

Self-Organization in Collective Action: Elinor Ostrom's Contributions and Complexity Theory*

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Elinor Ostrom's contributions to the understanding self-organization in collective action processes are discussed from a complexity theory perspective. It is argued that complexity researchers can learn from Ostrom's theory building process, as well her conceptualization of the conditions of self-organization in the management of common-pool resources. Her focus on self-organization helps rectify the problems with the assumption in the mainstream policy analysis that policy processes can be explained with external causes. The conceptual problems in her utility maximizing rational actor assumption and the potential for conceptual advancements in her recognition of complexity concepts are discussed. It is argued that Ostrom's conceptual framework is sophisticated, but it lacks a dynamic understanding of the micro–macro relationships in complex governance systems, and that complexity theory offers the conceptual tools to remedy this problem.

Keywords: collective action, complexity theory, Elinor Ostrom, self-organization, rational choice

Complexity theory concepts like self-organization can help us better understand governance processes. Self-organization is not original to complexity theory; the concept has a long history and it has been used by other theorists as well. It is important to trace the lineage of the concept and acknowledge the contributions of others, so that the contributions of complexity theory can be distinguished. In this paper, I focus on the works of the late Elinor Ostrom, not only to recognize her contributions, which are substantial, and show how complexity theorists can learn from them, but also to highlight the shortcomings in her conceptualizations and point to the areas in which complexity theorists can offer better conceptualizations.

Ostrom's primary contribution is her demonstration that self-organization happens under specific conditions and within specific domains in collective action processes. She and her colleagues conceptualized and empirically verified the conditions of self-organization particularly in the management of common-pool resources (Ostrom, 1990,

* I want to express my appreciation for Stefan Verweij's insightful and incisive comments on an earlier version of this paper and the two anonymous reviewers' helpful comments and guidance on the submitted version of the paper.



2005, 2007a, 2009; Ostrom, Gardner, & Walker, 1994). Ostrom and her colleagues observe that self-organization happens in structured environments. The idea that self-organizational ability of a system depends on external boundary conditions is not alien to complexity researchers (e.g., Moreno & Ruiz-Mirazo, 2007), but they do not elaborate on the implications of this idea for complex governance systems/networks. Ostrom and her colleagues conceptualized and empirically verified the structural characteristics that enable, or hamper, self-organizational dynamics in collective action processes.

Ostrom's conceptualizations have shortcomings, as well as strengths. Her institutional analysis and development framework (Ostrom, 2005, 2007a) has its roots in the core assumptions of rational choice theory. Although she distanced herself from some of the assumptions of this theory, her continued commitment to its assumption that actors in collective action processes are rational utility maximizers creates conceptual problems. This assumption is the basis of her static conceptualization of the conditions of self-organization in common-pool resource systems. She recognized the contributions of complexity theory concepts and adopted some of them in her works. In this paper I will elaborate on the problems the rational choice assumptions create in Ostrom's conceptualizations, as well as the potential for conceptual advancements her recognition of complexity concepts generates.

1. A Brief History of Self-Organization

The roots of Ostrom's and complexity theorists' thinking of self-organization can be found in the philosophical proposition that events and actions do not require external drivers, or hierarchically superior forces, to happen; they can happen for internal reasons, driven by the internal dynamics of systems (Göktuğ Morçöl, 2012a, p. 93). Since the Aristotle's teleological proposition that causes of events in nature are in their final purposes (Bogen, 1995, p. 868), philosophers and scientists debated whether events are caused internally or externally. The Newtonian scientific understanding, which emerged in the 17th century, was based on the notion that natural events are caused by external factors (Göktuğ Morçöl, 2002, pp. 13–17). This Newtonian understanding was countered by Kant's argument that organismic behaviors were driven by their "inner teleology" in the 18th century (Taylor, 2001, pp. 84–93). In the 19th century, in response to Auguste Comte's argument that external forces cause social events, phenomenologists argued that in order to understand social events properly, researchers have to understand the inner worlds of human beings (Göktuğ Morçöl, pp. 163–166). The logical positivists of the early 20th century refined the notion of external causation and made it the core of their vision for scientific explanation. The notion of self-causation, and self-organization, gained some popularity again in the middle of the 20th century, as general systems theory, cybernetic studies, mathematical models of neural networks, and the models of the nervous system adopted and refined it (Capra, 1996, p. 22).

Complexity theorists made two significant contributions to our understanding of self-organization. First, they demonstrated that self-organization is the norm, not an exception, in nature (Kauffman, 1993, 1995; Nicolis & Prigogine, 1989; Prigogine, 1996; Prigogine &

Stengers, 1984; Strogatz, 2003). Second, they identified a set of self-organizational mechanisms of the emergence of aggregate patterns or macro structures in animal and human societies (Axelrod, 1997; Holland, 1995; Strogatz, 2003).

2. Ostrom's Conceptualization of Self-Organization and its Foundations

Ostrom (2005) observes that most of the “contemporary policy recommendations” are based on the assumptions that governments are capable of objectively analyzing social problems, producing desired outcomes, and managing social resources and that people are not capable of managing themselves (p. 220). She counters these assumptions and argues that actually not all social problems can be solved centrally by governments and that people are capable of organizing themselves to solve these problems. She and her colleagues demonstrated that individual actors have self-organizational capabilities, but there are also conditions that determine whether or not they will organize themselves. Ostrom identified and codified the conditions of self-organization in collective action processes, particularly in the management of common-pool resources.

In her conceptualization of the conditions of self-organization, Ostrom draws primarily on rational choice theory. Although she tried to distance herself from some of the assumptions of this theory, she remained committed to some of its core assumptions. Therefore, to understand the value of and the problems in Ostrom's conceptualization, one needs to understand the assumptions and positions of rational choice theorists.

Rational choice theorists challenge the liberal-democratic theory of government, particularly its proposition that public interest is determined or represented by public authorities, such as governments, who are populated by public servants whose actions are not self-seeking and who are capable of knowing what public interest is and act accordingly to protect and promote it (Torfing, Peters, Pierre, & Sorensen, 2012, p. 149). In the liberal-democratic theory, “government” is viewed as a singular actor and a “policy” as an action taken by this actor. A policy is like an object that “impacts” a “target population” to generate an “outcome” (i.e., a policy causes an outcome, as in the Newtonian scientific image of external causation). Then the role of government's policy analysts is to trace the trajectory of a policy action and check whether the outcome is compatible with the pre-determined goal of the policy (for a classical example of this view of policy analysis, see Rossi, Lipsey, and Freeman, 2004).

Rational choice theorists argue that governments are not singular actors, that governmental employees are self-seeking actors, just like all other individuals, and that public interest is the aggregated outcome of the actions of all these self-seeking actors, not something protected or promoted by governmental actors only (Tullock, 1979, p. 31). In the rational choice view, public policies are collective outcomes of individual actions. Then the question is how do individual actions turn into collective outcomes? In answering this question, rational choice theorists make a set of simplifying assumptions. The limitations imposed by these assumptions are reflected in Ostrom's conceptualizations, as I will demonstrate in the next section.

The first simplifying assumption is that rational actors act in all economic, political, and other social arenas to maximize their utilities. This assumption has three components:

The preferences, interests, and actions of individual actors should be the basis of understanding any social and economic phenomenon (methodological individualism); the interests, values, tastes, and preferences of these utility maximizing actors are “fixed” in the sense that they do not have any individual histories or cultural affiliations that would affect the way they make their decisions (the fixed interest assumption); and individuals are self-interested and utility maximizing rational actors (the utility maximization assumption) (MacDonald, 2003). The utility maximization assumption has been criticized by behavioral and cognitive psychologists, who demonstrated that individuals cannot maximize their utilities because of the many cognitive biases and behavioral predispositions they have (Friedland & Robertson, 1990; Hogarth & Reder, 1986). Simon (1979, 1986) offered an alternative: Because humans have “ineradicable” cognitive limitations, their rationality could only be “bounded.” A few scholars also criticized the fixed interest assumption. Lichbach (2003, pp. 64–69), a proponent of rational choice, for example, argues that rational choice theorists should acknowledge that because each individual has a history and his/her behaviors are influenced by culture, individual interests and preferences cannot be not fixed. Methodological individualism is criticized rarely, and it remains the bed-rock principle in rational choice theory and in Ostrom’s conceptualization.

Although her thinking is rooted in the simplifying assumptions of rational choice theory, one can observe that there are tensions, nuances, and contradictions in Ostrom’s applications of them. Ostrom adopts Simon’s notion of bounded rationality (Ostrom, 1990, p. 45; 2005, p. 118), but she also thinks that the assumption that individual actors try to fully maximize their utilities can still be useful in understanding economic markets and some other social situations (2005, pp. 99–133). She acknowledges that because of the different mental models individuals use and a variety of feedbacks they receive from the world and their shared culture (p. 105) and the emotional states they are in (pp. 112, 119), their interests, preferences, or behaviors cannot be fixed; they are complex and context-dependent and the culture of a society and institutional structures constitute the context in which individuals make decisions and act (Ostrom, 1990, pp. 57–58; 2005, *passim*). However, in Ostrom’s framework these institutional structures function as external inducements for action; they do not shape individual preferences or values (Ostrom & Parks, 1999: p. 292). Because of this distinction between individual preferences and actions on the one hand and institutional structures on the other, Ostrom’s conceptualization is static, and thus problematic, as I discuss later in this paper.

3. Conditions of Self-Organization in Common-Pool Resource Situations

Ostrom’s commitment to rational choice assumptions is reflected in her conceptualization of the conditions of self-organization in the management of common-pool resources (CPRs). She defines a CPR as a “natural or man-made resource system that is sufficiently large as to make costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use” (Ostrom, 1990, p. 30). She focused on CPR situations

in her studies, because, she notes, the processes of self-organization and self-governance are easier to observe in them compared to many others (p. 29).

Ostrom (1990) poses the following as the central question in understanding self-organization in the management of CPRs: “How [can] a group of principals who are in an interdependent situation...organize and govern themselves to obtain continuing joint benefit when all face temptations to free-ride, shirk, or otherwise act opportunistically”? (p. 29). The underlying assumption in this question is that all the individuals in CPR situations are self-seeking and boundedly rational actors who use a “calculus” to decide whether or not to engage in self-governance (pp. 245–247).

Ostrom and her colleagues studied empirically the conditions under which these actors act and codified them. Ostrom identifies two sets of conditions that determine whether they will participate in self-organizational processes: those conditions that are conducive for individuals to begin governing themselves—what she calls the “attributes of resources and appropriators conducive to and increased likelihood that self-governing associations will form” (2005, pp. 244–245)—and those that will help them maintain self-governing institutions—what she calls the “design principles for long-enduring CPR institutions” (1990, p. 90) or the design principles for “long-enduring institutions for governing sustainable resources” (2005, p. 259).

According to Ostrom (2005), the *attributes of resources* that are conducive to appropriators’ self-organization are that there is a reasonable chance that the resources available to them can be improved, that there are sufficiently large resources and a good chance to improve them, that there are reliable and valid indicators of the conditions of resources available to appropriators at a relatively low cost, and that the resource system is sufficiently small so that appropriators can develop accurate knowledge of the boundaries of the system (pp. 247–248). The *attributes of appropriators* that would enable them to participate in self-governance in self-organization are that the CPR system is salient enough for their livelihood or their achievement of important social or religious values so that they will be motivated to self-organize, that they have sufficiently common understanding of the CPR system and how their actions will affect the system, that appropriators have “sufficiently low discount rate” in relation to their future benefits and costs for participating in a self-governing system, that they trust each other for keeping promises and reciprocating their actions, appropriators have enough autonomy to carry out their actions vis-à-vis “external authorities” (governmental authorities), and they should have organizational experience and leadership skills gained from earlier experiences (pp. 248–251).

Once a self-governing CPR system is established, it should be maintained. Ostrom formulated the conditions that would help self-governing CPR institutions to endure for a long period of time (1990, 90–102), which she later broadened to apply to all types of “socio-ecological systems” (2005, pp. 258–288). The compliance by participants of self-governing system should be enforced and monitored and trust and reciprocity levels among the participants are important factors that will determine the level of compliance with the rules. Ostrom (2005) observes that those systems in which participants select their own monitors of compliance—rather than external forces, such as governments, do

that—are more likely to survive for long periods of time (p. 265), as well as those in which “graduated sanctions” applied to rule breakers and those that have mechanisms of conflict resolution (pp. 265–268).

4. Ostrom and Complexity Theory

Ostrom’s assumption that actors are capable of organizing themselves in collective action processes resonates well with complexity theorists’ observation that self-organization is natural. The affinity between her conceptualizations and those of complexity theorists go beyond this general resonance. Particularly in her later writings and her Nobel Prize acceptance speech Ostrom acknowledged the contributions by complexity theorists and adopted some of their concepts (e.g., Ostrom, 2005, pp. 242–243, 256; 2007b; 2009). One might speculate about whether, when, and how complexity theory influenced her thinking. More important for the purpose of this paper is to acknowledge that with her conceptualizations and empirical findings, Ostrom demonstrated, directly and indirectly, that the concepts of complexity theory can help advance our understanding of governance/collective action processes. It is also important to highlight the parallels between her conceptualizations and those of complexity theorists, assess hers critically from the perspective of complexity theory, and draw lessons from them.

One of Ostrom’s positions that bring her close to complexity thinking is her rejection of simplified dichotomies like governmental intervention versus free markets (2005, p. 256). She rejects the propositions that either free markets or governments can generate the best solutions to all social and economic problems. An important contribution she makes is to dispel the myths that free markets equal to self-governance and that self-governance (or self-organization) is necessarily an egalitarian process. She points out that many studies demonstrated that local self-organization may be dominated by local elites (Ostrom, 2005, p. 220), for example. Ostrom also notes that although in many cases centralized governmental systems were not found to be as effective as locally self-organized common-pool resource governance systems, there is no common rule that would suggest that one or the other is always better (p. 222). She argues that there are different configurations of relationships among governmental, nonprofit, and private actors that will generate different solutions to social problems and the best configuration of the roles of governmental and other actors depends on the context (1990, pp. 8–15, 2009).

She also observes that collective action processes take place in nested polycentric systems. Drawing on Vincent Ostrom’s (1999a, 1999b) earlier conceptualizations of polycentric systems, Ostrom (2005) observes that when common-pool resources are larger than the boundaries of a local community, many organizational actors will be involved and this will create “multiple layers of nested enterprises” (p. 270). In these multi-layered systems, not only there are multiple organizations and actors involved, such as general-purpose and special-purpose governments and local community organizations, but also the authorities and functions of these organizations are layered: Some have more general authorities and functions than others. These polycentric governance systems are complex

adaptive systems, and as such, they should adapt to their environments by reconfiguring their components in order to maintain their desired system characteristics for a long period of time (p. 258).

She also notes that there are no simple, definitive, or universal rules that govern these systems, because we will always have incomplete knowledge of them and their relations with larger systems (p. 284). Although she makes some generalizations about the “design principles” of self-organizing systems, as summarized in the previous section, she notes that there are many areas in which no conclusive design principles can be devised. Therefore, a better approach is to develop a configurational understanding of these systems, to identify specific configurations of the variables for particular conditions, rather than trying to find out the optimal conditions for self-organization (p. 254). Because all our analyses and knowledge of systems are partial, we should design our institutions adaptively (p. 254).

Having noted the parallels between Ostrom’s thinking and complexity theory, I also should point out a major problematic area in her conceptualizations. As I mentioned earlier in this paper, Ostrom remained committed to some of the basic assumptions of rational choice theory. Because of this commitment, the conditions of self-organization she identified reflect a static conceptualization.

What is particularly problematic in this assumption is its methodological individualist element. Methodological individualists assume that individual behavior is a distinct and the only legitimate unit of analysis. Although they may recognize that social structures exist, as Ostrom does, in their conceptualization either these structures have independent existence from the behaviors of individuals, or they fail to explain how the social and individual processes may be related.

In Ostrom’s institutional analysis and development framework, individual actors act in “action arenas,” which social structures are created by external forces (e.g., governments) (2005, pp. 14–15). There are also “exogenous variables,” such as biophysical and material conditions, attributes of community (culture), and various rules set at different tiers of social existence. These rules are set for “operational,” “collective-choice,” “constitutional,” and “meta-constitutional situations” (pp. 58–62). Ostrom uses the term “institutions” for these rule sets and action areas. It is important to stress that all these rule sets and action areas exist independently of individual actors in her conceptualization. Ostrom and Parks (1999) specifically mention that these institutions are external to individual decision makers; they function as external inducements for action and they do not shape individual preferences or values (p. 292).

Methodological individualism is evident also in Ostrom’s descriptions of the conditions of self-organization in CPR systems. As I summarized in the previous section, in her conceptualization individual actors are utility maximizing individuals who make cost-benefit calculations to such an extent that they calculate “discount rates” to make decisions whether or not to participate in a self-governing CPR system. She defines even “trust” in terms of the “expected cost” of one individual trusting another one. Although she agrees with Simon’s proposition that individuals do not have the cognitive capabilities to be fully

rational, they still are “boundedly rational” (i.e., imperfectly calculating actors), according to Ostrom.

Then, where do the interests, tastes, preferences, and values of these calculating individuals come from? Institutions do not shape them (Ostrom & Parks, 1999). Is there anything else that shapes them? Do the personal histories of individual actors shape them, for example? Rational choice theorists have been criticized for assuming that the interests, values, tastes, and preferences of actors are “fixed” in the sense that they do not have any individual histories or cultural affiliations that would affect the way they make their decisions (MacDonald, 2003), as I mentioned earlier in this paper. Ostrom’s writings are not clear on whether she thinks that they are fixed. As I discussed in the previous section, she describes the “attributes of appropriators” that are conducive to making them participate in self-governance and by doing so she acknowledges that there are variations among actors. This acknowledgement might imply that their interests, values, etc. are shaped by their individual histories. However, she does not discuss specifically where the variations in the “attributes of appropriators” come from.

Because of the implicit, or explicit, assumption that the interests and values of individuals are fixed, Ostrom’s framework is static. She ignores the dynamics of the relationships between individuals and social structures (e.g., institutions). The nature and dynamics of micro–macro relationships is a core problem for complexity researchers who study social systems in general, and policy/governance systems in particular (Göktuğ Morçöl, 2012b). In complexity theory, macro structures (the properties of a system) emerge from the relationships at the micro level and in turn they can help shape the relationships at the micro level. In other words, the micro and macro levels are interdependent (e.g., culture and individuals’ behaviors and interests are interdependent). This is why a researcher has to understand not only the properties of the components (e.g., individual actors), but also those of the system (e.g., institutions) and the dynamic relationships between the two (Göktuğ Morçöl, 2012a, chapter 3).

Cilliers’s (1998) conceptualization of self-organization is a good example of the dynamic understanding complexity theorists put forth. According to Cilliers, “The capacity of self-organization is a property of complex systems which enables them to develop or change internal structure spontaneously and adaptively in order to cope with, or manipulate, their environment” (p. 90). In other words, a self-organizing system not only reacts to its environment, but also transforms itself through interactions with its environment (p. 108). “Self-organization is a self-transforming process; the system acts upon itself” (p. 108). The degree of openness of a system to its environment and the degrees to which the environment can influence the system and the system can influence the environment are open questions for complexity researchers (Göktuğ Morçöl, 2012a, pp. 115–119).

Another set of conceptual and empirical problems complexity researchers dealt with were about the boundaries of self-organizing complex systems and how the “self” should be defined in them. Ostrom (2005) states that how the boundaries of CPR systems is an important problem (p. 248), but she does not provide an answer to it. Complexity researchers aim to understand how boundaries of self-organizing complex systems are formed.

Rhodes, Murphy, Muir, and Murray's (2011) conceptualizations of the dynamics of setting and re-setting the geo-political boundaries in the urban regeneration and healthcare systems in Ireland and Northern Ireland are good examples (pp. 134–147). Applying two complexity theory concepts, path dependency and bifurcation, they demonstrate that the urban boundaries in Belfast and Dublin were set and changed over time, both geographically and politically, based on the histories of the neighborhoods in these cities.

If systems are composed of other systems and all systems are related to other systems, then how can we define the “self” in self-organizational processes? In Moreno and Ruiz-Mirazo's (2007) conceptualization, a system's components define themselves as a system from which emerges the notion of self. In describing the process of defining self, they use the term “self-encapsulation”: sharply differentiating the organization of the system—the set of relations that constitute it as a distinct unity—from the environment. By establishing a distinct set of relationships among themselves, a group of elements define a system, a self, according to Moreno and Ruiz-Mirazo. The best example of this is the process of developing the membrane of a living cell: Through self-encapsulation, a group of molecules become a cell.

In social systems self is defined through social construction processes, according to Gerrits (2008) and Gerrits, Marks, and van Buuren (2009). Complex social systems are defined jointly by their participants and their observers (researchers) these authors point out, and they illustrate this point with examples from the Netherland and Germany. This social constructionist approach is insightful but not adequate, because it may imply that social systems are merely the products of the conjectures of their participants and/or observers and that a social system is merely an imaginary entity that exists in some individuals' minds; also it does not adequately consider the dynamics of defining selves and systems. Complexity researchers need to develop better conceptualizations, in my view. Giddens' (1984) view that systems are not imaginary entities, but they are “situated activities of human agents, reproduced across time and space” (p. 25) is a better conceptualization, as I argued elsewhere (Göktuğ Morçöl, 2012a).

An important area of conceptualization and research in complexity studies is the nature of self-organizing agents. Whether they self-encapsulate or socially construct their identities to form a system, agents should have the capacity to do so. Teisman, van Buuren, and Gerrits (2009) point out that human agents have self-reflexive capacities and that “Self-organization is the reflexive capacity of actors and (sub)systems who are able to receive, encode, transform and store information and use this to consider actions” (p. 9). In other words, self-organization requires some information processing capacity by reflexive actors.

Whether agents must indeed have self-reflexive capacities for them to be able to self-organize is an unsettled issue in complexity theory. The larger question is whether or not intelligence or knowledge is a precondition for self-organization. This question is closely related to the issue of the rationality, or bounded rationality, of actors. Complexity theorists identified two kinds of agents: “cognitive agents” and “reactive agents.” Cognitive agents are intentional and deliberative; they have “internal models,” or “schema,” which helps

them anticipate future events and thus guide their actions (Holland, 1995, pp. 31–34). Cognitive agents are similar to boundedly rational actors, who can process information and make predictions into future, which help them guide their actions. Reactive agents do not have any internal models to guide their actions; they merely react to their immediate environmental conditions.

For complexity researchers the question is does self-organization require cognitive agents, or could reactive agents self-organize as well? Several researchers used agent-based simulations (ABS) to answer these questions. In some of these ABS studies, researchers demonstrated the self-organizational capabilities of cognitive agents (e.g., Ahmad, 2008; Castelfranchi, 1998; Naveh & Sun, 2006) or boundedly rational agents (e.g., Axelrod, 1997; Bednar & Page, 2007; Cohen, Riolo & Axelrod, 2001; Epstein, 2006; Holland, 1995; Miller & Page, 2007). As Sawyer (2005) notes, however, other researchers demonstrated that self-organizational processes can occur even when there are only reactive agents and objective structures can emerge from the interactions of such agents (p. 161). Epstein and Axtell (1996) demonstrated, for example, that identifiable social structures can emerge from the interactions of artificial reactive agents that have limited knowledge of their environments and limited capabilities to react. The question of whether, or to what extent, cognitive capabilities (or rationality) are needed for self-organization is still an open question for complexity theorists and researchers.

Although she does not discuss this explicitly, Ostrom's conceptualization seems to imply that self-organizational processes yield more organization and orderliness in collective action processes. The conceptual problems she poses are whether and how self-regulating orderly regimes emerge through self-organization in CPR situations. Complexity theorists show that the direction of self-organization may be toward more (higher levels of) organization and orderliness or toward disorderliness. According to Anderson (1999) complex systems organize themselves toward order (p. 218). Prigogine, on the other hand, shows that self-organizational processes may go in either direction. In his view, systems spontaneously evolve toward "far from equilibrium" conditions under which there are two possibilities: Either systemic properties break down (disorderliness), or new systemic properties emerge (orderliness) (Prigogine & Stengers, 1984; Nicolis & Prigogine, 1989; Prigogine, 1996). Prigogine's conceptualization of the two directions in self-organizational processes has implications for understanding governance/collective action processes. It can help researchers of these processes to conceptualize the emergence of failures and undesirable outcomes in such actions (disorderliness), as well as the emergence of successes and desirable outcomes (orderliness).

5. Conclusions

There is a major lesson in Ostrom's development of her Institutional Analysis and Development framework for complexity researchers: In order for complexity theory to become a viable alternative in policy/governance/collective action studies, complexity researchers would need to take Ostrom's example of meticulous theory building and

empirical verification as an example. The Institutional Analysis and Development framework has been recognized as the most developed of the theoretical frameworks explaining policy processes and the most widely applied framework in the United States and Europe (Sabatier, 2007, p. 9). Ostrom's contributions, which are encapsulated in this framework, were recognized with a Nobel Prize in Economics in 2009 (Ostrom, 2009). Ostrom's publications are among the the most frequently cited works. (A Google Scholar search in May of 2014, when this paper was written, yielded 77776 citations of her works, compared to Albert Einstein's 94081 citations.)

All in all it is clear that Ostrom's framework made significant impacts in the scholarly literature, which would be difficult to emulate, but it can be an example for the future works of complexity researchers. Complexity researchers should take the theoretical articulation of their concepts seriously. I proposed elsewhere that there already are two theoretical frameworks that are emerging within complexity studies: the micro-macro framework and the socio-ecological systems framework (Göktuğ Morçöl, 2014). The concepts of these frameworks need to be refined and empirically verified in future studies.

In doing so, complexity researchers could consider adopting and adapting Ostrom's conditions of self-organization. However, the researchers should keep in mind the limitations posed by the roots of Ostrom's framework in rational choice theory. Because of her loyalty to methodological individualism, her framework is static. Her descriptions of the layers of this framework and the relationships among them are conceptually and mathematically sophisticated, but they lack a conceptualization of the dynamics of these relationships. This deficiency can be seen clearly in her descriptions of the conditions of self-organization, particularly the attributes of resources and actors that are required for self-organization. In these descriptions, actors and social structures are conceptualized as distinct entities. She does not consider the effects of the interactions between actors and social structures and possible transforming effects of one on the other.

As I pointed out in the previous section, complexity researchers have already conceptualized, and investigated to some degree, various aspects of the dynamics of micro-macro interactions, but most of these conceptualizations lack the specificity of Ostrom's conceptualization of the conditions of self-organization in CPR situations. Ostrom's conditions could be reconsidered and re-conceptualized from a complexity theory perspective. For example, it could be asked whether utility maximization, as Ostrom suggests, or social construction is the primary force that determines the decisions of the appropriators of common-pool resources to self-organize. If the existence of "cognitive agents" is not a necessary condition for self-organizational processes to occur (reactive agents can self-organize as well), to what extent do appropriators need certain kinds of information (information about feasibility of improvement, reliability and validity of indicators, predictability of future outcomes, etc.) to self-organize? How do path dependencies affect appropriators' perceptions of the boundaries of common-pool resource systems?

Self-organization is an important concept that can help us rectify the Newtonian external cause-effect way of thinking, which dominates contemporary policy analysis. The philosophical debates on whether events are caused externally or internally have a

long history, as I noted in this paper. These debates have affected the thinking in studies on policy, governance, and collective action processes. In general the Newtonian external cause–effect thinking permeated most of the conceptualizations and empirical studies in these areas. Ostrom and complexity researchers not only demonstrated that policy/governance/collective action processes can be self-organizational, but they also identified the conditions and mechanisms of self-organization in them.

Elizabeth Ostrom's and her colleagues' contributions in this area are substantial, but they have shortcomings as well. With their systemic and dynamic understanding of natural and social phenomena, complexity theorists can build a better framework of understanding how complex governance networks work.

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