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 and Complexity Economics.

Towards a Systemic, Long-Run, Adaptive, and Interactive Policy Conception[1]

Wolfram Elsner[2]

Abstract: Policy implications of complexity economics (CE) are investigated. CE deals with "Complex Adaptive (Economic) Systems" [CA(E)S], generally characterized by mechanisms and properties such as "emergence" of structure or some capacity of "self-organization". With this, CE has manifold affinities with economic heterodoxies. CE has developed into a most promising economic research program in the last decades. With some time lag, and boosted by the financial crisis and Great Recession, a surge to explore their policy implications recently emerged. It demonstrated the flaws of the "neoliberal" policy prescriptions mostly derived from the neoclassical mainstream and its underlying more simplistic and teleological equilibrium models. However, most of the complexity-policy literature still remains rather general. For a subset of CA(E)S, those with heterogeneous human agents interacting, particularly on networks, using evolutionary games in the "evolution-of-cooperation" tradition, therefore, we exemplarily derive more specific policy orientations and tools, and a framework policy approach called Interactive Policy.
(150 words)

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

Keywords: Economic complexity; complex adaptive (economic) systems; equilibrium modeling; self-organization; structural emergence; microfoundations; social-dilemma games; evolution of cooperation; economic policy; regulation; institutional design; recognized interdependence; futurity; rime horizons; network structures; interactive/institutional policy; meritorics; pragmatism; negotiated economy.

---

[1] Paper given at the ASSA/ASE Meetings, Boston, January 3-5, 2015, Session on "Policy Options in an Age of Uncertainty". The author is grateful to the discussants and to Magda Fontana, 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 as in mass education, towards the mass media, and in the policy-advice business (e.g., Zuidhof 2014) – is a fundamentally *normative* prescription rather than a set of recommendations with a consideration of alternative options, diverse pathways and horizons, and estimations of actual action spaces. But it usually is not overtly normative but *crypto-normative*, particularly in its mostly "neoliberal"[3] attitude of "T-i-n-a" ("There-is-no-alternative!"), to creating ever "more market", or imitating some market ideal (ibid.). Its tacit message "There-is-only-one-optimal-point-in-the-universe", in turn, not only is unrealistic and crypto-normative, it also is derived from its *simplistic* approach. The latter is basically a mathematically tractable, *deterministic* model, serving a tacit historical function and message "The market economy is the optimum, the culmination and end of human history!" This is mirrored in models with a unique and universal-benchmark equilibrium, pretending to be strict *science* by (mistakenly) mimicking 19th-century equation models of mechanical physics,[4] oriented towards a deterministic analytical solution. The basic model of an always equilibrating "market" economy served neoclassicism's strive to be "hard science", based on "eternal laws", and the ultimate historical answer, but did rule out *reality* and *complexity*.[5] Thus, it is to be imposed on society and politics in a *teleological* vein and with a *coercive* attitude.

[3] This is neither "neo" (new) nor can, in its practical consequences, whether intended or not, be "liberal" for the common man in any reasonable sense. Note that, of course, we do not fully identify analytical neoclassical economics with political neoliberalism.

[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 analysis of the ruling out of complexity by neoclassical economics, e.g., Fontana 2010, 584; van den Berg 2015.

However, this is *methodologically* naïve and untenable in any respect.[6] Also, with this, this cannot provide any appropriate, theoretically fruitful understanding of evolving process or longer time horizon, of emerging coordination and cooperation,[7] of any collectivity, commonality, or collective rationality, and, finally, of any proactive and learning policy perspective, of participation, or democracy (more below). Everything is subordinated to a static comparison with an abstract ideal brain construct.

Logically, then, with the slightest alteration of the assumptions of a general-equilibrium, the available next *Second Best* state would require more violations of "optimality conditions", as was elaborated in the 1950s already (Lipsey, Lancaster 1956/7). Thus, if the "optimum" is not attained, there would be *no straightforward piecemeal policy* to re-approach it. Simple ways to the "optimum", through just "more market", however, is what the politically mostly neoliberal economic mainstream suggests in theory, mass education, and policy advice since four decades.

The much needed more adequate approach to deal with political control of a complex economy has never been elaborated for practical policy by this mainstream. The political-economic *power* play of simple and quick "solutions", the *neoliberal* rough-and-ready strategy of "de-regulation cum privatization", based on modern mythologizations of markets and money, has been reinforced, rather, by interested governments and super-bureaucracies. And, as was foreseeable, this has skyrocketed the *degeneration of the markets* into unprecedented *oligopolization and "power-ization"* and into multi-layered global hub&spoke networks under control of a few dozen core financial groups (e.g., Vitali, Glattfelder, Battiston 2011). It, obviously, has made the

[6] For a thorough methodological and epistemological critique of neoclassical crypto-normativism, immunization strategies, and unlimited "ad-hocery", e.g., Kapeller 2013.
[7] This distinction refers to the solution of coordination games and social dilemmas, resp.

powerful more powerful and the rich richer, and politics and policies their appendage. And it has been too alluring for many leading economists to stay with the powerful and rich, and their research sponsoring.

Manifold theoretical developments contributed to the simplistic and coercive current economic-policy worldview. In public-choice theory, for instance, *Arrow's voting paradox* was often (mis-)interpreted, namely in the policy-advice business in the neoliberal era, against the feasibility of collective and longer-run rationality and rational, ameliorating policy in general, stressing *state failure* instead. But this misinterpretation did not properly consider complex structures and processes either, with, e.g., endogenous preference change – as was elaborated namely by *A. Sen* (1970/1984), who managed in this way to initiate some broadening of the theoretical and policy perspectives, but, of course, could not change the dominating policy paradigm.

As another example, *Hayekian fallacies* also prevented the elaboration of complex and qualified policies beyond neoliberal privatization, commodification, "marketization", and dismantling of the welfare state. First, though, in a complexity approach, Hayek did recognize a *self-organization* capacity of market systems. This, however, also remained in a teleological vein, as it was considered to generate a *natural* "*spontaneous order*", relatively *optimal*, as compared, at least, to state intervention (with its allegedly dominating state failure). Heroic assumptions related to a *distribution of information* among agents so that some *wisdom of the crowd* (in a "market") would become effective. Second, an extreme version of an ultimate *unpredictability* of any policy consequences under such complexity contributed to a general attitude, if perhaps not of Hayek himself, but of most Hayekians, of a *policy abstinence* (see, e.g., Bloch, Metcalfe 2011, 87; Durlauf 2012, 62ff.). Policies, thus, again should be basically the creation of "more market".

But *self-organization* capacities of complex adaptive (economic) systems [CA(E)S] cannot redudantize *policy*, as the capability of some self-organization generally generates *no ("optimal", "natural") spontaneous order* in the Hayekian sense. It implies a so-called dissipative structure of an *open non-linear* system in a *non-equilibrium* process between *order and disorder*, as, e.g., structural emergence in evolutionary process, morphogenesis, or autopoiesis, how specified ever. Self-organized order as such, although relatively stable, is very relative, rather, dependent on system parameters, and may quickly be replaced by disorder in so-called phase transitions. Order and disorder, stability and volatility may alternate in (apparently) irregular ways (e.g., Room 2011, Chpt.17). 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 often myopic (individualistic) human agents (with only local knowledge and habituated short-sightedness), we do know too many, and mostly dominating, mechanisms of *fallacies of aggregation* and *unintended consequences* that undermine a clear-cut connection of "self-organization" with "optimality" and "naturalness" in any reasonable sense. For instance, inferior *lock-in* and other *sub-optimal* phenomena of CA(E)S may mirror technological conditions (such as *network externalities*) and/or *ceremonial* degenerations.[8]

[8] In a Veblenian understanding, reflecting a dominating value of differential power and status; for detail, e.g., Bush 1987.

A CA(E)S indeed is based on an *openness* towards, and increasing metabolism with, the social and natural subsystems, increasing its own complexity at the expense of increased metabolism with them and increasing entropy of the entire ecolo-socio-economic system (Georgescu-Roegen 1966). And, namely *capitalist* market economies, according to institutional and ecological economist K.W. Kapp, are even formally "designed" for reinforced institutionalized *exploitation* of the social and natural systems (Kapp 1950). This all prevents considering CA(E)S "self-sustaining" and "self-equilibrating" in any "optimal" or "natural" manner.

CE actually suggests that self-organization, in terms of equilibria, usually is one out of *multiple equilibria*[9], and, specifically under conditions of individualist rationality (a "hyper-rationality"), some *problem-solving* self-organization, e.g., some informal and instrumental *institutional emergence*, may be extremely *time-consuming* and *fragile* (prone to backslide), if not *blocked* at all (more below).

As said, self-organizing capacities of CA(E)S are part of *interacting forces of order and disorder*, often irregularly alternating between relative stability and sudden discontinuity. For instance, even scale-invariant phenomena, such as *fractals* and *power laws* (see below), often emerge just from simple local interactions, so-called *self-organized criticality*;[10] but particularly in complex socio-economic systems, any stable emerged structure (equilibria, attractors, fixed points), including "self-organized" scale-free distributions among components, is irrespective of any optimality (more below).

[9] In CAS in general, so-called *fixed points*, be they stable or instable.

[10] See the famous sand pile example, where new sand grains slowly sprinkled eventually cause avalanches and restore the same slope of the sand pile at any scale (see Bak, Tang, Wiesenfeld 1987).

In all, the requirement of *policy interventions* is strongly underpinned because of the different apparent shortcomings of self-organizing socio-economic processes. Such policy, then, will not be just any rampant interventionism, *no "road to serfdom"*.[11] On the contrary, complex, *systemic*, *long-run*, *learning* and *adaptive* policy would in fact avoid cumulatively increasing ad-hoc interventions. And while "stagflation", increasing distributional conflicts and other specters were, according to the neoliberal narratives of the 1970s and 1980s, the results of "Keynesian" welfare-state interventions, those specters were, at least in part, just a reflection of a perceived "over-complexity", from specific real-world problems, of the decision situation of a partly unwilling and partly incapable political, parliamentary, and party system, and of partly unwilling, partly under-qualified governments and public administrations.

Since the *financial crisis* and *Great Recession*, it has become obvious to an increasing number of economists that we need micro- and macroeconomic models different from conventional ones. This also applies to the allegedly more real-world and more policy relevant, but nevertheless linear and teleological "dynamic stochastic general equilibrium" (*DSGE*) models: Here, policy impacts are measured by comparisons between pre-and post-policy equilibria (or adjustment paths), where structures are constant and changes, including policy measures, just exogenous. Adaptations to new phenomena, as in the neoclassical research program in general, mostly occur through unlimited "ad-hocery", often even violating neoclassical standard axioms. [12]

But we need complex nonlinear models, and particularly those that reflect *new microfoundations* considering many heterogeneous agents in continuing interaction, i.e., dynamic *agent-based*

[11] For recent arguments in the Hayekian vein, e.g., Gaus 2007, and, against policies reacting to the financial crisis and Great Recession, e.g., Lewin 2014.
[12] For a more in-depth critique of DSGE models, e.g., Colander et al. 2008.

interactions (agent-based models, ABM), being only stochastically solvable, thus, computer simulations, rather than analytically tractable and uniquely solvable equation-based models.[13] Their policy implications will involve a completely *new policy paradigm*, where not only the CA(E)S itself but also the *feedbacks between the system and policy reactions* will be open-ended, dynamic, and structurally *variable* with the system development, and policy somehow becomes *endogenous*.

While discontent with the state of economics has grown both among practitioners and within the discipline, among both researchers and student networks, *CE* has developed into a most promising economic *research program* in the last three or four decades. [14] Its basic research questions are largely in line with long-standing heterodox issues and in obvious relation with current economic heterodoxies. But positive *policy implications* of CE have become a major theme only recently,[15] naturally occurring with some time lag vis-à-vis its basic explaining paradigm, and particularly boosted by the *financial crisis* and Great Recession (e.g., Geyer, Rihani 2010; Room 2011; Beinhocker 2012; Durlauf 2012; Fontana 2012; Colander, Kupers 2014; Fontana, Terna 2015; Elsner, Heinrich, Schwardt 2015, Chpt. 17).

However, much of this literature still is rather general, qualitative and verbal and has not sufficiently developed policy implications derivable from specified models yet.[16] Therefore, in

---

[13] For more detail on the different formal methods used in mainstream and in CE, e.g., Fontana 2010, 591f.

[14] For some core texts of the increasing richness of CE, see, e.g., Waldrop 1992; Keen 2001; 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 (beyond the classic of complex organization, e.g., Simon 1955), e.g., Bloch, Metcalfe 2011; Navarro-Meneses 2015.

[15] With few exemptions, e.g., Durlauf 1997; Salzano, Colander (Eds.) 2007.

[16] Again, with a few exemptions, e.g., Durlauf 2012, 57ff.; Fontana, Terna 2015. However, Durlauf concludes that complexity (economics) were just "a set of mathematical tools that can facilitate the modeling of richer economic environments than is allowed by the current set of mathematical methods available" (p.68). In contrast, e.g., Fontana 2010, 593f., considers CE a full-fledged *paradigm shift* in economics.

this paper, we will use the example of a *subset of complexity approaches*, particularly, as already indicated, *evolutionary-institutionally interpreted game theory* in the *evolution-of-cooperation* tradition (e.g., Elsner 2012), in order to derive a more specific set of policy orientations.[17] [18] Among all CA(E)S, we may generally distinguish between those that are "adaptive as a system" and those that are "composed of agents that employ adaptive strategies" (Wilson 2014, 3). While biological as well as macroeconomic systems tend to be of the first type, *microeconomic approaches* tend to be of the second. We then refer to those CA(E)S that have "large numbers of components, often called agents that interact and adapt or learn" (Holland 2006, 1).[19] We assume that our subset of approaches exemplarily mirrors important mechanisms, resulting properties, and critical factors of all CA(E)S. In that more specific area of approaches, we may delve somewhat deeper into the implications for complexity policy.

In the *evolutionary and institutionalist* traditions, some complexity-policy ideas were developed well before the financial crisis, with reference to economic complexity and systems analysis (e.g., Witt 2003; Elsner 2001, 2005; Hayden 2006). Evolutionary Institutionalists also combined the long-standing *instrumentalist/pragmatist* philosophy and its approach to policy (e.g., Dewey 1930; Commons 1934; Tool 1979/1985) with a complexity-policy conception into particular operative approaches (more below).[20]

[17] Similarly, e.g., Colander, Kupers 2014, 150ff., on "evolutionary and epistemic game theory", referring to Gintis 2009.
[18] Note that the mutual integration of "complexity" and "evolution" still is an issue. Not all CA(E)S are modeled as evolutionary, but evolutionary modeling is always complex (e.g., Castellacci 2006). But the degree of complexity may vary greatly during an evolutionary process, and, e.g., "fitness" may considerably change its content under different degrees of complexity (more below).
[19] We will, thus, not consider those CA(E)S that deal with aggregates only and, 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, Goodwin, and others), models of macroeconomic (systemic) risk, financial interaction and contagion models, and others (see, e.g., Acemoglu et al. 2015).
[20] For the so-called *Social-Fabric-Matrix* approach, Hayden 2006; Natarajan, Elsner, Fullwiler (Eds.) 2009.

This paper proceeds as follows: In section 2, we further characterize the relevant subset of CA(E)S. In section 3, we discuss some general orientations of a *complex adaptive (economic) policy* [CA(E)P], as received from the previous literature. In section 4, we will assume an evolutionary game-theoretic (EGT) perspective and refer to the older Axelrodian approach (Axelrod 1984/2006) and its policy implications. In section 5, we will generalize those and list more policy implications that can be derived from using game theory in an evolutionary and institutional interpretation. In section 6, we combine that perspective together with an instrumentalist approach of social valuation into some *modern meritorics* and, particularly a conception of an *Interactive/Institutional Policy*. Section 7 concludes.[21]

2. Mechanisms and properties of interaction-based evolutionary CA(E)S – A brief sketch

For the subset of economic-complexity approaches that we focus on, we will follow a simple distinction among antecedences ("structure"), consequences ("process"), and continuing feedback and interaction between the two ("circular cumulative causation" and "endogenous structure"). [22]

Structures

[21] Note that we make some use in this paper of Chpt. 17 of Elsner, Heinrich, Schwardt, *The Microeconomics of Complex Economies*, Amsterdam, San Diego, New York et al.: Elsevier/Academic Press, 2015, 499-527; the chapter is entitled "Policy Implications: New Policy Perspectives for Private Agents, Networks, Network Consultants, and Public Policy Agencies".

[22] It has often been counted how many *definitions of complexity* are in use, and there are many. So we better do not select a particular one and stick to it, but focus on these complexity dimensions (similarly, e.g., Fontana 2010, 588f.).

In that particular area of CA(E)S that apply EGT and embed it in a larger evolutionary-institutional interpretation (e.g., Elsner 2012), model structures include, as a baseline:

(1) *multiple* and (potentially) *heterogeneous* agents (i.e., with different behavioral options to be socially learned and habituated), being directly interdependent and interacting

(2) in different, more or less *"intricate" interdependence structures* of social (multi-personal) interaction problems and individual decision problems. The most-used formal language for this, as said, is provided by game theory. So we may think here of different coordination, anti-coordination, non-coordination, and social-dilemma problems, and other problem and incentive structures that are used in lab experiments. Different behavioral options fundamentally generate (initial) strong strategic *uncertainty*, and open a space for different *social rules and institutions*,[23] particularly when interactions will be *indefinitely repeated*, in a *time horizon* that exceeds the agents' practical planning horizons (formally considered as infinite repetition in prisoners' dilemma supergames – PD-SG; see below);

(3) those interdependence types also may be defined on different *network topologies*, i.e., structures of a *population* to be investigated, with different social or geographical *distance* and neighborhoods, related *differential probabilities to interact*, and critical consequences for decisions across many interactions and for learning behaviors, diffusion processes, general performance, segregation, systemic risk and stability, etc. (e.g., Acemoglu et al. 2012).[24] Network

[23] Note that, as *coordination* and *cooperation*, so do *social rules* and *social institutions* refer to coordination games and dilemma games, resp. (for the definitions, e.g., Elsner 2012; also below, section 4).

[24] For the exploding field of economic *network analysis* as a part of CE, and its significance for CA(E)P, e.g., Hollingsworth, Mueller 2008; Boyer 2008; Room 2011, Chpt.11; Ormerod 2012; Richards 2012. Of course, not all CA(E)S models do employ network theory. Also, network theory is, of course, not confined to networks of agents,

structures typically are not "complete" with full *connectivity*, where any agent interacts with all others in any given time period with certainty, but display different *patterns* of local neighborhoods in spatial *clusters* and *long-distance* relations – exogenously given or emerged in an interaction process with aspired "complexity reduction" (below). With this, there are many different interaction *densities*, critical for diffusion and other outcomes. Neighborhoods and interaction arenas in general may also be *overlapping* and *staged* systems (neighbors of neighbors; see below). If agents may die out, get born, learn, change strategies, move within the topology in reaction to earlier actions, or differentially replicate in response to their relative success, then network structure becomes *endogenous*.[25]

Real-world networks, as indicated, typically display combinations of *local clusters* and *long-distance relations*. Most discussed are so-called *small-world* networks (e.g., Watts, Strogatz 1998). These show some clustering for more effective local problem-solving (the coordination, conformism, and *stability* dimension), but also a relatively low mean path-length between any two agents, ensuring quick and effective long-distance exchange, diffusion and learning (the non-coordination, non-conformism, and *flexibility* dimension).[26] A small-world property seems to be existent in manifold variations in many relatively effective networks in all areas (such as the human brain), and some man-made socio-economic systems, such as logistics or planned

---

let alone to *games on networks*, although this appears as a particularly dynamic new research area (e.g., Zenou 2012; Jackson, Zenou 2015; Jackson, Rogers, Zenou 2015).

[25] Formally, then, we may distinguish among *interaction functions*, linking an agent's state to a summary measure of the states of all other agents (the *game* structure), a *network specification*, determining those summary measures as a function of other agents' states, and an *aggregation function*, determining how agent-level states collectively determine macro-outcomes (Acemoglu, Ozdaglar, Tahbaz-Salehi 2015).

[26] Note that problem-solving clustering may or may not be consistent with homophily, conformism, and resulting *segregation*, which often also may hinder network effectivity and success (e.g., Jackson, Rogers, Zenou 2015). On the ubiquitous and notorious *stability-flexibility balance* and a sometimes related *efficacy-flexibility* trade-off, e.g., Hallsworth 2012, 45f.; Jarman et al. 2015.

settlement systems, try to deliberately design it. Thus, obviously, it has some relevance for *policies* as well (more below).

Finally, in most real-world decentralized socio-economic topologies with deep-rooted individualist cultures, agents are different in terms of *power and status*, which is reflected in networks by the relative number and quality of relations an agent has, i.e., her *centrality*. There are, thus, a number of different critical "micro" (individual, or "local") and "macro" (aggregate or "global") network *patterns*, such as different (distributions of) *degrees of centrality* and different qualitative tie strengths and *positions* of agents (e.g., a "gatekeeper" position for a local cluster). Empirical research since *V. Pareto* has shown that in complex decentralized socio-economic systems with many agents (components or nodes) some *self-organization* capacity – again, driven perhaps by individual aspirations of reducing the complexity of the individual decision situation – often leads to a certain *size distribution* (power, centrality) among agents, as in such diverse areas as income (Pareto's empirical finding), firm size, or settlement (municipality) distributions. Typically, many agents have few relations and few have many. And typically for CA(E)S, those 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 falling graphs with an identical curve property at all scales (scale-invariance, as mentioned above). Such *scale-free networks* (e.g., Barabási, Albert 1999), consequently, have attracted much attention. We may think of stochastic processes that generate distributions invariant under different scaling, the phenomenon of *self-similarity*, with *repeating patterns* at different scales (so-called *fractals*, see above). Note again that such results, obviously, have little to do with optimality, as very large nodes, e.g., most *powerful agents*, may cause problems of network stability or *resilience*. We will return to *policy* implications below.

Networks, as said, may also be considered *overlapping and layered systems*, given or emerged as such from agents' interactions, where an agent may interact in different *arenas* (neighborhoods, clusters, or emerged platforms), which may overlap in many respects (with respect to agents, goods and other objects, settlement geography, etc.), and may form hierarchies. *Policies* and the system of *politics*, thus, may have to adapt to adapt to those structures (more below).

Processes

Formal structures of CA(E)S have been widely analyzed, showing, among others, that the boundaries between *micro* and *macro* properties blur (e.g., Acemoglu, Ozdaglar, Tahbaz-Salehi 2015). And, when it comes to evolutionary process and emergent structure, the *limits of analytical tractability, determinacy, and prediction* are quickly touched, while *stochastic* analysis quickly finds itself beyond just network structure and its link level (e.g., Jackson, Rogers, Zenou 2015; Acemoglu, Ozdaglar, Tahbaz-Salehi 2015), which fundamentally reflects *nonlinearities* of relational structures and the phenomenon of emergence (e.g., Fontana 2010, 591f.).[27]

Evolutionary CA(E)S with games on networks in particular deal with *continuing interaction* among agents. The often *mixed interests* (partially consistent, partially conflicting) then entail *lasting tensions* among agents, as reflected in different anti- and non-coordination and dilemma problems. And even in apparently simple and obvious-to-solve coordination problems (those with Pareto-different solutions), a collective incapacity to ensure the optimal solution 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, or the absence of

[27] The capacity of *emergence* is widely considered the distinctive property of complexity science, also coined "generative science" (Fontana 2010, 592); also, e.g., Harper, Lewis 2012.

(mechanisms to generate some) collective rationality, resp. In such cases, *T. Schelling*'s idea of *focal points* (Schelling 1960, 57) has provided some ways out for agents involved – and also has some *policy* relevance (see below).

But such *unintended consequences* of individualistic behavior appear to be pervasive, and *fallacies of aggregation* a resulting methodological feature, in markets with a dominating myopic individualistic culture. Technological and/or institutional lock-in, as well as *ceremonial* degenerations of previously instrumental institutions (e.g., Bush 1987; Heinrich, Schwardt 2013; Elsner 2012), are known instances of such non-optimality in both reality and theory.

But even if an individualistic culture, enforced by de-regulated markets and their often overly high turbulence, could be remediated (in a policy-supported evolutionary cultural process of instrumental institutionalization), in any otherwise complex structure and resulting process human individuals' *rationality* remains *bounded* as well, as stability and transparency may quickly become too little, and "knowability" or calculability of the systems' dynamics highly restricted, given human brains' capacities. This has been one of the earliest findings of CE, and a classic theme since, as developed by one of its pioneers, *H. Simon* (e.g., Simon 1955). Generally, in a formal perspective, already quite simple mathematical structures may generate very complex dynamics (e.g., May 1976; Boyer 2008, 738f.; Durlauf 2012, 57ff.).

Thus, for *policy*, we will have to deal with the issue of proper *complexity reduction* of individual decision situations (see below) – without having any hope, though, to be able – or even to wish – to reduce the *system complexity* so that global "perfect information" and certainty would result.

If, in particular, strategies have been interactively learned, adopted, and habituated as instrumental rule- and *institution-based solutions* of coordination and dilemma problems, emergent structure takes the form of problem-solving institutional emergence. In systems with planning, deliberating and anticipating human agents, rule- and institution-based coordination and cooperation do function as *complexity reduction* for agents. In this way, they relate to some *homeostasis* (equifinality) capacity of the system, holding some variable values within limits and, thus, ensuring some *continuity* and *stabilization* (e.g., Gilles, Lazarova, Ruys 2014). As said, in terms of *policy* relevance, this may include some *evasion* of policy measures. CA(E)P, thus, needs to be attuned in proper interaction with the interaction processes of the private (see below).

In our context, an example of a low-complexity system will be 2x2 *PD-SG*s played in a population in an *EGT* view, the *evolution-of-cooperation* perspective. But proper analysis of resulting processes with *many* strategies, let alone *endogenous* strategies, was feasible only through computer *simulations* (e.g., Axelrod 1984/2006; Lindgren 1997).

Indefinite *recurrence* of interactions in a population with many and evolving strategies and a *replicator mechanism* integrated is but a minor aspect of a typical open-ended and sequential process over *historical time*. Such process then typically is not only path-dependent, cumulative, and often idiosyncratic (i.e., at instances, so-called phase transitions, it is unpredictable or "chaotic"), as said, it also is *open-ended* with respect to often *instable and transitory fixed points* attained and periodic or non-periodic *orbits* performed (e.g. Room 2011, Chpt.9).

Related to such unpredictability, CA(E)S also are *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 can assume. This, in turn, relates to the fact that such systems are also "*sensitively dependent*" on initial conditions, which may come to vastly matter during a process (the well-known "history matters" issue).

What can be recognized from CA(E)S and their agent-based modeling and simulations, then, are behavioral *patterns* of systems (e.g., Room 2011, Chpt.10), an epistemological finding that has been long-standing also in the more qualitative strands of evolutionary-institutional and other heterodox economics (e.g., Wilber, Harrison 1978).

We may further integrate individual *learning* and *adaptation* algorithms and, in a population of agents, determine the *relative success* of certain rule-based behaviors or strategies and their carrier-subpopulations, over a period of time and across encounters with the many different other agent types. A full-fledged *evolutionary* process then accordingly will include, as said, differential *replication* of behavioral types. However, again, evolutionary *optimality*, in the sense of a *survival of the fittest*, across social environments and time, will not necessarily occur. It would require structurally stable and, with this, relatively transparent environmental conditions, where a "selection" mechanism has enough time to meliorate the system. However, this is typically not the environment of complex dynamic human populations. Particularly, when population shares are not only path-dependent and subject to differential replication, but, for instance, also subject to *first-mover* advantages, cumulative *power* acquisition, or *limits to growth*, situations of a *survival of the first*, *survival of the fattest*, or a *survival of all*, with possibly different shares, may occur – all situations of non-optimality.[28]

[28] For a general model with similar results, e.g., Nowak 2006, Chpt. 2.

Circular cumulative causation and endogenous structure

Such processes are, of course, not just bottom-up structural emergence (a microfoundation with upward causation) at proper meso- or macro-levels,[29] but also about *reconstitutive downward effects* (e.g., Hodgson 2002) from emerged structure onto the behavioral options, incentives, and evolving patterns of individual agents. *Circular cumulative* upward and downward mechanisms, a basic understanding of the economy in evolutionary institutionalism from Veblen through Myrdal till today (e.g., Berger, Elsner 2007), are definitely theoretical and methodological modules of CE.[30] They *endogenize* the network structure, and with complex interaction of structure and process, we are

> "… 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, Rogers, Zenou 2015, 41).

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

"Revising the concept of regulation"

As said, it is the manifold *non-optimality* of complex systems' mechanisms and processes, not appropriately reflected by the theory of "market failure" (e.g., Fontana 2012, 232f.), which basically opens the space for a proactive and systemic strategy of the public-policy agent. The "pervasiveness of unintended consequences" (Wilson 2014, 12) in CA(E)S with individualistic cultures and power relations justifies a strong role of policy.

[29] For emergence taking place at meso-levels and an approach to *meso-economics*, e.g., Elsner, Heinrich 2011.
[30] For a full-fledged evolutionary ontology and theory of economic systems, e.g., Dopfer 2005.

But also, evolution and complexity suggest a completely different concept of "regulation" than mainstream economics has imposed on society. As famous 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" (p.12) becomes a major policy task, while "moving the economy from an undesirable basin of attraction to a more desirable one" (Colander, Kupers 2014, 53) remains the overarching objective.

Policy system partly endogenous, partly exogenous

Note, as said, that 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, which (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 the required higher degree of complexity vis-à-vis the CA(E)S (below). We may, rather, also justify "*exogenizing*" it because of its different constitutional mechanism: ideally a unique, uniform, transparent, and *centralized* public discourse and decision-making, ideally well-informed of the complexity of the target system (and of its own complexity). This may be attained in spite of its perhaps *multi-layered* structure. With its particular centralized character, some *collective rationality*, compared to individualistic rationalities in the target system, may become effective.

Higher complexity of the control system

In fact, an early insight from information theory and cybernetics was that the complexity (e.g., the number of possible states, or degrees of freedom) of a *control system* needs to be at least as high as the complexity of the targeted system, the so-called *Ashby's Law*, where "only variety can absorb variety" (Ashby 1956). In order to shift a controlled system into an aimed-at area of outcome values (a superior attractor), while dealing with sometimes unpredictable adaptations of the system, including avoidance and evasion by agents, or some systemic sticking to an inferior attractor, the control system must be able to assume at least as many possible states as the controlled one.

In this way, policies towards CA(E)S need to be themselves 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.

It appears that this is impossible with a *neoliberal minimalist state* – ideally confined to a legal and court system, to tax and financial-speculation operations, and to police and military actions, but de-qualified and run-down otherwise (i.e., in its capacities of goal clarification, long-term planning, learning and adaptation, regulative frame-setting, and pursuing a holistic approach towards economy, society, and the commons). A political system with reduced democratic-participatory content, based on an oligopolistic or even duopolistic party system with the-winner-takes-it-all power incentives and related myopia, it has been argued recently, will not be able to solve such major problems (e.g., Fuller 2014) in terms of the reach of the ecological and social commons or the long-termism required.[31]

"Reducing complexity" of individual decision-making

Regarding complexity and its reduction, we already made the important distinction between the complexity of the *system* and that of the *decision situation* of individual agents.

Collectivities of interacting agents may generate, carry, and apply *social rules and institutions*, as a force of problem-solving and some self-organizing capacity, and, as said, of complexity reduction of their decision situations (e.g., Bloch, Metcalfe, 2011, 85f.). Thus, policy support for *institutional emergence* in CA(E)S of interacting human agents is helps reducing the complexity of individual and common or collective decision situations. That complexity may easily

[31] For the general neoliberal *winner-takes-it-all* culture and resulting systemic *short-termism*, e.g., Rappaport, Bogle 2011; Aspara et al. 2014.

overwhelm, as mentioned, the cognitive capacities of agents and run counter to their capabilities to orient themselves, act, or innovate. Supported institutional emergence, thus, may *de-block* and *free* common and collective action from the incapability of isolated individualistic agents, and *enable* and *empower* them.

The basic principle involved in such institutional emergence and its public support seems to be some tacit *contrât socia*l (J.J. Rousseau), a *collective self-commitment* (for some time), and the corresponding public assurance of individuals. This may limit some behavioral options and "flexibility", but also turbulence, thus sometimes reducing, sometimes increasing *efficacy* through more *stability*, which may increase transparency and individual empowerment.[32] Therefore, inserting such (supposedly superior) *collective rationality* is unavoidably ambiguous, as argued before. It may help the system to settle in aspired value areas, stabilize and improve. It may, however, also provide problem solution for a limited period only, and may then lead into a *lock-in* or *ceremonial encapsulation*.

Further, reducing complexity at the individual and group levels, and thus perhaps stabilizing the system and reducing its 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 at different times and phases. If the system is in a "basin of attraction", small policy interventions to redirect it may have little effect.

In any case, the system itself may remain highly complex, when individual decision situations become less complex. Reducing the *system's complexity*, if this were a policy objective at all,

[32] See above on the *efficacy-flexibility* trade-off.

might require quite different measures and face quite different difficulties and system reactions. Maintaining the system's *resilience*, for instance, may require that *diversification* rates, in the long run, remain ahead of selection, standardization, and institutionalization processes.[33]

On the role of calculation and simulations for policy

What has been said for analyzing CA(E)S has a bearing on the qualification of CA(E)P. While the calculation requirements remain higher for CA(E)S than for simplistic systems, indeterminacy and unpredictability remain as well. Population dynamics, e.g., easily becomes analytically intractable. And while computer simulations, of course, consist of *regular mathematical operations*, simple in their elementary algorithms, system complexity may easily translate into *computational complexity*, requiring calculation time that may easily go to infinity (e.g., Fontana 2010, 588ff.). But proper modeling and calibrations of *simulations* may nevertheless help detecting mechanisms, critical factors, and system-behavior patterns.

For instance, an *evolutionary* policy approach requires evolutionary analysis (e.g., Pelikan 2003; Witt 2003). And in an evolutionary-institutional approach, e.g., Hayden (2006) developed a *Social-Fabric-Matrix* approach to policy analysis in order to investigate the dynamic network structure among agents, institutions, and value systems, with their sequential input-output relations as directed graphs. This helps making transparent and pursuing policy actions throughout the socio-economic system.[34]

---

[33] On system *resilience* as a policy goal, e.g., Colander, Kupers 2014, 199ff.
[34] Also, e.g., Natarajan, Elsner, Fullwiler (Eds.) 2009; for evolutionary-institutional *system dynamics*, e.g., Radzicki 2009; for the transformation of system-dynamic models into directed graphs, as done in the *social-fabric matrix approach*, and subsequent application of *social-network analysis*, e.g., Schoenenberger, Schenker-Wicki 2015 (more below).

Note that cause and effect between the control and target systems are no longer simple, unidirectional, and structurally constant but interdependent and *structurally changing*. For instance, a reversal of an earlier policy will usually not generate reverse effects on the target system. Nor will the strengths of effects of identical measures be the same over time. The ability of *economic forecasting*, therefore, will be generally reduced and context-dependent. Although *formal methods* to be applied will be *more demanding* (dynamical system analysis, system dynamics, Social Network Analysis, ABM, and simulations), forecasting to the point and *technocratic illusions* of easy "manageability" will be infeasible. For instance, under path-dependence, "in order to understand policy options you must understand the past, which vastly complicates the analysis" (Colander, Kupers 2014, 54).

Policy interventions, therefore, have been said to necessarily remain *"nonalgorithmic"* in many instances (Velupillai 2007).[35] In other words, the problems of analytical intractability, often incalculability, relative indeterminacy, and more difficult predictability make policy measures not always exactly calculable and not fully determined on the basis of calculation. "Nonalgorithmic" action will be needed to move the system into an aspired (superior) basin of attraction with aimed-at outcome values.[36]

But this, in turn, does by no means absolve CA(E)P from the requirement of assuming a proactive role (e.g., Durlauf 2012, 62ff.) or making the best of its "algorithmic" underpinnings, where applicable.[37]

---

[35] Nevertheless, a new debate on new opportunities of calculation-based political planning, given modern computer capacities, seems to emerge; e.g., Cockshott 2015.
[36] Kauffman et al. 2015, in a biology-inspired neo-Schumpeterian interpretation of CA(E)S, even conclude that "unprestatable" and non-algorithmic system change prevents the provision of clear policies at all.
[37] E.g., Fontana and Terna (2015) suggest that combining empirical network analysis with ABM may qualify complexity policy.

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

Salzano and Colander (Eds., 2007) have been pioneering on the policy implications of economic complexity. Among their authors, Velupillai, as mentioned, clarified the limits of calculability (above; Velupillai 2007, also 2005). Policy recommendations of CE, he 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).

Such 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".

As another instance of a specific "complexity hint" for policy, Gallegati, Kirman and Palestrini (2007) showed that *system stabilization* under *power-law structures* (see above) may have to control "*idiosyncratic volatility*" caused by individual volatility in the highest classes of the power-law *distribution of firm sizes*. They conclude to propose an apparently traditional policy orientation: a reduction of firm centrality and concentration through reducing certain overly strong legal protections (namely of intellectual property rights). We will return to the policy implications of network structure and volatility below.

Against the background of such basic orientations for CA(E)P, we will have a closer look in the following at a simple model, as an exemplary exploration to advance some more specific complexity-oriented policy orientations.

4. The simple example of political frame-setting for institutional emergence in Prisoners'-Dilemma supergames

For the simple example, which, however, has exemplary policy relevance, we refer to Axelrod's (1984/2006) EGT-approach to the evolution-of-cooperation in PD-SGs. It was a simple formal reflection of his multi-strategy tournament simulations and has triggered a surge in the use of the PD and of PD-SG approaches for three decades. Too often, however, the PD is just taken for granted. But we have elaborated on the ubiquity and *everyday relevance* of social-dilemma structures elsewhere (e.g., Elsner, Heinrich 2009).

Axelrod's simple formal reflection

Following the well-known approach, the 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 $a > (d + b)/2$.

Axelrod's approach to the superiority (i.e., non-invadability or *evolutionary stability*, ES) of cooperation in a population playing 2x2-PD-SGs 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[38]:

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

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

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

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

ES follows the criterion, whether a population of cooperators cannot (or can) be invaded by defectors and thus be an evolutionarily stable strategy (or not). One of the ES-conditions (the one that Axelrod used) is:

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

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

$$\rightarrow \delta >! \; (b\text{-}a)/(b\text{-}c),$$

a logical condition for the *institution of* (conditional) *cooperation* (i.e., *TFT* behavior) to prevail in a population (i.e., not to be invadable).

[38] *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, which reflects a sequence of interactions (with one period memory) and is responsive and, thus, not always strictly dominated (like *ALL-C*, of course, is).

Note that *cooperation*, to solve the social-dilemma in a Pareto-optimal way, through a *sequential interaction process with social learning*, in an evolutionary-institutional interpretation, would be fully feasible only as an *institution*. As said, this is a social rule plus *endogenous sanction* (exerted through the credible threat of a so-called trigger strategy, such as *TFT*, to defect upon defection and in this way punish the defector), which prevents opportunism and keeps agents from chasing after their short-run maximum. Logically, it cannot be attained by "hyper-rational" (short-run) maximization (in a one-shot attitude), but must become *habituated* and pursued "semi-consciously" as long as there is no reason to assume that others intend to exploit.

The major theoretical question, and problem of proper modeling, then translates into the possibility of the *emergence* of such a *culture of longer-run rationality* (and related longer-run maximization calculation, as reflected by the current-capital values of infinite geometric series of payoffs, the so-called *single-shot* solution). The longer time horizon is reflected by a high discount factor δ, or low time preference, and is equivalent to the probability, in any particular interaction, to meet the current interaction partner again.

Also note that the single-shot payoffs, when the PD is solved, transform the PD matrix into a less intricate *coordination-game matrix* of the *stag-hunt* type (with two Pareto-different Nash equilibria). A general management and *policy* perspective for the superior solution of that stag-hunt structure, then, was presented early by *A. Sen* (1967). In a context of an independent and endogenous national development and related collective saving effort of a population to build a national capital and investment base, he introduced into a stag-hunt game the idea of a *public assurance* that all other agents will also contribute (i.e., will forego current consumption and increase saving for the national capital stock to make the next generation benefit). Such public assurance is considered equivalent with an informal contrât social, a general *trust* building that others will contribute as well (therefore it was termed "assurance" game), providing a Schellingian focal point for the Pareto-superior coordination (see above).

But in any sequential interaction, an existing dilemma structure still continues 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 process, therefore, will be open. The solution may remain *completely blocked* and the system caught in the one-shot Nash equilibrium. If the institutional solution emerges, it may also be very *time-consuming*. Finally, an emerged institution may be *fragile* and prone to backslide and later breakdown, depending on the evolution of population shares of cooperators and defectors, among others. Thus, there is much reason and space for *policy support* of the process of emergence.

As indicated, and first shown by Axelrod, this solution is accessible indeed for policy. It points to two *complexes of policy objectives and measures*:

(1) improving the *incentive (payoff) structure* in favor of cooperation, e.g., *rewarding cooperation*, weakening the social dilemma, making the structure gradually less intricate and difficult to solve; and

(2) promoting the *recognition of interdependence* ("recognized interdependence", in fact, an older institutionalist finding; e.g., Bush 1999) and, particularly, the awareness of the *common future*, i.e., enlarging the *time horizon* through a cultural learning process (Axelrod: „enlarging the shadow of the future"; which also is an older institutionalist issue, extensively dealt with as

futurity by Commons 1934) – a longer-run calculation as an enlightened self-interest, supporting a culture of reciprocity.

Axelrod also gave *policy examples* for the latter, less obvious issue, such as generating, and involving agents in, series of *common projects that overlap over time* so that agents always have a perspective to "*meet again*" (a high value of δ).[39] We have further elaborated on these two complexes and an *objectives-instruments continuum* involved (see below), and provided a real-world case study elsewhere (Elsner 2001). Among others, we showed how *regional networking* on common and collective issues may serve the second complex, and how the first complex (weakening the PD incentive structure)[40] may easily be addressed through *non-pecuniary payoffs* as well (such as early or selective provision of critical information).

A designer's perspective on the "single-shots solution"

A "designer's" perspective on such policy support of collective problem-solving would focus on increasing *expectations* "to meet again" ($\delta\uparrow$) and/or weakening the fierceness of the dilemma ($b\downarrow$, $a\uparrow$), so that the single-shot condition (the inequality above) will hold with greater probability. This can be illustrated as follows:

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

[39] Note 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 my earlier behavior.
[40] We do, of course, not assume that in reality we can isolate and clear-cut static normal-form games and derive clear-cut behavioral and policy conclusions from them. But we assume that we can identify, if only temporarily, certain basic incentive structures and attenuate those that run counter to complexity and volatility reductions.

We may qualify this illustration algebraically, writing the inequality as an equation and by this changing the earlier minimum δ into $\delta_{crit.}$:

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

with the marginal conditions:

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

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

and particularly for the individual variables:

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

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

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

This little exercise somewhat clarifies the policy implication re. the incentive structure. Ad (1): *Reduce the costs of common cooperation*, (*b*-*a*), so that the requirement, in terms of the *length of the individual time horizon and calculation period* ($\delta_{crit.}$), for the dilemma to be solved through a calculated long-run superiority of common cooperation, decreases as well. In this way, the probability that the dilemma will be solved by the agents will increase, as the single-shot condition will be easier met, c.p. The requirement for $\delta_{crit.}$ for a solution then could even be reduced, c.p., and the problem be easier solved anyway. Similarly, ad (2): *Increase the costs of* *common defection*, (*b*-*c*), i.e., increase the *frustration* (the endogenous potential 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 common cooperation*, *a*; and, ad (5): *reduce c* (and if *b* is reduced as well, then reduce *c* even more than *b*, in order to meet condition (2)). Do this in order to make the institution of cooperation ever more superior in the population and thus to support agents when learning to solve social dilemmas.

Again, the fierceness of the PD may be attenuated, e.g., by *financial subsidies* or *non-financial benefits* for common cooperation, to favor the collective-good production. But the structure must not be eliminated as such, as this might be a rather costly entertainment for the public agent. Such a solution would also be a static one, rather than informally acquired and habituated in a process – and theoretically trivial as well. Rather, as already discussed above, the *private agents still need to be held liable for their obvious individual interests in the collective solution* (indicated by the payoffs *a*), and have to correspondingly contribute. And their contribution needs to be intrinsically learned and emerge in an *adaptive process among themselves* – rather than being imposed (or provided on a red carpet) by the public agent. This stresses the fact that the system and the public support for its intended adaptation, through the tools related to δ and the payoff structure, are *gradual* issues.

Those gradual changes of the incentive structure through public policy, relative to δ, may indeed, in an evolutionary process, at some threshold values, *de-block* individualistic lock-in (i.e., the one-shot Nash equilibrium) or *accelerate* and *stabilize* the process of institutional emergence.

That single-shot solution may easily be integrated (with PD-SGs played in populations) with explicitly modeled *population size* (e.g., Elsner, Heinrich 2009). Then, total *maximum population*, *minimum critical population share of cooperators*, and even the *maximum carrier-group size of the institution* may be determined. Size, thus, can be shown to be another critical factor for the probability of structural emergence. [41]

5. More policy implications from the "deep structure" of the socio-economy: Game-theoretic and network considerations in an evolutionary-institutional perspective

"Framework" approach

The example above reflects a more general principle of CA(E)P, inferable from a broader set of game-theoretical and agent-based analyses: While the market, if not strictly regulated, is subject to system(at)ic failure, self-degeneration, and self-annihilation, the public agent, if properly legitimized and qualified (in a proper combination of participative democracy and hierarchical/bureaucratic realization of decisions) , might be able to create and implement basics of a long-run collective rationality, better collective-action capacity, and control of the decentralized private system to mitigate such systemic failure. However, there is no room in CE for claiming, even for a sophisticated and qualified public agent, "to know everything" or "to know better" in all contexts and dynamics of the eco-socio-economic system. Endogenously, and sometimes very quickly, changing structures and behaviors of the CA(E)S, rather, would basically require the policy agent to *make use also of the "knowledge of the system"* (but not at all of "markets" only). This implies, in the first instance, some *reduced policy* vision, as

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

mentioned before, which we now can qualify as a policy orientation towards specific *frame-setting*, *letting the system and its agents do their part and adapt*.

Such framework approach, using an *interactive* relation of different bodies of knowledge and action (yet to be specified), has also been advocated, but somewhat misleadingly called an "activist laissez-faire policy", by Colander, Kupers (2014, 214ff.), called political stewardship by others (e.g., Beinhocker 2012; Hallsworth 2012; Colander, Kupers 2014, 240ff.). It is certainly also 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 become indeed "a means through which individuals solve collective problems" (ibid.).

Analytical prerequisites of complexity policy

But at the same time, of course, policy also needs to always be *prepared to learn from the system's reaction* and further path – an "agile decision-making in a turbulent world" (Room 2011), which, obviously, is much more demanding for the policy system than all we know from the currently dominating policy approach.

CA(E)P, against this background, includes the task of *identifying* and analyzing the *components*, *mechanisms*, and *critical factors* that generate the visible processes, i.e., the (1) different *incentive structures* agents are involved in, their kinds and quantitative strengths (degrees of "intricacy"), (2) *arenas and networks* (given or emerged), their *sizes and structures*, (3) relative *collective goods* to be produced (or *commons* to be reproduced) in those arenas/networks by forms of coordination and cooperation, (4) the *deficiencies* of their private social provision processes, (5) social and political *objectives*, i.e., the *public interest* in the collective goods and commons, to be clarified in a proper participative process, (6) the *private interests* in the solution, i.e., the payoffs agents get for the solution, in order to be able to call them in to contribute accordingly, and (6) relevant *critical factors*, *intervention areas* and complexes of *tools and measures*.

Some more specific orientations, objectives, tools, and measures

(1) To resume our findings so far, major orientations, tools, and measures are the following:

- increasing the *awareness of interdependence* with the private agents;
- increasing *futurity*, i.e., improving private agents' time horizons and future expectations of cooperation of other agents, including expectations "to meet the same again (or a "knowing" agent) next interaction"; e.g., committing agents in *overlapping projects* that generate the collective goods both privately and publicly aspired; gradually increasing the discount factor this way will increase the probability of cooperative/coordinated solutions, yielded in myriads of interactions when agents aspire to improve in the long run;
- gradually improving the *incentive structures* from fierce to less fierce (from intricate to less intricate), without necessarily changing the kind of incentive structure, if this would require expensive pecuniary incentives;
- developing proper *interaction arenas*, and supporting *emergent cooperation platforms* of proper *sizes*; e.g., supporting local, regional, national, and global collective goods and commons through "structural" (industrial, regional, …) policies; shaping proper "*meso*"-sizes to increase solution capacities;

- caring for appropriate *network structures*; e.g., support *small-world* properties, while avoiding too much *centrality* and *power* (too many connections) for few agents;[42] put reversely: when regulating connectivity structures, and in particular reducing centrality degrees, the small-world property of networks should not be destroyed;
- generating structures of properly *overlapping and layered arenas and platforms*, according to the objective structures of interdependence around the (potential) collective goods and commons.

(2) We will briefly discuss, and add some references to these policy orientations. Note that favorable results always depend on whole constellations of such critical factors, which, in turn, obviously overlap.

- *"Improving" incentive structures, assuring, and supporting "focuses"*, helping agents to converge on *superior coordination options*: For instance, in transformed PD-SGs, i.e., in coordination structures of the "stag-hunt" type (or Arthur's technology choice with network technologies), a *public assurance* may work to *create focuses* for the Pareto-superior coordination (see on Schelling above; recently, e.g., McCain 2009).

- *Promoting recognition of interdependence, strengthening "futurity" and enlarging time horizons*: In approaches that include population size, *meso-size* of arenas, platforms, groups, or networks, with greater mean proximity, neighborhood, density, and probability to "meet again", may reduce the complexity of the decision situation

[42] This applies to the upper levels of power-law distributions, making them more even, and their graphs steeper.

of agents and thus plays a favorable role for emerging coordination and cooperation. Many theoretical, analytical, empirical, and simulation approaches have confirmed, over all, that *smaller groups* improve the quality of decision-making in realistic complex environments (e.g., Richards 2012; Elsner, Schwardt 2013, 2014; Kao, Couzin 2014). Better recognition of longer-run interdependence and easier institutional emergence might thus be generally promoted through systems of *layered and overlapping meso-sized interaction arenas*. Expecting to "meet the same again" or "to meet someone who knows" interrelates with the awareness of a *common future* and the *time horizon* (e.g., Jennings 2005; Hayden 2006). As said, this may support a socially learned and habituated culture of another, long-run rationality aspiring improvement (with or without opportunities of explicit calculation).

- *Reducing volatility, turbulence, and a disembedding mobility*: Reducing complexity of the decision structures of individual agents also may, under the above constellation, favor private collective-good production and *problem-solving* through institutionalized coordination and cooperation, in consistence with public objectives (i.e., not at the expense of third agents). It relates to increasing *transparency* and oversight, reducing volatility and turbulence for the individuals, in order to *provide the time required to learn, adapt, and stabilize expectations and relations* (e.g., Houser et al. 2014; Acemoglu, Ozdaglar, Tahbaz-Salehi, 2015). Another surprising and often counter-intuitive implication – running counter mainly established neoliberal dogmas, but making sense within an evolutionary-institutional game-theoretic 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). Similarly, it has 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. The system then may slow down in the longer run (e.g., Vega-Redondo 2013). Such results are shared by a large recent organizational and network literature, and they shed light on the counterproductive petrifactions in response to overly intensive de-regulation and "globalized flexibility".[43] A large literature of network analyses has emerged, particularly against the background of the financial crisis 2008ff., relating network structure and size/power structure with volatility, fluctuations, and vulnerability of networks. It basically supports the idea of *regulating connectivity structures*, and particularly reducing high-level power positions, in an effort to stabilize networks and increase their resilience (see Gallegati, Kirman, Palestrini 2007 above, and, e.g., Acemoglu et al. 2012). In other words, *network structures* should be somewhat *stabilized*.

- *Increasing transparency and complete information, agent capability, and time for learning*: Overlapping with the above, strengthening agents' capacity to appropriately deal with more or less intricate common and collective problem-structures further requires to provide them with "complete information" on their interaction, i.e., with a basic knowledge of the *character of their interdependence structure* (game type).

[43] We have argued elsewhere that in very large anonymous and/or highly turbulent populations with random partner change, agents would tend to stick to a PD-SG with the same partner as long as possible, provided this is part of their agency capacity (Elsner, Heinrich 2009).

Further, providing sufficient time for the social learning of proper solutions also relates – besides public information and assurance, recognized interdependence, and learned futurity – to strengthening agents' capabilities to *memorize*, *monitor*, *build reputation*, *use reputation chains*, and *select partners* in populations, the agents of which *interact sufficiently often*, even if in different problems and on different network structures. In game-theoretic approaches with such agency capacities and size included, it may be critical to support agents to *search and experiment* with *behavioral innovation* in order to generate the cooperative *minimum critical masses* required, to make cooperation paying, superior, survive, and spread (e.g., Axelrod 1984/2006; Elsner, Heinrich 2009).

- *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).[44] Restoring agents' problem-solving capacity and, with this, *promoting institutional adaptation* and emergence of new, more appropriate institutions, then will require some *break-out from institutional lock-in* (e.g., David 1984; Dolfsma, Leydesdorff 2009). Such break-out, in turn, would require some *information openness*, i.e., open basic innovation and the promotion, if possible, of *interoperability* among different simultaneous path options. But such openness, interoperability, and deliberate *multi-standard* policies may not only be counterproductive, as long as the unique technical

[44] The evolutionary-institutional issue of "ceremonial dominance" can be modeled as a series of overlapping dilemma games with sub-optimal short-run outcomes (e.g., Heinrich, Schwardt 2013).

and behavioral standard is coordinating and problem-solving (as argued so far), but also mostly infeasible. It has been shown that there are critical technological and institutional preconditions, so that such policy often becomes feasible only in *critical time windows*, dependent on particular phases of the system (e.g., Heinrich 2013; Elsner, Heinrich, Schwardt 2015, Chpt. 15).

- *Network structure and size: Local clustering and global exchange of experience*: The above may coincide with certain topologies, e.g., with arena and platform size, proximity and interaction *density*, and a certain network structure. Generally,

  "The 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, while Gallegati, Kirman, and Palestrini (2007) pointed out the problem of scale-free networks with their potentially volatile upper parts (see above), Watts (1999, Ch. 8), in a game-theoretic approach to dilemmas played on networks, confirmed a *small-world* characteristic of topologies to be particularly effective (see above on Watts, Strogatz 1998). The policy implication would be to support a balance of *"meso"-sized clustering* and some far-reaching ("global") interconnections.

- *Favoring equality*: In a game-theoretic perspective, S.P. Hargreaves Heap (1989) concluded that favoring equality among agents is a general policy orientation to be derived from game theory. In fact, it appears from many formal analyses that symmetrical incentive structures (games) are less intricate, easier to solve for agents, and more stable in a longer-run perspective. [45] Asymmetric structure, in contrast, may increase intricacy and volatility, through continuing redistribution battles, in the long-run, thus perhaps distracting agents' resources from the very problem-solving, i.e., from creation of value rather than redistribution of value already created.[46]

6. Complex adaptive economic policy: "Framework" approach and "new meritorics" – Outline of an "interactive policy"

Framework approach again

To change critical factors of the social interaction process and the system's motions through policy intervention, a basic orientation derived from the above has been a framework approach. This maintains space for the system's adaptation, even at the risk that this includes evading the policy measures. The rationale behind this is that interactively learned, habituated and institutionalized solutions should be more effective in the long run than solutions directly prescribed, or provided for them as a free-lunch by the public agent. An informally "enculturated" behavioral solution should be *more stable* and perhaps more effective than if, for instance, policy directly dissolved a dilemma structure as such (making the aspired cooperation

[45] For experimental support of more equal payoffs favoring voluntary collective-good contribution, e.g., Kesternich, Lange, Sturm 2014; for games on networks, Acemoglu, Ozdaglar, Tahbaz-Salehi 2015 conclude that more equal distributions among agents, generally, increase macroeconomic performance.

[46] This applies for 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 public-good problems. In *non-coordination games* (e.g., zero-sum games), *policy* may 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 with asymmetric payments and clearly sub-optimal in anti-coordination games with asymmetric payments. But again, we do not purport 2x2 normal forms to be easily identifiable in CA(E)S.

and production of the collective good the individualistically dominant behavior, with perhaps high monetary subsidies for cooperation). In the latter case, the agents' new behavior would not really be learned and institutionalized, but still part of their previous short-run culture. Such "big" public solution would not be just theoretically trivial but also *static* (non-process-oriented).

Such framework 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 the neoliberal regime, where the state often just provides public wealth and guarantees for new profit opportunities for private investors).[47]

In a game-theoretic perspective, the private clearly have *positive individualistic incentives* and interests to generate the *collective good*, and, thus, their problem, and the policy problem, is to deal just with the difference to the short-run extra benefit for unilateral defection (which, however, is highly uncertain among "clever" agents). Thus, the private may be drawn on and committed to produce the collective good *themselves* – even though with some specific public "framework" support.

Social evaluation: New meritorics and the "negotiated economy"

The *operative logic* of the "framework" approach is that the policy agent needs to evaluate the outcomes of the private social-interaction process: What are the relevant (and politically aspired) collective goods, and what are the *deficiencies of the process and outcomes* of the decentralized individualistic interactions? Why and how are the latter perhaps (1) completely *blocked*, (2) too

[47] Note also that this approach is clearer, too, than the celebrated approach of "*libertarian paternalism*", using *nudges* as a political strategy (Thaler, Sunstein 2003, 2008). The latter does not seem to provide theoretical clarification and to reflect system complexity (for a critique, e.g., Colander, Kupers 2014, 167ff.).

time-consuming, or (3) too *fragile*? A social evaluation of such multifariously deficient process and outcomes (with "market failure" included) is required. That is, the *public dimension of, and interest in, any collective good* needs to be identified and evaluated.

The outcomes of spontaneous, decentralized processes, particularly in an individualistic culture, where de-regulated markets are involved, thus, need to be evaluated, according to some "higher" *collective rationality*. And the criteria are the (1) *degree of uncertainty of emergence*, (2) *time requirement for emergence*, and (3) *degree of fragility of emergence*. Public policy then is to be oriented to (1) *unlock/de-block*, (2) *accelerate*, and (3) *stabilize* structural emergence, i.e., the emergence (production process) of the *common or collective good*, which is a *public objective* and *public good* as well, and, with this, economic improvement and development in a broad sense.

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, and then become a (3) *merit good* (according to the classic understanding of Musgrave 1959) through a social and political evaluation. The original merit-good criteria "price" and "quantity" (Musgrave) will, in a CA(E)S context, have to be *fundamentally extended* by the above-mentioned criteria derived from deficient complex process. In this new context, we may speak of a *new meritorics* (similarly already Musgrave 1987; also Ver Eecke 1998, 2007, 2008; Elsner 2001).

This policy conception can be considered not just "framework"-oriented, but particularly (1) double-*interactive*, as it, in definable ways, interactively relates to the private interaction system. Thus, we have termed it *Interactive Policy* earlier (e.g., Elsner 2001). Traditional perspectives on the economy as a machine, in contrast, have required and promoted dichotomic governments between "no government" (if "markets work") and fully centralized bureaucracy (if "markets" fail and governments have to act "as if" they were "the market") (Ormerod 2012, 37).Further, this policy may be considered (2) *institutional policy*, since it works in a perspective to support the agents' efforts to reduce the complexity of their decision conditions, reduce excessive volatility etc., and solve common and collective problems better by generating basic social rules and institutions. Thus, a *new kind of private-public interrelation* may be established: Setting specific framework conditions in favor of an easier, faster, and more stable coordination/cooperation, but leaving the system sufficient *degrees of freedom to adapt*.

To that effect, the state or policy-agent needs to be particularly *strong* and *qualified* – and this may include being, in more elaborated ways, *democratic* and *participatory*, as this may strengthen values, objective clarification, and commitment. The policy agent then needs to become able to *define, clarify, adapt, and maintain social values, policy objectives, target areas, and tools*. This is also what the "*pragmatist*" policy conception (Dewey 1930), with its conception of a *discretionary economy and policy*, its *instrumental value principle* (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 always been about.[48]

[48] On the role of democracy for complexity policy, also, e.g., Colander, Kupers 2014, 55, passim.

The approach may also work with *qualitative* rather than just pecuniary complexes of *instruments*, such as supporting agents' futurity (see above), certain preferential and early information through the public agent as a "reward" for mutual cooperation in specific program and project areas (e.g., in building common location factors of regional firms such as jointly used "soft" infrastructures etc.; e.g., Elsner 2001; Richards 2012). In any case, as mentioned, it may already be effective with only *gradually increased* policy impulses (e.g., subsidizing cooperation only in a relatively limited way may gradually increase the probability of problem-solving).

Therefore, it also can be considered a *cheaper and leaner* policy approach as compared to the full public production of public goods or a full subsidization of cooperative behavior to make it the individualistically dominant behavior (similarly, e.g., Colander, Kupers 2014, 280).

Learning, goals clarification and adaptation, and the blurred boundaries between objectives and tools

Furthermore, in a *Myrdalian* policy tradition, with unfolding knowledge of the policy maker about the system, the private agents and their evolving preferences, (1) policy objectives may become continuously clarified and adapted, and (2) a clear-cut static hierarchical *means-ends dichotomy* becomes *blurred*, while means may turn out to have dimensions of ends and v.v., and will thus have to be continuously revised (see Myrdal 1933; also, with respect to an evolutionary policy conception: Witt 2003, 84ff.).

Manifold policy agents and a layered state

Finally, this applies to policies in a broader sense, i.e., to the policies of different *types of policy agents*, namely (1) the agents involved themselves, who might establish those orientations, goals, and instruments in common discourses and commitments on related collective goods, if possible, (2) neutral "network" consultants engaged by the agents involved in an arena, and, of course, (3) the public policy agents proper and their intermediaries. They all may make use of the orientations, objectives, intervention areas, and tool complexes discussed here.

It has also been argued that a *smarter government* (stronger and more qualified, as explained) would have to be structured and *staged* itself (rather than just one central bureaucracy of the ideal neoliberal state, how reduced ever), according to the tiered and overlapping structures and reaches of the manifold common and collective goods and their potential carrier networks and groups, from *local* through *global* (e.g., Ormerod 2012; Richards 2012; Hallsworth 2012, 44ff.).

Again, the state with such a *proactive* orientation needs to be put in a strong participatory and democratic environment, it must become *stronger* and more *qualified* in many respects, be it its financial, technical, and informational endowments or the qualification of its personal agents, *independent* of dominant private powers and vested interests, non-corrupt, with the power to develop and clarify objectives, stick to them in the long run, be *reliable* and sustainable, but also *adaptive*[49], with the clear expectation of an *infinite engagement*, increasing its complexity and adaptiveness above that of the CA(E)S, prepared to intervene, in specified ways, forever.

7. Conclusion

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

This paper discussed and strived to qualify some policy principles suggested by previous CE literature, and to develop a set of more specific orientations, objectives, tools and measures of an economic "complexity policy", a CA(E)P, from the consideration of the economy as a CA(E)S. It exemplarily focused on a particular subset of CA(E)S, i.e., agent- and interaction-based CA(E)S, which additionally use evolutionary game-theoretic modeling in an institutional perspective and which consider network structures. We briefly investigated basic mechanisms, resulting properties, and critical factors (by verbal reasoning and with the illustration of a little model in the "evolution-of-cooperation" tradition). We did assume that they are relevant in all CA(E)S.

While the literature on policy implications of CA(E)S and CE has surged after the financial crisis 2007/8, it still has remained, with few exemptions, largely general. With the above, we hope to have provided an original contribution to it.

A set of policy *orientations*, potential *objectives*, complexes of potential *tools* and measures, and a conception of *politics* and policy *agents* resulted, fundamentally different from the narrow, allegedly compulsory, and mostly neoliberal, rough-and-ready "market"-oriented policy prescriptions of the economic mainstream. We developed a specific version (or subset) of a CA(E)P, a specified *framework* approach, called *Interactive Policy*, embedded in what we termed *new meritorics*. Referring back to a simple basic model used here, we could exemplarily integrate this CA(E)P with the older conception of *merit goods* (Musgrave) and the older pragmatist-institutionalist conception of the *negotiated economy* (Dewey, Commons). Fundamental aspects of such politics are the complexity of the system of politics and policies, democratic participation and inclusiveness, a *multiplicity of policy agents* and a structured, *multi-level* public agent. Not the least, such framework approach is particularly adaptive, and *lean* and inexpensive, in spite of its *pro-active frame-setting*.

Self-organization capacities of CA(E)S, thus, and ubiquitous requirements of CA(E)P, of policy *frame-regulation*, were shown not to be mutually exclusive but to form a new interrelation, as self-organization is independent of, and often contrary to, any sense of “optimality”. This applies particularly under conditions of a myopic individualist culture of de-regulated “markets”.

Such policy expects *path dependence*, *cumulative process*, and *structural emergence*, such as *institutionalization* and *lock-in*, but also *idiosyncrasies*, such as complex *non-linearities*, phase transitions, structural breaks, and surprise, and thus *non-predictability*. CA(E)P recommendations therefore are much less certain and apodictic than prescriptions based on the relatively simplistic mainstream models, but also lumbering much less into false point-predictions. Rather, CA(E)P will be geared to *permanent learning and adaptation*. Its orientations and frame-interventions require much more use of alternative *modeling*, *calculating*, *simulating* alternative paths, and *exploring* the spaces of policy discretion.

CA(E)P will of course also be “systemic” and needs to be *sufficiently complex itself*, but prepared to help agents to *reduce the often perceived over-complexity and over-volatility* of their decision-situations, particularly in de-regulated capitalist (“market”) systems.

Such policy will have to regulate in specified interaction with the private interaction system, leaving the private system space for adaptation, and making actively use of its change, thus recalibrating economic, social, and ecological systems and processes. Policy *objectives* and *tools* will have to be continuously developed, *clarified*, and changed in that process of interactive adaptation between the CA(E)S and CA(E)P.

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*, and equality, towards *network sizes and structures* and network stability, towards openness and critical *time windows* for intervention. In support of informal instrumental institutions-building by the private (while preventing and dissolving ceremonial petrifaction) it also may *shape appropriate systems of arenas* of private interactions, usually layered systems of overlapping and meso-sized arenas, platforms or networks. This may include the shaping of income distributions, settlement structures, or industrial size-distributions.

When trying to shift the economy towards sets of outcomes that are societally preferred, and to stabilize the socio-economy in that area, through facilitating institutions of reciprocal coordination and cooperation, it needs, as said, to be sensitive for its potential sclerotization (or ceremonialization), foster its *adaptability*, and preserve its *resilience* against shocks.

Such policy (and politics), in spite of being proactive and adaptive, needs to be *stable* and *reliable* in specific ways, long-run oriented, considering processes and their time requirement, thus, also "*strong*" and qualified with its strategies, measures, and personnel. Such policy orientation cannot provide predetermined rough-and-ready answers, strict prescriptions, and apodictic statements, but an oriented search strategy for the social provisioning process and for the concurrent social inquiry and valuation processes.

The recent surge in exploring more appropriate and properly complex economic policies has already led to the vision of a discernible and implementable better policy conception, and we hope this paper has made a contribution in that direction. But through its very object, CA(E)S, CA(E)P requires much more research. Further research may focus on deriving and exploring similarly specific and model-based policy implications from those subsets and classes of CA(E)S that we have left aside in this paper.

(12,757 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.), *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, A.-L., Albert, R., 1999, „Emergence of scaling in random networks," *Science*, 284 (5439), 509-512.

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.

Berger, Sebastian, and Wolfram Elsner, 2007, "European Contributions to Evolutionary Institutional Economics: The Cases of 'Cumulative Circular Causation' (CCC) and 'Open Systems Approach' (OSA)," *Journal of Economic Issues*, 41(2), 529-537.

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.

Boyer, Robert, 2008, "The quest for theoretical foundations of socio-economics: epistemology, methodology or ontology?" *Socio-Economic Review*, 6, 733-770.

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.

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.

Castellacci, Fulvio, 2006, "A critical realist interpretation of evolutionary growth theorizing," *Cambridge Journal of Economics*, 30, 861-880.

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.

Dolfsma, Wilfred, and Loet Leydesdorff, 2009, "Lock-in & Break-out from Technological Trajectories: Modeling and Policy Implications." *Technological Forecasting & Social Change*, 76, 932-941.

Dopfer, Kurt, 2005, "Evolutionary economics: a theoretical framework," in: K. Dopfer (Ed.), *The Evolutionary Foundations of Economics*, Cambridge, UK: Cambridge University Press, 3-56.

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, 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, and Henning Schwardt, 2015, *Microeconomics of Complex Economies. Evolutionary, Institutional, Neoclassical and Complexity Perspectives*, Amsterdam, Boston, San Diego et al.: Elsevier/Academic Press.

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.

Fuller, Roslyn, 2014, "Electoral Regimes and Socio-Economic Inequality: Resolving the Crisis through Political Reform", paper presented at the ASSA conference, Boston 2015; retrieved Jan. 9, 2015: https://www.google.de/search?q=Electoral+Regimes+and+Socio-Economic+Inequality:+Resolving+the+Crisis+through+Political+Reform+Dr.+Roslyn+Fuller,+R esearch+Associate,+INSYTE+Interdisciplinary+Group,+Waterford+Institute+of+Technology,+Ireland&ie=utf-8&oe=utf-8&gws_rd=cr&ei=zCKwVKmxFoL2UPe7gNAB.

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.

Georgescu-Roegen, Nicholas, 1966, *Analytical Economics – Issues and Problems*, Oxford, London: Oxford University Press.

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, 2014, "Stability in a Network Economy: The Role of Institutions," Tilburg University, TILEC Discussion Paper 2014-036; http://ssrn.com/abstract=2506643.

Gintis, Herbert, 2009, *The Bounds of Reason. Game Theory and the Unification of the Behavioral Sciences*, Princeton and Oxford: Princeton Univ. Pr.

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

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.

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.

Hollingsworth, Rogers, and Karl H. Mueller, 2008, "Transforming socio-economics with a new epistemology," *Socio-Economic Review*, 6, 395-426.

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; http://www.andrew.cmu.edu/user/exiao/transparency.pdf; accessed Feb. 23, 2015.

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.

Jennings, Frederic B., 2009, "Toward an Ethical Economics of Planning Horizons and Complementarity," in: J.B. Davis, (Ed.), *Global Social Economy: Development, Work and Policy*, London, New York: Routledge, 275-291.

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.

Kapp, Karl W., 1950, *The Social Costs of Private Enterprise*, Cambridge, MA: Harvard University Press.

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

Keen, Steve, 2001*, Debunking Economics. The Naked Emperor of the Social Sciences*, Annandale, NSW: Pluto Press Australia; 2nd ed. London, Zed, 2011.

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; http://www.sciencedirect.com/science/article/pii/S0167268114001371; accessed Feb. 23, 2015.

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

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.

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.

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, 1933, „Das Zweck-Mittel-Denken in der Nationaloekonomie," *Zeitschrift fuer Nationaloekonomie*, 4, 305-329.

Natarajan, Tara, Wolfram Elsner, Scott Fullwiler, (eds.), 2009, *Institutional Analysis and Praxis. The Social Fabric Matrix Approach*, New York: Springer.

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.

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.

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., 1988, "Institutional Dynamics: An Extension of the Institutionalist Approach to Socioeconomic Analysis," *Journal of Economic Issues* 22(3), 633-666.

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*, 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.

Schoenenberger, Lukas K., Andrea Schenker-Wicki, 2015, *Can System Dynamics Learn from Social Network Analysis?*, University of Zurich, Department of Business Administration, Working Paper No. 349, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2550593; retrieved March 23, 2015.

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).

Simon, Herbert A., 1955, "A Behavioral Model of Rational Choice," *Quarterly Journal of Economics*, 69(1), 99-118.

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.

Thaler, Richard H., and Cass R. Sunstein, 2008, *Nudge. Improving Decisions About Health, Wealth, and Happiness*, New Haven, CT, London: Yale Univ. Press.

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), Accessed January 16, 2013. http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0025995.

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

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.

Wilber, Charles K., Harrison, Robert S., 1978, "The Methodological Basis of Institutional Economics: Pattern Model, Storytelling and Holism," *Journal of Economic Issues*, 12(1), 61-89.

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

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.

Zenou, Yves, 2012, *Networks in Economics*, mimeo., prepared for the *International Encyclopedia of the Social and Behavioral Sciences*; CEPR Discussion Papers 9021; http://ideas.repec.org/e/pze5.html (accessed Dec. 12, 2012).

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