SELF-ORGANIZATION IN COLLECTIVE ACTION: ELINOR OSTROM'S CONTRIBUTIONS AND COMPLEXITY THEORY*

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* Please note that this is only a rough draft I wrote in a limited time. I apologize in advance for the poor writing quality and spotty conceptualization in the paper. I would appreciate any comments that would help improve its contents.

INTRODUCTION

Self-organization is a key concept of complexity theory. Complexity theory is relatively new, but the notion of self-organization has ancient roots. These roots of self-organizational thinking can be traced back to the notion of teleology in Ancient Greek Philosophy, particularly to Aristotle's notion of "purposive finality of nature" (Knodt, 1995). The self-organizational thinking has evolved over the centuries to find its current manifestation in the works of complex systems researchers and theorists. There are others who adopted the notion of self-organization for their theoretical frameworks in recent decades as well. One of them was the late Elinor Ostrom, who made significant contributions to our understanding of self-organizational dynamics in collective actions processes. In doing so, she made multiple references to the works of complexity theorists and acknowledged the parallels between her conceptualizations and theirs. In this paper I will recognize Ostrom's and her colleagues' contributions and discuss them from a complexity theory perspective.

What motivated me to write this paper was more than merely to recognize the significant contributions Ostrom made to the conceptualization of self-organization in collective action processes. She was already recognized with one of the highest honors for scientists: a Nobel Prize in Economics in 2009. What motivated me was my observation that some of the complexity theory concepts, such as self-organization, either had been used and refined by others before, or were developed parallel to, the advances in complexity theory. This observation inevitably forces us to question whether complexity theory is original or even a distinct theory. I do think that complexity theory brings forth a fresh perspective, a new understanding of science, to both the natural and social sciences, as I argued and elaborated on elsewhere (Morçöl, 2012a). The theory does so by offering a new configuration of some old concepts, however. In order to recognize and appreciate the significance of complexity theory, one has to recognize the origins and evolution of these old concepts and then identify the specific contributions of complexity theory.

It is important to recognize the concepts and conceptualizations of Elinor Ostrom and her colleagues' Institutional Analysis and Development (IAD) framework and Paul Sabaiter and his colleagues' Advocacy Coalition Framework (ACF) in this context. They study self-organizational processes in policy processes. The IAD framework brings insights particularly to our understanding of the self-organizational processes in "institutions for collective action" (Ostrom, 1990). In this paper, I will focus on these contributions of Ostrom and her colleagues who collaborated with her in developing the IAD framework. The contributions of the ACF will be the topic of another study in the future.

Ostrom's and her IAD colleagues' contributions can be summarized in two main points. First, self-organization is not the romantic notion that signifies participatory democracy that delivers equality or equitable distribution of resources (for examples of this notion, see Stacey, Griffin, & Shaw, 2000; Goldstein, 1994). In fact, as other complexity researchers demonstrated in various occasions, with many examples and analyses, hierarchical structures may emerge through self-organization (e.g., Barabási, & Albert, 1999; Epstein & Axtell, 1996). The relations between self-organizational processes on the one

hand and participatory democracy versus hierarchical structures on the other should be a focus of attention for complexity theorists in their studies and Ostrom's insights can be useful for such studies.

Second, 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 (see, for example, Moreno & Ruiz-Mirazo, 2007), but they rarely elaborate on its implications. One of Ostrom's and her colleagues' primary contributions is to conceptualize and empirically verify the structural characteristics that enable, or hamper, self-organizational dynamics in collective action processes. Complexity theorists can learn from their conceptual an empirical works, I argue in this paper.

In the next section, I briefly summarize the evolution of the concept of self-organization in human history. In the following section, I will discuss where in this evolutionary history Ostrom's contributions fit. Then I will assess and critique her contributions from a complexity theory perspective.

A BRIEF HISTORY OF SELF-ORGANIZATION

Self-organization thinking has a long history. Although theorists and researchers began using the term "self-organization" relatively recently, the basic notion that underlies it has a longer history. Its roots of its predecessors and synonyms, like spontaneity, endogeneity, and autonomy can be traced back to the Ancient Greek philosophy (and probably other ancient philosophies in human history). The basic notion of self-organization is 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 (Morçöl, 2012a, p. 93). This ancient notion of self-organization was challenged and replaced by the external cause–effect determinism of the Newtonian/positivist science in the 17th century (Morçöl, 2002, pp. 13–17). The Newtonian/positivist science rejected the notion that "systemic processes can fold back on themselves…. the 'causes' of systemic processes are within themselves" (Morçöl, 2012a, p. 93).

Newtonian scientists had a good reason to reject the notion of self-organization: It represented the teleological thinking, which was a major impediment to develop a science independent of theology. In the teleological thinking natural events have "purposive finality" (i.e., that causes of events in nature are in their final purposes), whose primary example could be found in the Aristotelian teleology (Bogen, 1995, p. 868). Aristotle suggested that events did not have to happen in response to external forces, but they could be driven by internal and pre-determined purposes. Aristotelian teleology does not necessitate a theological explanation of the world, as Bogen points out. However, there is only a short logical leap between the notion of purposive finality and the argument that everything in the world has purposive finality and the purpose of everything that happens is set by God, as Mavrodes (1995, p. 868) points out. Monotheistic religions take this logical leap and some fundamentalist versions of them have grown to be intolerant of alternative, non-purposive, explanations of the world. .

This is the problem the scientists of the 17th century (collectively called Newtonian scientists, Morçöl, 2002), and to an extent many scientists even today, have had to face. It is understandable that to break away from the theological connotations of purposive finality, these scientists negated teleology in general as well. However, as Bogen (1995) notes, teleological thinking does not have to be theological, as a substantial amount of research in biology has shown that organismic behavior can be explained in purposive terms. Therefore scientific explanation has some room in it for teleology. The issue of the role of teleology in science is important because there still are controversies over it and these controversies have direct bearing on the conceptualizations of self-organization.[1]

The 17th century scientific philosophers Descartes and Newton articulated models and methods that were built on the assumption that events could be understood by reducing observations to their essential elements and establishing the causal relations between these elements (Morçöl, 2002, pp. 59–61). This Newtonian view of science is still predominant today. This view has not gone unchallenged, however. In the 18th century Immanuel Kant argued that that organismic behavior could be understood in terms of their "inner teleology" or "internal purposes" (Taylor, 2001, pp. 84–93). Organisms, in other words, could self-organize and self-produce. In the 19th century, Auguste Comte argued that the Cartesian and Newtonian notion that external forces cause events should be applied to explaining social events as well. The phenomenologists of the same century challenged this Comtean position and argued that in order to understand social events properly, researchers had to understand the inner worlds of human beings. The logical positivists of the early 20th century continued in the Newtonian tradition; they refined the notion of "causation by external forces" and made it the core of their vision of scientific explanation. The notion of 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).

The latest advancements in these refinements came with the advent of complexity theory. Complexity theorists Prigogine, Kauffman, Strogatz, Holland, and Axelrod made two significant sets of contributions. First, they demonstrated that self-organization is the norm, not exception, in nature. Second, they identified some of the mechanisms of self-organization. Prigogine and his colleagues demonstrated that self-organizational processes were at the core of the perpetual dynamism of nature (Nicolis & Prigogine, 1989; Prigogine, 1996; Prigogine & Stengers, 1984). They showed that particularly thermodynamic and chemical processes are self-organizing (they do not need external causes to happen). Natural structures dissipate and new and more complex structures emerge self-organizationally. Prigogine and his colleagues also observe that autocatalysis is the primary mechanism of self-organization in nature. Kaffmann (1995) confirmed this observation by showing that autocatalysis is the primary self-organizational mechanism in biological evolution. He conceptualized a specific model of self-organization: the NK model, which shows when the number of complex molecules passes a certain threshold, a living metabolism crystalizes auto catalytically (p. 62).

Strogatz (2003) demonstrated that *synchronism* is pervasive not only in nature (e.g., in fireflies flashing in unison, sperms swimming in a synchronized manner, and millions of brain cells discharging in pathological lockstep and thus causing epileptic seizures), but also in human relations (e.g., female coworkers spontaneously synchronizing their menstrual periods and members of symphony orchestras

keeping perfect time even without a conductor).These are self-organizational events because they happen spontaneously, without a central controller or director. According to Strogatz, the common mechanism of self-organization in all these events is “mutual cuing.” Similarly according to Holland (1995) the primary mechanism of the endogenous emergence of “aggregate properties” from the interactions of individual agents is “tagging.” This mechanism works in a wide spectrum of natural and social phenomena, from the mating rituals of birds to the emergence of political aggregates (“meta-agents”), such as political parties, nations, etc. Individual actors have “internal model,” or “schema,” which helps them anticipate future events and thus guide their actions (pp. 31–34). According to Axelrod (1997) aggregate political actors emerge endogenously as well (p. 125). He developed models of understanding various mechanisms of the emergence of such political actors.

Although complexity theorists have made significant strides in conceptualizing self-organization in nature and societies, there still are several areas where further conceptualization is needed. I highlighted some of the areas elsewhere (Morçöl, 2012, chapter 4). Briefly here, there is a need to further conceptualize how systems self-organize and how these self-organizational processes are affected by their relations with their environments and their elements. Complexity theorists have established clearly that systems are not closed to their environments in principle. However, some systems may be more closed than others; so closeness actually is a matter of degree. Then the question is, how does the degree of closeness of a system affect its self-organizational capabilities? Also, how does a system’s relations with its environment, which is composed of other systems, affect its self-organizational capabilities? Systems are composed of elements that are systems themselves. (In human systems, these are individual and/or collective agents.) In this conceptualization, a system is a macro-level entity and an element is a micro-level entity. Then (how) do the self-organizational processes at the micro and macro levels affect each other? If systems are composed of other systems and that all systems are related to other systems, then how can we define “self” in self-organizational processes?

These are questions about systems in general. Whether or not they can be answered for all kinds of systems is questionable. It is more meaningful to attempt to answer them for specific kinds of systems, for example policy/governance systems. This is the kind of systems Elinor Ostrom’s and her colleagues’ studies can help us understand. In the next section, I will discuss their contributions to the study of “collective action systems.” In the following section, I will assess their contributions from a complexity theory perspective.

OSTROM’S CONTRIBUTIONS

Elinor Ostrom was interested in complexity theory and cited some of its concepts and the studies by complexity researchers in hers. She never presented herself as a complexity theorist or researcher, however. Her interest in complexity theory and its concepts can be observed in her

discussions of complexity issues and concepts in her publications (e.g., Ostrom, 2005, pp. 242-243, 256; 2009, passim) and her recognition of Axelrod's contributions to political science (Ostrom, 2007b).

She was interested particularly in the self-organizational processes in collective action systems. She and her colleagues constructed the institutional analysis and development (IAD) framework (aka, institutional rational choice theory), within which they meticulous conceptualized the preconditions self-organization and tested them empirically. There are some aspects of the IAD framework that are compatible with complexity theory. There are others that should be critiques from the perspective of complexity theory. After summarizing the theoretical bases and implications of her contributions, I will return to these compatibilities and critical issues.

Theoretical Bases of the IAD Framework

The IAD framework has its roots in the rational choice theory and the earlier conceptualization of polycentricism by Vincent Ostrom (Ostrom, V., Tiebout, Warren, 1961). Although Ostrom distanced herself from some assumptions of rational choice or adopted more advanced versions of them, she remained loyal to some of its core assumptions.

To begin understanding the conceptual bases of the IAD framework and the problems in it, one has to review rational choice theorists' position on the differentiation between private interests and choices on the one hand and public interests and choices on the other. Rational choice theorists counter the textbook view of public policy that it is what governments do (Dye, 2004; Simon, C., 2007). Rational choice theorists challenge this reified view of public policy and argue that actually governmental actions are taken by governmental actors who are "self-seeking" (i.e., not altruistic), just like all other individuals and that public policy is in the aggregation (collective outcome) of the behaviors of these self-seeking individuals (see, e.g., Tullock, 1979, p. 31). By doing so rational choice theorists bring down the conceptual barrier between individual interests and public interest, and individual actions and public policy and open up a conceptual space to develop a notion of self-organizations in collective action processes.

In the textbook view, which is based on the liberal-democratic theory of government, public interest is determined by public authorities, such as governments, who are populated by public servants whose actions are not self-seeking. In this view, politicians and public administrators not only have higher moral standing than the rest of the society, but also capable of knowing what public interest is (Torfing, Peters, Pierre, & Sorensen, 2012, p. 149).[2] Public administrators follow the policies set by the collective bodies of politicians to generate public goods for private citizens. In this view, public policies are disconnected from the complex behaviors and interactions of individuals. A "policy" is like an object that "impacts" a "target" population to generate an "outcome. This view of policy reflects the Newtonian image of external causation: One object hits another to move it from one stable state to another. An analysis of a public policy means tracing the trajectory and measuring the strength of its

impact. The compliance of the outcome with the predetermined goal of the policy can be verified with a policy/program evaluation study. (For a classic example of this view of policy/program evaluation, see Rossi, Lipsey, and Freeman, 2004.) This reified view of public policy and policy/program evaluation has been criticized by many. For example, the "implementation" literature showed that the relations between "policies" and "outcomes" are not as straightforward as the Newtonian image suggests (Pressman & Wildavsky, 1984).

If public policy is not so reified, and public interest is not so closely tied to the actions of a collective body, then how "public interest" happens becomes an important conceptual and empirical problem. In more general terms, how individual actions turn into collective actions is the problem. This is what Simon and his associates (1992) call "the aggregation problem" (p. 49). Rational choice theorists address the aggregation problem in a framework of an idealized system of markets. In this framework self-interested and rational actors act in economic, political, and other arenas to maximize their utilities. The interest, values, tastes, and preferences of these 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.[3] In the orthodox version of rational choice theory, the aggregation of public interest is a result of a simple, additive process. In other words, "'public interest' may be understood as the entirety of…individual preferences expressed as choices" (Cochran and Malone, 1995, p. 5). This additive view is the philosophical base of the laissez-faire view of economics that once the government is kept out of economic affairs, the self-interested actions of individual actors will aggregate into desirable collective outcomes, such as economic prosperity. This additive view has been criticized even by many, even some proponents of rational choice theory. For instance, Lichbach (2003: pp. 64-69) points out that the additive view gets in the way of solving the problem of aggregation theoretically. To solve the problem, he argues, theorists should acknowledge that individuals have histories and their behaviors are influenced by culture.

The roots of Ostrom's work are in rational choice theory and she agrees with the foundational assumptions of this theory. She also recognizes the conceptual problems in it and points out that "additive" (linear) approaches are not adequate in understanding interest aggregation and recognizes the interdependencies among rules, configurations of rules, and individual actors.

One of the areas Ostrom part company with the orthodox rational choice theorists is their assumption that governmental intervention is the categorical opposite of free markets; she argues specifically that there are different configurations of relationships among governmental, nonprofit, and private actors that will generate desirable outcomes for different solutions in different contexts (1990, pp. 8-15; 2009). Therefore, free markets are not necessarily the best solution under all conditions. The absence of a governmental authority is not necessarily the best situation for solving policy problems. Free markets do not necessarily mean self-governance. Self-governance (self-organization) is not necessarily an egalitarian process; as studies show local self-organization may be dominated by local elites (2005, p. 220), for example. Ostrom also notes that in many examples centralized governmental systems were not as effective as locally self-organized common-pool resource governance systems, but

there is no common rule that would suggest one or the other is always better (2005, p. 222). The best configuration of the roles of governmental and other actors depends on the context (Ostrom, 2009).

With these views, Ostrom contextualizes policy processes and opens up the conceptual space for exploring the complexity of these processes. Her explicit recognition of the context and complexity of policy processes is important, but the intellectual roots of Ostrom's IAD framework in rational choice theory create problems in conceptualizing this context and complexity. I will address these problems in the next section.

Rational choice theorists make the fundamental assumption that all actors in social (political, economic, policy, governance) systems are rational (i.e., they are rational utility maximizers who act in economic, political, and bureaucratic markets). This has two components: that individual actors should be the unit of analysis in any kind of economic and social theory (i.e., methodological individualism) and that individuals are self-interested and utility maximizing rational actors (what Ostrom, 2005, calls the "rational egoist" assumption).The second (rational egoist) assumption has been criticized from a variety of perspectives (see the discussions in Friedland & Robertson 1990; Hogart & Reder, 1986) and consequently some rational choice theorists, including Ostrom, revised them. Methodological individualism, which is a deeper ontological belief, has been criticized less and remains the bedrock principle in all versions of rational choice, including Ostrom's. This is a deep theoretical problem, as I discuss in the next section.

Behavioral and cognitive psychologists demonstrated that utility maximization cannot be achieved because of the many cognitive "biases" and behavioral predispositions of human beings. Simon (1979, 1986) offered an alternative: Because humans have "ineradicable" cognitive limitations, their rationality could only be "bounded." He stressed that the rationality of a certain behavior can be judged only in the context of its premises, which include its social situation, the goals of the decision maker, and the computational means available to him/her (Simon, 1986).

Ostrom adopts Simon's notion of bounded rationality, but she is not ready to give up on the possibility of full (utility maximizing) rationality yet. This tension is evident in her writings. On the one hand, she stresses that the bounded rationality assumption should be substituted for the "extreme assumptions such as unlimited computational capability and full maximization of net benefits" (Ostrom, 1990, p. 45) and that the results of her and her colleagues' research are consistent with the assumption of bounded rationality (Ostrom, 2005: p. 118). On the other hand, she thinks that the utility maximizing individual assumption is still useful in understanding economic markets and some other social situations (2005, p. 131). Ostrom (2005) views the rational egoist assumption (the self-interest and utility maximization assumptions) as a useful starting point in analyses (pp. 99-133), but also acknowledges that the messiness of reality forces theorists to modify it (p. 103). 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 behaviors are more complex and context-dependent than the rational egoist assumption suggests. The "attributes of a particular

community" (i.e., culture) and institutional structures constitute the context in which complex individuals make decisions and act (Ostrom, 1990, pp. 57-58; 2005, passim).

This is the context of self-organizational processes in Ostrom's view. In other words, the attributes of a community and institutional structures provide the preconditions of self-organization. It is important to stress that in Ostrom's framework, these institutions are external to individual decision makers.[4] They function as external inducements for action; they do not shape individual preferences or values (Ostrom & Parks, 1999: p. 292). The relationship between individual actors and institutions may be one of mutual influence (p. 292), but even then the two are external to each other. In other words, Ostrom's theory remains methodologically individualist, which has significant implications, as I discuss in the next section. This mutually exclusive nature of individual actors and institutions in Ostrom's conceptualization is important to understand her conceptualization of self-organization as well, as I will discuss shortly.

Ostrom's Conceptualization of Self-Organization

Ostrom argues that solutions to policy problems do not have to be centralized. Individuals can organize themselves to generate collective outcomes and that they do not always need governmental intervention to do so. Like governance and governance network theorists and researchers (e.g., Jessop, 1990; Kettl 2002; Koppenjan & Klijn, 2004; Salamon, 2002; Torfing, Peters, Peirre, & Sorensen, 2012), Ostrom problematizes the role of the government, or governmental agencies, in self-organizing collective action systems (i.e., policy systems).

Ostrom's (2005) motivations to apply the notion of self-organization to understanding collective action problems can be understood by looking into her critique of the three "broad assumptions that underlies many contemporary policy recommendations" (p. 220). The common premises of these policy recommendations are that "resources are so interconnected that they all need to be managed centrally," that "resource appropriators are not themselves capable of designing rules to sustain resources over time," and that "designing rules to improve outcomes is a relatively simple analytical task that is best done by objective analysts" (p. 220). According to Ostrom, these assumptions are false. The interconnected of resources does not always necessitate a central management. People in general, resource appropriators (those who use "common-pool resources," which is the main focus of Ostrom's research interest) in particular are in fact capable of designing their own rules and governing themselves. And designing rules to govern resources is not simple analytical task.

Ostrom applied the notion of self-organization to understanding the conceptual problems in the governance of "common-pool resources" (CPR) situations particularly. She defines common-pool resources as "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 the "processes of self-organization and self-governance are easier to observe in this type of situations than many others" (1990, p. 29).

Conditions of Self-Organization in CPR Situations

Ostrom (1990) poses the central question of self-organization in CPR situations as follows: "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). According to Ostrom, there are two sets of conditions of self-organization in CPR situations: those conditions that are conducive for individuals to begin governing themselves and those that will help them maintain self-governing institutions. In her own words, Ostrom calls these respectively the "*attributes of resources and appropriators* conducive to and increased likelihood that self-governing associations will form" [emphases added] (2005, pp. 244-245) and 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).

It is important to note that in Ostrom's view, the appropriators of resources are boundedly rational individuals who make cost-benefit calculations to decide whether or not engage in self-governance. (She even offers mathematical formulas what she calls the "rules of calculus" to approximate the decision making processes by these individuals (2005, pp. 245-247). This calculus includes two groups of elements, according to Ostrom: the "attributes of the *resources*" and the "attributes of the *appropriators*."

She lists four attributes of resources, which she enumerates from R1 to R4. The first one is that there must be a reasonable chance that it is feasible that the resources available to appropriators can be improved (R1). If there is an abundance of resources, there will not be a motivation for appropriators to organize, because each can exploit resources without the help of others. If the resources are "substantially destroyed" and there is not reasonable chance to improve them, again, appropriators will not be motivated to organize. So, only under the in-between conditions, when there are sufficiently large resources and a good chance to improve them, appropriators will be motivated to self-organize.

The knowledge of the resources by appropriators is important for their chances to self-organize as well. Reliable and valid indicators of the conditions of resources should be available to appropriators at a relatively low cost (R2). Also, the flow of resources for appropriators' use should be relatively predictable (R3). The boundaries of a resource system are important as well, according to Ostrom. The resource system should be sufficiently small, given the capabilities of the transportation and communication system, so that appropriators can develop accurate knowledge of the boundaries of the system (R4). The cost of defining and maintaining these boundaries should be at acceptable levels for the appropriators, according to Ostrom.

Ostrom also cites six attributes of appropriators that would enable to participate in self-governance in a CPR situation. (She enumerates them from A1 to A6). First, the CPR system should be important (salient) enough for appropriators' livelihood or their achievement of important social or religious values so that they will be motivated to self-organize (A1). If they do not acquire a major part of their income from the CPR, then the high cost of self-organizing will not be worth their efforts.

The knowledge of certain conditions also affects self-organizational processes. Appropriators should have sufficiently common understanding of the CPR system (as summarized in the items R1-R4 above) and how their actions affect the CPR system (A2). Without this common understanding, they cannot agree on future joint strategies. CPR situations are usually complex and this affects adversely appropriators' chances of obtaining sufficient information and forming a common understanding about the situations. Another factor that can adversely affect developing a common understanding is "asymmetric private information" (unequal distribution of the information about resources). Another element of the knowledge of the CPR system is the "discount rate" appropriators apply to future benefits of their actions (A3). The discount rate concept is based on the assumption that both benefits and costs of money one owns diminishes over time. According to Ostrom, if the rate of diminishment for the benefits an appropriator obtains from participating in a self-governing system is low, then he/she will be more motivated to participate.

Appropriators should trust each other for keeping promises and reciprocating their actions (A4). Trust is important, according to Ostrom, because if one has trust in others, this will decrease the "expected cost involved in monitoring and sanctioning one another over time" (2005, p. 248).

The relations of appropriators with "external authorizes" can significantly increase or decrease the chances of self-organization as well. Appropriators should have enough autonomy to carry out their actions; external authorities should not be in a position to "countermand" their actions (A5). Autonomy reduces the cost of self-organizing, according to Ostrom. Regulations imposed by external authorities increase the cost because they may undo the efforts of appropriators (p. 249). Appropriators should also have developed sufficient organizational and leadership skills from their earlier experiences (A6). Appropriators are more likely to agree on rules with which they are familiar from their past experiences. They are less likely to agree on the rules that are imposed on them by external actors (p. 249).

Once a self-governing CPR system is established, it should be maintained; it is not guaranteed that this self-organizing system will continue indefinitely. Then what are the conditions that would help a self-governing CPR system to endure for a long period of time? Ostrom formulated design principles for "long-enduring *CPR institutions*" (1990, 90-102), which she later applied to a broader set of systemic arrangements, what she called the "design principles for robust *socio-ecological systems*" (2005, pp. 258-288). A "robust complex system" is one that maintains its "desired system characteristics" for a long period of time by adapting to the disturbances in its environment and its component parts, according to Ostrom (p. 258).

The first three of Ostrom's (2005) design principles are reformulated versions of the attributes of resources and appropriators I mentioned above. The first of these principles is that the boundaries of a CPR system should be defined clearly, as stated in rule R4 above. Ostrom further notes that by defining the boundaries, participants can define "who is in and who is out." These boundaries may be marked by "well-understood attributes, such as residing in a particular community or joining a specific local cooperative" or by various "tags," symbolic boundaries, such as joining certain rituals (p. 261). If these boundaries are defined by participants, rather than by external powers, like governments, the chances for the robustness of a system are increased. The second design principle is that the rules used to

maintain the system should allocate benefits proportionate to the inputs (costs) required by participants (p. 262). Participants should have the understanding that their costs and benefits are distributed fairly (p. 263). The third principle is that most of the individuals who are affected by the "resource regime" should be authorized to participate in making and modifying its rules. This ability to craft local rules is as important as the fairness rule.

Once a self-governing resources system is established, the compliance for its rules should be enforced and monitored. The trust and reciprocity levels among the participants are important factor 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, doing that—are more likely to survive for long periods of time (p. 265). Those participants break the rules should be sanctioned. The level of the sanctions imposed by the monitors is another determining factor for the longevity of a system, according to Ostrom. She points out that "graduated sanctions," sanctions that are impose at lower levels initially and intensified later, are more effective (pp. 266-267). She also observes that participants may interpret the rules differently and conflicts may arise because of these different interpretations. There must be mechanisms of conflict resolution to address such situations (pp. 267-268).

Ostrom also observes that the nature of the relations between the self-organizing system and larger systems, such as governments, is important in determining its robustness. A government should recognize the rights of the participants in a local self-governing system; local communities should be allowed to craft their own rules (p. 268). When common-pool resources are larger than the boundaries of a local community, governments will be involved in "multiple layers of nested enterprises" (p. 270). Ostrom calls these multi-layer (or multi-tier) systems "polycentric systems." In polycentric systems there are not only 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. They are nested systems. Ostrom argues that in nested systems the systems should be relatively separable from each other so that each system can experiment with solutions to policy problems separately. That way, the failures in one system would not cause the failure in en entire region (p. 284).

Ostrom also notes that these nested (polycentric) systems are complex adaptive systems. As such, there are no definitive and universal rules to govern them (p. 284). The knowledge of CPR systems and their relations with external (or larger) systems, like governments, is always incomplete, because of this complexity, according to Ostrom. Therefore, it would be erroneous to assume that simple, optimal, and universal designs can be devised to govern them.

Ostrom then generalizes her propositions about polycentric systems to policy problems in general. Complex systems require complex forms of knowledge. Policy problems are complex and therefore cannot be solved through the adoption of simple designs. She objects to using simplistic dichotomies like "markets vs. the state" and the absolute preferences for one or the other (p. 256). Instead, she proposes a framework to understand policy problems in terms of nested systems in which local actors self-organize (such as the participants of CPR systems). Self-organization, therefore, is a key

concept in understanding the complexity of policy systems in Ostrom's view. Although she makes some generalizations about the "design principles" of self-organizing systems, as mentioned above, she also notes that there are many areas in which no conclusive design principles can be devised. For example, empirical studies yielded conflicting results about two key issues in self-organization: the size of the group of the appropriators and their heterogeneity. She argues that actually what matters is the most is understanding the specific configurations of the variables for particular conditions, rather than trying to find out the optimal conditions for self-organization (2005, p. 254). She also argues that we need to understand that all our analyses and knowledge of policy situations is partial and therefore we should design our institutions adaptively (p. 254).

AN ASSESSMENT FROM THE PERSPECTIVE OF COMPLEXITY THEORY

Ostrom and her colleagues made significant contributions to our understanding of collective action processes by identifying and codifying the conditions of self-organization in CPR situations. Some aspects of Ostrom's IAD framework and detailed conceptualization are compatible with complexity theory and complexity researchers can learn from them for their own studies. Ostrom's adherence to the foundational principles of rational choice theory, primarily methodological individualism, and her separation of individual behaviors from collective structures has some shortcomings. In this section I discuss her contributions and shortcomings from a complexity theory perspective.

Ostrom's first and arguably most important contribution was to demonstrate that self-organization (self-governance) is a normal state of affairs in collective action processes. Through empirical research, she and her colleagues demonstrated that the appropriators of common-pool resources are capable of designing their own rules and governing themselves; they do not always need a central management, interference by an external authority. She also shows that actually it is not a simple task to centrally analyze the problems in CPR situations or manage these resources centrally. To what extent, a system of managing a CPR system should be centralized and to whet extent it can be self-organizational depend on certain conditions (attributes of appropriators and attributes of resources), as discussed in the previous section. She also recognizes that collective action processes take place in nested (polycentric) systems, which are complex adaptive systems. As such, there are no definitive and universal rules can be designed to govern them. All our analyses and knowledge of policy situations is partial and therefore we should design our institutions adaptively (2005, p. 254) .It is, therefore, necessary to understand the specific configurations of variables that affect the behaviors of these systems (p. 254).

With her propositions and empirical findings, Ostrom contextualizes our understanding of collective action processes and stresses that these are complex processes. Thus she opens up the conceptual space for applying complexity theory to these processes.

Complexity theorists have already made contributions that can be applied in this conceptual space. They have demonstrated that self-organization is the norm, not exception, in nature: Natural processes do not require central regulations or control; they can happen spontaneously. Complexity theorists also identified some of the conditions and mechanisms of self-organization in nature (see Morçöl, 2012, pp. 98-100). Although these conditions and mechanisms are quite generic, there are some applications of them in public policy and administration. Then how are these generic and specific contributions by complexity theory compare with Ostrom's conceptualizations?

To begin answering this question, I must first point to a generic problem in complexity theory: How do systems self-organize and how these self-organizational processes are affected by their relations with their environments and their elements? (for a detailed discussion of various aspects of this question, see Morçöl, 2012, chap. 4). Ostrom's general answer is that self-governance (self-organization) happens in structured environments; she and her colleagues identified the structural characteristics (conditions) that enable, or hamper, self-organizational dynamics in collective action processes, as summarized in the previous section. These conditions of self-governance are insightful, and empirically verified, but they are static and based on simplified assumptions of human behavior: the rational actor assumption of rational choice theory.

What is particularly problematic in this assumption is its methodological individualist element. As I mentioned in the previous section, Ostrom criticized and revised another element of the rational actor assumption (that these actors are utility maximizers who have the full cognitive abilities to make completely rational decisions), but she retained methodological individualism. 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 (or ignore) to explain how the social and individual processes may be related.

Ostrom's IAD framework has multiple tiers. At the lowest of these tiers individual actors who act in "action arenas," which are social structures 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 as well. 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; 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 situations. As I summarized in the previous section, in her conceptualization individual actors are rational individuals who make cost-benefit calculations to such an extent that they calculate "discount rates" in their 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 position that individuals do not have the cognitive capabilities to be fully rational, they still are "boundedly rational" (i.e., imperfectly calculating actors).

Then where do the interests, tastes, preferences, and values of these calculating individuals come from? Institutions do not shape them (Ostrom & Park, 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 interest, 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). This assumption of fixed preferences, values etc. is a key elements of methodological individualism.

In Ostrom's writing it is not perfectly clear whether she thinks that they are fixed. On the one hand, as 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. On the other hand, she does not discuss where the variations the "attributes of appropriators" come from. As I discussed earlier in this paper, she is ambivalent about the universal applicability of the rational actor assumption. Considering Ostrom and Park's assertion that institutions do not shape them, we can assume that she does not think that institutions (social structures) do not have anything to do with the variations in the attributes of appropriators or the rationality of actors. This implicit position indicates that she is not willing to abandon methodological individualism.

Consequently, Ostrom's framework is static; she ignores the dynamics of the relationships between individuals and social structures (e.g., institutions). I argued elsewhere, in my view, the nature and dynamics of micro–macro relationships should be the core problem of complexity researchers studying social systems in general, and policy/governance systems in particular (Morçöl, 2012b).These relationships have been studied by sociologists and political economists under the rubrics of the "micro–macro problem," "agency–structure problem" (Coleman, 1986), or "aggregation problem" (Simon and associates, 1992).

Complexity theorists and researchers have addressed the micro–macro problem, in general and in their studies of policy/governance systems. The conceptual basis of addressing the problem from a complexity theory perspective is the methodological holism, as opposed to methodological individualism, this theory suggests. This methodological holism is a product of a key concept of complexity theory: emergence. Briefly this concept suggests that the properties of a system emerge from those of its components and therefore these two are interdependent (e.g., the interdependencies between a culture and individuals' behaviors, or interests) and systemic properties are not simple additions of individual properties (e.g., public interest is not a simple addition of individual interests). This is why one has to aim to understand not only the properties of the components (e.g., individual actors), but also those of the system (e.g., institutions) and the relationships between the two (for an elaborate discussion, see Morçöl, 2012a, chapter 3).

Another key concept complexity theorists use to understand the interdependencies between individuals and systems and among systems is co-evolution. According to Kauffman (1995), a species evolves in the niche afforded by its environment, and as it evolves it changes its environment. Economic markets and political systems also evolve in the niches afforded by their environments (i.e., social norms, legal structures, and institutions). When individual actors act in these systems, they change social norms, legal structures, and institutions. Complexity theorists use agent-based simulations to illustrate the emergence of systemic properties and the co-evolutions of systems with their components (for an example, see Epstein & Axtell, 1996).[5]

Complexity theorists' dynamic and holistic understanding can also be seen in Cilllier's (1998) conceptualization of self-organization in complex systems. 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 it environment but also transforms itself in an interaction with its environment. (p. 108). "Self-organization is a self-transforming process; the system acts upon itself" (p. 108). There are conceptual and empirical problems in this description for complexity researchers to study. For instance, 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 future empirical research.

Another set of conceptual and empirical problems complexity researchers dealt with, and will have to deal with in the future, are about the boundaries of self-organizing complex systems and how the "self" should be defined in them. Ostrom proposes that for appropriators to self-organize they should be able to define the boundaries of a CPR system clearly; this definition would determine "who is in and who is out" of the system (R4 above). Complexity researchers go beyond this important, but descriptive, observation and 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 examples (pp. 134-147). Rhodes and her colleagues apply two key concepts of complexity theory in their cases studies of these systems: path dependency and bifurcation. They demonstrate that the urban boundaries in Belfast and Dublin were set both geographically and politically, based on the histories of the neighborhoods in Belfast and Dublin. The authors also show that at certain points in the histories of these cities, bifurcations occurred and they changed the geo-political boundaries suddenly and in unexpected ways.

Another important concept that complexity theorists have grappled with is the "self" in self-organization. If systems are composed of other systems and that all systems are related to other systems, then how can we define "self" in self-organizational processes? This question is obviously related to the question how are system boundaries defined? 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. I argued elsewhere that 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 people's minds (Morçöl, 2012, p. 101). This social constructionist approach does not adequately consider the dynamics of defining selves and systems. I proposed Giddens' (1984) structuration theory as a better alternative, which posits that systems are not imaginary entities, but they are "situated activities of human agents, reproduced across time and space" (p. 25). Stressing on human activities, in addition to social construction processes, will help us better understand the dynamics of the formation of selves (systems).

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. According to Teisman, van Buuren, and Gerrits (2009), agents have self-reflexive capacities: "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 should 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 not a precondition for self-organization. This is closely related to the issue of the rationality, or bounded rationality, of actors, which Simon, Ostrom, and rational choice theorists have dealt with, as mentioned earlier in the paper. Complexity theorists identified two kinds of agents: "cognitive agents" and "reactive agents." Cognitive agents are intentional and deliberative who 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 guide their actions. Reactive agents do not have any internal models to guide their actions; they merely react to their immediate environmental conditions.

The question, for complexity researchers is, whether self-organization requires cognitive agents. In other words, could reactive agents self-organize as well? Complexity researchers use agent-based simulations (ABS) to answer these questions. In many applications of ABS, cognitive agents are used and their self-organizational capabilities are demonstrated (e.g., Casterfranchi, 1998; Naveh and Sun, 2006; Ahmad, 2008) or "boundedly rational agents" (e.g., Holland, 1995; Axelrod, 1997; Cohen, Riolo & Axelrod, 2001; Epstein, 2006; Bednar & Page, 2007; Miller & Page, 2007). As Sawyer (2005) notes, however, other researchers demonstrated that self-organizational processes can occur when there are

only reactive agents as well: “Objective structures can emerge, and the existence of those structures can ‘constrain’ individual agents (via changes in patterns of local interactions) even when agents have no internal representations” (p. 161). Indeed, 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, in Ostrom’s conceptualization it is implied that self-organizational processes are toward more organization and orderliness in collective action processes. Her conceptual problems are whether and how self-regulating orderly regimes emerge through self-organization in CPR situations. In most of complexity studies the direction of self-organization is the same: more (higher levels of) organization and orderliness (see the ones cited in the previous paragraph). This direction of self-organization makes intuitive sense. Complexity theorists consider self-organization in the direction of disorderliness as well, however.

Anderson’s (1999) definitions following description illustrates the conceptualization of self-organization in the direction of more orderliness: “… complex systems exhibit 'self-organizing' behavior: starting in a random state, they usually evolve toward order instead of disorder" (p. 218). Prigogine, on the other hand, acknowledges 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 direction of self-organization has profound implications. It can help researchers of collective action processes (policy, governance processes) to conceptualize the emergence of failures and undesirable outcomes in such actions, as well as the emergence of successes and desirable outcomes.

CONCLUSIONS

The summary and discussion of Ostrom’s contributions to our understanding of self-organization in collective action processes shows that she and her colleagues built an elaborate theoretical framework and empirically verified and refined it with meticulous work over decades. In order for complexity theory to become a distinct and viable alternative in policy, governance, or collective action studies, complexity theorist and researchers would need to take their example of meticulous theory building and empirical verification as an example.

Each of Ostrom’s propositions on the attributes of resources and actors would be worth considering adopting and adapting for complexity theory applications in policy, governance, collective action studies. However, in such applications, researchers should keep in mind the limiting and potentially misleading effects of the roots of Ostrom’s framework and propositions in rational choice

theory. Because of her loyalty to methodological individualism, her multi-layered IAD 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 is clearly seen 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 socials structures and possible transforming effects of one on the other.

That is where complexity theory can make a contribution and distinguish itself. As I briefly summarized in the previous section, complexity theorists' methodological holism guides them to develop rich conceptualizations of self-organizational processes. They conceptualized and investigated various aspects of the interactions between agents and systemic structures. They studied the systems boundaries, how self is defined in self-organization, the nature of self-organizing agents (cognitive or reactive), and the direction of self-organization (toward orderliness or disorderliness). Most of these studies are admittedly abstract; they lack the specificity of Ostrom's conceptualizations of the attributes of resources and appropriators in CPR situations. It should be on the agenda of complexity researchers to refine and apply their concepts and conceptualizations and verify them empirically. With such refined conceptualizations and empirical verifications, complexity theory can take its place among the leading theories of policy, governance, or collective action processes.

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NOTES

[1] See Morçöl (2012a, pp. 93-95) for a longer version of the following brief discussion of this topic.

[2] Torfing and his colleagues trace the roots of this liberal-democratic view to F. Hegel's, J. S. Mill's, W. Wilson's, and M. Weber's works in the 19th and 20th centuries.

[3] As MacDonald (2003) puts it, in rational choice "macrosocial outcomes are the sum of discrete, intentional acts by preconstitited actors…. [It] is the purposive, intentional, self-propelled behavior of individuals that aggregate into outcomes; structures neither constitute this behavior nor constitute the actors" (p. 558).

[4] The role of culture ("attributes of a community") are not clear in her framework. She does not seem to be concerned about the effects of culture.

[5] Agent-based simulations did not originate in complexity theory. Similar methods and models (e.g., cellular automate, genetic algorithms, neural networks) originated in computer science and related fields (see Anderson, 1999) and used in evolutionary biology (see Dawkins, 1987).