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Governing Institutional Complexity: The Ecology of Games Framework

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This paper provides an overview of our adaptation of Norton Long's concept of the "ecology of games" into a theoretical framework for analyzing institutional complexity. I discuss the basic concepts of the framework, discuss hypotheses related to fundamental questions in governance and policy, and outline some basic analytical approaches. The conclusion assesses the future prospects of the ecology of games framework, including future research needs for theoretical and empirical development.

Introduction

Institutional complexity is a defining characteristic of modern governance. Take, for example, one of the empirical settings that inspired the development of this paper: water policy in San Francisco Bay, California (SF Bay). SF Bay features a collaborative policy institution called Integrated Regional Water Management (IRWM), and analyzing the effectiveness of such collaborative institutions is the subject of a considerable literature (Ansell & Gash, 2008; Koontz et al., 2004; Lubell, 2004; Sabatier et al., 2005). But IRWM is not the only collaborative institution—there is also the Delta Plan, the Bay Area Joint Venture, the San Francisco National Estuary Program, the Sonoma Creek Total Maximum Daily Load, and numerous other institutions where stakeholders make water policy decisions. In fact, our empirical study discovered over 100 different policy institutions operating simultaneously in SF Bay (Lubell, Robins, & Wang, 2011). This complex set of institutions governs multiple environmental policy issues affecting the interests of hundreds of different policy actors.

Future and ongoing empirical research will demonstrate that SF Bay and environmental policy are not unique; some level of institutional complexity exists in every region of the globe, and for all types of policy issues (e.g., health, education, etc.) not just environmental policy. Institutional complexity is not a hypothesis—it is a fact and reality of governance, and the policy sciences sorely need a theoretical approach and empirical research to analyze the structure, process, evolution, and outcomes of such complex adaptive systems.

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To address these issues, my colleagues and I have worked for the last several years to revive and update the "ecology of games" (EG) concept first developed by Norton Long (1958), and apply the concept to a number of empirical cases in environmental policy (Berardo & Scholz, 2010; Lubell, Henry, & McCoy, 2010; Lubell et al., 2011; McAllister, McCrea, & Lubell, 2013). The core insight of this updated EG framework is that governance involves multiple policy games operating simultaneously within a geographically defined policy arena, where a policy game consists of a set of policy actors participating in a rule-governed collective decision making process called a "policy institution." The policy institutions that exist at a particular time and place combine to define the institutional arrangements of governance. The EG framework challenges the traditional approach to policy analysis that focuses on one policy at a time, and adopts a complex adaptive system perspective where policy outputs and outcomes are the function of decisions made in multiple games over time.

This paper describes the conceptual foundations of the framework, offers some potential insights about major questions in governance and policy, and illustrates some analytical approaches and specific hypotheses. But before continuing the discussion, it is crucial to clarify some issues regarding the epistemology, intellectual origins, and contributions of these ideas. First, the reader should decide whether the EG framework constitutes a framework or a theory in the terminology of E. Ostrom (1999). One argument is to call the EG approach a *theory* of polycentric governance that extends E. Ostrom's Institutional Analysis and Development (IAD) *framework*. Indeed, the EG approach is consistent with V. Ostrom's (1994, p. 225) definition of a polycentric system as a self-organizing system composed of "(1) many autonomous units formally independent of one another, (2) choosing to act in ways that take into account of others, and (3) through processes of cooperation, competition, conflict, and conflict resolution."

However, the EG framework seeks to go beyond the normative focus (i.e., polycentric systems are better than others) and qualitative descriptions (i.e., how different action arenas might be linked) of the extant polycentric governance literature. Instead, the EG framework intends to produce empirically testable hypotheses about the structure and function of complex adaptive governance systems, analyze the causal processes driving individual behavior and institutional change, and ultimately understand how different types of institutional arrangements are linked to policy outputs and outcomes in order to provide recommendations about how to manage the system. Existing policy theory is not adequate for this task, and policy analysis that focuses only on narrow slices of the complex system risks making serious errors in understanding, prediction, and recommendation.

Second, the EG framework represents what Cairney (2013) would call a "supersynthesis," where the aim is to combine insights from multiple theories into a hybrid approach that links hypotheses from previous theories in new ways, and also produces new stand-alone hypotheses. Thus, the EG framework is cumulative; it shares hypotheses and owes a heavy intellectual debt to previous theories, especially Norton Long (1958) and the IAD framework. But the EG framework also borrows ideas from other policy and social science theories, such as venue shopping

(Baumgartner & Jones, 1991, 2009), advocacy coalitions (Sabatier & Jenkins-Smith, 1993), political power (Knight, 1992; Moe, 2005), and cultural evolution (Richerson & Boyd, 2005). It also draws on ideas from the literature on complex adaptive systems, including how global patterns are a function of numerous local interactions among heterogeneous components and self-organizing actors at different scales, and the evolutionary dynamics of system change (Cairney, 2012; Levin, 1998, 2003; Miller & Page, 2007). Given its synthetic nature, and also for narrative ease, this paper will use the term "framework" throughout.

Third, this initial version of the EG potentially contributes new insights to several major issues in the study of governance and political systems. Importantly, the EG framework simultaneously considers three core processes of governance: cooperation, distribution, and learning. This goes beyond the existing institutional literature, which focuses primarily on issues of efficiency from solving collective action problems, and does not pay enough attention to how actors learn about the solutions, or how political power shapes resource distribution (Moe, 2005). The EG framework adopts a realistic model of human decision making drawn from biological and cultural evolution, which recognizes how behavioral, social, and cognitive processes constrain rational choice. Because of the focus on multiple institutions, the EG framework provides insights into the sources of fragmentation and unintended consequences in policy decisions, and the role of boundary-spanning institutions in system-level policy coordination. By integrating the idea of complex adaptive systems, the EG framework analyzes the evolution of institutions over time in the face of pervasive uncertainty (Miller & Page, 2007; Mitchell, 2009).

The next section provides a qualitative sketch of some of the basic concepts of the EG framework, followed by a more detailed analysis of some of the insights and broad hypotheses the EG framework may provide for theories of governance. This is followed by some examples of analytical approaches that might be useful for further developing and empirically testing some specific hypotheses, with a particular focus on interaction effects, agent-based models, and network analysis. The conclusion discusses the current status and future prospects for advancing the EG as a theory of the policy process and governance.

Basic Concepts of the EG Theory

The EG framework relies on six interrelated concepts: policy games, policy issues, policy actors, policy institutions, policy systems, and time. While the discussion here relies on examples from environmental policy and watershed management, the concepts are transferable to any substantive policy domain. The EG concepts are also amenable to comparative analysis, where different political cultures and macro-political institutions will shape the structure of the local policy ecology. The rest of this section describes the working parts in more detail, using Figure 1 to illustrate the simplest multi-game setting featuring two actors (A and B; in this case a government agency and resource user group), two policy institutions (X and Y), and two policy issues (1 and 2).

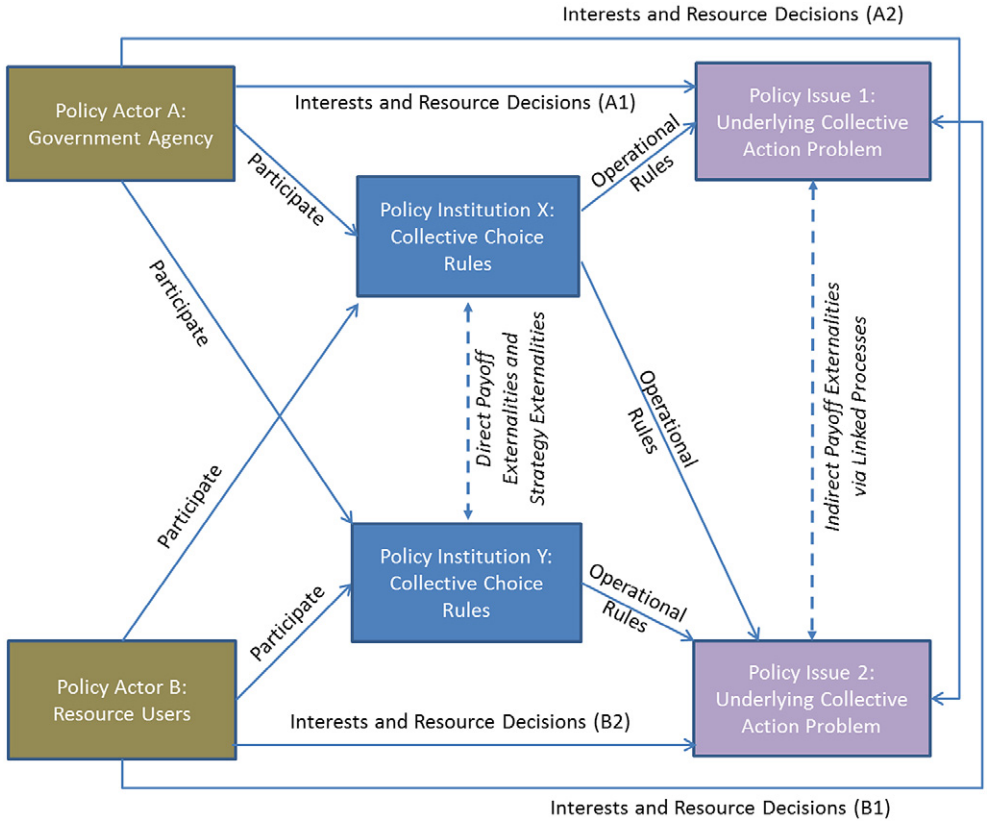

Figure 1. An Ecology of Two Games.

Policy games are defined by the constellation of policy actors, policy institutions, and policy issues that are at hand in a particular geographically defined policy system (Scharpf, 1997). A game occurs when actors jointly participate and make decisions according to the collective choice rules of a specific policy institution, where the outputs are operational rules that apply to issues within that institution's jurisdiction. To clarify, a game is not equivalent to a policy institution—a game only occurs when actors are making collective decisions subject to a particular set of institutional rules. A sports metaphor is helpful here—a soccer game only occurs when the players take the field, but the rules of soccer still exist even when the players are not participating. Accordingly, the phrase "participate in an institution" is equivalent to "playing a game."

Figure 1 portrays a specific constellation of interdependencies to illustrate the basic structure. Both actors have interests in both of the collective action problems, and thus participate in both of the institutions. Institution X has jurisdiction over both policy issues; that is, collective decisions made according to the rules of institution X produce operational rules governing resource use in both policy issues. But institution Y only has jurisdiction over policy issue 2. Decisions made independently in the two policy games will have various types of payoff and strategy externalities

described later. While Figure 1 displays a simple two-game ecology, in reality there are often many different actors, policy institutions, and policy issues operating simultaneously and at different scales within a single geographically defined system.

Policy issues involve some type of substantive collective action problem, such as water supply, water pollution, air pollution, traffic congestion, or loss of biodiversity in the case of environmental policy. The strategic structure of these collective action problems are the same as in traditional game theory—payoffs from using resources are interdependent, actors often ignore the social costs of their decisions, and equilibrium outcomes (if they exist) are often inefficient. Depending on the nature of the issue, the strategic structure and payoffs of the collective action problem might be represented by a prisoner's dilemma, coordination game, or other type of game with a disjuncture between individual and social preferences. The EG framework adds the complication that issues may be interconnected through biophysical, economic, or social processes, so that policy decisions regarding one issue may directly influence payoffs in other issues.

Policy outcomes depend on how individuals make decisions regarding the use of resources involved with each issue, for example the amount of nonpoint source pollution that flows into a watershed, fish harvested from a fishery, effort invested in maintaining a levee system, etc. While E. Ostrom's (1990) original formulation of the IAD framework typically considered a single focal collective action problem like a fishery or forest, the EG framework features multiple linked collective action problems.

Policy institutions consist of sets of formal rules and informal norms that structure how actors make collective decisions about the "operational" rules governing on-the-ground decisions about particular policy issues, such as appropriation of resources and provision of public goods (Ostrom, 1990). Real-world policy actors often refer to policy institutions as "planning processes" or "policy venues" that shape implementation of specific resource management activities. Each policy institution that exists within an EG provides an opportunity for different actors to interact and make collective decisions, and the resulting policy outputs are germane (have jurisdiction) over some portion of the affected issues.

Policy institutions typically have jurisdiction over multiple issues at a given time, and hence conversely policy issues are linked to multiple institutions. For instance, biodiversity issues in a watershed are simultaneously affected by numerous local planning processes, rulemaking under the Endangered Species Act, the 1972 Clean Water Act, and many other policy institutions. These interconnections increase the likelihood of decisions in one institution affecting decisions in other institutions. The overall set of operational rules governing different policy issues is an output of collective choice within multiple policy institutions.

The idea of policy institutions is linked to Ostrom's perspective on nested institutions at multiple scales, ranging from operational rules governing resource decisions, to collective choice rules, to constitutional rules. At this stage, the EG framework has mostly been applied to the collective-choice level because that is where decisions are made about regional environmental problems like watershed management. Policy institutions at the collective-choice level usually derive

authority from some type of legislative, administrative, or judicial decision made at higher levels of the political system. Since institutions exist at multiple scales, it is important to identify the level of analysis being targeted by a particular study or theoretical model (Brondizio, Ostrom, & Young, 2009). The existence of nested institutions implies that higher level rules, such as macro-political institutions at the country level, will shape the dynamics of the policy ecology at lower levels. Policy actors may also engage in cross-scale strategic behavior in order to reshape institutions at different levels to better pursue their interests.

Policy actors have some interest or "stake" (hence the policy vernacular term "stakeholder") in the outcomes of decisions made in policy institutions and the resulting operational rules governing specific issues. Policy actors could be individual resource users like farmers or fishermen, or political actors like agency officials, interest groups, or elected officials. Many policy actors also make specific resource use decisions, such as appropriation of resource units or provision of public goods, according to their perceptions of the operational rules. The nature and magnitude of the interests may vary across different policy actors—fishermen care about the fish populations and catch limits, bureaucrats care about budgets, politicians care about votes, and interest groups care about members and funding. Actors participate in policy institutions with jurisdiction over issues they care about, and also form networks with others actors in order to gain key political resources like information, credibility, and political influence (Berardo & Scholz, 2010).

Policy systems are geographically defined territories that encompass multiple issues (e.g., flooding, water supply, and biodiversity), multiple institutions (e.g., IRWM, Total Maximum Daily Load programs, and recovery planning for endangered species), and multiple actors (e.g., local, state, and federal government agencies and interest groups). The boundary of a specific policy system is defined primarily by the issues at hand; in environmental policy, these are often ecological boundaries. Any policy institution that has jurisdiction over an issue within a particular geography, or an actor with an interest, is potentially included in the ecology. Actors participating in these institutions constitute the EG at hand in a particular policy system, and each game provides different opportunities for involved actors to acquire resources and achieve their policy goals. Policy systems can be defined at different scales, for example local, regional, statewide, national, and global. The choice of geographical scale determines the scope of inquiry for a particular analysis, but still leaves open the possibility of cross-scale interactions.

The EG that exists in a particular geographical territory constitutes a complex adaptive system that changes over time. Change can be endogenously driven by the actors as they participate in different institutions, try out different strategies, engage in policy learning, and even create and destroy institutions. Change can also be imposed exogenously according to the dynamics of the underlying resources, which may change incrementally or with tipping points. Exogenous change may also come from higher level institutions because the EG that occupies a spatially defined subsystem like a watershed is usually nested in higher level institutions at the state and federal levels (or whatever the relevant terminology would be from other countries).

Contributions to Governance Theory: Assumptions, Conjectures, and General Hypotheses

This section discusses several topics where the EG framework is most likely to make some initial contributions to the scientific analysis of governance systems and policy. The discussion includes some conjectures, assumptions, and broad hypotheses. Ultimately, we believe the EG framework will evolve into a "fertile" theory (Lave & March, 1993) offering many specific and empirically testable hypotheses. Reaching this goal requires more intellectual development and empirical investigations from the growing community of researchers interested in this approach. In this way, the EG framework is no different from the trajectory of other policy theories, where over time the research moves from testing some initial specific hypotheses to testing a broader array of basic assumptions. For example, recent research on the Advocacy Coalition Framework has tested the basic assumption that policy beliefs link together coalitions of actors (Henry, Lubell, & McCoy, 2011), while research in the IAD tradition has empirically tested the idea that monitoring increases cooperation (Coleman, 2009).

Governance: Cooperation, Distribution, and Learning

To solve the collective action problems that are the heart of the underlying policy issues, the EG framework hypothesizes that governance systems involve three fundamental processes: cooperation, distribution, and learning. As with the IAD framework and other institutional approaches, cooperation means shaping behavior in ways that produce more efficient outcomes. Political institutions influence cooperation because the outputs of collective choice are policies that provide incentives, for example by punishing uncooperative or rewarding cooperative behavior. The ability to solve these multiple collective action problems is one measure of the effectiveness of different policy systems.

However, while solving a collective action problem by definition means making efficiency gains (Pareto improvements), there is no requirement for these gains to be distributed equally, as is assumed in many of the canonical two-player game theoretic examples of collective action problems, such as the prisoner's dilemma. In contrast, Snidal (1985; see also Bowles, 2004; Knight, 1992) uses a "graduated prisoner's dilemma" to describe a collective action problem where multiple efficient solutions exist, each of which divides the gains from cooperation in different ways. The EG framework hypothesizes that actors use political power to capture the largest gains from cooperation, for example by forming advocacy coalitions (Sabatier & Jenkins-Smith, 1993) that attempt to influence outcomes across multiple political institutions. These same actors may also try to create or destroy political institutions in order to capture the greatest gains from cooperation.

The EG assumes that in general, actors prefer one of the possible efficient cooperative solutions if the other involved actors will also cooperate. For collective action problems like the prisoner's dilemma, this requires overcoming a short-term temptation to defect. But the EG framework also hypothesizes that some actors may use political power to protect their own interests in ways that are detrimental to the

overall system, for example when a minority faction of actors protects a status quo set of polices in order to avoid a potential loss when the system moves to a more efficient outcome, and the benefits of the majority outweigh the loss to the minority. Or conversely, a powerful minority actor or coalition could seek to change the structure of the system, for instance by creating a new political institution that leads to policies that benefit the actor but decrease the overall efficiency of the system by imposing diffuse costs on others. An important research question is, thus, the conditions under which these more perverse (at least from the efficiency standpoint) uses of political power are prevalent. One hypothesis is that political systems with multiple opportunities to participate in existing institutions, create new ones, or destroy old ones may provide checks and balances that mitigate any one actor becoming a barrier to solving a set of policy issues. This is one argument that may support more open democratic political systems; some designers of the U.S. Constitution, such as James Madison, were clearly concerned about these issues.

But cooperation and distribution cannot occur without learning. Real policy issues feature high levels of uncertainty; problem causes and solutions are not always known, and there are multiple possible solutions within the space of efficient outcomes. A large body of research (Gerlak & Heikkila, 2011; Pahl-Wostl, 2009; Weible, 2008) recognizes the importance of policy learning, but this literature has mostly remained separate from the idea of solving collective action problems. At a minimum, policy learning encompasses learning about new technologies, the underlying biophysical or social processes driving policy problems, the preferences of other involved actors, and different policies that could be implemented to structure resource behavior. Thus, many of the research questions in the policy learning literature, such as the effectiveness of policy learning in different institutional contexts and the role of science in policy, are germane for the EG framework.

Social Tribal Instincts: The Evolutionary Roots of Cooperation

Human decision makers are the actors who undertake these fundamental tasks of learning, cooperation, and distribution; people are the source of "agency" in the EG framework, and institutions themselves do not act on their own volition. To satisfy the assumption of methodological individualism (Schlager & Blomquist, 1995), the EG framework adopts the "social tribal instincts" model of the individual (Richerson & Boyd, 1998, 1999; Richerson & Henrich, 2009) that combines bounded rationality with evolutionary views of human cognition. Individuals are boundedly rational and rely on different decision heuristics to deal with uncertain and dynamic environments. Decisions are made according to the subjective belief systems of individuals (Aoki, 2007), which develop through cognitive information processing. The boundedly rational view of human decision making is a central assumption of the IAD framework.

The social tribal instincts model adds the evolutionary roots of human cognition to the equation, in particular the importance of emotions, instinctual "fast thinking," cooperation, in-group biases, and social learning. Humans have primate brains, and their information-processing strategies are heavily affected by emotions like anger

and fear, and affect-based attitudes like trust are crucial to cooperation. While self-interest is certainly an important driver of human behavior, the emergence of large-scale human cooperation has created a mixed (polymorphic) population consisting of some individuals who are altruistic, others who conditionally cooperate, and a minority who pursue their self-interest regardless of the welfare of others (Kurzban & Houser, 2005). These social instincts developed in the context of small-scale societies that ultimately aggregated into modern nation states. But many of the decision heuristics from small-scale societies still govern decision making. The majority of daily decisions are guided by these "fast thinking" instincts and heuristics, rather than the more calculated analysis envisioned by rational choice theory (Kahneman, 2011).

While institutions must guard against malevolent self-interest, the prospect for cooperation is more optimistic than a strict rational choice approach. However, cooperative behavior tends to occur within "tribal" and in-group boundaries, which is similar to the hypothesis from the Advocacy Coalition Framework that policy actors tend to form ideologically based coalitions that vilify opponents (Sabatier & Jenkins-Smith, 1993). The dynamics of group identity, thus, becomes a core challenge in policy analysis, and coalitions become a source of political power for negotiating over the distribution of resources.

Lastly, humans heavily engage in social learning from others, sometimes conforming to the behavior of the majority, and other times adopting the behavior of the most successful or prestigious individuals. Such social learning influences how individuals make decisions across different games in which they participate, and learn over time about different ways of solving collective action problems. While social learning often produces adaptive behavior, there are also circumstances where maladaptive behaviors can spread through a population (Richerson & Boyd, 2005).

The EG framework assumes that uncertainty is rampant, and individuals make decisions according to limited information and belief systems. This uncertainty is often driven by exogenous dynamic processes that may be nonlinear, complex, and feature punctuations and nonequilibrium dynamics—the policy issues are always shifting. But the uncertainty is also a function of the limited cognitive resources of the actors—they never have complete knowledge of all currently existing and potential future institutions, how decisions made in one institution might affect decisions in others, or the strategies and preferences of other actors. Even within the context of one institution, different actors will perceive different payoffs from playing the game (Aoki, 2007). Hence, policy actors constantly engage in trial-and-error learning, and refine their beliefs about the system over time. Some actors have more comprehensive views than others, but no single actor or set of actors sees the whole picture.

Institutions: Fragmentation, Coordination, and Redundancy

Institutional analysis traditionally defines institutions as the set of formal rules and informal norms that govern decision making, which could apply to collective choice in political institutions or operational rules regarding resource use (Ostrom, 1999). The EG framework uses this same definition, but stresses the fact that

multiple institutions are involved with governing multiple collective action problems, and any single collective action problem could be under the authority of more than one institution (i.e., overlapping jurisdictions). The EG hypothesizes that such fragmentation creates the potential for institutional externalities or spillovers, where decisions made in one institution could have positive or negative consequences for other institutions. Given bounded rationality, stakeholders are often not aware of the existence of other institutions or how decisions made in one context have spillover effects, and thus have minimal capacity to consider the full consequences of their decisions or think about optimizing over a range of policy decisions. This lack of understanding is one source of the classic problem of unintended consequences.

The EG framework hypothesizes the existence of two types of institutional externalities: payoff externalities and strategic externalities (see Figure 1). Payoff externalities occur when a decision made in one institution affects a collective action problem that is in the jurisdiction of another institution. A *direct payoff externality* occurs when two institutions have overlapping jurisdiction over the same policy issue. For example, during the conflict over an arcane federal law called RS2477, there were counties in the western United States where the Bureau of Land Management closed a rural road but a county general plan left it open; road signs declaring the conflicting rules were physically located right next to each other. An *indirect payoff externality* occurs when a decision made in one institution affects a policy issue that is linked via some type of other process (e.g., biophysical) to a policy issue problem in the jurisdiction of another institution. For example, in SF Bay, efforts to protect the habitat of an endangered shorebird (Clapper Rail) increase the costs of eradicating an invasive sea grass. Because many policy issues are interconnected, payoff externalities can have ripple effects throughout an EG.

Second, Bednar and Page (2007) illustrate the idea of *strategy externalities* that occur when a policy actor learns a repertoire of behavioral strategies that are effective in one game, but which are less effective in another game with different incentive structures. However, due to cognitive constraints, it is costly for actors to expand their behavioral repertoire to adjust to a new institutional setting. Thus, actors will not optimize their decision making across the ensemble of institutions in which they participate. Instead, actors will develop a series of simplified heuristics that they use to choose the policy institutions in which they participate, and how to make decisions within policy institutions of different types. Actors with extensive experience in a particular EG will have a more sophisticated set of strategies than more intermittent actors. This basic idea is likely to apply to beliefs (e.g., how many fish are left in this river?) and attitudes (e.g., how trustworthy is a particular type of actor?) as well, which may be acquired in the context of one particular policy institution but misapplied and inadequately adjusted in another.

The potential costs of fragmentation naturally lead to the question of how to achieve coordination in a complex, polycentric system. Long (1958) was pessimistic about coordination: "A great deal of the communities' activities consist of undirected cooperation of particular social structures, each seeking particular goals and, in so doing so, meshing with others" (p. 252). While Long argued that political leadership

and public opinion may provide some more unifying forces, the overall patterns of the complex system emerge from the interactions of the different parts. More optimistically, Long viewed this process as producing largely functional results—"the territorial system is fed and ordered" (p. 254).

Following Scharpf (1997), our version of the EG framework assumes that institutions can serve a coordinating function due to the rules that govern collective decision making. Indeed, the very existence of fragmentation creates an evolutionary niche for institutions that function to ameliorate negative institutional externalities and capitalize on positive ones. This is one hypothesis for the emergence throughout the United States (and many other countries) of the so-called collaborative institutions with the purpose of integrating decisions across many policy actors and issues (Ansell & Gash, 2008; Lubell, Schneider, Scholz, & Mete, 2002). In many policy systems, these collaborative institutions have become central elements of the overall policy ecology. The potential coordinating function of institutions is a saving grace for policy analysis that seeks to provide recommendations about how to "steer" the dynamics of the EG (Klijn, Koppenjan, & Termeer, 1995). If the EG is immune to purposeful intervention, the policy sciences will largely be confined to description and causal analysis rather than applied usefulness.

The EG framework also hypothesizes that not all fragmentation is "bad" from the perspective of system performance, but for reasons different than the polycentric governance literature, which assumes that multiple institutions produce more efficient outcomes when actors are allowed to "vote with their feet" (V. Ostrom, Tiebout, & Warren, 1961). Multiple institutions can provide redundancy in a system (Landau, 1969) because institutions are vulnerable to forces like budget cuts, personnel turnover, and political change at higher levels of the system. Hence, it is not obvious that consolidating all decision-making authority into a single institution is beneficial, despite the common reaction among policymakers that something must be done to reduce the mess. If that single or small set of institutions fails, or makes an incorrect decision, then the whole system could fall apart. Additional benefits of multiple institutions may include specialization in particular governance functions (e.g., research, monitoring, and enforcement; McGinnis, 2011), and providing multiple opportunities for political participation and veto points.

This discussion potentially provides a different perspective on institutions because, instead of looking for a specific efficient policy tool, the question becomes how the overall structure of the political system balances the benefits and costs of institutional complexity. Conceptually, transaction cost theory (Lubell et al., 2002; North, 1990; Williamson, 1985) has some relevance to this question because the overall EG in a particular geographical area defines the benefits and transaction costs of solving the underlying policy issues. The transaction costs of searching, bargaining, monitoring, and enforcement are analogous to the fundamental governance tasks of learning, distribution, and cooperation. Unfortunately, given the bounded rationality of policy actors and analysts, it is naïve to believe that an optimal system could be exogenously designed. Rather, as described in the next section, the system will change through an evolutionary process as different actors create and participate in institutions in order to obtain the greatest gains from cooperation. The role of

policy scientists is, thus, to find ways to structure the system so that institutional evolution solves collective action problems over time.

Complex Adaptive Systems and Institutional Evolution

The EG embraces the idea of complex adaptive systems, which Levin (1998, 2003) defines according to three basic principles rooted in evolutionary theory: diversity and individuality of different components, localized interaction among those components, and an autonomous process that selects a subset of those components for replication and enhancement over time. Complex adaptive systems are inherently dynamic, and their evolution is driven by the results of local interactions among the components.

Any particular EG does include a diverse set of individual components: actors, institutions, and policy issues all interacting over time. The actors have different preferences and political capacity, which are a function their knowledge, access to police power of the state, and physical and financial resources. The policy issues vary in structure and severity, for example public goods problems versus common-pool resources problems, with different levels of under provision or over appropriation, respectively. The policy issues may also feature different levels of uncertainty and complexity driving change over time, such as the population dynamics of a fishery or hydrological variability in river runoff patterns. As emphasized by Ostrom (2005), institutions are diverse both in the rules that structure collective decision making and the operational rules governing resource use.

The localized interactions among these diverse actors, institutions, and policy issues determine the overall pattern of policies and behavior over time. In this way, the EG is a self-organizing system because no single institution or actor has the capacity to direct all the local interactions. However, as discussed earlier, some institutions may serve to organize larger portions of the system. Levin describes the emergence of such hierarchical organization as a natural consequence of local interaction; the resulting structure constrains interactions over time leading to path dependence. The decisions of actors are the driving force of interactions in the EG because actors participate in, create, and dismantle institutions as they seek to gain benefits from solving different policy issues.

Change over time is shaped by the process that selects a subset of components for replication and enhancement; in biological evolution, this is natural selection based on fitness. The analogous idea in the EG is that the survival of institutions depends on political support from actors. Hence, institutions that are more effective at solving collective action problems and distributing resources in a manner perceived to be fair by enough powerful policy actors are more likely to survive. Institutions will be perceived to be unfair when the process of decision making does not adequately incorporate the viewpoints of particular actors (Lind & Tyler, 1988), or when the benefits of policy decisions are not distributed with some positive correlation to contributions. When an actor believes an institution is not providing fair benefits, that actor will attempt to destroy the institution, or move to another institution, or create a new institution.

A crucial question is whether this evolutionary process is adaptive in the sense of solving more policy issues and moving the overall system to a more efficient outcome over time; the ability of a system to find higher peaks on a fitness landscape is a key attribute of "adaptive capacity." Democratic institutions may offer some benefits in this respect by providing multiple opportunities to reshape institutions; institutions are unlikely to survive very long if they incur costs on a set of actors with enough political power to change the policies. As mentioned earlier, democratic institutions also provide multiple veto points to guard against institutional changes that benefit a minority of actors at the expense of the broader system performance. In theory, some type of equilibrium distribution of institutions and participation could emerge if the system stabilizes on a single fitness peak. The overall fitness of a system is analogous to the net benefits of an institutional arrangement, which is equal to the benefits of solving collective action problems minus transaction costs. Hence, *ceteris paribus*, institutional arrangements that reduce transaction costs will increase the fitness of the system.

However, such an equilibrium is unlikely if there is exogenous change in the underlying resources that are causing collective action problems (e.g., climate change), or the higher level institutions (e.g., turnover in presidential administrations) that shape a particular EG at a lower scale. Such dynamic change is always occurring through exogenous natural or social forces; the changes are difficult to predict (Black Swans) and sometimes dramatic. Hence, efficiency is probably not the best criteria to judge any particular EG; it is better to think about the resilience (Gunderson, 2000), robustness (Anderies, Janssen, & Ostrom, 2004), and adaptive capacity (Smit & Wandel, 2006) of the EG such that it can adjust to the changing environment and continue to provide sufficient resources (i.e., solutions to collective action problems) over time.

Illustrative Analytical Approaches and Specific Hypothesis Tests

This section summarizes some analytical approaches and initial empirical research that have been useful for testing specific hypotheses consistent with the more abstract discussion above. One common thread among these analytical approaches is that they all include some ideas from complex adaptive systems, where individual and system outcomes are a product of interdependent interactions among elements of the system. Another theme is that most of the hypotheses currently focus on how actors choose to participate in different institutions, and the behaviors and attitudes of those actors within the institutions.

Interaction Effects

Interaction effects in general linear models can represent the interdependence among multiple institutions and the possibility of negative or positive institutional externalities. Interaction effects are interpreted as the influence of one variable being

conditional on the level of some other variable, with the strength of the influence represented by a model parameter (e.g., partial slope coefficient in a regression model).

In the context of collaborative land use and transportation planning in California, Lubell et al. (2010) test the hypothesis that how participation in a collaborative institution influences an actor's behavior or attitudes is conditional on participation in other institutions. One argument is that participation in collaborative institutions may increase cooperation in other institutions, for example by providing a mechanism for building social capital that spills over into other institutions. However, an alternative hypothesis is that participation in a collaborative institution could reduce cooperation in other institutions, for example if there is budget constraint on the overall capacity of any particular actor to cooperate in multiple games.

Using survey data from policy stakeholders in California, the paper finds strong negative interaction effects between participation in collaborative institutions and participation in traditional land use and transportation institutions. Participation in a collaborative institution decreases the influence of participation in more traditional institutions on cooperative implementation activities, and also attitudes of fairness and policy satisfaction. This surprising finding highlights the usefulness of the EG framework in terms of challenging existing understanding by considering the simultaneous operation of multiple institutions. Furthermore, it points out that despite the potential coordinating role of collaborative institutions, not all of them are equally effective (Figure 2).

Agent-Based Computational Models

Agent-based computational models are a useful formal approach for analyzing the EG framework. Agent-based models rely on simple behavioral rules to characterize actors' decisions to participate in different institutions, the strategies they use when making decisions within an institution, and potentially connecting the political behavior to their decisions regarding the policy issues. Like game theory, the payoffs are determined by the aggregation of different actors' decisions, but no single actor needs a comprehensive understanding of the parameters in the entire system. Of course, as with any formal approach, the dynamics of agent-based models are a function of how behavioral rules and institutions are specifically operationalized.

Some agent-based models incorporate ideas from evolutionary game theory, which is another formal mathematical approach that could be usefully applied to the EG framework. Unlike classical game theory, evolutionary models do not require agents to optimize best response strategies for all institutions and policy actors. Rather, behavior can be modeled as emerging from trial-and-error learning, hindsight instead of foresight, heuristics, and the use of social instincts. The probability of a strategy surviving over time is proportional to its relative payoff in the population, and thus better strategies will often (but not always) spread through a population.

Smaldino and Lubell (2011) use an agent-based model approach to analyze how levels of cooperation are affected by institutional rules and actor characteristics

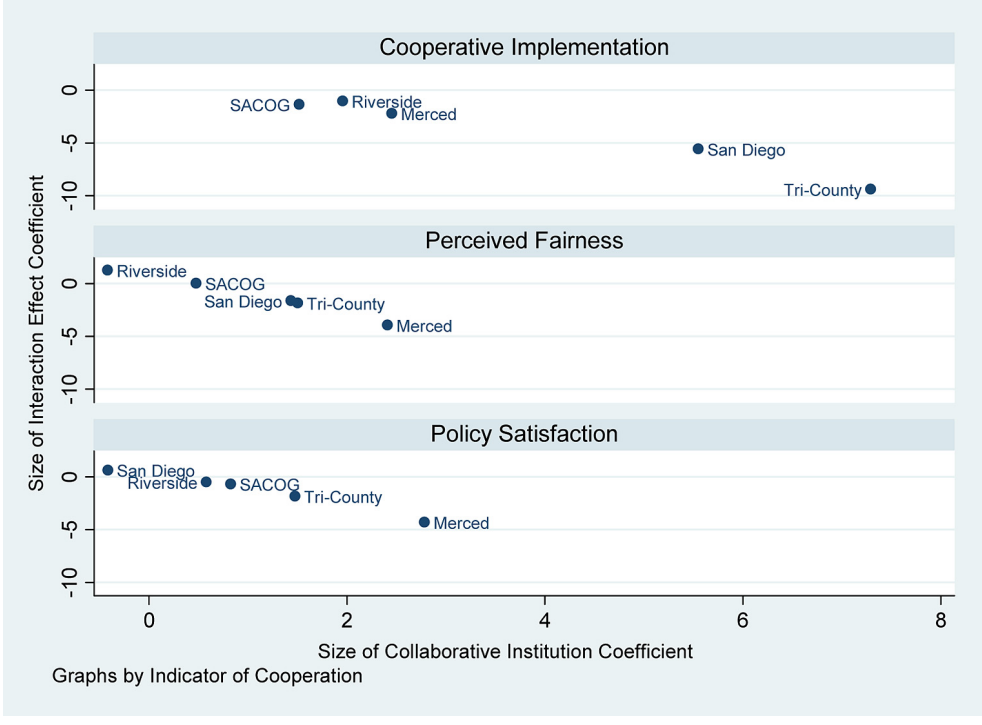

Figure 2. Size of Interaction Effect as Function of Collaborative Process Coefficient.
Note: Data come from a survey of stakeholders in five collaborative land use and transportation planning processes in California. Regression models are estimated with three dependent variables (cooperative implementation, perceived fairness, and policy satisfaction), with key independent variables participation in traditional land use planning institutions, participation in the collaborative institution, and an interaction term between the two types of participation. The figure shows how the interaction term becomes more negative as the effect of collaborative institutions becomes more positive.

related to participating in different policy games. The model represents the EG as a collection of public goods games where players choose to cooperate or defect in each game, and then may choose to join or leave games based on relative payoffs (see Figure 3). The model compares a "capacity constraint" institution that limits the total number of actors who can participate in a game, to a "budget constraint" where actors can only participate in a limited number of games. The model results suggest that capacity constraints are more effective than budget constraints because cooperators tend to flee low-payoff games more quickly, and then reach the capacity constraints of a limited set of games. The defectors then cannot enter the cooperator games, which limits their ability to gain the higher free-riding payoff. While budget constraints limit the total number of games, they do not prevent defecting actors from joining games and taking advantage of cooperators.

The key to promoting cooperation in this model is the clustering or "positive assortment" of cooperators such that the probability of cooperative strategies participating in the same game is higher than the base rate of cooperative strategies in the overall population. Institutional and behavioral rules that accelerate this

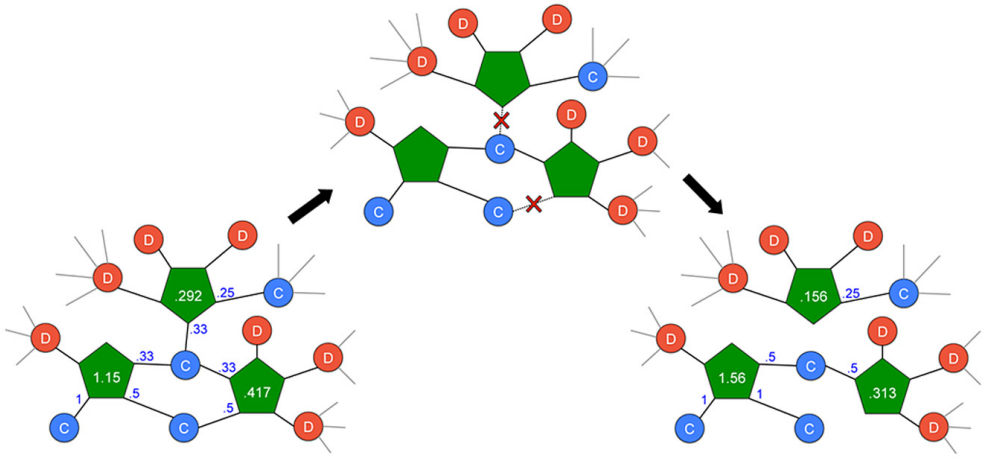

Figure 3. An Agent-Based Model of the Ecology of Games.
Note: Player contributions (cooperators only) to each game are indicated in blue at the end of the links connecting players to games, with a public good production function of r = 2.5. Each public goods game (green pentagons) pays out π_j to each of its players, as indicated in white. Players may then attempt to join or leave games. Cooperator-heavy games are much more stable. For illustrative convenience, in this example, none of the agents shown join a new game, and all agents are allowed to leave the games which are shown. For the individuals playing games not shown in the figure (gray links), it is assumed that either those agents were not chosen to attempt to join or leave this turn, or that they were unable to join any new games and that their offscreen games all yielded payouts greater than their contributions.

clustering, thus, will be more effective. This theoretical principle is not new; it was highlighted by Axelrod (1984) in his pioneering analysis of the evolution of cooperation, although his analysis focused on single well-mixed populations instead of multiple games. Capacity constraints are not the only institutional rule that can promote positive assortment; a more recent version of the model uses reputation-based gatekeeping to produce a similar result (Smaldino & Lubell, 2013).

The positive assortment result produces a counterintuitive hypothesis for field research in public policy. For example, collaborative institutions are theorized to promote cooperation by relying on some norm of inclusiveness, which requires inviting all affected stakeholders to participate in policy decisions. According to the model, this is a risky approach because it may allow noncooperative strategies into the mix of games, and thereby reduce the overall evolution of cooperation. And although the model does not explicitly include learning, it is possible that there is a trade-off among cooperation, distribution, and learning if bringing in a more diverse set of actors promotes learning through idea exchange (Hong & Page, 2004), but increases the heterogeneity of preferences.

Although we know of no empirical field research explicitly designed to test the clustering hypothesis, there is ample anecdotal evidence that it does occur. For example, many practitioners of collaborative approaches note the importance of carefully selecting participants and focusing on actors who can "play well with others." They often observe that collaborative institutions are derailed by extreme interests from different sides of a debate, who are incapable or unwilling to listen to

and compromise with other actors. Hence, despite the inclusiveness of collaborative institutions, mechanisms for clustering are likely present in real-world EG systems.

Network Science

Network theory and analysis has recently emerged as an important tool in the policy sciences (Lubell, Scholz, Berardo, & Robins, 2012), and has attributes that make it well suited to studying the EG framework (Cornwell, Curry, & Schwirian, 2003). Importantly, network science recognizes the complex interdependency that is inherent in the EG framework, not only in terms of single actors being related to many other actors or participating in multiple institutions, but also that different structural properties of an entire network may influence the behavior of any given individual. The broader field of network science embraces the ideas of complex adaptive systems, with many interesting models of how such systems change over time, often in surprising ways.

Bipartite networks, where connections are formed between actors and institutions, are one way to usefully represent the EG framework and test some initial hypotheses about the structure of the system. Lubell et al. (2011) study water management in the SF Bay, and use policy stakeholder surveys to identify the range of different actors participating in over 100 different water management institutions. Figures 4a (full network) and 4b (most central nodes) show the resulting bipartite network, where red circles represent actors, and blue squares represent institutions, with the size of the shapes scaled in proportion to the "degree" centrality of the nodes.

The analysis tests three hypotheses about the structure of the network related to what types of actors and institutions are more likely to function as coordinating elements of the system, and what types of network structures are more likely to evolve if the system is facing a series of linked collective action problems. Specifically, they hypothesize that state and federal government agencies are the actors with the most capacity to coordinate policy decisions, while collaborative institutions are designed to integrate across multiple actors and problems. In addition, more "closed" network structures are expected to evolve in the network in order to solve cooperation problems, while more "open" network structures will solve coordination problems (Berardo & Scholz, 2010). Figure 5 presents some descriptive network statistics on the centrality of different types of actors and institutions; the results are consistent with the hypotheses about the coordinating roles of state and federal agencies, and collaborative institutions. Statistical analysis using exponential random graph models shows that these actors and institutions have a significantly higher level of centrality in the network, and are more associated with closed network structures. The growing availability of statistical models of networks is another major advantage of network science for studying the EG framework (Lusher, Koskinen, & Robins, 2013).

There are significant limits to the above analysis that must receive future research attention. In particular, the analysis focuses mostly on the structure of the EG, not the function. This assumes that structural analysis is a necessary precursor to

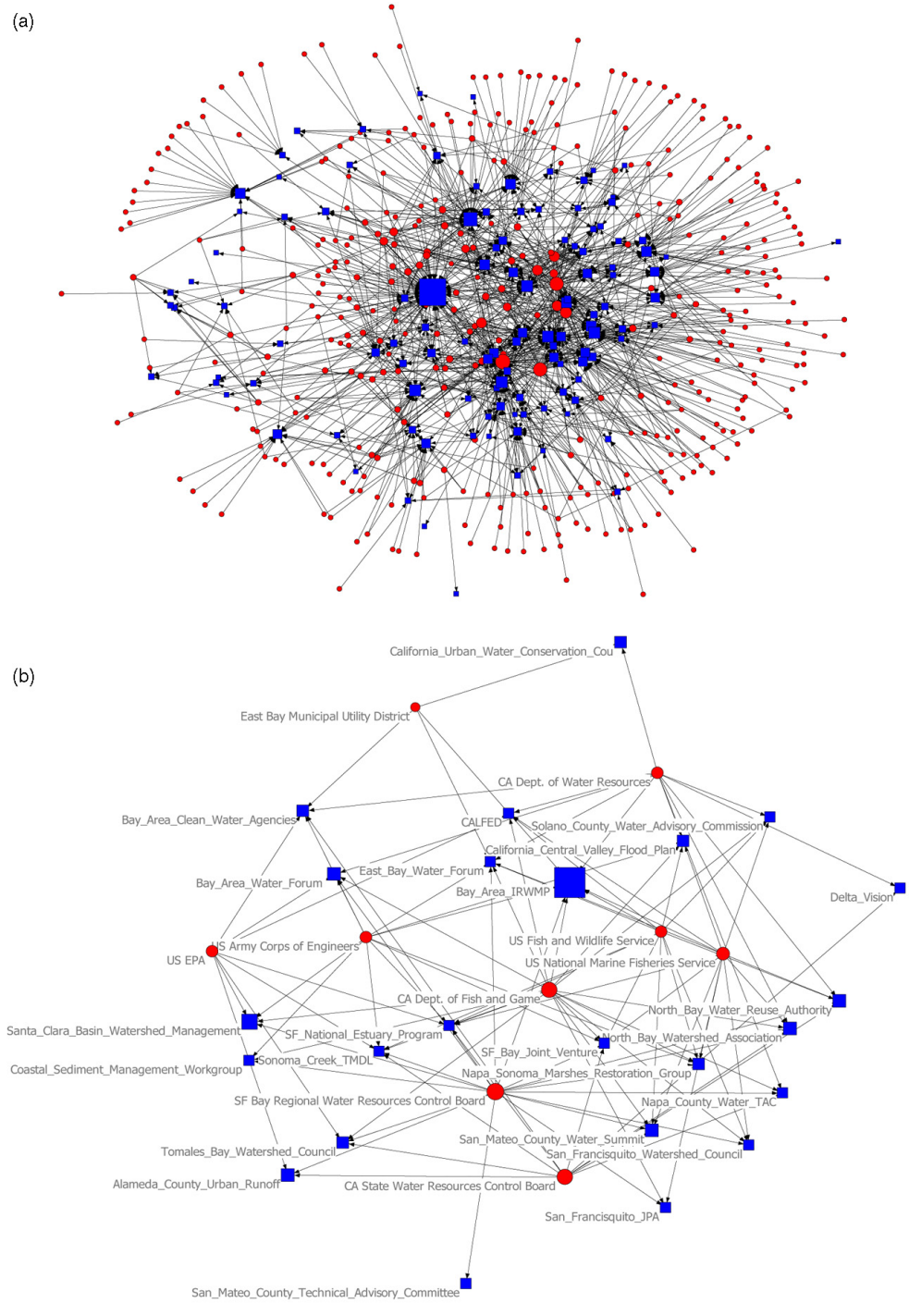

Figure 4. (a) Bipartite Network for the Bay Area Ecology of Games. (b) Most Central Actors and Institutions in the Bay Area Ecology of Games.

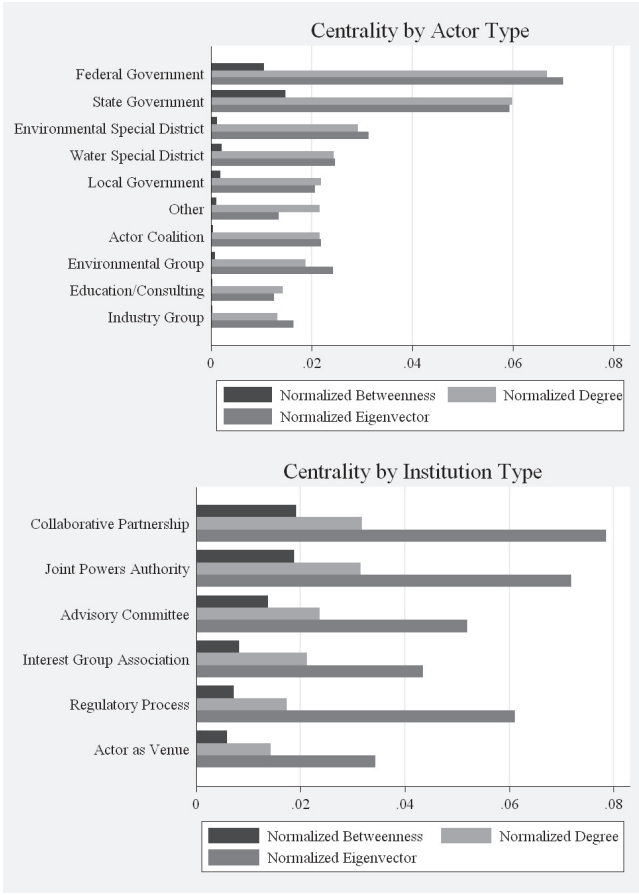

Figure 5. Centrality by Actor and Institution Type.

Note: Data for Figures 4 and 5 are from an Internet/telephone survey of San Francisco Bay water management stakeholders administered in April/May 2008. A total of 167 responses were received (157 via Internet, 10 via telephone) for a response rate of 50.8 percent. Each respondent identified up to three policy institutions (blue squares in Figure 4) in which they participated, and the set of actors they collaborated with in each policy institution (red circles in Figure 4).

understanding function. However, even the structural analysis provides some clues about function since closed network structures are hypothesized to be better for solving cooperation problems. Another limitation is that the analysis focuses on only one point in time, but some of the most interesting hypotheses about the EG framework are explicitly dynamic and evolutionary. For example, dynamic data are required to test the hypothesis that institutions are more likely to survive over time if they are perceived as effective and fair by enough powerful actors.

Conclusion: Toward a New Theory of the Policy Process?

The EG framework's most important contribution is recognizing the necessity of analyzing multiple policy institutions at the same time, where governance is viewed

as a complex adaptive system. This is the reality of governance faced every day by real-world policy actors as they attempt to make strategic policy decisions. Policy theorists and analysts have a responsibility to adequately understand this complex reality to further basic scientific knowledge about human society and also provide recommendations to policy stakeholders that help them achieve their goals.

The minimal contribution of the EG framework is to extend the idea of polycentric governance, offering a range of new hypotheses and insights about governance systems. However, the EG framework is a synthetic approach that integrates some of the best ideas from a number of different policy, social science, and systems theories. Hence, the EG framework has the potential to develop into a broader policy process framework that offers an alternative to some of the existing approaches. There is an important epistemological question of whether it is useful to pursue this route; do we really need another policy process framework or should we view the EG framework as an investment and fleshing out of the IAD approach? Regardless of the answer to this question, it is valuable to further refine the theory, crystallize the abstract concepts and definitions presented in this paper into more concrete and testable hypotheses, empirically test those hypotheses, and make the results useful to decision makers.

While this paper provides an initial attempt to assemble all the ideas of the EG framework into some semblance of a coherent logic, the other papers and publications to date have focused on more specific and narrow research questions and hypotheses (Dutton, 1995). These types of narrow investigations must continue in order to provide insights and empirical findings that can further inform the development of the broader enterprise. The overall idea should be pursued by multiple researchers, in different policy settings, with an eye toward comparative analysis. At the same time, concepts would benefit from more formal approaches, such as agent-based models, evolutionary game theory, or classical game theory.

Feedback and criticism from the broader community of policy scientists is also crucial for further development. Constructive advice is needed on how to better refine and flesh out these ideas. Reviews of the emerging empirical research using the EG framework will hopefully recognize stepping-stone contributions toward the longer road of theory development. Expecting some of this initial research to test a full-blown theory is overly optimistic, and has not occurred for any of the other existing policy theories where empirical testing takes a piecemeal approach by focusing on specific hypotheses embedded within a broader framework, and using the results from the empirical studies to further hone the theory.

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