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# Bridging and Bonding Capital in Two-Mode Collaboration Networks

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*Public management and policy scholars have empirically demonstrated that in complex policy arenas, governments depend on the collaboration of policy actors outside their direct control to produce needed goods and services. Government-sponsored shared-cost programs are one of the premier mechanisms to foster such cooperation, yet little is known about the inner patterns of participation in such programs and whether they are conditional on specific resource needs that partners may have. In this article, I study the participation of organizations in projects seeking funds from the Cooperative Funding Initiative, a program sponsored by the Southwest Florida Water Management District that finances projects dealing with the management of water resources. Through the estimation of a series of Exponential Random Graph Models in the networks that form when organizations participate in projects (two-mode networks), I show that centralization around popular organizations results in greater bridging network capital, which facilitates the flow of nonoverlapping information from project to project. I analyze the implications of these findings and discuss how the formation of these bridging structures may enhance the capacity of the program to find innovative solutions to the problems the projects are designed to deal with.*

**KEY WORDS:** shared-costs programs, collaboration, networks, water management, bridging capital, bonding capital

## Introduction

Public management and policy scholars have empirically demonstrated that in complex policy arenas, governments depend on the cooperation and resource mobilization of policy actors outside their direct control to produce needed goods and services (Kettl, 2000; Salamon, 2002). This loss in the capacity of governments to act autonomously is even more noticeable in the fragmented subnational policy arenas of federal systems, where multiple agencies hold regulatory overlapping power and institutional collective action dilemmas are common in the provision of public goods and services (Feiock & Scholz, 2010; Feiock, Steinacker, & Park, 2009).

However, governmental actors are often able to facilitate the emergence of the conditions to deliver goods and services effectively, particularly when they can both




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"frame" and "synthesize" the activities that take place in collaborative networks where multiple actors work with each other (Agranoff & McGuire, 2001). Consider the familiar case of shared-costs programs of a local or regional scale, where multiple actors in dire need of financial resources try to obtain funds distributed by governmental agencies. In shared-costs programs, which some scholars brand as the preeminent mechanism to foster cooperation in the fragmented subnational arenas of the United States (Agranoff, 2006; O'Toole & Meier, 2004), it is assumed that neither a single public agency nor the private sector have all the resources it takes to provide a given public good or service (Mandell, 2001; Rethemeyer & Hatmaker, 2008), so governments build collaborative partnerships to increase the likelihood of delivering those goods and services. This is done by having the partners share the financial burden for whatever activities they collectively embark on.

Studying the bilateral relationships that take place between partners may provide critical information to evaluate how specific collaborative efforts progress in the context of the programs. However, to properly understand the overall functioning of shared-costs programs and how they address the underlying problems they are designed to tackle requires the careful study of the more complex landscape that forms when actors partake in collaborative efforts with multiple partners. This is because different configurations of relationships may distinctively affect the likelihood of the program solving the problems it was created to address, as will be explained below.

Thus, the research question I answer in this article is: *How do the individual decisions of actors to participate in particular collaborative efforts in shared-costs programs aggregate to shape the overall structure of interactions in the programs?*

Berardo and Scholz (2010), for instance, described in previous research how particular configurations of relationships in networks formed by policy stakeholders are more likely to lead to the solution of coordination problems in regional arenas (where multiple actors want roughly the same thing without easily agreeing on how to achieve what they want) and cooperation problems (where the dominant strategy for each of the actors is to free-ride on the efforts of others). Solving coordination problems demands "bridging" network social capital (network capital for short) provided by central actors that connect otherwise disconnected actors, thus improving the flow of nonoverlapping information that makes finding innovative solutions to problems more likely. Solving cooperation problems, on the other hand, requires "bonding" network capital, which can be represented by the prevalence of close-knit structures in the network that enhances the systemic capacity to detect and quickly punish defection by individual actors.

The logic fits nicely in the study of shared-costs programs because they are often designed to tackle problems that cannot be solved in the absence of coordinated behavior, thus bridging network capital should be prevalent. For example, consider the hypothetical case of a shared-costs program in which a state government agency provides cost-share reimbursement to private landowners who engage in forestry-related conservation efforts (e.g., tree planting, foresting riparian buffer areas, and engaging in wildlife habitat restoration). Matching individual efforts by the program sponsor helps the individual landowners deal with their particular needs but, at the same time, the sponsor benefits by having multiple actors simultaneously tackling problems related to its main goal of improving the conservation of forested areas. In situations such as this, giving the landowners the ability to learn from each other is valuable because they may be more efficient and/or innovative in their practices. This can be accomplished if a central actor emerges who can fulfill a bridging role among the program participants and transfer relevant information among them. Of course, a sponsor concerned with increasing the chances of success of its program is likely to fulfill this role.

To answer the research question, I examine the participation of organizations in projects that apply for funds to a shared-costs program sponsored by the Southwest Florida Water Management District (henceforth "the District"[1]). The program, called the Cooperative Funding Initiative (CFI), was created by the District to financially support projects that are designed by applicant organizations (primarily local governments) to address problems related to one or more of the District's main areas of responsibility: (i) protection of natural resources, (ii) prevention of flooding, (iii) provision of water for human uses, and (iv) improvement of water quality. Projects vary in nature. For example, they may include construction of infrastructure to treat storm runoff, educational programs to promote conservation practices among the general population, restoration efforts in estuarine natural systems, etc. Approved projects are eligible to have up to 50 percent of the budget financed by the District.

It is important to note that organizations that design projects and apply for funds to the CFI do not work alone. Instead, they seek the assistance of other organizational actors (including the District itself), from whom they obtain needed expertise to improve the quality of their applications; in so doing, they create and mobilize network social capital (network capital, for short), which can be loosely defined as the resources embedded in social networks that actors can access and use (Lin, 1999). By exploring the specific patterns of organizational participation in projects, it is possible to assess whether structures that indicate bridging capital are predominant or not.

I estimate a series of Exponential Random Graph Models (ERGMs) to study the types of network capital that exist in the four different two-mode networks that form when actors assist project managers in: (i) securing funding for the project, (ii) solving regulatory and permitting issues, (iii) achieving public and political support, and (iv) addressing technical issues.

In two-mode or bipartite networks, there are two types of actors *O* and *P* (organizations and projects in this case) with *n* organizational nodes and *m* project nodes. The relationships between those two kinds of nodes can be represented in a rectangular matrix (*X*), where a given cell $x_{ij}$ will assume a value of 1 if organization *i* in the set *O* participates in project *j* in the set *P*, and 0 otherwise.[2] In this study, there are four two-mode networks on which I estimate ERGMs, one for each type of resource that the organizations can provide for projects, as described in the previous paragraph.

ERGMs are a type of statistical model to account for the presence (or absence) of ties in networks that form small local structures, allowing the researcher to infer the presence of specific processes that create particular types of structures, and not others. ERGMs work by enabling a comparison between observed structural configurations in a given network of interest for the researcher with the configurations that result from a large number of simulated random networks. When certain configurations are found in the observed network that are not significantly present in the simulated ones, the researcher can conclude that those configurations cannot be attributed solely to the existence of a random process of link formation.

The next section introduces a discussion on network capital in two-mode networks. Later sections present a detailed description of the CFI, data collection process, methodology, and results. The article closes with a discussion of the implications of this work, as well as its limitations.

## Network Capital in Two-Mode Networks

Studies that examine governance in fragmented policy arenas through a network lens assume that the transaction costs of cooperation can be reduced by, among other things, generating social capital among stakeholders (Lubell, Schneider, Scholz, & Mete, 2002; Ostrom, 1990, 2005). Greater social capital lubricates social and political relations in the form of increased trust and trustworthiness (Bromiley & Cummings, 1995; Sabatier, Leach, Lubell, & Pelkey, 2005; Scholz & Lubell, 1998) and, in general, helps to produce the conditions that facilitate sustained cooperation in policy networks (Scholz, Berardo, & Kile, 2008).

There are, however, different types of capital that can be created in networks, and they can facilitate or hinder the solution of specific problems faced by the members. The basic distinction made by network theorists is between bonding and bridging capital. Bonding capital results when actors in a group create relationships that bring them closer together, thus improving the quality of information available to each of them about what others in the group are likely to do in specific situations. The simplest form of bonding in a three-member group, for example, is a closed triangle, where all three members are linked to each other. Bridging capital, on the other hand, results when actors in a group create ties that extend beyond their close set of acquaintances and connect them to other groups with whom they had little or no contact up to that point. Creating bridging structures, which is usually done by centralized brokers who can fulfill coordination roles by "keeping one foot in each group," does not provide the overlapping information that builds reputations in small groups, as bonding capital does. Instead, the creation of links that form bridging structures in a network give the actors in the different groups a shot at gathering nonoverlapping information that can be used, for instance, to solve problems in an innovative way.

Both bridging and bonding capital have been widely studied in one-mode networks but have not yet been examined in detail in two-mode networks. In the remainder of this section, I present a discussion of how bonding and bridging capital can be measured in the two-mode networks that emerge in the CFI when multiple organizations contribute different resources to the projects. This discussion is by no means intended to exhaust the debate on how to measure bonding and bridging capital in two-mode networks, but rather it should be viewed as an initial effort to spark a meaningful scholarly conversation on how to study network capital beyond the more familiar confines of one-mode networks.

### *Bonding Capital in Two-Mode Networks*

Defenders of the benefits of bonding social capital in groups claim that it is easier to reach cooperation when the members of a group are linked to each other through dense, overlapping relationships that make it easier to detect and punish defective behavior by noncooperators (Coleman, 1988; Putnam, 1993, 2000). Bonding social capital creates an advantage for the members of a group because it decreases the risk associated with unmonitored behavior (Berardo & Scholz, 2010; Burt, 2005), which helps build trusting relationships (Provan & Sebastian, 1998; Schneider, Scholz, Lubell, Mindruta, & Edwardsen, 2003) that increase the probability of sustaining cooperation over time. In one-mode networks, where there is only one type of nodal entity (organizations, individuals, etc.), bonding social capital is usually indicated by a number of basic configurations, the simplest of which is the reciprocal dyad. Reciprocity in collaborative behavior engenders trust and sends positive signals about the members of the dyad to other actors that may consider creating links to them (Berardo & Scholz, 2010).

One higher order representation of bonding—and the most commonly studied—is the triangle, where three actors are connected to each other; the larger the percentage of possible triangles in a network (the higher the clustering in the network), the larger the amount of bonding capital.[3] Closure indicates bonding because bonding configurations are inherently "inward-looking," whereas bridging structures are inherently "outward-looking" (Geys & Murdoch, 2010; Paxton, 1999).

In two-mode collaborative networks where actors are connected to each other only through their common participation in a given event (projects in our case), the presence of bonding capital is represented by different types of structures. In this article, I present three such configurations that could be used to indicate bonding of different strength among actors who participate in projects seeking CFI funds (though the reasoning is applicable to any other instances where actors attend events in which they can interact with others).[4]

In each of the illustrations in Figure 1, a square represents a project and a circle represents an organization. Figure 1a contains a configuration I call "Strong Bonding (project-based)," where two organizations are linked to each other through their participation in a number of different projects. The overlapping participation in projects sets a precedent to sustain cooperation in the long run because actors involved in many projects with the same counterparts may perceive defection to be a costly strategy when the system is relatively stable and the partners are not likely to disappear or "go away" after the initial interactions (Berardo, 2010).

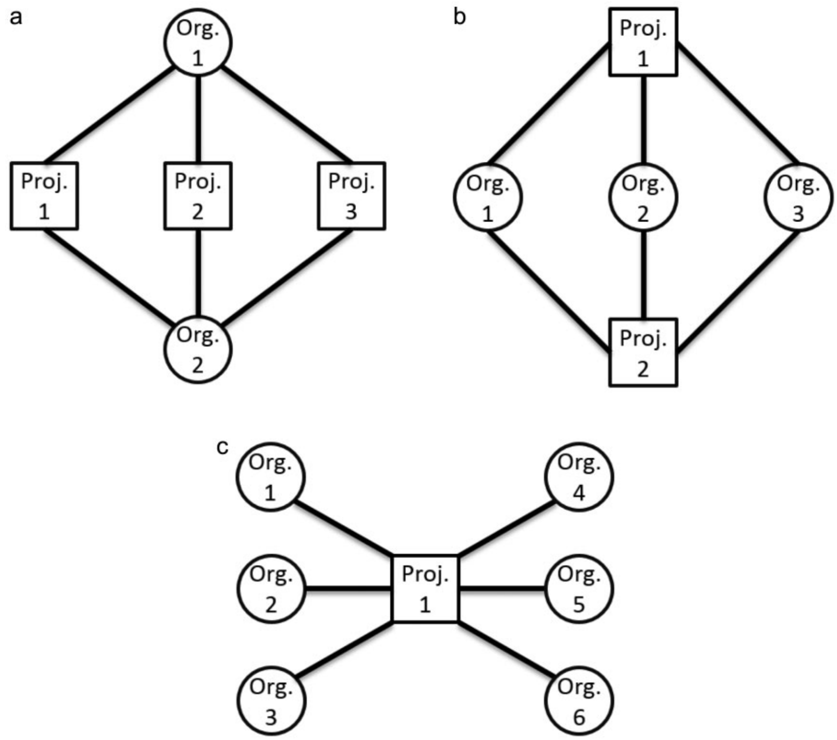


**Figure 1.** Bonding Social Capital. (a) Strong bonding (project-based). (b) Strong bonding (organization-based). (c) Weak bonding (project star).

Figure 1b is the "Organization-Based" equivalent of 1a, with three organizations linked to each other through their participation in two different projects, but the mechanisms at work that foster cooperation are the same, with the organizations being constrained in their behavior by the pattern of overlapping participation in projects that they share with others. In a program such as the CFI, in which the participants are likely to interact with others beyond the near future (e.g., the shadow of the future is long enough), it would be detrimental for a given organization to not live up to its commitments in one of the projects if it was also involved in other projects with the same organizations, as its collaborative reputations could be tarnished. This, of course, could imperil its ability to secure future assistance in case of need from both the organization that designs a project and from others who contribute to it and may hear about the defection through the project manager.

Both Figure 1a and Figure 1b represent strong bonding because the shared participation in projects does not stop at one project, but extends to at least two of them. The third configuration in Figure 1c represents a weaker type of bonding structure indicated by a "Project Star." In this case, a large number of organizations participate in the same project, and in so doing they may learn about each other's interests, policy-related views and opinions, and particular organizational strengths that project managers can benefit from. However, the interactions take place only in the context of that particular project. Therefore, they create a bond with each other by virtue of assisting the project during its design stage but that bonding is fleeting because it is not strengthened by the repeated interactions that take place in the design of multiple projects, as indicated in 1a and 1b.

### *Bridging Capital in Two-Mode Networks*

While bonding capital provides assurances against defection—though that assurance decreases as the strength of bonding drops—it also may decrease the capacity for innovation facilitated by multiple nonoverlapping relationships. Networks of collaboration can be fragmented, with multiple clusters of actors disconnected from each other; when this fragmentation takes place, information cannot flow beyond the boundaries of each connected component. This, in turn, may negatively affect the overall capacity of the network to generate innovative responses to problems.

The problem can be solved if there are central actors who can build connections between otherwise disjointed parts of the networks. In particular, two beneficial outcomes may result from the existence of bridging ties. First, the actor who builds the bridging connections may accrue the benefits that result from controlling information or whatever resource flows in the network of collaboration. These benefits usually amount to a comparative advantage over peers in the same network (Burt, 2000, 2005; Granovetter, 1973; Scholz et al., 2008). A second type of benefit results for the connected groups themselves, which are now exposed to a greater dissemination of information that is possible only because of the existence of the bridges (Calvó-Armengol & Jackson, 2004).[5]

A proxy that has been used to indicate bridging in networks is the centralization of activity around particularly popular actors, under the assumption that central actors are more likely to fulfill a coordination role that can lead to more innovative responses to problems that are difficult to handle collectively (Batallas & Yassine, 2006; Burt, 2004, 2005; Fernandez & Gould, 1994; Friedman & Podolny, 1993; Gould & Fernandez, 1989; Ibarra & Andrews, 1993). However, this proxy makes sense when bridging is studied in one-mode networks. In Figure 2, I present a simple

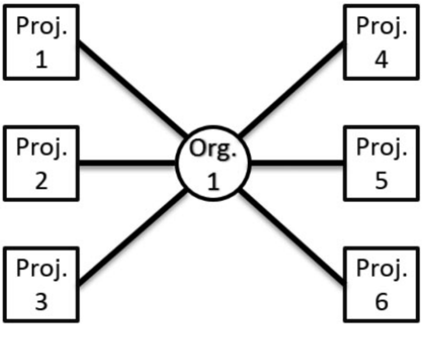


**Figure 2.** Bridging Social Capital (Organization Star).

configuration that can be utilized to indicate the presence of bridging capital in affiliation networks where organizations are linked through their common participation in specific events. As was the case with Figure 1, a square represents the event (a project) and a circle represents an organizational actor.

The structure is similar to Figure 1c in that both are star-like configurations. However, they represent very different types of network capital. Whereas Figure 1c captures the generation of weak bonding capital, with many organizations participating in the same project, Figure 2 represents the bridging capital an organization can generate by participating in many activities at the same time. Applied to the CFI setting, this "organization star" is the representation of an actor participating in multiple projects, which may facilitate the transference of information from one project to others that could strengthen the latter's applications.

As a hypothetical example of this mechanism for innovation through bridging in the CFI two-mode networks, imagine that Organization 1 in Figure 2 is technically assisting a project in the design of a retention pond to clean storm water runoff from a nearby shopping center before it enters a river or creek. Organization 1 is contacted by that project manager because it has detailed information about past similar infrastructure projects in the area and thus can provide valuable information about—among other things—size of similar projects' budgets that have been approved (or rejected) by the District, service area of funded projects, exact geographic locations, and effectiveness of those projects.

It is important to keep in mind that even though Organization 1 is contacted to provide technical advice to the project, it can also gather valuable information from the project manager as well. For instance, the project being designed may propose the use of a new, more advanced filtering process that increases the percentage reduction of targeted pollutants or may be the first to integrate storm water treatment with fish habitat development by stocking native species of fish in the pond (if its size is big enough), etc. This information can then be used by Organization 1 if another manager requests information that can be used to strengthen the quality of another project's application, particularly (though not necessarily) if that project is also designed to improve infrastructure for storm water treatment. To put it simply, what Figure 2 shows is that by participating in multiple projects, Organization 1's stock of relevant, novel information grows. The fact that at least a higher potential for transmission of innovative information from one project to others exists is an indicator of the presence of bridging capital in the network.

## Network Capital and Resources for Projects

The CFI funds projects that tackle problems linked to the main areas of District responsibility, as explained in the introductory section of this article. The main goal of the organizations that design projects is to obtain financial resources from the District to pursue these projects. However, in order for this to happen, applicants must be sure that projects are soundly designed, so they usually require the assistance of multiple actors that can contribute resources to strengthen the applications.[6]

To find out what types of resources are needed to design high-quality applications and successfully implement projects, an expert advisory panel of active policymakers in southwest Florida was formed in 2006, who identified the following resources as critical to designing strong projects: (i) funding availability, (ii) technical information, (iii) public buy-in and/or political support for the project and, (iv) the ability to meet regulatory requirements that make the project legally viable.[7]

Securing these resources is not a simple task for project managers because it is rare that one advising organization can provide all the needed resources, but it is reasonable to expect that the District's assistance is requested at a much higher frequency than any other organization, simply because as the main funder of projects, the District is in a clear position to advise project managers on how applications should look to improve their funding chances.

However, this higher frequency of participation of the District should, to some extent, be conditional on the type of resource that the project managers demand. For instance, when assistance is needed to make sure that the project meets regulatory requirements, the relative participation of the District in providing assistance to projects should increase, as it should for state or federal-level agencies that may have their own regulatory hurdles in place that the project would need to clear in the road to implementation. On the other hand, if a project is well designed from a regulatory point of view but does not have enough political or public support to move forward or lacks technical strength, then the District's importance may lower in relative terms, with other actors stepping in and increasing their level of assistance to projects (local governments, NGOs, research institutions, etc.).

In any case, a comprehensive analysis of the inner functioning of the CFI requires an exploration of the network capital that forms in not one, but four two-mode networks, one for each type of resource that organizations can help project managers secure.

## Data Collection

In the summer of 2007, I led a research team composed of Ph.D. students at Florida State University who were tasked with identifying the managers for projects that applied for funding to the District in December of 2006.[8] The managers were then approached over the phone and asked to answer a semi-structured questionnaire that contained questions about the project and the process of developing the application. A total of 95 out of 138 individuals answered the survey for a rate of response of ~69%.[9]

Each respondent was asked to first identify other organizations that participated in the project and then asked to clarify the nature of that participation by stating whether each of those organizations had assisted the leading organization in (i) obtaining technical information, (ii) securing adequate funding, (iii) obtaining public and/or political support, and (iv) solving the project's permitting/regulatory issues. A total of 198 organizations were identified as providing assistance in at least one of these areas in the 95 projects in question. This organizational set included federal,

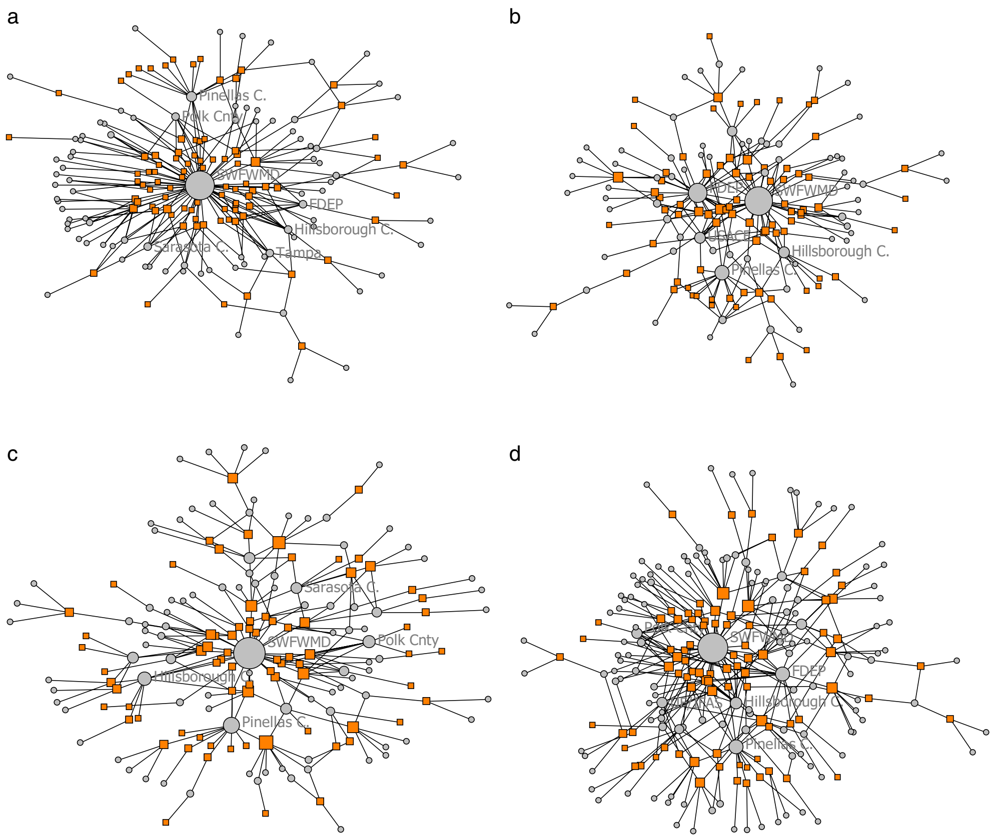


**Figure 3.** Networks of Assistance to Projects.[14] (a) Assistance in securing adequate funding. (b) Assistance in solving regulatory and permitting issues. (c) Assistance in securing public buy-in and/or (d) Assistance in obtaining political support technical information.

state, regional, and local government agencies (the District among this group), as well as research institutions, environmental organizations, business organizations, neighborhood associations, and other types of organizations.

With this information, I built four two-mode matrices of organizational participation in projects. Each of these matrices had 198 rows (organizations) and 95 columns (projects); in each of them, a cell $x_{ij} = 1$ when organization $i$ participates in project $j$ providing assistance to obtain the resource in question and 0 otherwise. The graphic representation of these matrices is contained in Figure 3, where squares represent projects and circles represent organizations. The figure contains only the main components to make the pictures easier to read, but there are other components in each of the networks, formed by single projects with one, two, or three participants in them.

The network of provision of technical information for the projects (Figure 3d) is the most active of the four (311 links), followed by provision of assistance to secure funding (Figure 3a: 243 links), provision of assistance to secure public buy-in (Figure 3c: 239 links), and provision of assistance to solve regulatory and permitting issues (Figure 3b: 225 links). All four networks have a main component that is connected primarily through the central participation of the District, which tends to be active in a large percentage of projects, as expected. Local governments are also highly active as, in general, the county governments in the area assist many of the projects that participate in the CFI.

The District itself has a more central role in absolute terms in the network of assistance to secure funding (participating in more than 60 projects) and the network to obtain technical information (participation in 40 projects). In the remaining two networks that absolute centrality is somewhat diluted, but the District remains dominant. In the particular case of the network of assistance for regulatory and permitting issues (Figure 3b), the District's centrality remains high, but other governmental authorities at both the federal (U.S. Army Corps of Engineers) and state level (the Florida Department of Environmental Protection) adopt a more preeminent role (the District still participates in 34 projects). Finally, the network of provision of assistance to obtain public and/or political support shows more of a "spread" pattern (the District participates in 29 projects). Table A1 shows the five most central actors in each of the networks.

This simple description illustrates the critical role of the District (a regional governmental organization) and local-level governments in shaping the structure of networks that form when organizations assist projects. However, it does not provide a definitive answer to the question of which of the configurations in Figures 1 and 2 are prevalent. To provide such a test, I turn to a statistical cross-sectional analysis of the networks using ERGMs.

## An ERGM Analysis of Networks of Organizations and Projects

To analyze whether bonding or bridging structures are present in the networks, I fit ERGMs to the data. ERGMs were first developed about a quarter century ago (Frank & Strauss, 1986), and they basically conceive observed network structures as possible realizations of stochastic network processes (Lubell, Robins, & Wang, 2012; Robins & Morris, 2007; Robins, Pattison, Kalish, & Lusher, 2007; Robins, Snijders, Wang, Handcock, & Pattison, 2007). At essence, ERGMs are tie-based models for understanding how network ties arise.

Intuitively, in the case of the two-mode networks I examine, for each of them there is a network space $\chi$ (with $n$ organizations and $m$ projects), which contains all possible realizations of networks with that number of organizations and projects.[10] Each of the four observed networks is represented by a random variable $X$ composed of a set of tie variables $X_{ij}$ (in other words, $X = \{X_{ij}\}$), and a particular realization of $X$ can in turn be denoted by $x = \{x_{ij}\}$, which are the observed ties. In these networks, two ties are *neighbors* if the existence of one depends on the existence of the other, and *neighborhoods* are local configurations in the network where ties are conditionally dependent on each other (such as those in Figures 1 and 2). The goal of an ERGM is to determine which of these configurations is dominant in the observed networks.

To clarify, consider that ERGMs have the following general form (Frank & Strauss, 1986; Wasserman & Pattison, 1996):

$$\Pr(X = x) = \frac{1}{\kappa}\exp\sum_{Q}\theta_Q z_Q(x) \tag{1}$$

where $Q$ is a given type of neighborhood or configuration, $z_Q(x)$ is the network statistic that equals 1 when the configuration is present in the observed network, and $\theta_Q$ its parameter. There is also a normalizing constant in the equation ($\kappa$), which is generated over the graph space $\chi\,(n, m)$ and forces the probability of all graphs to add to 1.

Substantively, organizations form local network configurations that indicate bridging or bonding network capital when they provide assistance to projects; these configurations have parameters attached to them that represent just how likely they are, given all the other configurations included in the model. If a particular configuration is a likely outcome of a social process occurring within the network, that configuration will occur at a higher frequency in the observed network than in networks where links are generated by "chance," which will be reflected by a positive and significant coefficient.

To estimate the models, I used BPNet, an open source software package that estimates ERGMs on two-mode matrices.[11] The software implements a Markov Chain Monte Carlo Maximum Likelihood estimation, which proceeds in three basic steps. During the first phase, it produces a vector of estimates that generates a graph (network) distribution with expected values of configurations indicating bridging and bonding equal to those in the observed graph (network). When the estimation is concluded, a second phase follows, during which many simulations (1,000 in this case) are performed with the parameter estimates obtained in phase 1 to determine whether they can generate a network distribution centered at the observed network. The parameter estimates are adjusted multiple times as needed in different subphases during this second phase, with the procedure stopping after a preset number of subphases have taken place. The third and last phase simulates graphs from the final parameters obtained at the end of phase 2. Standard errors are also estimated during the last phase, and convergence checks are performed. A $t$-ratio is produced for each coefficient that captures how much convergence exists in this process. Values of $t < 0.1$ are interpreted as a sign of good convergence; the observed values lie in the center of the graph distribution of model-predicted network configurations.

### *Dyadic Independent Formation of Links*

As explained, ERGMs allow for the modeling of dyadic-dependent processes in which the existence of ties (which shape local configurations) are dependent on the existence of other ties in the network. However, ERGMs also allow for the modeling of *dyadic independent* processes that may lead to the formation or dissolution of ties

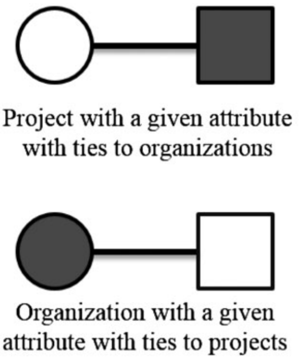


**Figure 4.** Basic "Activity" Configurations.

(Morris, Handcock, & Hunter, 2008). In dyadic-independent processes, the existence of a tie depends not on the presence of other ties but rather on particular attributes of the node that creates (or receives) the tie (Robins, Elliott, & Pattison, 2001), as shown in the next equation:

$$\Pr(X = x \mid Y = y) = \frac{1}{\kappa}\exp\left\{\sum_{Q}\theta_Q z_Q(x) + \sum_{A}\theta_A z_A(x, y)\right\} \tag{2}$$

The difference between this and the previous equation is simply that equation 2 includes a term that captures the interaction of ties ($x$) and nodal attributes ($y$); in other words, equation 2 also represents the probability of observing particular configurations in graph x given the observed attribute vector $y$ in the nodes.

To put it simply, in the networks of organizational assistance I study, it is possible that the level of activity is explained by particular attributes that organizations or projects have. So, in addition to the configurations in Figures 1 and 2 that indicate the presence of bonding and bridging network capital, I include basic "activity" configurations based on certain organizational and project attributes, which are basically used to capture whether organizations or projects with certain attributes are more likely to be active (have a higher degree or ties connecting them to other nodes) or not. Figure 4 shows the two simple configurations associated with network activity. As before, a circle represents an organization and a square represents a project. A filled circle or square represents an organization or project (respectively) with a particular attribute, which is supposed to be associated with a higher activity level (higher degree).

I include activity parameters for the following organizational and project attributes.

*Activity Level for Different Organizational Types.* As mentioned in a previous section, the 198 organizations that participate in the two-mode networks providing assistance to at least one project can be of nine different types: federal government (8 organizations), state government (12), regional government (14), local government (79), business (22), environmental NGOs (22), research institutions (24), neighborhood associations (11), and other type of organization (6). To model activity based on organizational type, I created seven dummy variables from this categorization: (i) federal/state government, (ii) regional government, (iii) local government, (iv) business organization, (v) environmental NGO, (vi) research institution, and (vii) neighborhood association/other type. I grouped federal and state government organizations and neighborhood associations and other types of organizations because there were not enough federal government actors and other types of actors to warrant separate dummy variables for each of those two categories. In the models, I include six of these dummy variables, leaving out the dummy for "local government." This means that the coefficients for the included dummies will tell us whether that particular organizational type is more active (positive coefficient) or less active (negative coefficient) in the networks than local governments. The dummy "local government" is chosen as the comparison category because local governments are the actors with more presence in the networks, with a majority of project applications produced by them.

In general, I expect the dummy for "regional government" to have a positive and significant coefficient in all four networks, given that the District (a regional governmental organization) is central in all of them and thus should be distinctively more active than the organizations in the baseline category of "local government." I also expect the dummy for federal/state government to have a positive and significant coefficient in the network of assistance to solve regulatory and permitting issues for the project, as many of the regulatory hurdles faced by the project need to be cleared at the state and federal levels. On the other hand, I expect the federal/state government dummy to have a negative and significant effect in the network of assistance to achieve public and political support for the project, because accomplishing this goal usually requires a strong effort by organizations at the local level—the baseline category. Finally, I expect research institutions to be more active than those in the baseline category of "local government" in the network of assistance to solve technical issues. I do not have strong expectations for the coefficients of the other dummies, but they are included to empirically elucidate the types of actors that may drive activity in each of the four networks.

*Activity Level of Funded Projects.* The models also include parameters to estimate the formation of ties based on project-level attributes. The first such attribute is whether projects have obtained a favorable funding decision by the District or not. Out of a total 95 projects, 73 projects obtained funding; as such, it is relevant to assess whether projects that obtained funds were also more active (i.e., had more organizations participating in them). The information to code this variable was obtained from the bimonthly budget notebooks published by the District, which are available in its website with detailed information about funding decisions for every applying project.

*Project Budget.* I also include an activity parameter in the models for the size of the project's budget with the expectation that larger projects request assistance from more participants (they are more active) simply because they are more likely to face greater technical, regulatory, public, and funding challenges.

There is a sizable variance in the proposed budget of the 95 projects studied here; the minimum budget for a project is \$1,000 and the maximum is \$61,366,000. The mean value equals \$3,969,968, with a standard deviation of \$9,561,022.

*Project Evaluation.* Another activity parameter that I include in the models is for a variable that captures whether respondents to the survey evaluate their projects positively or not. Respondents were asked to state their level of agreement with the following three statements: (i) "The project will fully satisfy my organization's expectations," (ii) "The project will fully satisfy the expectations of those who initiated the project," and (iii) "The project will deliver the full public value that the community expects for this type of project." The respondent placed responses in scales ranging from 1 (strongly disagree) to 7 (strongly agree) for each of the statements, and the mean value was then calculated from the high correspondence among the three questions (Cronbach's alpha = 0.83). As with the project budget, the expectation is that projects that are better evaluated by the managers would be more engaged, because projects that gather the assistance of more organizations will be better endowed with needed resources that strengthen applications, which should result in better evaluations. The minimum score for this variable in a project is 2.33, with a maximum value of 7. The mean score is 6.04 with a standard deviation of 0.94.[12]

*Organization Type Homophily.* In addition to all the activity parameters described above, I also control for organizational type *homophily*. The term *homophily* is used in social network analysis to illustrate the tendency of nodes to create connections to others that are similar on some particular characteristic (Weick, 1979; see McPherson, Smith-Lovin, & Cook, 2001, for an outstanding review of the concept) and has been widely documented in the study of policy networks (Knoke, 1990; Termeer & Koppenjan, 1997).

Here I test for Organizational Type Homophily, or the tendency of organizations to work in projects where other organizations of the same type are involved. Certain organizational types are more likely to provide specific resources for projects. For instance, environmental NGOs and neighborhood associations should be more likely to be contacted when project managers need public buy-in; universities and research centers should be contacted when technical information is needed, etc. Figure 5 illustrates the type of configuration that would indicate Organizational Type Homophily and that I include in the models.

If project managers need more resources of one kind to make a project application competitive and that type of resource is distinctively provided by one type of actor, then organizational homophily should be expected and the configurations in Figure 5 should be observed with a higher frequency than expected under a random process of links generation.

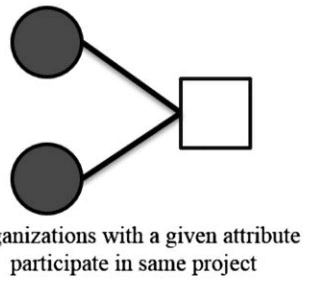


**Figure 5.** Homophily Configuration.

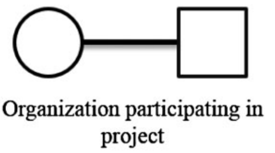


**Figure 6.** Density Configuration.

*Density Parameter.* Finally, I include a simple density parameter in the models to account for the formation of ties independently of other configurations or nodal attributes that have been described up to this point. The density parameter is illustrated in Figure 6.

In the estimation of ERGMs, parameters are correlated due to the conditional dependence assumption, so a density parameter will typically become more negative as effects with positive values are added.

## Results

Table 1 contains the results of the estimations in the four different two-mode matrices that represent the participation of organizations in projects. All models converged with $t$ values $< 0.1$ for all the coefficients but only after removing the parameter indicating the existence of strong triangles, which impeded good convergence. The converged models' fits were assessed with Goodness of Fit (GOF) tests available in BPNet, as described in Wang, Sharpe, Robins, and Pattison (2009). See the Appendix for more information about GOF tests.

The density parameter—included in the last row of the table—is negative and significant in all the models, which indicates that there are fewer links in these networks than expected in random networks when taking into account the other structural configurations included in the models. In other words, the formation of links in these networks can be attributed to specific nonrandom processes driven by the configurations included in the models.

The most central finding is the absence of configurations indicating bonding network capital in all four networks, coupled with a positive and significant

**Table 1.** ERGMs for the Two-Mode Matrices of Organizations Participating in Projects

| | Assistance to Secure Funding | Assistance to Solve Regulatory & Permitting Issues | Assistance to Achieve Public and Political Support | Assistance on Technical Issues |
|---|---|---|---|---|
| Bonding Capital | | | | |
| Strong bonding (project-based) | 0.00 (0.24) | –0.60** (0.26) | 0.03 (0.17) | 0.06 (0.08) |
| Weak bonding (project star) | –0.85 (0.71) | 0.74 (0.56) | 0.03 (0.36) | –0.42 (0.39) |
| Strong bonding (organization-based) | Models do not converge | Models do not converge | Models do not converge | Models do not converge |
| Bridging Capital | | | | |
| Organization star | 1.23*** (0.12) | 1.36*** (0.12) | 0.88*** (0.12) | 0.79*** (0.12) |
| Dyadic Independent Formation of Links | | | | |
| Activity of federal/state gov. | –0.34* (0.20) | 0.21* (0.12) | –0.66** (0.28) | 0.11 (0.16) |
| Activity of regional gov. | 0.39** (0.15) | 0.28** (0.13) | 0.18 (0.19) | 0.54*** (0.15) |
| Activity of environmental NGO | –0.75*** (0.29) | –0.39 (0.28) | –0.44* (0.25) | –0.37 (0.24) |
| Activity of business org. | –0.87** (0.34) | –1.00** (0.51) | –0.63* (0.38) | –0.45* (0.25) |
| Activity of research org. | –0.75** (0.30) | –0.43 (0.28) | –0.72** (0.29) | 0.03 (0.16) |
| Activity of neighborhood associations/other orgs. | –2.25** (0.97) | –0.85* (0.49) | –0.47* (0.27) | –0.69** (0.32) |
| Organization type homophily | –0.26 (0.17) | 0.07 (0.13) | –0.06 (0.12) | 0.07 (0.09) |
| Activity of funded projects | –0.20 (0.20) | –0.16 (0.20) | –0.07 (0.15) | 0.06 (0.14) |
| Activity of larger projects | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| Activity of better-evaluated projects | –0.12 (0.09) | –0.25** (0.10) | –0.03 (0.07) | –0.09 (0.06) |
| Density parameter (overall activity) | –3.17*** (0.86) | –4.00*** (0.82) | –4.85*** (0.52) | –4.03*** (0.63) |

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$ (two-tailed test). Standard errors in parentheses.

coefficient for the *organization star* parameter, which indicates the prevalence of bridging network capital in all cases.

In regard to the effects included in the models that indicate bonding, both the *weak bonding (project star)* and *strong bonding (project-based)* coefficients are indistinguishable from 0 in all the networks, with the exception of the network of assistance to solve regulatory and permitting issues in projects, where the *strong-bonding (project-based)* parameter is negative and significant at the 0.05 level. On the other hand, the *organization star* coefficients are positive and significant to the 0.01 level, indicating that there are more of these configurations than what would be expected by chance. To put it simply, this means that there are some organizations that are highly central (have links to many projects), which potentially allows for the transference of localized knowledge generated in particular projects to the larger community of projects that participate in the CFI program. The main actor driving this finding is obviously the District, whose staff is expectedly contacted by many project managers to discuss project-related issues (presumably because this should increase the chances of the projects being funded).[13]

It is interesting to note that the size of the *organization star* coefficients are larger in the network of assistance to secure adequate funding and the network of assistance to solve permitting and regulatory issues (1.23 and 1.36, respectively). This simply reflects the fact that the project managers require assistance to solve funding and regulatory issues from a smaller group of key organizations that can provide the needed resources, and thus become centrally attached to multiple projects. In the case of the network of assistance to solve permitting and regulatory issues, this is even more noticeable, and the result must be considered together with the negative and significant coefficient for the *strong bonding (project-based)* configuration that I mentioned in the previous paragraph. One must keep in mind that effects in an ERGM are conditional on one another, and so a strict interpretation of the findings for this particular network is that there is a tendency *against* the formation of bonding given the strong tendency *for* the formation of organizational stars around actors with enough knowledge on regulatory issues.

In the case of the network of assistance to obtain public buy-in and political support for the project and the network of assistance to obtain technical information, the smaller size of the bridging social capital coefficients (0.88 and 0.79, respectively) indicate the presence of somewhat less centralized networks, which suggests the availability of alternative sources of assistance for the provision of these resources. In general then, bridging is clearly dominant in the four networks, but the results also show that this dominance is conditional on the type of resource project managers seek to secure for their projects.

This initial depiction of how the design of the projects unfolds in the CFI becomes more nuanced and complete when one considers the parameters of the nodal attributes that were included in the models. The "activity" parameters for organizational types helps flesh out a coherent story about who assists the projects and why. Federal and state governmental agencies, for instance, are more active than local governments (the comparison category that was excluded from the models) in assisting project managers to solve regulatory and permitting issues (although the

0.21 coefficient is only significant at the 0.1 level) but less active in providing assistance to secure funding and to achieve public and political support for the project (coefficients of –0.34 and –0.66, respectively). This makes sense as projects are usually designed to tackle water-related issues at the local level, yet need to comply with a complex architecture of regulations that extends beyond that level.

Regional governmental actors, on the other hand, are more active in all the networks when compared with the comparison category of local governments, with the exception of the network of assistance to achieve public and political support. These positive effects were expected, as the District is a regional governmental organization, and so its inclusion among this group of actors drives these sets of coefficients upward.

The remaining effects for the dummies capturing other organizational types are mixed, although they do not show a positive and significant coefficient in any instance, which simply means that none of them are more active in the four networks than the main players in this shared-cost program, which are the local governments. In some cases though, they are clearly *less* active than local governments, but this is conditional on the type of assistance that project managers seek. For instance, environmental NGOs are less likely to be asked for assistance to secure funding, which is expected (coefficient of –0.75 significant at the 0.01 level), but they are also less likely to be called upon for providing assistance to achieve public and political support, although this relation is weaker (coefficient of –0.44 significant at the 0.1 level). Business organizations, on the other hand, are less likely to be contacted to assist projects in every one of the four areas, as are neighborhood associations and other types of organizations. Research organizations are also less likely to be contacted to provide assistance to secure funding and to achieve public and political support (coefficients of –0.75 and –0.72 significant at the 0.05 level, respectively). Contrary to expectations, however, they are not more likely than local governments to be asked to assist project managers on technical issues their projects may face (the coefficient is statistically indistinguishable from 0).

The remaining coefficients in the models are not significant at conventional statistical thresholds. Across the four networks, there is no evidence of homophily on organizational type, which suggests that in general project managers gather assistance from a variety of organizational types, depending on the needs they face. Projects with larger budgets, or those that have ultimately been funded, have not been more active in the networks (they have not requested assistance from more participants), and projects that have been better evaluated by their managers have not been more active either. In fact, in one of the networks (assistance to solve regulatory and permitting issues), projects that have been better evaluated are *less active* (coefficient of –0.25 significant at the 0.05 level). It is not possible to discern with the available information why that is the case, though one could submit as a plausible explanation that projects that are better designed (at least in the eyes of the project managers) are less likely to demand assistance from outside sources. Still, it is not clear why this would happen only in the case of network of assistance to solve regulatory and permitting issues, and so more research is needed to elucidate this finding.

In general, the results show that in the four two-mode networks I examine in this article, there is a strong presence of bridging structures in the form of organizational stars that exceeds what one would expect to see if the process of providing assistance to projects was driven by random choices made by project managers. In other words, project managers know who to go to for assistance and this creates centralized structures that are slightly modified based on the need of resources that each project has.

Network theory indicates that these structures could favor the transmission of relevant know-how from project to project, providing a bridging effect that would be absent if the central organizations were more peripherally connected to projects. Of course, one needs to assume that the central organizations in these networks are willing to share what they "learn" in one project with the project managers of other projects that require its assistance. This is a fairly realistic assumption in the case of the CFI program, given that one of the main goals of the District (the most central actor in all the networks that I have analyzed) is to gather relevant knowledge from its interactions with the partners and make sure that that knowledge gets incorporated into the program to be reused in the future (R. Baldwin, personal communication, August 13, 2007). By assisting many projects at the same time, the District contributes to increasing the capacity of its shared-costs program to generate more innovative responses to problems (in the form of better-designed projects) that would otherwise be lacking.

This is a feature of critical importance in the system given that the Cooperative Funding Program is competitive in nature, with many actors preparing projects and competing for limited financial resources. It is in this competitive setting that the intervention of the central actors in projects may be thought of as a catalyst for what we could call "inadvertent collaboration" among applicants. This is the case because project managers require the assistance of partners, but the latter could also widen their knowledge base by assisting projects (they may learn about new individual strategies to strengthen applications, for instance). There is nothing in principle that would impede the knowledge generated in one project from being used to assist other projects, and so the project managers may end up unknowingly contributing to strengthening projects they compete with when they share information with the central nodes that assist them. In this sense, the central nodes that are embedded in large "organization stars" may vest the network with a capacity to generate more innovative projects even when that is not the intention of some of the participants.

Of course, only the potential for the transference of expertise or relevant knowledge from project to project is embedded in bridging structures. The fact that bridging configurations are prevalent does not mean that innovation will necessarily take place. Thus, the notion of "inadvertent collaboration" needs to be explored further in situations where researchers can actually gauge whether parallel learning in different organizations linked to the same central actors is taking place or not. This would contribute to filling an ongoing gap in current network studies in public management and policy, which have not yet assessed precisely whether bridging or bonding affect organizational performance.

## Conclusion

Among the most relevant issues in public management and policy studies is the extent to which resource interdependencies shape and structure collaborative networks, and how this affects performance both at the nodal (Berardo, 2009) and the whole-network levels (Provan, Fish, & Sydow, 2007). A less explored issue is the capacity of key actors to affect these configurations, and the sensitivity in the formation of network configurations to the types of resources actors share with each other. On top of this, policy scholars heretofore have remained ignorant of how these issues pan out when actors link to each other only indirectly through their participation in common events or projects.

This work's main contribution is to address these issues comprehensively. By exploring the two-mode networks where organizations provide a specific type of resources to projects that are in the design stage, I have shown that the participation of small subsets of highly active central organizations explains the existence of particular configurations that may facilitate the flow of information among the projects. This finding is important by itself because it illustrates how governmental actors can connect otherwise disjointed efforts to provide solutions to problems of a regional scale. Recent scholarship on self-organizing collaboration in fragmented federal systems contends that governmental authorities do not necessarily assume a steering role to mitigate institutional collective action dilemmas in networked environments (Feiock & Scholz, 2010). The results I have presented complement this view in one important respect: even when governmental authorities do not explicitly seek to steer collaborative processes, they can still help in the creation of bridging structures that increase the likelihood of implementing better-designed responses to problems. Designing and implementing shared-costs programs may be a preeminent way to achieve that goal, since partners seeking to strengthen their collaborative efforts are likely to build the ties that in the end favor the transmission of novel information throughout the system.

The contribution of governmental actors, however, is not independent of the specific needs their partners face. The results in this article showed that project managers gather different resources from different actors, and this affects the overall structure of the collaboration networks. To obtain assistance to secure funding and to make sure that the project meets regulatory requirements, managers rely heavily on a small set of central governmental actors who can provide such expertise. Project managers also require their assistance to make sure the project is soundly designed from a technical point of view and that it has public and/or political support. However, in these cases, they require more assistance from nongovernmental actors that can provide those resources too, which reduces the level of centralization in the networks. This new knowledge about the different collaboration patterns that result from specific needs for resources complements the findings of scholars who have shown that the exchange of resources is an important variable to understand the success of collaborative practices at least in the realm of environmental management in general (Koontz et al., 2004) and water management in particular (Leach & Pelkey, 2001; Sabatier et al., 2005).

A final contribution of this work is to explore the emergence of particular network capital configurations in two-mode networks, where organizations are linked to each other through their participation in common events. Many of the networks studied by political scientists and public management and policy scholars are two-mode in nature, with events represented by projects, multiparty contracts for service delivery, etc. However, analyses of these networks have been largely absent in scholarly work, perhaps because the set of tools to study them remained relatively underdeveloped until now. The techniques used in this article illustrate how the structure of two-mode networks can be analyzed in a level of detail that is not possible with methods that do not account for the interdependence of links (Lubell, Scholz, Berardo, & Robins, 2012).

Certainly, this initial approach to the study of two-mode collaborative networks is not without its shortcomings. First, these results do not provide information to assess how the structural configurations in the networks really affect the behavior of organizations and the performance of projects. For instance, bridging structures can give actors the chance to identify valuable partners (Granovetter, 1973), but it is not possible to know with the available data whether partnerships actually form among actors weakly connected through participation in projects. To see whether these partnerships form or not, studies need to collect longitudinal data, which also would allow for an assessment of whether nodal attributes change or not as a consequence of being embedded in certain structures and not others.

Future research also needs to explore in more detail the connections that exist at the intraorganizational level in central nodes as complex as the District or other public agencies. These organizations participate in different projects, but they are usually represented in them by a group of individuals who may or may not communicate fluidly with each other. To realize the potential for innovation facilitated by the bridging structures that emerge when certain organizational actors participate in multiple projects, one needs to assume that communication among individuals working for them is of a high-enough quality to allow for the transference of meaningful information from project to project. Future research on interorganizational collaboration through participation in joint activities needs to account for this complex feature of networks.

Finally, a third limitation of this work is its focus on a single shared-costs program. This prohibits generalizations based on the findings, which have more of a descriptive tone and are intended as an illustration of a novel way to study networks in public policy and management. Collecting more data across multiple programs would help solve this problem. I should note, however, that this limitation may not be too important for scholars who believe in the highly contextual nature of networks and the relationship structural patterns have with organizational behavior and/or policy performance. For instance, the existence of bridging structures (instead of bonding) in the CFI reveals a picture of centralized flow of resources through a small set of actors that is clearly self-organized, as project managers are not legally mandated to work with the partners they choose. Yet many of the networks that public management and policy scholars study can be managed more or less explicitly, with some actors determining what links should be created and which destroyed. In circumstances like these, a network may end up being centralized as well, but the effect this could have on organizational behavior or project performance may end up being quite different than the effect in a self-organized network. In any case, a more complete understanding of how links form and how this affects overall network structure needs to enter more decisively into the research agenda of network scholars in the near future.

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## Notes

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1. Southwest Florida contains approximately one quarter of the state's rapidly growing population, which poses great environmental threats to the stability of ecosystems in the area (Marella, 2004). The Southwest Florida Water Management District—one of five that exist in Florida—is the main regional authority that can regulate water use in the area (http://www.swfwmd.state.fl.us/).
2. The study of two-mode networks has been common in the social sciences since the publication of Davis, Gardner, and Gardner's (1941) *Deep South*, which included the classic study of the pattern of attendance to social meetings among a small group of women during a nine-month period. From that point forward, a wide variety of social phenomena have been studied through the analysis of two-mode networks, including membership in voluntary organizations and clubs (Bonacich, 1978; McPherson, 1982), participation in interlocking boards of directors (Koskinen & Edling, 2010; Levine, 1972; Mizruchi, 1982; Robins & Alexander, 2004; among others), etc. However, in public management and policy sciences studies, the analysis of two-mode networks has not yet received widespread attention, despite the fact that many of the networks that scholars study are bimodal in nature (see Jasny, 2012; Lubell, Robins, et al., 2012, for exceptions).
3. This conception of bonding capital is rooted in Heider's (1958) early work on balance theory.
4. The configurations in this figure have been proposed by Wang et al. (2009) for new ERGMs specifications that improve convergence for large bimodal networks, a task not easily accomplished with the Markov models that until recently had dominated the analysis of one- and two-mode networks (Frank & Strauss, 1986; Skvoretz & Faust, 1999). The "strong bonding" structures in Figure 1 (1a and 1b) are properly named by Wang et al. as *alternating two-paths*, whereas the "weak bonding" structures of 1c and Figure 2 are *alternating k-stars* (a *k-stars* is just a node of degree *k*).
5. The overall argument portraying bridging and bonding capital in networks as two fundamentally different ways of appropriating the benefits of participating in networks finds a strong correlate in organizational studies in March's ideas (March, 1991) on the existing tension in organizational settings between the needs to "explore" new opportunities in the surrounding environment (engaging in searches that reach beyond the most immediate neighbors) and to "exploit" existing resources that are available in more local settings.
6. Each year, the deadline for the presentation of applications is the first Friday of December. Each completed application contains detailed information including the goal(s) of the project, the name of the leading organization presenting the application, and its "contact person" (the project leader), as well as milestones, budgetary requirements, etc. In the months following the submissions of applications, District's staff reviews applications and ranks them (from high to low priority). Finally, the District makes funding decisions in July of the following year.

7. The panel included the Executive Director of the Tampa Bay Estuary Program, a Senior Scientist at the Florida Fish & Wildlife Commission, the Director of the Pinellas County Department of Environmental Management, a former member of the District's Governing Board, and the District's Director of the Resource Management Department.
8. The projects in the study range from multimillion dollar regional water supply projects to neighborhood flood control and trail projects. The 76% that was funded accounted for matching grants from the District exceeding $300 million, with project partners contributing an equal amount. Applications are available on the District's website at http://www.swfwmd.state.fl.us/. The names of project managers were obtained from the bimonthly Budget Notebooks published by the District (also available on the website).
9. A copy of the questionnaire used for this project is available at https://pantherfile.uwm.edu/berardo/www/research.htm. Project managers who did not answer the survey are not significantly different than those who did in regard to the likelihood of their projects being funded or the proposed budget of their projects, which considerably lessens concerns about nonresponse bias.
10. The material covered in this and the following paragraphs draws heavily from Wang et al. (2009), who explain in detail how ERGMs can be adapted to analyses of bipartite networks.
11. The software is developed by scholars at the University of Melbourne (Australia) and can be obtained for free at: http://sna.unimelb.edu.au/PNet.
12. Given the heavy tipping in the distribution of this last variable, models were also calculated with the transformed version of the variable:

$$\frac{e^{project\ evaluation}}{\max\left(e^{project\ evaluation}\right)}$$

Where $e$ is just the base of the natural logarithm (approximately 2.718), project evaluation is the value of the original variable, and max ($e^{project\ evaluation}$) equals the maximum value possible of $e^{project\ evaluation}$ (1095.837). This transformation makes the variable project evaluation more uniformly distributed with values ranging from 0 to 1. The results in the estimation of the model did not differ when this modified version of the variable was used.

13. For two-mode networks of $n$ rows and $m$ columns, one can model stars up to size $n$ and $m$. At the moment of estimating a model in BPNet, one can choose the value of a weight parameter $\lambda$ (lambda), which dampens the effect of large changes in the statistics of large stars when set to a value equal or larger than 1 (see Wang et al., 2009, for a detailed description of the weight parameter). For instance, when $\lambda$ equals 2, the model treats nodes with degree higher than five almost equivalently and as it grows beyond that value the model estimates the existence of stars of lower degree. As $\lambda$ approaches infinity, the star parameter is almost equivalent to a 2-star. I estimated the models with the default value of 2.
14. Illustrations in the figure were produced with UCINET (Borgatti, Everett, & Freeman, 2002). Labels of all projects and most organizations were removed to preserve readability.

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## Appendix

### *A Note on Goodness of Fit*

BPNet calculates the models' Goodness of Fit by simulation; the configurations from the observed networks are compared with the configurations that result from a number of simulations (3,000,000 in this case) run with the coefficients available from the converged models in Table 1. The software runs a check to see whether the observed networks are located "at the center" of the simulated graph distributions, which would indicate a good fit. Of course, the graph statistics included in the goodness of fit test cannot include only those in the estimated models, since that would lead invariably to good fit given that the models converged.

Thus, I included two-star parameters for organizations and projects in the dyadic-dependent part of the model, which simply capture structures where one organization (project) is connected to two projects (organizations). I also included two-star parameters for all the organizational and project attributes in the dyadic-independent part of the model. In these cases, the structures show whether an actor with a given attribute is more connected to nodes of the other mode. For example, a two-star parameter for the “research organization” dummy indicates whether these types of actors are more active in two-stars, in comparison to the baseline category of “local governmental actor.”

Results showed that the configurations in the observed data (both the ones included in the models in Table 1 and those that were not) were, in general, very well replicated in the simulations, as indicated by small Malahanobis distances, which capture the difference between the value of the statistics in the observed data and the (mean) value of the statistics obtained from the simulations (see Wang et al., 2009, for more details).

However, this was not the case for the two-star configurations for the organizations mode and for the two-star configurations of “Regional Governmental Organization” dummy. In both cases, the number of configurations in the observed network clearly exceeds the mean number of configurations obtained through the simulations. Substantively, what this means is that the data is even more centralized on the organizations and particularly on the actors that are classified as “regional governmental organization” than predicted from the model. These results obviously do not detract from the inferences I have made when analyzing the results, since more centralization in general indicates more, not less, bridging. An obvious “fix” to try to improve the fit of the model would be to include the two-star configurations, but doing so causes convergence problems in all four models. Thus I report the original models in Table 1, knowing that their fit to the observed data is clearly less than perfect.

Detailed outputs for the GOF tests of the four networks, as well as replicating material, is available at https://pantherfile.uwm.edu/berardo/www/research.htm.

**Table A1.** Most Central Organizations in the CFI (measured as Degree Centrality) Top Degree Centrality Scores

| Centrality Ranking | Organization (Normalized Degree Centrality Score) | | | |
|---|---|---|---|---|
| | Assistance to Secure Funding | Assistance to Solve Regulatory & Permitting Issues | Assistance to Achieve Public and Political Support | Assistance on Technical Issues |
| 1 | The District (0.64) | The District (0.36) | The District (0.31) | The District (0.42) |
| 2 | Pinellas County (0.15) | FDEP (0.22) | Pinellas County (0.13) | Pinellas County (0.16) |
| 3 | Hillsborough County (0.08) | Pinellas County (0.15) | Hillsborough County (0.09) | FDEP (0.15) |
| 4 | FDEP Polk County City of Tampa (0.07) | U.S. Army Corps of Engineers (0.10) | Polk County (0.08) | Hillsborough County (0.11) |
| 5 | Sarasota County (0.06) | Hillsborough County (0.09) | Sarasota County (0.07) | Polk County University of Florida (0.09) |