulence (e.g., Glaeser et al. 2002; Room 2011, Chpt.12). In a similar vein, the *social costs of territorial uprooting* have been analyzed (e.g., Solari, Gambarotto 2014). It has also been shown that under higher environmental volatility the reaction of CA(E)S may be to switch into higher rigidity, as agents cannot properly organize search and learning any longer; and the system may slow down in the longer run (e.g., Vega-Redondo 2013). Thus, the stabilization of complex systems tends to require strict and more complex institutions to govern interactions (e.g., Gilles et al. 2015). Such results are shared by a large recent organizational and network literature, and they shed light on many

counterproductive petrifications in response to overly extensive de-regulation and "globalized flexibility".[42]

(6) *Increasing transparency and complete information, agent capability, and time for learning*: Closely overlapping with the above, strengthening agents' capacity to deal with intricate problem-structures further would require to provide them with "complete information" on their interactions, i.e., with a basic knowledge of the *character of their interdependence structure* ("game type"). Further, providing sufficient time for the social learning of proper solutions also relates to strengthening agents' capabilities to *memorize*, *monitor*, *build reputation*, *use reputation chains*, and *select partners*. It may be critical then to support agents to be somewhat *risk taking* (of being exploited at least once, when trying to escape social dilemmas) and *non-envious* (should this happen once), further, to *search and experiment*, with behavioral innovation in order to generate cooperative *minimum critical masses* required to make cooperation paying, superior, survive, and spread (e.g., Axelrod 1984/2006; Wasko et al. 2009).

(7) *Information openness, multiple-path creation, and windows of opportunity*: Emerged institutions may *degrade* into abstract norms and *ceremonial* structures, removed from solving the original problem and based, for instance, on differential *power* and related increasing *inequality* of cooperation gains (e.g., Elsner 2012).[43] Restoring agents' problem-solving capacity and *promoting progressive institutional adaptation*, then, will require some *break-out from institutional lock-in* (e.g., David 1984). Such break-out, in turn, will require some *information openness* and, under *net externalities*, some open basic

---

[42] We have argued elsewhere that in very large anonymous and/or highly turbulent populations with frequent random partner change, agents would tend, as far as possible, to stick to a PD-SG with the same partner as long as possible, or "meet again" more often, provided some preferential mixing is part of their agency capacity (Elsner, Heinrich 2009).

[43] The evolutionary-institutional issue of "ceremonial dominance" may be modeled as a temporal series of overlapping dilemma games with inferior short-run, but superior long-run outcomes of any new game, thus a tendency of agents to stick to the old, outmoded institution (e.g., Heinrich, Schwardt 2013).

innovation and the promotion, if possible, of *interoperability* among different technologies and path options. A *multi-standard policy*, though, may not only be counterproductive, as long as the unique technical and behavioral standard still is coordinating and problem-solving, but also infeasible. It has been shown that there are critical technological and institutional preconditions, so that *openness policies* become feasible only in *critical* (often early) *time windows* (e.g., Heinrich 2013; also Witt 1997).

(8) *Favoring equality*: In GT, it has largely been concluded that favoring equality among agents is a general policy orientation warranted (e.g., Hargreaves Heap1989; Binmore 2011, 165ff.; López-Pérez et al. 2015). It appears from many formal and experimental analyses that more even (among the agents) payoff structures are less intricate, easier to solve for agents, thus more stable in the longer-run, *facilitate voluntary collective-good contributions* (e.g., Kesternich et al. 2014; Nishi et al. 2015; Krockow et al. 2015), increase macroeconomic performance (e.g., Acemoglu et al. 2015) and (objective and perceived) welfare (e.g., Wilkinson, Pickett 2009). Also, equality (or fairness, or justice) may provide a focal point for evolving equilibria in processes based on coordination problems (Binmore 2012). *Asymmetric payoffs*, in contrast, may increase intricacy and volatility, through continuing redistribution battles, thus perhaps distracting agents' resources from the very problem-solving, the creation of value rather than redistribution of value already created.[44]

[44] This applies to 2x2 normal-form games even if the formal analysis provides equilibria with asymmetric payoffs for the agents as, e.g., in coordination games of the battle-of-the-sexes type. In anti-coordination games with asymmetric payoffs (e.g., chicken/hawk-dove type), long-run stability is dubious, and a population may split into different sub-cultures (strategies), rather than uniquely solving the collective problem. In non-coordination games (e.g., zero-sum games), policy might need to mitigate the resulting extreme distribution struggle by changing the interdependence structure as such. Note that formal solutions through mixed strategies are instable in coordination games and dissatisfying in anti-coordination games with asymmetric payments. But again, we do not purport 2x2 normal forms to be easily related to CA(E)S.

## 6. "Framework" approach and "new meritorics" – Outline of an "interactive policy"

***Framework approach again***

To shape critical factors of the social interaction process and of the system's motions through some policy action, a basic orientation derived above has been a specific "framework approach", where policy would have to *shape specific factors* to influence *adaptive interaction* processes. This will maintain some space for the agents' and the system's adaptations, even at the risk that these include some evasion. The rationale here was that interactively learned, habituated, and institutionalized solutions, emerging through setting appropriate incentives structures, should be *more effective and stable in the long run* than solutions just imposed or prescribed, or provided as a "free-lunch" instead of agents' own efforts. Agents' new behavior then perhaps would remain part of their inherited short-run culture. Such substituted public "solution" would not be appropriately process-oriented.

Such framework policy approach is about finding *game rules* and *parameter constellations* entailing adaptive processes with outcomes consistent with broad social goals (the traditional *mechanism design* perspective; e.g., Hurwicz 1987; Weimer 1995). Such approach then also provides a clearer definition of the *relative private and public interests, responsibilities, and contributions* (in contrast to often fuzzy "Public-Private Partnerships" so much en vogue under neoliberal auspices, where the state often provides public assets and guarantees for new profit opportunities for private investors, who then bear little risk).[45]

---

[45] This approach seems clearer, too, than the recently celebrated approach of "libertarian paternalism", using "nudges" as a political strategy (e.g. Thaler, Sunstein 2003). The latter does not seem to properly reflect system complexity (e.g., Colander, Kupers 2014, 167ff.).

In a game-theoretic perspective, as indicated, the policy problem is to deal just with the threshold of the difference between the collective-cooperation payoff and the short-run extra benefit for unilateral defection (which, however, is highly uncertain among equally "clever" agents, thus, ideally *b-a*, but often, in fact, *c-a*, which is a gain).

***Social evaluation: "New meritorics"***

The general *operative logic* of this "framework" approach is that the policy agent needs to evaluate the outcomes of the spontaneous private social-interaction processes: What are the relevant (and politically aspired) collective goods, and what are the *deficiencies of the process* and its outcomes? Are solutions, as indicated, (1) completely *blocked*, (2) too *time-consuming*, or (3) too *fragile*? And if yes, why and how? A social evaluation of such multiple deficient processes (with "market failures" at its core) has to identify and evaluate the *public dimension of, and interest in, the collective goods*, being well-informed about the system's properties and behavior.

The outcomes of spontaneous decentralized processes, particularly in an individualistic culture in de-regulated markets, thus, will have to be evaluated according to some *collective rationality*. Basic criteria already discussed may be the (1) *degree of uncertainty of emergence*, (2) *time requirement* for emergence, and (3) *degree of fragility* of emergence. Policy orientations then are to (1) *unlock/de-block*, (2) *accelerate*, and (3) *stabilize* structural emergence of common or collective goods, which supposedly is a public good as well, fostering collective economic improvement and development.

In terms of a *goods classification*, the (1) initial (neoclassical) *collective good*, ideally infeasible through "private production", may, in a CA(E)S, assume the character of a (2) *private good* in the particular sense that it might emerge in an interactive evolutionary-institutional process of self-organization, but then will have to become a (3) *merit good* (Musgrave 1959) through social and political evaluation, as its emergence is deficient. The original merit-good criteria of "wrong" price and quantity, however, will have to be *extended* by the above criteria derived from deficient complex process. In this perspective, we may speak of a *new meritorics* (e.g., already Musgrave 1987; also Ver Eecke 1998, 2007, 2008; Elsner 2001).

Such policy, therefore, is not simply "framework"-oriented but (1) *double-interactive*, as it, in definable ways, interactively relates to the private interaction system. We have termed it *interactive policy* earlier (e.g., Elsner 2001), while traditional perspectives on the economy as a mechanical machine promoted dichotomies between "no government" (if "markets work") and fully centralized bureaucracy (if "markets" fail and governments have to act "as if" they were "the market") (e.g., Ormerod 2012). Such policy may also be considered (2) *institutional policy*, as it works to support agents' efforts to reduce the complexity of their decision conditions and improving their outcomes in the long-run by generating problem-solving social rules and institutions. A *new private-public interrelation* sets specific framework conditions, but leaves the system *degrees of freedom* to adapt.

***Legitimation, qualification, and learning of the public agent***

The state or policy-agent needs to become particularly *strong* and qualified, and this may include being democratic in more *participatory* ways, as this might bolster its independent stance vis-á-vis the target system and its independent evaluation process, goal clarification, and longer-run commitment to its decisions. The policy agent needs to become able to *define, clarify, maintain, and adapt* social valuations, policy objectives, target areas, and tools.

This is also what the *pragmatist* policy conception (e.g., Dewey 1930) of evolutionary-institutional economics, with its conception of a *discretionary policy*, its operationalization of *instrumental social values* (e.g., Tool 1979, 1994), and its conception of a participatory *negotiated economy* (e.g., Commons 1934; Ramstad 1991; Nielsen 1992; Hayden 2006; Hodgson 2012) has been about.[46]

With unfolding knowledge of the policy maker about the system and the private agents and their evolving preferences, (1) policy objectives will become continuously clarified, elaborated, and *adapted*, and (2) a clear-cut static *means-ends* dichotomy becomes *blurred*, as means may turn out to have different dimensions of ends and v.v., very much in a *Myrdalian* sense (e.g., Myrdal 1959); policy will thus have to be continuously revised and conceptualized a s an *evolutionary policy* (e.g., Witt 2003, 84ff.).

***Manifold policy agents and a layered state***

Finally, this may apply to different types of policy agents, namely (1) neutral "network" consultants engaged by the agents involved in an arena, sector, cluster or network, (2) the public policy agents proper, and (3) different kinds of intermediaries somewhere between those two types.

[46] On the role of democracy for complexity policy, also, e.g., Colander, Kupers 2014, passim.

A *smarter government* would have to be structured, *overlapping* and *staged* itself, rather than just one central bureaucracy. This would have to reflect the already discussed tiered and overlapping structure and reaches of the common and collective goods, related arenas, their carrier groups and platforms, clusters and networks, from local through global (e.g., Ormerod 2012; Richards 2012; Hallsworth 2012, 44ff.; Kroetz, Sanchirico 2015; Wilson, Hessen 2015).

As said, a state with such *proactive* orientation needs to be embedded in a strong democratic-participatory environment, it must become both stronger and more qualified in its financial, technical, informational, and personnel endowments, more *independent* of dominant private powers and vested interests, with the power to develop and clarify social objectives and stick to them for some appropriate period of time, thus be *reliable*, sustainable, and stabilizing, but also adaptive,[47] with an awareness of a required *never-ending engagement* (e.g., Ivarola et al. 2013), increasing its own complexity and adaptiveness above that of the target CA(E)S.

## 7. Conclusion

This paper reviewed and discussed some policy implications suggested by previous CE literature, and strived to develop a set of somewhat more specific orientations, objectives, and complexes of tools and measures of an adaptive economic "complexity policy", CA(E)P. This was done against the background of the main properties of CA(E)S, and in a perspective of the "evolution-of-cooperation" considering games on topologies.

[47] Some authors phrase this "experimental" policy (e.g., Beinhocker 2012; Colander, Kupers 2014, 276f.).

We briefly reviewed basic mechanisms, resulting properties, and critical factors of CA(E)S and exemplarily focused on a subset of CA(E)S, agent- and interaction-based systems. We referred to EGT arguing, social network analysis, and some games-on-networks literature in an evolutionary-institutional perspective. We derived illustrated some more specific policy implications with a simple modeling approach, trying to show that and how they are generalizable beyond just PD-SGs.

While the literature on policy implications of CE and CA(E)S has surged after the financial crisis 2007/8, it still is, with exemptions, largely general. With the above, we hope to have substantially contributed to this expanding set of literature. A set of policy orientations, potential objectives, complexes of tools and measures, and a socio-political conception of politics and its agents resulted. This appears to be considerably different from some still dominant rough-and-ready "market"-based policy orientations, while, however, we are aware that between "mainstream" and "CE" there are a number of smooth transitions, both analytical and in policy orientations.

We developed an outline of a CA(E)P as a specified *framework approach*, termed *interactive policy*. We embedded it in what we called *new meritorics*, modifying the older conception of *merit goods* (Musgrave), relating such CA(E)P to the older *pragmatist-institutionalist* conception of a *negotiated economy* (Dewey, Commons, Tool). Such policy implies a *larger complexity of the control system* over the target system, higher (and different) *computational* requirements, greater *strength* and *qualification*, a longer-run commitment and adaptability, stronger democratic-participatory *legitimation*, and an overlapping and *multi-level* structure of the public policy agent. Such approach is particularly learning, *adaptive*, and, as demonstrated, also *leaner* and more inexpensive, with its committed, *reliable*, sustaining, and pro-active frame-setting.

*Self-organization* capacities of CA(E)S and ubiquitous requirements of CA(E)P for specified *frame-regulations* proved not to be mutually exclusive but to form a new interrelation, independent of considerations of "optimality" or unique "equilibrium". The latter seems to apply particularly under conditions of a myopic individualist culture in de-regulated "markets".

Such policy will be aware of *path dependence* and non-ergodicity, non-linearities and *cumulative process*, and *structural emergence*, such as both instrumental *institutionalizations* and forms of *lock-in*, also of *idiosyncrasies*, such as quick phase transitions, structural breaks, and surprise, and thus particular *non-predictability*. CA(E)P recommendations, therefore, are much less certain and apodictic than mainstream prescriptions, but also lumbering much less into false point-predictions. Such CA(E)P requires use of alternative *modeling*, *computations*, *simulating* alternative paths, and *exploring* the spaces of policy discretion.

CA(E)P will in this way be prepared to support private agents to *reduce* the often *perceived over-complexity* and over-volatility of their decision-situations, and perhaps try to reduce the systemic complexity itself.

Such policy will regulate in specified interactions with the private interaction system, leaving to the private system degrees of freedom for adaptation, but taking the definitive individual interest of private agents in the collective institutional solutions into account, thus committing them to the production of relevant collective goods.

More specifically, such policy will be sensitive towards critical *incentive structures*, agents' *information* endowments, experience and *expectations*, towards *futurity* and "encultured" *time horizons*, *recognized interdependence*, towards *(meso) network sizes* and *"small-world" structures*, overlapping and layered arena, platform, cluster and network systems, towards basic equality, towards systemic openness, and, finally, critical *time windows* for intervention. In support of informal instrumental institutions-building by the private (while preventing and dissolving "ceremonial" petrifaction and lock-in) it may shape systems of arenas of private interaction. This often has been dealt with in systems theory under conceptions of *decomposability*.

Influencing network structures may imply the shaping of income distributions, settlement structures, or firm-size distributions, in order to shift the socio-economy towards societally preferred outcomes (some "superior attractor"). Such policy would pursue concurrent social inquiry and valuation processes.

The recent surge in exploring more appropriate, and properly complex, economic policies has already led to discernible, operational, and implementable, superior and better informed policy conceptions than currently practiced, and we hope this paper has made a substantial contribution in that direction. But by its very object, CA(E)S, a CA(E)P requires much more analytical and computational research. Further research, thus, will have to focus on deriving and exploring more specific model- and simulation-based policy implications from broader subsets of CA(E)S than we could investigate in this paper.

(13,807 words)

**References**

Acemoglu, Daron, Vasco M. Carvalho, Asuman Ozdaglar, and Alireza Tahbaz-Salehi, 2012, "The Network Origins of Aggregate Fluctuations," *Econometrica*, 80(5), 1977-2016.

Acemoglu, Daron, Asuman Ozdaglar, Alireza Tahbaz-Salehi, 2015, "Networks, Shocks, and Systemic Risk," prepared for *The Oxford Handbook on the Economics of Networks*, Columbia Business School Research Paper No. 15-18, hq.ssrn.com/Journals/RedirectClick.cfm?url=http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2560015&partid=356430&did=244421&eid=332463, retrieved March 8, 2015.

Aoki, Masahiko, Kenneth Binmore, Simon Deakin and Herbert Gintis (Eds.), 2012, *Complexity and Institutions: Markets, Norms and Corporations*, Houndsmills, Basingstoke, UK: Palgrave Macmillan.

Arthur, W. Brian, 1989, "Competing Technologies, Increasing Returns, and Lock-In by Historical Events," *Economic Journal*, 99, 116-131.

Arthur, W. Brian, 2013, *Complexity economics: A different framework for economic thought*, SFI Working Paper 2013-04-012; accessed Jan. 15, 2015: http://tuvalu.santafe.edu/~wbarthur/Papers/Comp.Econ.SFI.pdf.

Ashby, W. Ross, 1956, *An Introduction to Cybernetics*, London: Chapman&Hall.

Aspara, Jaakko, Kalle Pajunen, Henrikki Tikkanen, and Risto Tainio, 2014, "Explaining corporate short-termism: self-reinforcing processes and biases among investors, the media and corporate managers", *Socio-Economic Review*, 12(4), 667-693.

Axelrod, Robert, 1984/2006, *The Evolution of Cooperation*, New York: Basic Books (repr. 2006).

Bak, Per, Chao Tang, and Kurt Wiesenfeld, 1987, "Self-organized criticality: an explanation of 1/*f* noise," *Physical Review Letters*, 59(4), 381-384.

Barabási, Albert-László, Albert, Réka, 1999, „Emergence of scaling in random networks," *Science*, 284 (5439), 509-512.

Battiston, Stefano, Guido Caldarelli, Robert May, Tarik Roukny, Joseph Stiglitz, 2015, "The Price of Complexity in Financial Networks," http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2594028.

Beinhocker, Eric D., 2007, *The Origin of Wealth. Evolution, Complexity and the Radical Remaking of Economics*, London: Random House.

Beinhocker, Eric D., 2012, "New Economics, Policy and Politics," in: T. Dolphin and D. Nash (Eds.), 134-146.

Berninghaus, Siegfried, Werner Gueth, Stephan Schosser, 2013, "Reciprocity in Locating Contributions: Experiments on the Neighborhood Public Good Game," *games*, 4(2), 144-162.

Biggs, Reinette, Maja Schlueter, Michael L. Schoon, (Eds.), 2015, *Principles for Building Resilience*, Cambridge, UK: Cambridge University Press.

Binmore, Ken, 2011, *Natural Justice*, Oxford, New York: Oxford Univ. Press.

Binmore, Ken, 2012, "Fairness as an Equilibrium Selection Device," in: M. Aoki, et al. (Eds.), 134-150.

Bloch, Harry, and Stan Metcalfe, 2011, "Complexity in the theory of the developing firm," in: C. Antonelli (Ed.), *Handbook on the Economic Complexity of Technological Change*, Cheltenham, UK, Northampton, MA, USA: Edward Elgar, 81-104.

Bush, Paul D., 1987, "The Theory of Institutional Change," *Journal of Economic Issues*, 21(3), 1075-1116.

Bush, Paul D., 1999, Art. "Recognized interdependence," in: O'Hara, P.A. (Ed.), *Encyclopedia of Political Economy*, Vol. 2, London, New York: Routledge, 963-964.

Calvert, Randall L., 1995, "The Rational Choice Theory of Institutions: Implications for Design", in: D.L. Weimer, 63-94.

Charness, Gary, Chun-Lei Yang, 2014, "Starting small towards voluntary formation of efficient large groups in public goods provision," *Journal of Economic Behavior and Organization*, 102, 119-132.

Cockshott, Paul, 2015, *Calculation, Complexity and Planning: The Socialist Calculation Debate Once Again*, mimeo.; https://ideas.repec.org/p/wop/pokear/_014.html, accessed Jan. 26, 2015.

Colander, David, Peter Howitt, Alan P. Kirman, Axel Leijonhufvud, Perry Mehrling, 2008, "Beyond DSGE Models: Toward an Empirically Based Macroeconomics," *American Economic Review*, 98(2), 236-240.

Colander, David, Richard Holt and Barkley Rosser, 2011, "The complexity era in economics", *Review of Political Economy*, 23(3), 357-369.

Colander, David, and Roland Kupers, 2014, *Complexity and the Art of Public Policy: Solving Society's Problems from the Bottom Up*, Princeton, NJ: Princeton University Press.

Commons, John R., 1934, *Institutional Economics*. *Its Place in Political Economy*, New York: Macmillan (repr. New Brunswick: Transaction Publishers, 1990).

David, Paul A., 1985, "Clio and the Economics of QWERTY", *American Economic Review*, PP, 75(2), 332-337.

Dewey, John, 1930, *The Quest for Certainty: A Study of the Relation of Knowledge and Action*, London: Allen&Unwin.

Dolphin, Tony, and David Nash (Eds.), *Complex New World*. *Translating New Economic Thinking into Public Policy*, London: Institute for Public Policy Research.

Durlauf, Steven N., 1997, "What Should Policymakers Know About Economic Complexity?", https://ideas.repec.org/p/wop/safiwp/97-10-080.html; accessed February 16, 2015.

Durlauf, Steven N., 2012, "Complexity, economics, and public policy," *Politics, Philosophy & Economics*, 11(1), 45-75.

Elsner, Wolfram, 2001, "Interactive economic policy: toward a cooperative policy approach for a negotiated economy," *Journal of Economic Issues*, 35(1), 61-83.

Elsner, Wolfram, 2005, "Real-World Economics Today: The New Complexity, Co-ordination, and Policy," *Review of Social Economy*, 63(1), 19-53.

Elsner, Wolfram, 2012, "The Theory of Institutional Change Revisited. The Institutional Dichotomy, Its Dynamic, and Its Policy Implications in a More Formal Analysis," *Journal of Economic Issues*, 46(1), 1-43.

Elsner, Wolfram, 2013, "State and Future of the ‚Citadel‘ and of the Heterodoxies in Economics: Challenges and Dangers, Convergences and Cooperation," *EJEEP – European Journal of Economics and Economic Policies*, 10(3), 286-298.

Elsner, Wolfram, and Torsten Heinrich, 2009, "A simple theory of 'meso'. On the co-evolution of institutions and platform size—with an application to varieties of capitalism and 'medium-sized' countries", *Journal of Socio-Economics*, 38, 843-858.

Elsner, Wolfram, and Henning Schwardt, 2014, "Trust and Arena Size. Expectations, Institutions, General Trust, and Critical Population and Group Sizes," *JoIE—Journal of Institutional Economics*, 10(1), 107-134.

Elsner, Wolfram, and Henning Schwardt, 2015, „From Emergent Cooperation to Contextual Trust, and to General Trust:  Overlapping Meso-Sized Interaction Arenas and Cooperation Platforms as a Foundation of Pro-Social Behavior," *Forum for Social Economics*, 44(1), 69-86.

Elsner, Wolfram, Torsten Heinrich, Henning Schwardt, 2015, *The Microeconomics of Complex Economies*, San Diego, Oxford, Amsterdam: Elsevier/Academic Press.

Fainmesser, Itay P., David Goldberg, 2011, "Bilateral and Community Enforcement in a Networked Market with Simple Strategies,", http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1742960.

Fontana, Magda, 2010, "Can Neoclassical Economics Handle Complexity? The Fallacy of the Oil Spot Dynamic*"*, *Journal of Economic Behavior & Organization,* 76(3), 584-596.

Fontana, Magda, 2012, "Policy in Complex Social Systems," in:  P. Heritier and P. Silvestri (Eds.), *Good Government, Governance, Human Complexity*, Firenze:  L.S. Olschki, 221-233.

Fontana, Magda, and Pietro Terna, 2015, *From Agent-Based Models to Network Analysis (and Return): The Policy-Making Perspective*, Università Degli Studi di Torino, Working Paper Series 07/15.

Foster, John, 2005, "From simplistic to complex systems in economics," *Cambridge Journal of Economics*, 29(6), 873-892.

Foster, John, 2006, "Why Is Economics Not a Complex Systems Science?", *Journal of Economic Issues*, 40(4), 1069-1091.

Fukadai, Mao, Keigo Inukai, 2015, "History of cooperation: a positive analysis of the overlapp8ng mechanism," http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2592822.

Gallegati, Mauro, A. Kirman and A. Palestrini, 2007, "Implications of scaling laws for policy-makers," in: Salzano, M., Colander, D. (eds.), *Complexity Hints for Economic Policy*, Milan, Berlin, Heidelberg, New York: Springer, 291-302.

Garnsey, E., and McGlade, J., 2006, *Complexity and Co-Evolution*. *Continuity and Change in Socio-Economic Systems*, Cheltenham, UK, and Northampton, MA: Edward Elgar.

Gaus, Gerald, 1998, "Why all welfare states (including laissez-faire ones) are unreasonable," *Social Philosophy and Policy*, 15(2), 1-33.

Geyer, Robert, and Samir Rihani, 2010, *Complexity and Public Policy: A New Approach to Twenty-first Century Politics, Policy and Society*, London, New York: Routledge.

Gilles, Robert P., Emiliya A. Lazarova, Pieter H.M. Ruys, 2015, "Stability in a Network Economy: The Role of Institutions," Journal of Economic Behavior and Organization, 119, 375-399.

Glaeser, Edward L., David Laibson and Bruce Sacerdote, 2002, "An Economic Approach to Social Capital", *Economic Journal*, 112(483), F437-F458.

Glasserman, Paul, H., Peyton Young, 2015, "Contagion in Financial Networks", Working Paper 15-21, Office of Financial Research, Washington D.C.

Gulati, Ranjay, Maxim Sytch, Adam Tatarynowicz, 2012, "The Rise and Fall of Small Worlds: Exploring the Dynamics of Social Structure", *Organization Science*, 23, 449-471.

Hallsworth, Michael, 2012, "How Complexity Economics Can Improve Government: Rethinking Policy Actors, Institutions, and Structures," in: Dolphin, Nash (Eds.), 39-49.

Hargreaves-Heap, Shaun P., 1989, *Rationality in economics*, New York: Blackwell.

Harper, David A., Paul Lewis, 2012, "New perspectives on emergence in economics," *Journal of Economic Behavior and Organization*, 82(2-3), 329-337.

Hayden, F. Gregory, 2006, *Policymaking for a Good Society*. *The Social Fabric Matrix Approach to Policy Analysis and Program Evaluation*, New York: Springer.

Heinrich, Torsten, 2013, *Technological Change and Network Effects in Growth Regimes*. *Exploring the Microfoundations of Economic Growth*, London, New York: Routledge.

Heinrich, Torsten, and Henning Schwardt, 2013, „Institutional Inertia and Institutional Change in an Expanding Normal-Form Game," *Games*, 4, 398-425.

Helbing, Dirk, 2013, "Globally Networked Risks and How to Respond," *Nature* 497, 51-59.

Hodgson, Geoffrey M., 2002, "Reconstitutive Downward Causation: Social Structure and the Development of Individual Agency," in: E. Fullbrook, (Ed.), *Intersubjectivity in Economics: Agents and Structures*. London, New York: Routledge, 159-180.

Hodgson, Geoffrey M., 2012, "Business Reform: Towards an Evolutionary Policy Framework," in: Dolphin, Nash (Eds.), 62-69.

Holland, John, 2006, "Studying complex adaptive systems," *Journal of Systems Science and Complexity*, 19(1), 1-8.

Houser, Daniel, D.M. Levy, K. Padgitt, S.J. Peart, E. Xiao, 2014, "Raising the price of talk: An experimental analysis of transparent leadership," *Journal of Economic Behavior and Organization*, 105, 208-218.

Hu, Hai-hua, Jun Lin, Wen-tian Cui, 2015, "Intervention Strategies and the Diffusion of Collective Behavior," *JASSS*, 18(3)16, 1-14.

Hurwicz, Leonid, 1987, "Inventing New Institutions: The Design Perspective", *American Journal of Agricultural Economics*, 69(2), 395-402.

Ivarola, Leonardo, Gustavo Marqués, Diego Weisman, 2013, "Expectations-based Processes – An Interventionist Account of Economic Practice," *Economic Thought*, 2(2), 20-32.

Jackson, Matthew O., Zenou, Yves, 2015, "Games on networks," in: P. Young, S. Zamir (Eds.), *Handbook of Game Theory*, Vol. 4, Amsterdam et al.: Elsevier, 91-157.

Jackson, Matthew O., Brian Rogers, Yves Zenou, 2015, "The Economic Consequences of Social Network Structure," http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2467812, accessed March 3, 2015.

Jarman, Matthew, Andrzej Nowak, Wojciech Borkowski, David Serfass, Alexander Wong, Robin Vallacher, 2015, “The Critical Few: Anticonformists at the Crossroads of Minority Opinion Survival and Collapse,” *Journal of Artificial Societies and Social Simulation*, 18(1), 1-14.

Jennings, Frederic B., 2005, “How Efficiency/Equity Trade-offs Resolve through Horizon Effects," *Journal of Economic Issues*, 39(2), 365-373.

Jones, Matthew T., 2014; “Strategic complexity and cooperation: An experimental study,” *Journal of Economic Behavior and Organization*, 106, 352-366.

Jun, Tackseung, Rajiv Sethi, 2007, “Neighborhood structure and the evolution of cooperation,” *Journal of Evolutionary Economics*, 17, 623-646.

Kao, Albert B., Lain D. Couzin, 2014, “Decision accuracy in complex environments is often maximized by small group sizes,” *Proceedings of the Royal Society B*, Biological Sciences, 281 (1784), 20133305; http://classic.rspb.royalsocietypublishing.org/content/281/1784/20133305.short; accessed Feb. 23, 2015.

Kapeller, Jakob, 2013, “Model Platonism” in economics: on a classical epistemological critique,” *Journal of Institutional Economics*, 9(2), 199-221.

Kauffman, Stuart, Roger Koppl, Teppo Felin, Giuseppe Longo, 2015, “Economics for a creative world”, *Journal of Institutional Economics*, 11(1), 1-31.

Kendall. G., Yao, X., Chong, S.Y., (Eds.), 2007, *The Iterated Prisoner's Dilemma – 20 Years On*, Singapore: World Scientific Publ.

Kesternich, Martin, Andreas Lange, Bodo Sturm, 2014, “The impact of burden sharing rules on the voluntary provision of public goods,” *Journal of Economic Behavior and Organization*, 105, 107-123.

Kirman, Alan, 2011, *Complex economics: individual and collective rationality*, The Graz Schumpeter Lectures, London, New York: Routledge.

Krockow, Eva M., Briony D. Pulford, Andrew M. Colman, 2015, “Competitive Centipede Games: Zero-End Payoffs and Payoff Inequality Deter Reciprocal Cooperation,” *games*, 6(3), 262-272.

Kroetz, Kailin, James N. Sanchirico, 2015, "The Bioeconomics of Spatial-Dynamic Systems in Natural Resource Management", RFF DP 15-14, Washington, repr. *Annual Review of Resource Economics* 7.

Lewin, Peter, 2014, "Policy Design and Execution in a Complex World: Can We Learn from the Financial Crisis?", Univ. of Texas at Dallas; accessed Dec. 22, 2014: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2473258.

Lindgren, Kristian, 1997, "Evolutionary Dynamics in Game-Theoretic Models," in: *The Economy as an Evolving Complex System II*, ed. by W.B. Arthur, S.N. Durlauf, and D.A. Lane, Reading, MA, USA: Addison-Wesley, 337-367.

Lipsey, Richard G., and Kelvin Lancaster, 1956/7, "The general theory of the second best", *Rev. Econ. Stud.*, 24(1), 11-32.

Lloyd, Seth, 2001, "Measures of Complexity: A Nonexhaustive List," *IEEE Control Systems Magazine*, August, 7-8.

Loasby, Brian J., 2012, "Building systems," *Journal of Evolutionary Economics*, 22(4), 833-846.

López-Pérez, Raúl, Ágnes Pintér, Hubert J. Kiss, 2015, "Does payoff equity facilitate coordination? A test of Schelling's conjecture," *Journal of Economic Behavior and Organization*, 117, 209-222.

Lux, Thomas, and Michele Marchesi, 1999, "Scaling and Criticality in a Stochastic Multi-Agent Model of a Financial Market", *Nature* 397, 498-500.

Mantilla, César, 2015, "Communication networks in common-pool resource games: Field experimental evidence," *Journal of Economic Behavior and Organization*, 118, 215-226.

May, Robert M., 1976, "Simple mathematical models with very complicated dynamics", *Nature*, 261(5560), 459-467.

McCain, Roger, 2009, *Game Theory and Public Policy*, Cheltenham, UK, Northampton, USA: Edward Elgar.

Miller, John, and Scott Page, 2007, *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*, Princeton, NJ: Princeton Univ. Pr.

Mirowski, Philip, 2013, "Market complexity and the nature of crises in financial markets," in: L. Taylor, A. Rezai, T. Michl, (Eds.), Social Fairness and Economics. Economic essays in the spirit of Duncan Foley, London, New York: Routledge, 374-393.

Mitchell, Melanie, 2009, *Complexity. A Guide*, Oxford, New York: Oxford Univ. Press.

Musgrave, Richard A., 1959, *The Theory of Public Finance: A Study in Public Economy*, New York: McGraw-Hill.

Musgrave, Richard A., 1987, Art. "Merit goods," in: *The New Palgrave. A Dictionary of Economics*, London, Basingstoke: Macmillan, 452-453.

Myrdal, Gunnar, 1958, *Value in Social Theory: a selection of essays* on *methodology*, ed.by P. Streeten, London: Routledge & Kegan Paul.

Navarro-Meneses, Francisco J., 2015, "Complexity-Based View of the Firm: Evidence, Features and Method", http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2552459; accessed February 16, 2015.

Nichi, Akihiro, Hirokazu Shirado, David Rand, Nicholas Christakis, 2015, "Inequality and visibility of wealth in experimental social networks," *Nature*, DOI:10.1038/nature15392.

Nielsen, Klaus, 1992, "The mixed economy, the neoliberal challenge, and the negotiated economy," *J. Soc. Econ*, 21, 325-351.

Nowak, Martin A., 2006, *Evolutionary Dynamics: Exploring the Equations of Life*, Cambridge, MA: Harvard University Press.

OECD, 2009, *Applications of Complexity Science for Public Policy. New Tools for Finding Unanticipated Consequences and Unrealized Opportunities*, Paris: OECD.

Ormerod, Paul, 2012, "Networks and the Need for a New Approach to Policymaking," in: Dolphin, Nash (Eds.), 28-38.

Pelikan, Pavel, 2003, "Why economic policies need comprehensive evolutionary analysis," in: P. Pelikan, G. Wegner, (eds.), *The evolutionary analysis of economic policy*, Cheltenham, UK, Northampton, MA, USA: Edward Elgar, 15-45.

Radzicki, Michael J., 2009, "Convergence of the Social Fabric Matrix and Complex Modeling," in: *Institutional Analysis and Praxis*. *The Social Fabric Matrix Approach,* ed. by T. Natarajan, W. Elsner, and S. Fullwiler, London: Springer, 69-85.

Ramstad, Yngve, 1991, "From desideratum to historical achievement: John R. Commons's reasonable value and the 'negotiated economy' of Denmark," *Journal of Economic Issues*, 25, 431-439.

Rappaport, Alfred, John C. Bogle, 2011, *Saving Capitalism From Short-Termism: How to Build Long-Term Value and Take Back Our Financial Future*, New York: McGraw-Hill.

Richards, Sue, 2012, "Regional Policy and Complexity: Towards Effective Decentralisation," in: Dolphin, Nash (Eds.), 121-133.

Room, Graham, 2011, *Complexity, Institutions and Public Policy*. *Agile Decision-Making in a Turbulent World*, Cheltenham, UK, Northampton, MA, USA: Edward Elgar.

Salzano, M., Colander, D., (eds.), 2007, *Complexity Hints for Economic Policy*, Milan, Berlin, Heidelberg, New York: Springer.

Schelling, Thomas, 1960, *The Strategy of Conflict*, Cambridge, MA: Harvard Univ. Press.

Schelling, Thomas, 1971, "Dynamic models of segregation," *Journal of Mathematical Sociology*, 1, 143-186.

Schotter, Andrew, 1981, *The economic theory of social institutions*, Cambridge, UK: Cambridge Univ. Pr.

Sen, Amartya K., 1967, "Isolation, assurance and the social rate of discount," *Qu. J. Econ*, 81(1), 112-124.

Sen, Amartya K., 1970, *Collective Choice and Social Welfare*, San Francisco, CA: Holden-Day (repr. 1984, Elsevier).

Sen, Amartya K., 1977, "Rational Fools: A Critique of the Behavioral Foundations of Economic Theory," *Philosophy & Public Affairs*, 6(4), 317-344.

Simon, Herbert, 1962, "The Architecture of Complexity", *Proceedings of the American Philosophical Society*, 106, 467-482

Solari, Stefano, and Francesca Gambarotto, 2014, "Territorial Rooting as an Element of Well-Being," *Review of Social Economy*, 72(4), 504-522.

Thaler, Richard H., and Cass R. Sunstein, 2003, "Libertarian Paternalism," *The American Economic Review*, 93(2), P&P, 175-179.

Tool, Marc R., 1979/1985, *The Discretionary Economy: A Normative Theory of Political Economy*, Santa Monica, CA: Goodyear Publ., 1979 (repr. Boulder, CO: Westview Pr., 1985).

Tool, Marc R., 1994, Art. "Instrumental value theory," in: Hodgson, G.M., Samuels, W.J., Tool, M.R., (eds.), *The Elgar Companion to Institutional and Evolutionary Economics*, Vol. 1, Aldershot, UK, Brookfield, USA: Edward Elgar, 406-412.

Van den Berg, Hendrik, 2015, "Mainstream Economics' Flight from Complexity," *Forum for Social Economics*, (forthcoming).

Vega-Redondo, Fernando, 2013, "Network organizations," *Journal of Complex Networks*, 1, 72-82.

Velupillai, K. Vela, (Ed.), 2005, *Computability, Complexity and Constructivity in Economic Analysis*, Hoboken, NJ: Wiley-Blackwell.

Velupillai, K. Vela, 2007, "The impossibility of an effective theory of policy in a complex economy," in: Salzano, M., Colander, D., (eds.), *Complexity Hints for Economic Policy*, Milan, Berlin, Heidelberg, New York: Springer, 273-290.

Ver Eecke, Wilfried, 1998, "The concept of a 'merit good'. The ethical dimension in economic theory and the history of economic thought or the transformation of economics into socio-economics," *J. Soc. Econ*, 27, 133-153.

Ver Eecke, Wilfried, 2007, *An Anthology Regarding Merit Goods*, West Lafayette, Indiana: Purdue University Press.

Ver Eecke, Wilfried, 2008, *The concept of "merit good" and the history of economic thought. Ethical Dimensions of the Economy. Making Use of Hegel and the Concepts of Public and Merit Goods*, Berlin, Heidelberg: Springer.

Vitali, S., J. B. Glattfelder and S. Battiston, 2011, "The Network of Global Corporate Control," *PLoS ONE*, 6(10).

Waldrop, M. Mitchell, 1992, *Complexity: The Emerging Science at the Edge of Order and Chaos*, New York, London: Simon&Schuster.

Wasko, Molly M., Robin Teigland, Samer Faraj, 2009, "The provision of online public goods: Examining social structure in an electronic network of practice," *Decision Support Systems*, 47, 254-265.

Watts, Duncan J., 1999, *Small Worlds*. *The Dynamics of Networks between Order and Randomness*, Princeton, NJ, Oxford, UK: Princeton Univ. Pr.

Watts, Duncan J., and Steven Strogatz, 1998, "Collective dynamics of 'small-world' networks," *Nature*, 393(6684), 440-442.

Weaver, Warren, 1948, "Science and Complexity", *American Scientist*, 36(4), 536-544.

Weimer, David L., 1995, (Ed.), *Institutional Design*, Boston, Dordrecht, London: Kluwer Acad. Publ.

Whitmore, Andrew, 2014, "Could Information Technology Enable Efficient Central Economic Planning?", http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2524877.

Wilkinson, Richard, Kate Pickett, 2009, *The Spirit Level*. *Why more equal societies almost always do better*, London: Penguin.

Wilson, David S., 2014, *Two Meanings of Complex Adaptive Systems*, mimeo., Binghamton Univ., NY.

Wilson, David S., John M. Gowdy, 2013, "Evolution as a general theoretical framework for economics and public policy," *Journal of Economic Behavior and Organization*, 90S, S3-S10.

Wilson, David S., Dag Hessen, 2015, „Bernie Sanders and His Critics Should Know Why Norway Works", *Evonomics*, http://evonomics.com/bernie-sanders-critics-know-norway-success/.

Witt, Ulrich, 1997, "Lock-in vs. critical masses. Industrial changes under network externalities," *Journal of Industrial Organization*, 15, 753-772.

Witt, Ulrich, 2003, "Economic policy making in evolutionary perspective," *Journal of Evolutionary Economics*, 13(1), 77-94.

Zuidhof, Peter-Wim, 2014, "Thinking Like an Economist: The Neoliberal Politics of the Economics Textbook," *Review of Social Economy*, 72(2), 157-185.

(17,150 words)