Network Effects Research: A Systematic Review of Theoretical Mechanisms and Measures

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Abstract
This article contributes to the network effectiveness literature by identifying the theoretical mechanisms and network measures scholars in public administration and policy use to draw inferences between network structures and network effects. We conducted a systematic review of empirical network effects research in 40 public administration and policy journals from 1998 to 2019. We reviewed and coded 89 articles and described the main social theories used in the network effectiveness literature and the associated mechanisms that translate network structures to network effects. We also explain how scholars operationalize those theoretical mechanisms through network measures. Overall, our findings reflect that there is limited use of social theories for the explanation of network effects and in some cases, inconsistent use of network measures associated with theories. Moreover, we identify several challenges confronting network effects research. These challenges include the difficulty of isolating specific mechanisms related to a particular social theory, the use of network structures both as a mechanism and as a measure, and the lack of data to examine network dynamics and coevolution.

Keywords
systematic review, network effects, theoretical mechanisms, network structures, network measures

Introduction
Networks have long been viewed as a suitable form of organizing to address complex policy problems and coordinate public service delivery (Provan & Milward, 2001). However, much of the empirical research on the effectiveness of networks in public settings did not begin until the 1990s. Since that time, network research has grown tremendously. There exist relevant frameworks to assist researchers in assessing network performance (Herranz, 2010; Provan & Milward, 1995; Raab et al., 2015) along with syntheses of the extant network effectiveness literature (Cristofoli & Markovic, 2016; Kenis & Provan, 2009; Turrini et al., 2010). Despite this growth, there remains a lack of understanding as to how network structures determine outcomes. Therefore, it is important to identify the specific mechanisms associated with different relational configurations that produce outcomes for the network members or the whole network (Hedström, 2008).

Provan and Milward (2001) identified two critical challenges confronting research on network effectiveness: (i) how to reach consensus on network goals and performance metrics and (ii) how to identify the primary aspects of networks that may influence performance. Our study is concerned with the latter challenge. We conducted a systematic review of the network literature in public administration and policy to identify the theoretical mechanisms and network measures scholars use to draw inferences between network structures and network effects. Our systematic review covers network research for 21 years (1998–2019) in 40 public administration and policy journals. In this research, we focus on network effects in a broad sense and define them as the desired impacts or consequences that a network may have on participating actors or the system itself. Besides “network effects,” in this manuscript, we also use the terms “network effectiveness” and “network performance” as they are used in the reviewed articles.

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This systematic review includes empirical network effects research at the node and system levels. Network effects research at the node level analyzes the extent to which the characteristics of an individual’s network affect the desired outcome (Raider & Krackhardt, 2017). For instance, Maroulis (2017) analyzed if teachers with more connections among different subgroups within their network are more likely to present innovative behaviors. Network effects research at the systems level considers aggregate and collective outcomes. Thus, system-level effects would include both network-level and community-level outcomes as defined by Provan and Milward (2001). Network effects research at the system-level studies how the characteristics and structure of the network affect aggregate outcomes for the community served by the network or for the functioning of the network itself (Provan & Milward, 2001). For example, Lee (2013) compared two local governments and found that dense networks lead to a greater perception of e-government effectiveness because information and knowledge flow faster in denser structures.

This article contributes to the network effects literature in three ways. First, we provide a concise description of the theories and the associated mechanisms that translate network structures into network effects. This description and review distill the primary mechanisms by which our field connects network structure to performance at the node and system levels. Overall, we find that there is limited use of social theories for the explanation of network effects. Second, we examine how scholars operationalize those mechanisms through different nodal and network measures. We find an inconsistent use of measures associated with specific social theories as scholars often use the same network measure to operationalize different theoretical mechanisms. We further analyze which network measures are most closely associated with particular mechanisms and offer suggestions for future research. Third, we identify the main challenges related to the extant research on network effects. These challenges include the difficulty of isolating particular mechanisms when multiple mechanisms are associated with a given theory or outcome and the lack of suitable data to study the coevolution of network structure and effects. In the following section, we explain the methodology used for the systematic review and then discuss the main theories and network measures used in the network effects literature.

**Systematic Review: Methodology**

To examine the theoretical mechanisms explaining network effects in public administration and policy, we reviewed empirical articles about public sector networks published from January 1998 to May 2019. To identify relevant network effects articles, we followed the slightly modified PRISMA protocol (Moher et al., 2009) used by Siciliano et al. (2021) and Kapucu et al. (2017). We conducted a general search in 40 main journals of public administration and policy. Our search and exclusion process consisted of five steps. First, we searched on the websites of each journal for articles that included in the title, abstract, or keywords the following terms “network,” “network analysis,” “collaboration,” or “collaborative.” This first step resulted in a total of 2,402 articles. Then, we reviewed the abstracts of these articles to ensure they were empirical network studies, including descriptive articles, comparative case studies, and articles that use inferential methods. We excluded purely conceptual articles and network studies in which no network data were collected. This process excluded 1,340 articles and included 1,062 articles. Third, we reviewed the methodology sections of the articles to verify that the authors use social network analysis methods or included network measures. A total of 282 articles met this criterion, and 780 articles were removed. Fourth, we confirmed the articles were about public sector networks and removed studies concerning private networks (e.g., articles about engineering firms, the airline industry, or high-tech companies); 196 articles met this criterion. Finally, since we were interested in understanding the effects of networks, we removed 107 articles that use the network as the dependent variable. Articles that treat the network as the dependent variable focus on analyzing network processes like tie formation and dissolution or how a specific structural property is formed. Thus, we kept 89 articles that included networks as independent variables and analyzed how different network structural properties impact performance or outcomes at the node or system levels.

For the analysis of the 89 articles, we designed a comprehensive coding protocol to extract specific information on the type and number of nodes in the network, type of ties, method of network data collection, primary level of analysis, area of study, research method, each network-related hypothesis and its associated use of theory and measures, and the different factors identified by the authors as drivers for performance. We also reviewed how authors conceptualized and measured (i) the dependent variable related to network effects, (ii) the use of perceptual or objective measures, (iii) whether the network effect variable was an output or a longer-term outcome, and (iv) the level of analysis of the dependent variable. Based on this coding we remove 15 articles from further analysis due to a lack of clear conceptualization and measurement of the network effects. Therefore, the final number of articles included in the analysis was 74.

Prior to coding, we initiated a pilot test where each of the four authors coded ten articles to compare and develop consistency in coding and adjust the coding protocol where needed. Once we concluded the pilot test and finalized the coding protocol, we created two teams with two coders each and coded all articles. Since we were interested in identifying the use of theories and network measures in the network effects literature, we conducted open coding of each hypothesis, the theoretical mechanism used by the authors to frame and support the hypothesis, authors’ description of the theoretical mechanisms illustrating the
relationship between network structures and effects, and the network measures used to operationalize these mechanisms. During the open coding process, we identify a set of ten theoretical mechanisms, nine structural arguments, and 21 distinct network measures used in the reviewed articles. Once we identified these categories, each hypothesis was recoded into its appropriate category. The final inter-coder agreement was 82.35%, above the acceptable rate of 70% agreement for nominal coding (Campbell et al., 2013). The entire team discussed all disagreements between coders, and consensus was reached on all coding decisions.

The specificity of the coding protocol allowed us to analyze the results at both the article and hypothesis levels. At the article level, we identified that out of the 74 articles, 34 focus on the node level and 40 on the system level. Some network scholars have stated the importance of distinguishing between unit and level of analysis (Borgatti et al., 2018; Krackhardt, 2009). The unit of analysis refers to the different types of entities considered as nodes in the network (e.g., people or organizations), while the level of analysis is associated with the type of questions researchers are interested in addressing (Krackhardt, 2009). This distinction is relevant for the network effects literature because researchers can identify different drivers for network outcomes at the nodal, network, and community levels.

Eighteen articles were descriptive papers. These descriptive papers did not conduct inferential tests; however, they are maintained in the analysis as they include a clear description of the relationship between actors’ attributes, network structure, and network effects. For instance, one descriptive article analyzed the impact of heterogeneity (as measured by the diversity of network members) on network effectiveness (Varda & Retrum, 2015). Despite the relevant contribution of descriptive and comparative case studies to the network effects literature, these studies did not include hypotheses. Therefore, for the hypothesis-level analyses, we focus on inferential studies. The analysis at the hypothesis level allows us to identify the use of social theories, network measures, and mechanisms at work behind the hypotheses posited by network scholars to predict network effects.

### Findings: Theories and Measures in the Network Effectiveness Literature

We identified and coded 223 hypotheses across the 56 inferential articles. Each hypothesis was coded based on the theory used by the authors as well as the network measures used to operationalize the theory. However, there were cases where the authors did not rely on a particular theory or mechanism to justify their hypothesis regarding network structure and performance but rather relied on the general network literature and thus offered more structural arguments. For example, some scholars hypothesized that a higher number of collaboration partners is associated with better performance and operationalized the number of collaboration ties through degree centrality scores. Building on Contractor et al. (2006), Siciliano et al. (2021) created a categorization of social theories associated with the analysis of network formation. We followed that same approach for identifying theories or Justifications associated with network effects and grouped them into two main categories: social theories and structural arguments. According to Coleman (1994), the main focus of a social theory is the explanation of social systems, and “this could be as small as a dyad or as large as a society or a world system” (p. 2).

The category of social theories includes contagion, resource dependence, collective action, exchange, and homophily theories, while the structural arguments focus on the effect of network centralization, density, or embeddedness. Another distinction between these two categories is that the social theories are based on mechanisms that are generally exogenous to the network or can operate in non-network settings, while the structural arguments emphasize mechanisms that are endogenous to the network (Contractor et al., 2006; Siciliano et al., 2021). Table 1 shows the different theories and arguments we have identified in the eligible articles.

Figure 1 shows the number of times these different theories and structural arguments are used in the network effects literature. We found that the majority of the hypotheses relied on a select few theories to predict network effects. The most prominent ones are social capital-bridging and structural arguments around centrality. Approximately 2% of the hypotheses were coded as “Multiple” when the authors relied on more than one theory for the justification. Nearly 4% were coded as “Other” when scholars relied on theories that were not commonly used and as such were

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**Table 1. Categorization of Theories.**

| Theory                        | Social theories                  | Structural arguments          | Other |
|-------------------------------|----------------------------------|--------------------------------|-------|
|                              | Collective action                | Structural argument-centrality| NA    |
|                              | Heterophily                      | Structural argument-density   |       |
|                              | Homophily                        | embeddedness                  |       |
|                              | Policy diffusion/social influence| Structural argument-structural |       |
|                              | Resource dependence              | equivalence                   |       |
|                              | Social capital-bridging          | Structural argument-transitivity|     |
|                              | Social capital-bonding           |                                |       |
|                              | Social capital-generic           |                                |       |
|                              | Social capital—trust             |                                |       |
|                              | Social exchange                  |                                |       |
| Other                         | Multiple                         |                                |       |
|                               | Other                            |                                |       |
|                               | NA                               |                                |       |
only found in one hypothesis. This “Other” category includes work on production theory, systems theory, and entropy theory. In addition, 40% of the hypotheses were coded as “NA” in the theory category because the authors did not rely on either social theories or structural arguments for the hypothesis framing. We will discuss this category further in the findings section.

In addition to identifying theory use, we also coded the specific network measures used by the authors to capture the particular mechanism posited by the theory/argument along with the rationale supporting the use of that measure. Figure 2a shows the most common network measures used to operationalize the theoretical mechanisms across the inferential articles. Figure 2b reflects the distribution of network measures used in descriptive articles. Degree centrality is the most common network measure in both inferential and descriptive articles. The fourth most common measure among the inferential studies is cohesion. Interestingly, cohesion is one of the least used measures in the descriptive articles. Betweenness centrality was a common measure in both inferential and descriptive articles. Across the inferential studies, the most common measure used for the operationalization of variables was “Other.” We included in this other category a large number of infrequently used measures such as efficiency measure, participation coefficient, mutual dependence, etc. These measures were only used two or fewer times. Measures were placed into the “Moderation effects” category whenever a hypothesis predicted that the impact of one variable would be moderated by another variable. For example, Shrestha (2018) states that the positive relationship between the number of collaboration partners and the possibility of being funded is stronger when the frequency of contact increases.

Due to space constraints, below we provide a summary of the social theories and structural arguments that were used in four or more hypotheses. For each, we describe the theory and its associated mechanisms along with the specific network measures used to capture the theory.

**Social Theories**

**Social capital—bridging**

_Theory and Mechanisms_. We identified 18 hypotheses from 15 articles using social capital theory based on bridging relationships. These bridging relationships are often discussed as structural holes and brokerage. Bridging, structural holes, and positions of brokerage in networks are linked to network effects through two primary mechanisms: information and control (Borgatti & Foster, 2003; Burt, 1992; Lin, 1999). The general argument for the informational benefits of structural holes is largely based on the work of Granovetter (1983) and Ronald (Burt 1992, 2005). Burt (1992) argues that actors that are directly connected tend to share similar opinions, ideas, and knowledge. Therefore, having ties to multiple individuals from the same group is inefficient as you can obtain roughly the same informational benefits from a single tie to the group (Burt, 1992). Access to diverse information and nonredundant ideas is best achieved by forming ties to individuals who are not connected. Individuals and organizations who span structural holes are viewed as entrepreneurs who obtain informational and vision advantages from their investment in bridging
disconnected actors (Burt, 2005). Seven of the fifteen articles emphasize the role of informational benefits and the value of access to novel ideas and resources. For example, Jokisaari and Vuori (2010), in their research on job training programs in Finland, contend that brokerage provides individuals with early access to information about new programs. Thus, these individuals are more likely to be early adopters of innovative practices. This hypothesis was supported, and the authors found a positive relationship between the brokerage position of individuals and the early adoption of new practices.

In terms of control, structural holes and brokerage are thought to provide benefits by allowing the broker to manage the flow and movement of information. The benefits are captured by the concept of tertius gaudens, which translates to “the third who benefits” (Simmel, 1950). Monge and Contractor (2003) discussed two situations where benefits of control accrue to the broker (p. 144). First, brokers are uniquely positioned to profit when the two actors they broker are competing for the same resource. In this case, the broker can obtain a higher reward for that resource by playing the two bidders against each other. The second situation occurs when the two actors are seeking different resources, allowing the broker to operate as a mediator, controlling the information flow and ultimate resolution (Monge & Contractor, 2003, p. 144). As noted by Borgatti and Foster (2003), if one can keep actors in the network disconnected, especially one’s adversaries or competitors, then those actors are less able to coordinate against you (p. 1003). Eight of the fifteen articles emphasize the role of control and influence over the movement of information and resources. For instance, Faulk et al. (2016) argued that organizational power results from an organization’s ability to influence others by controlling the movement of information and the availability of opportunities in the network. Similarly, Marcum et al. (2012) argued that direct ties are insufficient to maintain authority in an interorganizational network. Rather, they found that indirect ties, where organizations can act as gatekeepers of information and resources, provide positions of authority over the actors they broker (p. 521).

**Measures.** Several structural and non-structural measures have been used to capture brokerage and structural holes in networks. The two most common structural measures are betweenness centrality (Freeman, 1979) and brokerage scores (Gould & Fernandez, 1989). Other scholars have used network constraint or efficiency as measures of structural holes. Each of these four primary measures emphasizes an individual’s bridging position between non-connected actors—a structural role that aligns with both the mechanisms of information and control. However, several scholars have utilized measures based on direct connections, such as degree centrality or the average degree of actors in the network, to assess hypotheses about bridging or structural holes. These measures have less alignment with the theoretical mechanisms posited in the literature. Finally, not all scholars drawing on structural hole theory rely on structural measures. Sandström and Carlsson (2008) argued that heterogeneity and diversity in networks lead to improved outcomes. Thus, rather than focusing on one’s structural position to measure information diversity, Sandstrom and Carlsson used the diversity of the actors themselves and interactions that cross boundaries within the network as measures of structural holes.

**Social capital-bonding**

**Theory and mechanisms.** We identified eight hypotheses from seven articles using the bonding social capital theory. Unlike bridging social capital, bonding social capital refers to connections and resources in densely connected homogeneous groups with similar backgrounds or interests (Putnam, 2002). Bonding social capital is primarily described in two ways: the strength of the ties connecting the actors and network cohesion. Tie strengths and network cohesion...
affect networks by (a) directly encouraging cooperative behavior or (b) addressing differences and mitigating the transaction costs in the coordination process. Strong ties provide opportunities for network members to exchange information in a timely manner, build trust, and establish social norms, therefore enhancing collaborative commitment and promoting cooperative behavior (Coleman, 1988). Furthermore, a well-connected and closed network structure makes it easy to verify the credibility of information, leading to a reduction in uncertainty and prevention of defective behavior (Arnold et al., 2017; Berardo & Scholz, 2010).

Measures. Among the articles reviewed, researchers operationalized the strength of ties as the frequency of interactions between two nodes. For instance, Lee (2013) used communication frequency to measure tie strength and examined its impacts on perceived e-government effectiveness. The positive findings of his research suggested that stronger ties between employees of IT and program units contribute to perceived e-government effectiveness. Similarly, Lee and Kim (2011) used communication frequency to measure employees’ tie strength and studied their relationship with affective commitment; however, their research did not provide support for this relationship and the authors suggested that other measures like centrality or structural holes are more suitable to predict individual behaviors (p. 216).

Network cohesion has been operationalized as the structural measures of transitive triads, clustering coefficients, and subgroup cohesion (e.g., Arnold et al., 2017; Shrestha, 2013; Yi, 2018). A high proportion of transitive triads have been found useful in building shared identity, offering support, and making it difficult for outside interventions to influence network members (Arnold et al., 2017). A high clustering coefficient (the proportion of links among an ego’s alters) suggests a high level of redundancy of linkages exists in the network, which can help address differences or conflicts among members (Yi, 2018). Shrestha (2013) proposed a similar measure, “subgroup cohesion”—the percentage of the organization’s alters or partners working on the same projects—to study its impacts on securing program funds for the collaborative Rural Water Supply and Sanitation Program (RWSSP) in Nepal. Supporting evidence is found for this hypothesis.

Social capital—trust

Theory and Mechanisms. Six hypotheses across four papers focused on the role of trust in shaping network effects. A basic definition of trust is the expectation that actors will take each other’s interests into account when making decisions or taking action (Lin, 2001, p. 147). Trust is seen as a critical element to the basic functioning of society and the multitude of formal and informal relationships that exist (Simmel, 1950). Trust is tightly linked with the concept of social capital. Because social capital emerges through one’s relations and the resources made available from those relations, trust is viewed as a component or attribute of social capital (Kadushin, 2012). As such, “Networks are both indicators of social capital and also are a process that leads to social capital” (Kadushin, 2012, p. 177). In the articles reviewed, the trust component of social capital is used as a predictor of network effects. The implications of trust examined in the articles range from charitable giving (Markovic, 2017) to obtaining project funds for community development (Shrestha, 2013).

Measures. Trust is an inherently difficult concept to measure. Authors most often use survey questions to obtain perception-based measures of trust. For example, Hawkins (2010, p. 260) developed an additive index based on respondents’ level of agreement with a number of items, such as: “local government officials from different jurisdictions trust one another.” Herzog and Yang (2018) and Markovic (2017) used a similar approach but relied on a single survey item. Shrestha (2013) examined the role of social trust in a community on that community’s success in obtaining financial resources. He relied on a measure of civic engagement to capture social trust. Based on Putnam et al. (1993), civic engagement was measured by the proportion of households in the community who were members of local organizations. In general, these articles found a positive relationship between trust and network effects (Hawkins, 2010; Herzog & Yang, 2018; and Markovic, 2017).

Policy diffusion/social influence theories

Theory and Mechanisms. Ten hypotheses across seven articles used policy diffusion/social influence theories. Burt (1987) identified two primary mechanisms associated with the diffusion of attitudes and innovation: cohesion/peer influence and structural equivalence. The primary idea behind cohesion and peer influence is that through repeated communication with network members, ego is more likely to gain information regarding the new behavior, policy, or attitude from alters that have already adopted it (Jokisaari & Vuori, 2010). Furthermore, the larger the number of actors adopting a behavior or attitude in one’s immediate network, the more legitimate the behavior or attitude is perceived socially (DiMaggio & Powell, 1983). Structural equivalence is different. Structural equivalence addresses the similarity in connection patterns that two nodes have with the other nodes in the network, regardless of whether the two nodes are themselves directly connected. Having the same connections to others means that they pick up the same information from other nodes in the network, including new behaviors or innovations. Moreover, the competition between two structurally equivalent nodes is likely to motivate the adoption of innovations (Burt, 1987; Valente, 2010). If one node adopts an innovation, the other is very likely to adopt it in order to stay competitive or legitimate in the eyes of other nodes in the network. The third, though less common, the mechanism associated with diffusion is the role of agents in the transfer of knowledge and innovation. The transfer of agents across networks provides an opportunity for the
diffusion of policies or innovations when they are moved from one organization to another (e.g., Yi et al., 2018).

Measures. We observe multiple ways that scholars operationalize diffusion and influence. A popular way to operationalize social influence is to examine the number of direct contacts that have adopted a certain behavior or attitude (Jokisaari & Vuori, 2010; Kammerer & Namhata, 2018). Interactions with direct contacts expose an actor to this new behavior or attitude; the more contacts adopt this behavior, the more socially appealing it becomes. Jokisaari and Vuori’s (2010) research supported this hypothesis and found a positive relationship between direct contacts and the adoption of job training programs during an early phase of the diffusion process. Building on this approach, Siciliano and Thompson (2018) constructed a weight matrix that adjusts the relative influence of any given alter’s influence based on the strength of the ego’s connection to that alter relative to the strength of the ego’s other connections.

Based on the structural equivalence mechanism, in the context of international trade, Cao and Prakash (2011) show how competing actors will tend to emulate each other if they have the same patterns of connections with others because they want to be perceived as equally legitimate. In this approach, social influence is caused mainly by perceived legitimacy.

Finally, Yi et al. (2018) examined how the transfer of agents from one organization to another promotes innovation. The authors found that when an innovative public officer is transferred from one province to another, new performance management and innovation practices are more likely to be adopted by the receiving provincial government.

Resource dependence theory Theory and Mechanisms. Resource dependence theory is used to support six hypotheses across five articles. Resource dependence theory characterizes organizations as open systems that depend on their environments for critical resources (Pfeffer & Salancik, 1978). Therefore, maintaining a stable supply of critical resources influences how organizations interact with other organizations. For example, organizations may adopt strategies such as merger or diversification of supplies to reduce their dependence on others. Researchers can thus study organizational decisions to build or dissolve relationships from a resource-dependence perspective. Relationships within networks are not always equal. Some organizations rely more heavily on others for critical resources, creating imbalances in power between organizations (Emerson, 1962). For instance, if a nonprofit organization relies on a single agency for funding, then the nonprofit is vulnerable to the funder’s changing funding demands (AbouAssi & Tschirhart, 2018).

Measures. Resource dependence theory is thus often used to study how organizations manage relationships within networks, but there are various ways to operationalize key constructs: power and dependence. Provan et al. (2009) took a structural approach and used organizational centrality in a network to measure the influence or power of an organization. The idea is that “central organizations can maintain a ‘gatekeeping’ role in the network, controlling access to valued resources” (p. 877). For organizations that rely on others for resources, measuring the degree of dependence is an important question. AbouAssi and Tschirhart (2018) used the percentage of a nonprofit’s funding that comes from a funding agency to measure the degree of dependence. They found that when a nonprofit organization heavily depends on a funding agency its behavior will adjust to the agency’s funding priorities.

Other scholars use a survey approach to measure resource access. For example, Lee and Lee (2018) studied how social interactions derived from resource exchanges are related to distrust among members. They measured resource exchange relationships between organizations by asking respondents whether their organizations shared six types of social interactions derived from resource-dependence relationships with all other organizations. However, their research findings did not support a relationship between resource dependencies and levels of distrust. Resh et al. (2014) hypothesized that interorganizational relationships based on resource exchanges facilitate organizational learning. Their measurement is based on surveys that asked respondents to evaluate the importance of financial resources, and the influence that an alter has in determining ego’s coordination with the alter. The authors found that individuals report higher levels of organizational learning when they chose collaboration partners with greater access to financial and social resources.

Structural Arguments

Centrality

Theory and Mechanisms. We identified 45 hypotheses across 24 articles that relied on the centrality of actors for the prediction of network effects. Centrality is one of the most common nodal measures used in network analysis for understanding the relevance of a node based on its position in a network (Wasserman & Faust, 1994). As noted in the social theories above, centrality has been used to test several mechanisms posited to increase network effectiveness. Here, rather than centrality being the chosen measure to capture a particular mechanism, authors rely on structure-based arguments to predict network effects and consider centrality as the driver of better network outcomes. At the network level, centralization has also been tested to identify if network effectiveness increases when the network is organized around one or a few actors.

Measures. We found nine hypotheses that focus on how the central position of actors within a network facilitates access to novel and broader information that leads to network effectiveness. This mechanism is similar to the one associated with the social capital bridging theory. However,
we coded these hypotheses under the centrality argument category because authors rely mainly on the benefits of centrality as a structural driver of network outcomes and not on arguments based on social capital bridging theory. Scholars operationalize this argument through different centrality measures like degree centrality, closeness centrality, and betweenness centrality. Some scholars used degree centrality, predicting that having more ties offers the actor greater access to broader and more complex information and resources, leading to improved network effectiveness (Arnold et al., 2017; Lee, 2013; Pappas & Wooldridge, 2007; Schalk et al., 2009; Scott & Thomas, 2017; Shrestha, 2013; Siciliano, 2017). Closeness centrality was used to test that in addition to having more ties, the shorter distance between nodes, the faster the information flows (Borgatti et al., 2018), leading to greater effectiveness.

Thirteen hypotheses across six articles test how direct control and influence impact network effectiveness. Researchers used a range of centrality measures to operationalize control over other actors, including degree centrality (Dekker et al., 2010; Marcum et al., 2012; Wong & Boh, 2014), indegree centrality, and outdegree centrality (Hu & Kapucu, 2016). The main argument posited by these authors is that central actors in the network have better capability to use the information for coordination purposes and develop innovative managerial skills. Other articles examined the impact of a node’s position in the network on access to better resources. Koliba et al. (2017) used betweenness centrality to test how positioning between other actors controls the flow of information and resources in the network. They found that actors’ strategic position in the network as information bridges between other actors allows them to control information and resources.

Four hypotheses tested indirect control over other actors. Scholars operationalize this mechanism using eigenvector centrality and power centrality. Eigenvector centrality assesses the indirect influence one can have over others based on their connections to highly connected nodes (Bonacich, 1987; Borgatti et al., 2018; Wasserman & Galaskiewicz, 1994). For instance, Pappas and Wooldridge (2007) used eigenvector centrality to test its association with managers’ skills in communicating new strategic actions. The authors found that managers’ strategic activities are positively related to their level of eigenvector centrality. Similarly, Marcum et al. (2012) found in their research on multiorganizational disaster response networks that indirect control over others is easier when communication is conveyed through a small number of third parties. Another centrality measure related to indirect control, power centrality (also referred to as beta centrality), is similar to eigenvector centrality in that a node’s status depends on the status of the other nodes to whom it is connected (Bonacich, 1987).

Arnold et al. (2017) test if groups promoting legislation are more successful when their partners are connected to well-connected municipal actors. They found support for this hypothesis in their research of high-volume hydraulic fracturing policy networks in New York.

Finally, centrality is also operationalized at the system level to test the impact on network effectiveness when the network is organized around a particular actor or set of actors (Provan & Milward, 1995). Based on this argument, five hypotheses used centralization measures to predict that integration and coordination lead to greater network effectiveness (Markovic, 2017; Raab et al., 2015). Akkerman et al. (2012) analyzed the performance of intercollege networks in Dutch higher education and found a positive relationship between centralization and performance even in the presence of conflicting goals. In their research about education and employment networks in the Netherlands, Klaster et al. (2017) stated that centralization in the short run leads to greater effectiveness because the implementation process starts sooner due to a shorter time of decision-making and discussion processes. They posited that centralized networks may have higher goal attainment but also lower levels of relationship quality (p. 685).

**Structural embeddedness**

*Theory and Mechanisms.* Eight hypotheses from five articles were built upon structural embeddedness. Granovetter (1985) noted that economic actions are influenced by their embeddedness in the network of social relations. The embeddedness argument suggests that the exchange and flow of resources within and between organizations may depart from what economic models would predict (Kilduff & Tsai, 2003). Actors could prefer to have work-related relationships with other actors with whom they have other types of relationships, such as friendship, instead of behaving according to purely economic logic (Kilduff & Tsai, 2003; Uzzi, 1996).

Different from relational embeddedness which focuses on the quality or strength of relations, structural embeddedness focuses on the pattern of relations in the network (Granovetter, 1992). In other words, structural embeddedness refers to “the configuration of one’s network” and relational embeddedness focuses on “the quality of these relationships (Moran, 2005, p. 1131).” Existing literature suggests multiple ways to operationalize structural embeddedness. Some scholars operationalize structural embeddedness as the extent to which a node’s contacts are connected (Moran, 2005) or the extent to which “a dyad’s mutual contacts are connected to one another” (Granovetter, 1992, p. 35). A node can access and control a diverse range of information and resources if its connections are loosely connected. A node belonging to a closed, cohesive group can benefit from the formation of social norms and group identity that encourage cooperative behaviors and facilitate the exchange of tacit knowledge (Moran, 2005). Others use structural embeddedness to refer to the extent to which a node takes a central position in the network (e.g., Provan et al., 2009).
Measures. In the five articles reviewed, different measures of structural embeddedness have been proposed in public administration and policy research, including degree centrality, power centrality, density, centralization, cliques, and the number of shared collaborators between organizations (Provan et al., 2009; Sandström & Carlsson, 2008; Schalk et al., 2009; Villadsen, 2011). For instance, in a study of the collaboration among rural economic development organizations, Ofem et al. (2018) argued that structural embeddedness —“the extent to which two organizations share multiple collaborators” —influences their collaborative outcomes (p. 1116). The authors’ research supported this hypothesis and found that mutual dependence can increase trust and reduce uncertainty. Building structural embeddedness through common collaborators not only allows the actors to more easily verify important information and reduce risks of coordination but also enhances network partners’ commitment and cooperative behavior (Ofem et al., 2018).

Network centrality has often been used to operationalize structural embeddedness. In the context of a network of Danish mayors, Villadsen (2011) posited that the structural embeddedness of mayors, measured by their degree of centrality in the policy network, influences policy isomorphism in municipalities. Provan et al. (2009) also operationalized structural embeddedness as centrality in their research of mental health service networks. They argued that Bonacich power centrality is a better indicator of structural embeddedness than degree centrality because power centrality considers both the direct ties a focal node has and the position of alters in a network. Through power centrality, Provan et al. (2009) tested if embeddedness leads to higher levels of trust and reputation. They found a positive relationship between embeddedness and trustworthiness as the network matures.

Structural embeddedness has also been operationalized as “cohesive subgroup membership” (Schalk et al., 2009, p. 630). Schalk et al. (2009) argued that strong and close relations within cohesive subgroups are important for trust-building and reducing transaction costs. In their study of Dutch higher education, they found that colleges’ affiliation with cohesive subgroups (cliques), rather than their degree centrality, contributes to their performance as measured by student evaluations.

Density

Theory and Mechanisms. We found six hypotheses across six articles that use density arguments to predict network effectiveness. Density is a network-level variable that is measured as the ratio of the number of ties in the network to the number of possible ties (Borgatti et al., 2018). Dense networks are often viewed as an indicator of bonding social capital, trust, and cooperation (Coleman, 1994; Gauthier, 2020, p. 468; Lin, 1999). Scholars offer several means by which densely connected networks lead to network effectiveness, that is, increases collaboration (Hawkins, 2010), trust and support (Dekker et al., 2010), or information sharing and certainty (Lee, 2013).

Measures. As noted above, density is the proportion of ties present out of the total possible ties (Borgatti et al., 2018). While density is a straightforward measure, there are some important caveats when comparing the level of interconnectedness among networks of different sizes. As network size changes, similar levels of density do not necessarily reflect the same levels of connectedness among the network members (Bodin et al., 2017; Borgatti et al., 2018; Sandström & Carlsson, 2008). For instance, if we compare a network with 10 members against a network with 100, where each member has two ties in both networks, the density of the smaller network is 0.22, whereas the density of the larger network is 0.02. In this regard, as Borgatti et al. (2018) state, when comparing networks of different sizes, we need to consider that levels of density tend to be lower in large networks because as the network grows, it is difficult for the nodes to create ties with the same percentage of the members.

Hawkins (2010) used density to test if greater policy network cohesion increases collaboration with other local governments for economic development purposes through the possibility of a joint venture formation, but the author did not find support for this hypothesis. In Dekker et al.’s (2010) research about civic organizations’ participation in neighborhood projects in Dutch cities, the authors tested if behaviors like trust, support, and cooperation are more likely to be found in dense networks. They found that as the network density increases, so does its level of participation in city projects. Lee (2013) found that a dense network facilitates information sharing, increases the decision-making process, and reduces uncertainty, and all of these factors led to a higher perception of effectiveness.

Other and multiple categories. Eight hypotheses across four articles were coded as “Other” in the theory category as the theories were not frequently used in the network literature. Some examples are entropy theory, cooptation theory, production theory, systems theory, and the advocacy coalition framework. We also found five hypotheses across four articles that use multiple theories or structural mechanisms for support. For example, Akkerman et al. (2012) relied on social capital and resource dependence theory to test if participation in collaborative subnetworks (cliques) positively affects performance due to resource exchange and the building of interorganizational trust. Similarly, Provan et al. (2013) used arguments from policy diffusion and homophily theories to predict that frequent and more intensive ties between similar organizations will allow for greater information exchange and increase the awareness of new practices.

NA category. We coded 89 hypotheses across 31 articles as “NA” in the theory category. Hypotheses were placed into the NA category when authors framed their hypotheses based on the specific research context instead of a social theory or structural argument. As Siciliano et al. (2021) stated, many context-framed hypotheses in public
administration and public policy are related to the fact that these fields are not only scientific but also applied (p. 13). For instance, Resh et al. (2014) tested if learning is higher in collaborative venues where government actors are more central or in venues with higher levels of trust. Instead of framing the hypotheses according to a specific social theory, the authors relied on general findings of collaborative governance, public management, and public policy literature. Similarly, Faulk et al. (2016) tested the extent to which nonprofit organizations gain more grants if they have board interlocks with foundations. The authors framed this hypothesis based on the nonprofit management literature and on empirical findings related to factors that increase the probability of nonprofit organizations accessing foundation grants. Thus, an NA designation does not necessarily mean that the hypothesis lacked theory or had weak justification (though this was true in some cases). Rather, the applied nature of research on networks may lead to hypotheses that are context-specific rather than tied to specific theories.

**Discussion**

This systematic review aimed to understand the mechanisms and measures used by public administration and public policy scholars studying network effects. Based on our systematic literature review of 40 journals in public administration and policy, we present five main topics and challenges to our field’s scholarship on network effects: (i) limited use of social theory for explanation, (ii) structure as mechanism versus measure, (iii) inconsistent use of network measures associated with particular theories, (iv) multiple mechanisms associated with any single theory, and (v) ability to capture network dynamics and coevolution.

**Limited Use of Social Theories**

One of the main findings from our review is the limited use of social theories to justify hypotheses that predict network effects. As shown in Figure 3, out of the 223 hypotheses we extracted from the 56 inferential articles, only 71 (32%) were justified based on specific social theories. The most common social theories used by network scholars were social capital-bridging (18 hypotheses) and policy diffusion (10 hypotheses). Ninety hypotheses (40%) relied on either the research context for hypothesis development and/or failed to provide clear theoretical justification. Thus, these studies did not directly address the mechanisms through which network effects were produced. In comparison with the use of social theories, we found that 62 hypotheses (28%) were framed based on structural arguments, centrality being the most common structural argument (45 hypotheses) followed by structural embeddedness (8 hypotheses).

We summarized empirical findings associated with social theories and structural arguments in Table 2. The designation of “supported” suggests that the hypothesized relationship has empirical support. Note, however, that while not a frequent occurrence, some scholars posited a negative relationship between network mechanisms and network effects, while others hypothesized positive relationships. For instance, Arnold et al. (2017) argued that the opponents of a new policy are more successful in securing a preferred outcome when they are embedded in less cohesive networks. In contrast, Ingold and Leifeld (2016) found that the higher the betweenness centrality of a collaboration partner the more likely the actor is going to report the collaborator as influential. The first example used social capital-bonding arguments to posit a negative relationship between
In the reviewed articles, we found that scholars also used a range of different network measures to test the same mechanism. This is not surprising as there are multiple ways to, for instance, control, or some subset of related mechanisms?

**Structure as Mechanism Versus Measure**

An important question arises as to whether network consequences derive from specific structural arrangements or if structure only serves as a proxy measure of some mechanism. Take the research on bridging social capital as an example. Networks effects have been posited to arise due to both the structural arrangement of the actors in the network that better position some actors for more novel information as well as based on the attributes of the individuals one is connected with (e.g., Ter Wal et al., 2016). Some authors rely on purely structural measures (e.g., constraint, efficiency), while others rely on non-structural measures such as the diversity of the actors. However, one could have strong, close ties to a set of diverse actors or bridging ties to actors who may be very similar (say all from the same administrative unit).

Similarly, Borgatti and Lopez-Kidwell (2011) discuss different mechanisms of the social capital theory that relate network structural properties to network outcomes. They argue that if central actors are higher performing, there are at least two different models consistent with that finding. One, a network flow model that highlights the increased opportunity to acquire resources and information through their central position. The other, a network architecture model that points to the greater ability of central actors to coordinate the actions and behaviors of others. Borgatti and Lopez-Kidwell (2011) thus highlight the importance of theory to unveil the unseen mechanisms that are associated with network outcomes and show how the same network structure can lead to network effectiveness via very different explanations of how the social system works. Consequently, relying on the structure to serve as both the measure and mechanism can lead to less clear theorizing about the underlying causal processes linking structures to outcomes.

If we rely on structure-based arguments to predict network effects, we assume that the structure itself leads to better outcomes, without any further exploration of the mechanisms at work. This approach would not align with Burt (2004), who states that “Networks do not act, they are a context for action” (p. 354). Therefore, we find that our field needs to engage in greater discussion of network structure as a mechanism versus as a measure in order to create shared knowledge about the exogenous and endogenous drivers of network effectiveness. This distinction between mechanism and measure is crucial in instances where researchers and practitioners seek to intervene in networks in ways that may potentially alter their shape. Successful policy or managerial action to influence a network’s structure is dependent upon accurate knowledge of the mechanism and the shape or structure most beneficial to that setting (Siciliano & Whetsell, 2021).

**Inconsistent Use of Network Measures**

Another challenge we found in the effectiveness literature is the operationalization of mechanisms through network measures. For instance, degree centrality was the most common measure used across inferential and descriptive articles. However, this measure is used to test different mechanisms like access to broader information, coordination of activities, and direct control and influence. The challenge we find with the use of measures like degree centrality is that when the same measure is used to test different mechanisms, it potentially limits our ability to identify which specific mechanism is at work. For example, if degree centrality has a positive association with an outcome of interest, is the association due to information access, better coordination, greater control, or some subset of related mechanisms?

In the reviewed articles, we found that scholars also used a range of different network measures to test the same mechanism. This is not surprising as there are multiple ways to, for

| Table 2. Summary of Hypotheses Findings |
|-------------------------------|-------------------|
| **Social Theory**             | **Finding (Number)** |
| Social Capital - Bonding      | Supported (7)     |
| Social Capital - Trust        | Supported (5)     |
| NA Category (Hypothesis based on research context) | Supported (64) |
| **Structural Argument**       | **Finding (Number)** |
| Structural Argument - Centrality | Supported (31) |
| Structural Argument - Density | Supported (4)     |
| Structural Argument – Structural Embeddedness | Supported (8) |

The small number of hypotheses associated with the different structural arguments does not allow us to reach conclusions about how a specific structure is associated with effectiveness. Additionally, without knowing more about the context under which these hypotheses were framed, it is difficult to assert when a more cohesive and dense network leads to innovation or higher individual performance; or under what circumstances having more direct contacts leads to innovation or greater access to resources. In this regard, we suggest that relying merely on network structures as a mechanism hinders our understanding of the actual drivers of collaboration and better network outcomes. This leads to our second challenge.

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| Table 2. Summary of Hypotheses Findings |
|-------------------------------|-------------------|
| **Social Theory**             | **Finding (Number)** |
| Social Capital - Bridging     | Supported (15)    |
| Social Capital - Trust        | Supported (5)     |
| NA Category (Hypothesis based on research context) | Supported (64) |
| **Structural Argument**       | **Finding (Number)** |
| Structural Argument - Centrality | Supported (31) |
| Structural Argument - Density | Supported (4)     |
| Structural Argument – Structural Embeddedness | Supported (8) |

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instance, capture brokerage. However, there are instances where the use of a specific network measure is not justified according to the literature. For instance, according to the social capital literature, the mechanisms associated with bridging are better operationalized through network measures like betweenness centrality and brokerage rather than degree centrality or average degree (Wasserman & Faust, 1994). Because degree only considers one’s direct connections, it is less useful, and perhaps even misleading, as a measure of one’s bridging position between other nodes. Scholars should be careful to ensure the mechanism and measure are as closely aligned as possible.

**Multiple Mechanisms Associated With a Single Theory**

A fourth challenge is that even for a single theoretical argument, several mechanisms may be operative. Social theories are inherently complex and are often comprised of multiple mechanisms. For example, with regard to social capital bridging, the advantages to brokers are argued to result from information diversity, information control, or both. While some authors rely on information diversity as the driver of performance and others on information control, the structural measures used to capture these processes are often identical. Developing designs to isolate the operative mechanisms is needed to better understand how social capital from structural holes and brokerage positions translates into better outcomes. Similarly, research relying on social capital-bonding as a performance driver focuses mainly on the structural benefits of being in a cohesive network, but alters’ attributes, support, and resources also have important implications on performance (Lin, 1999).

This challenge is particularly acute when scholars rely on structural arguments to support their hypotheses. For instance, in our analysis of the hypotheses relying on the structural argument of centrality, we found that authors associate centrality with greater access to information, acquisition of resources, speed of information flow, ability to establish control and influence in the network, as well as affective feelings of belonging and commitment. Density is another example of a structural argument used to test different mechanisms like trust, support, and collaboration. Thus, in the same way, a single structural measure, like degree, can be associated with multiple mechanisms, many of the social theories and structural arguments are also linked to multiple mechanisms.

A good example where multiple mechanisms have been tested comes from the research on policy diffusion. Scholars have posited that the mechanisms of peer influence and structural equivalence serve as two different processes that may lead network members to have similar behaviors. Those mechanisms have been tested against each other (Burt, 1987). Such theory-informed measures can guide authors interested in testing and disentangling the impact of different mechanisms against each other.

**Network Dynamics and Coevolution**

Networks are not static. The ties may dissolve and at times reappear. As the relationships change, so too may the observed behavior of the actors in the network. For instance, one of the challenges with identifying the implications of trust in networks is that while networks can enable the establishment of trust, trust also facilitates the development of network relations. The potential tautology among trust and networks was a source of criticism in Putnam’s book Bowling Alone (2000). Critics have highlighted the issue of logical circularity. Portes (1998, p. 19) states “As a property of communities and nations rather than individuals, social capital is simultaneously a cause and an effect. It leads to positive outcomes, such as economic development and less crime, and its existence is inferred from the same outcomes.” A similar challenge is faced by scholars who analyze the role of trust in producing network effects. Those network effects, such as higher funding levels or willingness to donate to charities, are driven by the trust but also those successes or actions further the development of trust. Trust develops over time as actors exchange resources and maintain promises; thus, as trust is continually confirmed, additional interactions and exchanges are more easily accomplished (Koppenjan & Klijn, 2004). Trust, as with many other feelings and behaviors, coevolves alongside the network.

This challenge raises important questions for research on network effects. With cross-sectional data, it is impossible to differentiate between selection and influence (Shalizi & Thomas, 2010). Thus, when individuals with similar attitudes or behaviors are connected in a network, it is unknown if the similarity in behavior drove their social relationship or if the social relationship produced their similar behavior. When attempting to distinguish between selection and influence effects in networks, longitudinal data can help. However, only seven out of the 74 reviewed articles used data on two or more waves and only three articles used data on three or more waves.

**Conclusion**

By analyzing 74 articles related to network effects, we identified the most common social theories and structural arguments used to justify hypotheses and mechanisms associated with network effects. We acknowledge that our review excluded conceptual network studies and articles that do not explicitly describe or analyze the relationship between the characteristics or structures of the networks and the network effects. While some of these network studies may have relied on different social theories and made important contributions to the network effects
literature, in this manuscript, we focus on empirical studies that consider how different network structures impact the actors and their collective outcomes.

Overall, more theory-based research is needed as a way of advancing knowledge within the field of how network structure and actor attributes influence effectiveness. In general, the findings of this article can assist scholars in identifying different theories and mechanisms associated with network effectiveness. In addition, this analysis provides an opportunity for network researchers in our field to build agreement on how to operationalize mechanisms related to network effectiveness framed under a specific theory. Finally, further examination is required to understand the extent to which the hypotheses used in the network effectiveness literature are supported, and if so, under what specific circumstances the mechanisms at work have a positive or negative impact on effectiveness.

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Supplemental Material
Supplemental material for this article is available online.

Note
1. We followed the approach of Kapucu et al. (2017) and included in our search 39 public administration and policy journals previously identified by scholars as relevant journals in the field (Bernick & Krueger, 2010; Forrester & Watson, 1994). As Siciliano et al. (2021) did, we added Public Management Review, given the number of network studies published by this journal. A list of the 40 journals and the number of articles extracted from each journal is available in an online Supplemental Appendix.

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