

## The Impact of Forum Interdependence and Network Structure on Actor Performance in Complex Governance Systems

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*One of the main assumptions of the Ecology of Games Framework (EGF) is that governance processes are heavily affected by the interactions among policy actors that take place in multiple decision-making forums, which often function interdependently. In this article, we use data collected in the Tampa Bay and California Delta water governance systems to examine how “biophysical interdependence”—the extent to which forums deal with interconnected policy problems—impacts the costs that actors face when they participate in forums, which in turn can affect their performance in them. Furthermore, we examine how the individual information exchange networks that actors have (i.e., their ego-networks) can mediate the previous relationship. We find that actors with networks that have more closure are better able to mitigate the costs associated with participating in biophysically interdependent forums, thus leading to better in-forum performance. Our findings shed new light on the relationship between structure and function in complex ecologies of games.*

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**KEY WORDS:** ecology of games, institutional externalities, forums, network closure

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政策决策论坛常常相互依存地发挥作用，政策行为者会在多个这样的论坛中进行互动，而治理过程会在很大程度上受到这些互动的影 响，上述理论是生态博弈框架 (EGF) 的主要假设之一。在本文中，我们从坦帕湾和加利福尼亚三角洲水治理系统中收集数据，并利用这些数据来研究“生物物理相互依存性”，即论坛对相互关联的政策问题的讨论程度，如何影响参与者在参与论坛时所面临的成本，而这些成本反过来又会如何影响他们在论坛中的表现。除此之外，我们还研究了行为者所拥有的个人信息交换网络 (即以他们自己为中心的自我网络) 如何影响他们之前所拥有的关系。我们发现，拥有更多闭合网络的行为者能够更好地降低成本——这些成本是与参加“生物物理相互依存性”论坛所相关的——进而提升他们在论坛中的表现。我们的研究结果揭示了复杂的生态博弈中结构与功能之间的关系。

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Public policy is often the result of complex decision-making processes that are shaped by policy actors who can participate in a variety of (more or less) interdependent forums, which serve as arenas of interaction for the exchange of ideas about how to address policy problems (Berardo & Lubell, 2019; Fischer & Leifeld, 2015). While forum interdependence can be conceived of in multiple ways, recent Ecology of Games Framework (EGF) research has predominately focused on understanding

the role of “biophysical linkages,” which are a common feature of complex governance systems (Lubell, 2013; Lubell, Henry, & McCoy, 2010). Two forums are considered biophysically linked when the state of the policy problem addressed in one forum is dependent on the state of the policy problem addressed in another forum (Mewhirter, Lubell, & Berardo, 2018). For example, one forum might deal with decisions about how to manage effluent levels in a given river while a second forum might be charged with reducing pollution levels in the bay where that river flows. In this example, decisions made in the former forum may have a crucial effect on the severity of the problem discussed in the latter forum.

When two forums are biophysically linked, the decisions made in one forum may impact how the second forum operates: a phenomenon referred to as “institutional externalities” (Lubell, 2013). Such externalities can strongly affect the performance of individual actors because they can alter the costs of participating in forum activities (Mewhirter, Coleman, & Berardo, 2017). Forum participation costs include, but are not limited to, the costs associated with learning about forum-specific policy problems, identifying and devising policy alternatives that match an actor’s agenda, as well as learning about the interests of (and bargaining with) other forum participants. Actors that face lower participation costs will exhibit greater performance.

In this article, we posit that biophysical interdependence between forums can affect the magnitude by which different types of participation costs impact actor performance. We argue that actors that participate in biophysically linked forums face relatively low costs when learning about forum-specific problems because the resources spent learning about the policy problem in one forum may also provide useful information to deal with problems in linked forums. Conversely, actors participating in forums that are not biophysically linked must invest considerable resources learning about the different policy problems that the forums in which they participate deal with. In other words, participating in nonlinked forums requires actors to access a greater breadth of information to succeed in pursuing their individual goals when attending forums (relative to actors who participate in interdependent forums).

Participating in biophysically linked forums, however, drives up the costs associated with devising policy solutions that maximize the individual benefits. When considering how to craft solutions to problems in a given forum, these actors must consider (i) how potential outputs impact their forum-specific payoffs, (ii) whether outputs will generate institutional externalities, and (iii) whether/how externalities will impact their interests in other forums. Thus, actors must devise “integrated” solutions that suit their interests within multiple linked forums. Doing so requires actors to have a deep understanding of the specific policy problems that they deal with as well as the intricacies related to the interactions between those problems. Actors that participate in non-linked forums, however, only have to consider how policy alternatives impact their interests in the individual forums in which they participate without paying attention to the institutional externalities: a considerably less complicated task.

We argue that it is important for actors to develop strategies that allow them to mitigate the participation costs that pose the greatest threat to their success.

Consistent with past EGF research, we claim that actors can realize this goal by building networks of information exchange with other actors in the governance system (Berardo, 2014b; Berardo & Scholz, 2010; Jasny & Lubell, 2015; Lubell, Robins, & Wang, 2014; McAllister, McCrea, & Lubell, 2014). We claim that actors that participate across interdependent forums most readily benefit from having ego-networks characterized by high levels of closure, in which the actor's contacts (the "alters") are more likely to interact with one another, providing access to overlapping information regarding a small subset of topics relevant to the ego. Given that actors participating in biophysically linked forums require access to a depth of localized information and that closed ego-networks provide this, we expect that increases in ego-network closure will be associated with greater forum performance for those participating in linked forums. Alternatively, actors who participate in forums that are mostly independent from one another would likely benefit from ego-networks where closure is lower (i.e., in which the alters have no or few ties to each other). These more open ego-networks provide a wider breadth of information and expertise about a greater range of problems (Scholz, Berardo, & Kile, 2008), and thus actors embedded in them should be better prepared to deal with the unique challenges that are encountered in forums that are not linked with each other.

We use survey data collected from forum participants in the Tampa Bay and California Delta water governance systems to test our hypotheses. To construct our measure for ego-network closure, we rely on the respondents' perceptions about the structure of their ego-networks. This measure is less precise than what would result from an alternative measure built from perfectly collected sociometric data, but it allows us the ability to avoid potential biases caused by improper network boundary specification and missing data that are common in studies with a large number of respondents (Kossinets, 2006). As our current data preclude us from measuring forum interdependence directly, we rely on a proxy: the geographic proximity of forums. We believe that geographic proximity serves as a viable proxy as policy problems that are closer in distance are more likely to be biophysically linked. Utilizing a series of cross-nested regression models, we find support for our hypotheses.

### **Forum Interdependence in an Ecology of Policy Games**

Individual forums function as venues where relevant policy actors (e.g., representatives of federal, state, and local agencies, NGOs, businesses, universities) can discuss policy problems that impact their mutual interests and devise solutions (Berardo & Lubell, 2019; Fischer & Maag, 2019). Forums in a governance system vary widely in terms of the number and types of problems that they address. Forums also vary with regard to the enforceability of outputs as well as the institutions that govern actor interactions (Fischer & Leifeld, 2015): some forums may rely on informal norms and pass nonbinding resolutions, whereas others may have codified procedures and enact legally binding policies. Although in some cases forum participants may be incentivized to reach mutually beneficial agreements, actors have unique preferences that they pursue in negotiations (Choi & Robertson, 2014; Scott & Thomas, 2017). Those actors that yield greater levels of influence are better able

to steer deliberations, ultimately allowing them to shape outputs in a manner that reflects their interests (Lubell et al., 2017; Mewhirter et al., 2017).

While past research tends to focus on how endogenous forum features (heterogeneity of actors, rule-making procedures, the issues addressed, etc.) impact forum decision making (see Fischer and Leifeld [2015] for a summary of the literature), recent EGF research contends that forums are often biophysically linked, which can give rise to institutional externalities (Lubell, 2013; Lubell et al., 2014; Mewhirter et al., 2017, 2018). Such externalities can drive up or drive down the costs associated with participating in the externality receiving forum, thus impacting an actor's performance in it (either negatively or positively).

For instance, Mewhirter et al. (2018) find that biophysical linkages are common in the Tampa Bay and California Delta water governance systems (most forums are linked to multiple other forums; few operate in complete isolation) and that such linkages tend to give way to negative externalities. In the California Delta, for example, a collaborative effort to remove invasive cordgrass in the San Francisco Bay resulted in a 50 percent decrease in the population of the endangered Ridgeway Rail, a seabird that uses the cordgrass for nesting (Lampert, Hastings, Grosholz, Jardine, & Sanchirico, 2014). Here, the outputs of one forum impacted the state of the policy problem (Ridgeway Rail population) of concern to other, mainly biodiversity focused, forums in the region, forcing participants to update protection strategies.

### **Forum Interdependence, Participation Costs, and Actor Performance**

While forums allow actors to pursue their policy agendas, successful forum participation requires actors to invest significant time and effort (i) learning about the problems addressed in the forums, (ii) investigating and potentially aiding in the design of various policy alternatives, (iii) learning about the interests and policy views of other participants, (iv) negotiating with others to craft policy outputs, and (v) implementing and enforcing agreements (Mewhirter et al., 2017). Actors that face lower costs will be better able maximize their gains from participating in such forums (Lubell, Mewhirter, Berardo, & Scholz, 2017). The extent to which forum outputs align with an actor's preferences serves as a good gauge for "actor performance" in the forum, with greater alignment indicating better performance.<sup>1</sup>

Regardless of the type and variety of problems that a forum addresses, the biophysical interdependence of forums affects the magnitude of costs for actors that participate in them.<sup>2</sup> For actors that participate in interdependent forums, the participation costs associated with learning about policy problems should be relatively low. Consider, for instance, the decision-making procedures and deliberations within a hypothetical forum where participants aim to improve water quality in a watershed with extensive agricultural production. To achieve this overall goal, participants would benefit from knowing how many farms operate in the watershed, what crops they harvest and how often they rotate them, the topographic features of the agricultural land, etc. Actors that participate in this forum could take what they learn in it, and apply it to other forums in which they participate to address different, linked problems. For instance, a participant in the aforementioned forum might

find the information that they gained to be of value in an alternative, biophysically linked forum focusing on promoting the adoption of best management practices for soil protection among farmers (operating in the same area).

On the other hand, actors that participate in non-linked forums will find that learning is not readily transferable. For example, the lessons learned about water quality in the first forum will not be easily applicable to a forum located in a different watershed where actors are mostly concerned with mitigating the negative effects of climate change on migrating bird species. In short, actors that participate in independent forums are forced to acquire a breadth of diverse information regarding forum-specific problems, which will drive up the costs of participation.

While participating in interdependent forums reduces the participation costs associated with learning about policy problems, it may increase the costs associated with investigating and devising policy solutions that reflect the actor's interests. Here, actors who participate in forums that are biophysically linked need not only concern themselves with how outputs affect their forum-specific performance, but must also consider how such outputs affect their interests in related forums. In other words, when considering which policy output to support, actors must understand how their forum-specific interests are affected by them, but also how they might produce externalities that impact their performance in linked forums. Actors must then devise forum-specific strategies that both promote their interests within the said forum and help (or at least do not harm) their interests in linked forums (Mewhirter et al., 2018). Effectively developing integrated strategies across forums is not an easy task, as it requires actors to draw on intimate knowledge of each policy problem as well as maintaining an understanding of the relationship between them. In other words, these actors require a tremendous depth of highly localized information.

Consider again the case of the invasive sea grass removal forum in the San Francisco Bay that we described in an earlier section. If a member of that forum has an agenda that pursues both removal of invasive species and protection of biodiversity, then failing to anticipate the potential negative externalities from sea grass removal on Ridgeway Rail populations could run counter to the actor's interests. In such situations, actors need to spend considerably more resources trying to devise solutions to problems in ways that do not hinder their individual agendas.

Conversely, actors who participate in independent forums may not face this problem as the decisions made in one forum will not impact what occurs in the next. As such, these actors need only concern themselves with devising policy alternatives that align with their forum-specific interests.

### **Mitigating Participation Costs Through Networks**

We have argued that the magnitude of participation costs that affect actor performance can be explained by the level of interdependence between the forums in which an actor participates, but previous research shows that actors can offset the direct costs of forum participation when they develop networks of communication and information exchange with other actors (Berardo, 2014b; Berardo & Lubell, 2016; Shrestha, 2013). Findings show, for example, that the level of closure on ego-networks

may help solve cooperation problems, while more open structures may facilitate the solution to coordination problems (Berardo, 2014b; Berardo & Scholz, 2010; Bodin, 2017; McAllister, Taylor, & Harmon, 2015; Meek, 2013).

Closed ego-networks (where nodes tied to ego have ties linking them to each other) tend to arise when actors share common interests, operate in proximate geographic areas, and/or possess similar organizational resources and information that is deemed of value for the group (Coleman, 1990; Fischer et al., 2014; Lubell et al., 2014; McPherson, Smith-Lovin, & Cook, 2001). Actors in closed networks are more likely to share common goals and work in concert to achieve them (Berardo, 2014b), which promotes more efficient bargaining and improved communication (Berardo & Scholz, 2010). Yet a potential disadvantage of closed networks is that actors are more likely to be insulated from members outside of the subgroup (Berardo & Scholz, 2010; Burt, 1992, 2002; Ingold & Leifeld, 2014), limiting the breadth of information that comes from participating in more open networks that give access to nonredundant communication sources (Bodin & Crona, 2009; Lin, 1999; Reagans & McEvily, 2003; Scholz et al., 2008).

#### *Interdependent Forums and Network Closure*

We argued previously that actors may face increased participation costs to investigate and design responses to problems when participating in forums that are biophysically linked because they must understand how different alternatives can create externalities that could negatively impact their interests in linked forums. If actors lack the adequate depth of information to do so, their performance across forums will decline. Having ego-networks with a higher degree of closure may help actors overcome this information hurdle, simply because it is more likely that, in such networks, actors can access a greater wealth of overlapping information that could be more useful to address issues that are more localized from a spatial standpoint (Breschi & Lissoni, 2009; Singh, 2005). By working closely with other actors who have worked in close proximity with who often share common “interests, concerns, or pressures” (Lubell et al., 2014, p. 23), actors may be readily able to acquire the depth of the localized policy knowledge and information necessary to develop integrated solutions. This logic leads us to the following hypothesis.

*Hypothesis 1: When participating in interdependent forums, actors with ego-networks characterized by higher levels of closure will exhibit higher performance.*

#### *Independent Forums and Open Networks*

When participating in forums that are not biophysically linked, actors face increased costs associated with learning about forum-specific problems (as the lessons learned in one forum do not apply to others). As such, actors that participate across disconnected forums require access to a greater breadth of information in order to

succeed in forum deliberations. Rather than forming closed network structures that provide a glut of localized information, actors participating in independent forums will be better served by the new, nonoverlapping information that is more likely to flow in more open networks (Berardo & Scholz, 2010; Lubell et al., 2014). In doing so, such actors will reduce the costs associated with forum participation, leading to increased performance.

*Hypothesis 2: When participating in independent forums, actors with ego-networks characterized by lower levels of closure will exhibit higher performance.*

## Research Design

We test these hypotheses with data collected in the Tampa Bay (FL) and California Delta (CA) water governance systems. These are examples of complex governance systems where policy decisions are shaped by a variety of (more or less interdependent) policy forums. For the purposes of our research, the Tampa Bay water governance system (hereafter, Tampa Bay) is geographically bounded by the jurisdictional limits of the Southwest Florida Water Management District (SWFWMD, henceforth “the District”), which extends through 16 counties encompassing an area of nearly 10,000 square miles and serving a population of 4.7 million (Berardo & Lubell, 2016). The District was founded in 1961 as a flood control agency, but its institutional structure has significantly expanded. Currently, forums in the region address a wide range of issues, including but not limited to, water supply and quality, biodiversity protection, climate change adaptation, and flood control (<http://swfwmd.state.fl.us/about>). The California Delta (hereafter, CA Delta), on the other hand, is a highly decentralized system where local, state, and federal agencies have historically engaged in costly litigation with private users and each other. The CA Delta is a vulnerable source of water for northern and southern California, and is the scene of animated debates over how to allocate scarce resources among competing uses (Madani & Lund, 2011).

### *Survey*

In order to test our hypotheses, we use online survey data collected from the forum participants in both of the research sites. The survey was administered from November 2010 to February 2011 by the Indiana Center for Survey Research. The list of potential participants was developed through web and media-based searches identifying all forums in the research areas that dealt with water-related issues (even if water management was not the sole or even primary function of the forum). Only actors that had participated in forum activities in the previous year were considered. A snowball sample was also collected from the original set of respondents identified in the original search.

In Tampa Bay, the web and media-based searches yielded a total of 1,037 possible respondents. Of those, 338 participated in the survey (32.60 percent), 31 refused (2.99 percent), 97 indicated that they had not participated in a forum in the 12 months before answering the survey (9.35 percent; these respondents were not asked to take the survey), and 571 did not respond (55.06 percent). In the CA Delta, a total of 1,396 possible participants were identified. Of those, 354 completed the survey (25.36 percent), 42 refused (3.01 percent), 194 respondents indicated that they had not participated in a forum in the previous year (13.90 percent), and 806 did not respond (57.74 percent).

The survey participants were asked to “fill in the names of the forums in the (Tampa Bay | California Delta) region with which (you have | your primary organization has) been actively involved in the past year.” The respondents were able to list up to 15 forums: respondents in Tampa Bay listed anywhere from 1 to 7 forums; respondents from the CA Delta listed anywhere from 1 to 12 forums. Actors were then asked a series of questions regarding (i) *each forum* that they listed, (ii) their organization, and (iii) individual demographic variables. The data allow us to test whether a respondent’s evaluation of each forum in which they participate is impacted by the interdependence that exists between those forums and the level of closure in their ego-networks.

Two datasets (one for each site) are used to test the hypotheses. The unit of analysis in each dataset is the actor–forum dyad. There are multiple observations for each actor (contingent on how many forums the actor claimed to have participated in) and multiple observations per forum (contingent on how many actors claimed to have participated in the same forum). It should be noted that while some actors in the system participate on their own behalf in forum proceedings, the vast majority of the respondents serve as organizational representatives. There are many different types of organizations represented in these complex governance systems, including: government agencies (federal, state, regional, and local), water infrastructure special districts, environmental special districts (like a park district, or open-space district), environmental groups, trade/business/industry groups, homeowner associations, education/research, multi-stakeholder coalitions, and agricultural groups.

### *Dependent Variable*

Our dependent variable is *Actor Performance*. As a variable indicator, we use the extent to which an actor believes that their interests have been served *in each forum in which they participated*. The respondents answer the following question: “Overall, have the activities that took place in the forum during the past year had a major negative impact, no net impact, or a major positive impact on (your | your organization’s) interests?” The variable is measured on a 0–10 scale where a score of 0 equals a “major negative impact,” 5 equals “no impact,” and 10 equals a “major positive impact.” Higher values are evidence of better actor performance.

### *Independent Variables*

Our hypotheses concern the interactive relationship between the interdependence of the forums in which actors participate and the level of closure of its ego-network on their performance within forums. The variable *Forum Independence* measures the number of watersheds in which an actor's forums are active, which we argue serves as a viable proxy for biophysical interdependence. In the survey, the respondents were asked to select the watersheds that were managed by the forums that they participated in. The responses can range from 1 to 11 in Tampa Bay and 1 to 16 in the CA Delta. Lower scores indicate that actors participate in more geographically clustered forums which exhibit greater interdependence: higher scores reflect greater forum independence. Forums that are geographically clustered are more likely to be biophysically linked, and thus more likely to generate institutional externalities for one another, relative to those that are distant.

The variable *Actor's Network Closure* captures the extent to which an actor perceives their ego-network to be closed. To measure this variable, the respondents were first asked how many organizations they/their organization dealt with directly on a regular basis regarding water-related issues in the previous 12 months. We then asked them to report how much those organizations interacted with each other, using the following prompt: "Thinking of the organizations that you deal | your organization deals with directly, would you say that most of these organizations deal directly with each other on a regular basis or do they generally not directly deal with each other at all?" Answers are coded on a 0–10 scale: 0 = none interact; 5 = some interact; 10 = they all interact. A score of 0 indicates a fully open ego-network and 10 indicates a fully closed ego-network.

Several studies criticize the use of proxy network measures on two accounts. First, actors may not be able to correctly specify their network (Marsden, 1990; Valente & Pumpuang, 2007). Second, actors may bias their answers if they view a specific type of network structure as favorable (Molitor, Hinz, & Wegman, 2011). We are less concerned about these problems for a number of reasons. First, more recent research (McEvily, 2014) disputes the claim of unreliability, finding that actors are able to reliably identify not only their immediate connections, but also the extent to which those connections also interact. McEvily finds that respondents correctly identify relationships between their connections at a rate of 78–87 percent.

Second, while some measurement errors likely exist in the data, there is no reason to believe that actors in our research sites hold strong prior beliefs regarding the value of having more closed (or open) networks and its effect on their work. Given the nature of the confidential, web-based survey, it is unlikely that actors will have incentive to misrepresent answers in a systematic fashion. If such errors are randomly distributed across actors, empirical findings will not be biased, but will be less consistent and precise.

### Control Variables

We include several control variables in our model. The variable *Organizational Degree* measures the total number of connections that an actor possesses across the system. Actors that work with organizations with greater degree centrality are simply engaged in more collaborative relationships, and thus might have greater influence, resulting in better performance in forums. We asked each respondent the following question: "Consider all the stakeholder organizations involved in all forums and all water management activities in the (Tampa Bay | California Delta) region. About how many of these organizations (have you | has your organization) dealt with directly on a regular basis regarding water-related issues in the past year?" Responses can take the following values: 1 = none; 2 = 1 organization; 3 = 2–4 organizations; 4 = 5–10 organizations; 5 = 11–25 organizations; 6 = more than 25 organizations.

We also control for the *Number of Forums* that an actor participates in across the governance system (measured by counting the number of forums listed by the respondent). Actors participating in more forums may be more productive within a forum due to their increased experience in dealing with forum matters and greater knowledge regarding effective bargaining techniques, at least in the forums that most readily impact their interests (Mewhirter et al., 2017). Such actors may also, over time, increase their knowledge of bargaining strategies and policy knowledge, which may impact their performance.

Another variable we control for is *Frequency of Participation* in forums. This variable captures the degree to which the actor is directly involved in the forum in which she/he participates. Other things equal, actors that are more actively involved in the forum should be more likely to have a more positive outlook about the deliberative process in the forum as well as its output (Wondolleck & Yaffee, 2000). We ask each actor to identify, on average, how often they participate in forum activities in each listed forum: 1 = daily participation; 2 = weekly participation; 3 = monthly participation; 4 = quarterly participation; 5 = annual participation.

*Experience* controls for the extent to which an actor is invested in the governance system. Actors that are more invested in forum participation will have fewer opportunity costs for participating in forums, allowing for a greater proportion of time and cognitive and political resources to be invested in forum-related matters (Fischer & Leifeld, 2015). *Experience* takes a value of 0 when respondents indicate that participating in forums is "incidental" to their work and 1 when they indicate that it is a "primary aspect" of their work.

We control for the *Organization Type* of the actor. As noted earlier, a wide array of public and private organizations participate within the forums that compose the institutional architecture of a complex governance system. Power asymmetries (and hierarchies) likely exist between different types of organizations, which impact their capacity to achieve their forum-specific goals (Broome, 2002; Purdy, 2017; Sayles & Baggio, 2017). For instance, representatives of local governments likely possess fewer resources than representatives of state agencies, limiting their forum performance; similarly, local government representatives may acquiesce to

state government demands in forum proceedings given the hierarchical nature of the relationship. Moreover, different types of organizations vary in the scope of their interests, which impacts the breadth of their forum participation (Ernstson, Barthel, Andersson, & Borgström, 2010). For instance, a state organization has broader interests than a local government: as such, we should expect state actors to participate in geographically distant forums and local actors to participate in geographically clustered forums. The variable, which ranges from 1 to 14, is generated by asking respondents to identify which category of the following categories best describes the organization that they represent: federal Government (=1); State Government (=2); Regional Government (=3); Local Government (=4); Water Infrastructure Special District (=5); Environmental Special District (=6); Environmental Group (=7); Trade/Business/Industry Group (=8); Homeowner Association (=9); Education/Consulting/Research (=10); Multi-Stakeholder Coalition (=11); Recreational Group (=12); Agriculture (=13); Independent (=14).<sup>3</sup> Table A1 in the supporting information reports the number of forums participated in by each type of organization as well as the mean value of *Actor Network Closure* and *Forum Independence* for each type.

We also account for the fact that actors do not value each forum equally. Given that actors have limited resources, they may have an incentive to concentrate their efforts in forums that have the largest impact on their organizational interests. Thus, we include the dummy variable *Primary Forum*, which takes a value of 1 when it was the first forum named by the respondent, and a value of 0 otherwise. This approach is largely consistent with that used in Mewhirter et al. (2017).

Finally, we also include the variable *Required Forum*, which is a dichotomous variable indicating whether the actor is attending the forum voluntarily (=0), or whether their participation is legally mandated (=1). Actors that are legally mandated to participate often represent organizations that sponsor the forum and, thus, may have different incentives and goals than those that participate voluntarily (for example, facilitating forum deliberations or mitigating conflicts).

Descriptive statistics for all the variables used can be found in Table A2 in supporting information.

## Analysis and Results

Our unit of analysis is the actor–forum dyad, with each observation in our dataset corresponding to a specific actor participating in a specific forum. This data structure allows for (at least) four forms of interdependence between the observations. First, the dataset includes as many observations for a single actor as the number of forums that actor identified in the survey (e.g., an actor that indicated participation in 7 forums will have 7 observations in the dataset). It is likely that actors' evaluations of individual forums may be correlated with their evaluations of other forums in which they participate. Second, specific forums are evaluated by multiple actors in the dataset: responses among actors that participate in the same forum are potentially correlated, though this may not always be the case (especially in circumstances where forum participants have heterogeneous goals and preferences). Third, multiple actors in the dataset may work for the same organization:

thus their responses are potentially correlated, and the organization is potentially overrepresented. Table A3 in supporting information shows the number of organizations that have multiple representatives in the dataset (as well as the number of representatives). Fourth, respondents in the dataset may be connected to one another (for example, three respondents are members of the same subgroup), which may result in correlated responses.

To correct for the interdependencies that arise due to multiple forum evaluations per actor and multiple observations per forum, we utilize a cross-nested regression model, specifying random intercepts at the actor and forum levels. The supporting information contains additional models to assess the robustness of our findings, which adjust for dependence that may arise from unobserved network connections and from different actors working for the same organization. The supporting information also contains an alternative model that includes controls for the organizational composition of forums. The results presented in Table 1 are consistent with those of the alternative models discussed and presented in supporting information (Tables A4, A5, and A6).

Table 1 presents the model estimates. As seen in columns 1 and 2, we find evidence of an interactive relationship between *Actor's Network Closure* and *Forum Independence* in both the Tampa Bay and CA Delta research sites. Because interpreting the effects of interactive models can be unintuitive, we rely on Figure 1, which plots the estimated marginal effect of a one unit increase in *Actor's Network Closure* on *Actor Performance* across varying levels of *Forum Independence*.

The results in the CA Delta find support for hypotheses 1 and 2. When *Forum Independence* is low (indicating higher level of interdependence among the forums in which actors participate), a one-unit increase in *Actor's Network Closure* is associated with better actor performance in the forum. Holding *Forum Independence* at its lowest value of 1 (all forums are only active in one watershed) and all other variables at their means produces a predicted value of 6.62 in *Actor Performance* for those with closed ego-networks (*Actor's Network Closure* = 10) as opposed to 5.13 for actors with open ego-networks (*Actor's Network Closure* = 0). At higher levels of *Forum Independence* (above 13), increases in network closure are associated with decreases in *Actor Performance*. Holding *Forum Independence* at 16 (forums are active in many watersheds) and all other variables at their means, moving from an open to closed network decreases the predicted value of *Actor Performance* from 8.42 to 5.66.

The results for the Tampa Bay regression also provide support for hypothesis 1: a one unit increase in *Actor's Network Closure* is associated with increased forum performance when *Forum Independence* is low. The contrast in expected payoffs between actors with closed and open networks when participating in geographically clustered forums is striking. When *Forum Independence* is set at 1 (all forums are active in only one watershed), moving from an open to closed network increases the expected value of *Actor Performance* from 3.25 to 8.07: an increase of roughly 148 percent. As expected, this effect diminishes as *Forum Independence* increases. However, it never becomes negative. Thus, there is no support for hypothesis 2 in Tampa Bay.

While we cannot know for sure, we believe that the variation in support for hypothesis 2 across sites is likely attributable to differences in network leadership

Table 1. Main Regression Results

	CA Delta	Tampa Bay
Actor's network closure	0.18** (0.09)	0.55*** (0.09)
Forum independence	0.22** (0.10)	0.43** (0.18)
Actor's network closure × forum independence	-0.03** (0.01)	-0.06*** (0.02)
Number of forums	0.15* (0.08)	-0.07 (0.10)
Experience	-0.15 (0.35)	0.01 (0.31)
Required forum	-0.23 (0.30)	0.35 (0.25)
Issues	-0.15 (0.09)	0.30*** (0.09)
Primary forum	0.30 (0.20)	0.12 (0.20)
Organization type (reference category = federal)		
State government	0.31 (0.57)	-0.23 (0.80)
Regional government		1.27* (0.75)
Local government	-0.37 (0.61)	-0.13 (0.65)
Water infrastructure special district	-0.47 (0.57)	-0.53 (0.78)
Environmental special district	-0.67 (0.84)	
Environmental group	0.07 (0.60)	-0.36 (0.79)
Trade/business/industry group	-0.95 (1.02)	-1.52* (0.84)
Homeowner association		0.95 (1.80)
Education/consulting/research	0.20 (0.73)	-0.77 (0.78)
Multi-stakeholder coalition	-0.60 (0.84)	1.56* (0.84)
Agriculture	-5.26** (2.52)	-1.13 (1.02)
Independent	0.95 (0.83)	-0.58 (0.83)
Frequency of participation (reference category = daily)		
Weekly	0.49 (0.42)	0.40 (0.31)
Monthly	0.51 (0.43)	0.23 (0.32)
Quarterly	0.70 (0.46)	0.59 (0.46)
Yearly	1.61*** (0.58)	2.05*** (0.62)
Degree centrality (reference category = 0)		
1	-1.32 (1.58)	0.29 (1.02)
2-4	-1.74 (1.31)	0.44 (0.91)

(Continued)

Table 1. (Continued)

	CA Delta	Tampa Bay
5-10	-2.06 (1.35)	0.13 (0.93)
11-25	-1.93 (1.36)	1.11 (0.98)
More than 25	-1.89 (1.42)	0.32 (1.05)
Constant	6.45*** (1.50)	1.28 (1.18)
SD actor ID	1.04*** (0.14)	1.1*** (0.17)
SD forum ID	.91*** (0.17)	.81*** (0.15)
Observations	390	318
LR test	56.98***	35.90***

Standard errors in parentheses: \* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$ .

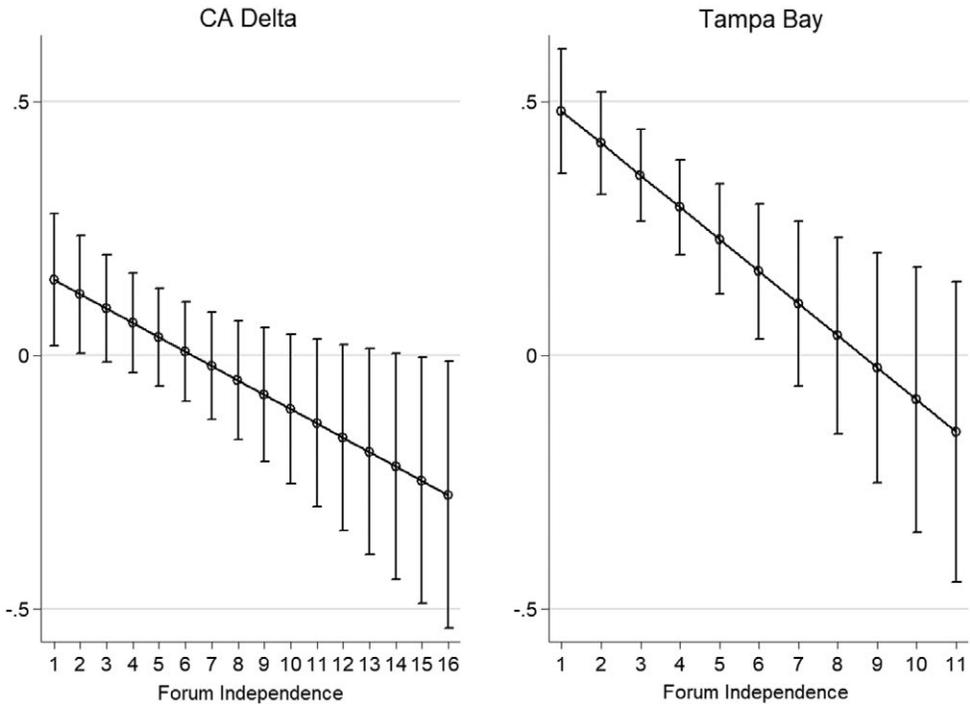


Figure 1. The Marginal Effect of a One-Unit Increase in an Actor's Network Closure Across Varying Levels of Forum Independence in Tampa Bay.

and/or the level of decentralization in the governance system. In Tampa Bay, the Southwest Florida Water Management District (the organization with the greatest water management responsibilities and authority) plays a key role in starting forums, recruiting other organizations to participate, and is the largest forum participant. The district is also charged with increasing the technical capacity of local organizations

(<https://www.swfwmd.state.fl.us>), so its very presence in a forum may subsidize the participation efforts of other participants by providing information regarding forum-specific policy problems. Actors that participate across independent forums in which the District acts as a sponsor or participant may face reduced costs, and thus will not as readily benefit from the breadth of information provided by open networks. Actors that participate in forums that are linked, however, still have to devise solutions that take into account their interests across forums, which requires more esoteric information regarding interlinkages between forums of relevance to a particular actor that the district may not readily provide. As such, closed networks drive up actor performance when participating in interdependent forums, whereas open networks do not advantage actors participating in interdependent forums. No such leading organization exists in the CA Delta network, which has been described elsewhere as highly decentralized (Berardo & Lubell, 2016).

### Conclusion

Our results demonstrate that understanding how actors perform in complex ecologies of games can be facilitated by a careful examination of the interconnectivity of forums in which they participate and the types of networks of exchange of information that they have. These findings build on recent work in the EGF demonstrating that forum interdependence can have a profound impact on policy-making processes and influence dynamics within complex governance systems (Berardo & Lubell, 2016; Jasny & Lubell, 2015; Lubell, 2013; Lubell et al., 2017; Mewhirter et al., 2017, 2018).

In particular, our research builds on the work of Mewhirter et al. (2018), who find that institutional externalities are rampant in resource governance systems, and when present tend to increase the participation costs associated with forum participation, leading to lower levels of actor satisfaction with their participation in the system. Our findings demonstrate that forming closed networks is a possible strategy for actors to shape the direction of institutional externalities. Here, closed networks promote the accumulation of resources that are needed to develop an integrated approach to their forum participation, allowing actors to develop policy alternatives in one forum that promote their interests both within that forum and in the other affected forums in which they participate.

Our findings also build on the closed vs. open network structure debate (and subsequently, the bonding vs. bridging capital debate) that is of increasing importance to the complex governance literature (Berardo, 2014a, 2014b; Berardo & Scholz, 2010; Fischer et al., 2014; Ingold & Leifeld, 2014; Shrestha, 2013). We find (as others have) that there is no panacea: the extent to which either structure is advantageous is conditional on the needs of the individual actor and that these needs vary between actors in the same system.

This work is not without limitations. Perhaps the most noteworthy is that our data-collection process did not produce a full measure of ego-networks based on responses by both the ego and the alters. Instead, the extent to which alters in the networks are in contact with each other is estimated through the ego's beliefs

regarding those interactions. While one could argue that egos are likely to know in some detail how their alters know each other (and the strength of their exchanges if they exist), it is easy to see that the exactitude of these perceptions is likely a function of variables we do not measure, and thus cannot control for, such as the sheer number of alters an actor interacts with and the history of collaboration between the ego and each individual alter. Furthermore, we assume that ego-networks with higher levels of activity are less open than those with lower levels. But it is entirely possible for a fully dense ego-network (which we label as a high-closure network) to have multiple connections to a wide range of actors that are removed by at least two steps from the ego and have no direct connections to it. In such a situation, and assuming that information can flow rather freely through the network, one could argue that a fully closed ego-network can still appropriate the benefits of bridging connections that produce nonoverlapping information.

Moreover, it is important to acknowledge that our emphasis on the connections between actors and the forums in which they participate (and in which we assume that interactions among actors take place) must not underplay the importance of informal interactions that take place among actors *outside* of those forums, which we do not measure. Knowledge, one of the main ingredients to achieve high individual performance in a complex governance system, is more easily exchanged through face-to-face interaction that can be sustained in time (Faulconbridge, 2006; Gertler, 2003). Those exchanges can take place in forums (particularly the long-lived ones), but not necessarily so. Future research needs to untangle the relative importance of informal interactions *vis-à-vis* those that take place in more formal settings where multiple actors convene.

Finally, while this study has detailed how one form of interdependence impacts the costs associated with forum participation, we have not addressed other types of forum linkages that likely exist. For instance, forums could be “socially-interdependent” when they share common forum participants (Kimmich, 2013; McGinnis, 2011), “issue-interdependent” when they address the same policy problem, or even “sponsor-interdependent” when they share common organizational founders. These linkages are not mutually exclusive: forums may be linked in numerous ways, one way, or not linked at all. Future works should seek to disentangle the impact that different linkages have on actor performance as well as examine whether interactive or compounding effects exist.

Despite these limitations, our study is the first to evaluate the interaction between the structure of individual networks and the structure of interdependence of decision-making forums to explain actor performance, and as such it sheds light on the relationship between structure and function that constitutes the theoretical core of the EGF (see Berardo & Lubell, 2019). Whereas forum interdependence determines the resources that actors need, political networks (at least partially) determine the resources that actors possess. Actors who are able to match their resource capital to their individual needs when participating in the governance system will be better equipped to successfully traverse the inherent complexity of it. This research is a first step to understanding how actors can achieve this goal.

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### Notes

1. It should be noted that the magnitude of these costs varies between forums. When a forum deals a simple issue that has an easily identifiable solution, participants will face low costs when learning about problems and identifying solutions (relative to forums dealing with more complex problems). Similarly, these costs vary between actors in the same forum. For instance, actors that are seasoned forum participants face lower costs when devising and implementing bargaining strategies (relative to less experienced participants) as they have done so before, and know which approaches have historically been more effective.
2. Please note that while up to this point we have discussed linkages that emerge between forums across the system, *we are now referring to linkages that exist between the forums in which an actor participates*. If an actor participates in two forums that are not biophysically linked, then they are considered independent (even though they may be connected to other forums across the system).
3. Only two respondents (one at each site: collectively making up five observations) indicated that they represented a recreational group. All five observations contained missing data and were listwise deleted.

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## Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web site:

**Table A1.** Forum Independence and Actor Performance by Organization Type

**Table A2.** Descriptive Statistics

**Table A3.** Occurrences of Multiple Respondents per Organization

**Table A4.** Main Regression Results with Variables Controlling for Organizational Composition of Forum Participants

**Table A5.** Regression Results with Data Collapsed at the Organizational Level (Mean Values)

**Table A6.** Random Permutation Regression Results