Formal Hierarchies and Informal Networks: How Organizational Structure Shapes Information Search in Local Government

Travis A. Whetsell
Department of Public Policy and Administration, School of International and Public Affairs
Florida International University
travis.whetsell@fiu.edu

Alexander Kroll
Department of Public Policy and Administration, School of International and Public Affairs
Florida International University

Leisha DeHart-Davis
School of Government
University of North Carolina

Abstract: Attention to informal communication networks within public organizations has grown in recent decades. While research has documented the role of individual cognition and social structure in understanding information search in organizations, this article emphasizes the importance of formal hierarchy. We argue that the structural attributes of bureaucracies are too important to be neglected when modeling knowledge flows in public organizations. Empirically, we examine interpersonal information seeking patterns among 143 employees in a small city government, using exponential random graph modeling (ERGM). The results suggest that formal structure strongly shapes information search patterns while accounting for social network variables and individual-level perceptions. We find that departmental membership, hierarchical layers, supervisory status, power proximity, and permission rules all affect employees’ information search. Understanding the effects of organizational structure on information search networks will offer opportunities to improve information flows in public organizations via design choices.

Keywords: local government, intraorganizational, interpersonal, social network analysis, ERGM

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Introduction

Research in public administration has increasingly drawn attention to the salience of interpersonal communication networks within public organizations (Moynihan and Pandey 2008; Siciliano, 2015; Nisar and Maroulis, 2017). To accomplish daily work tasks, individuals often lack the requisite information necessary to perform effectively. They seek out information from other individuals whom they perceive to have access to important knowledge. With the increasing informational intensity of the workplace, public organizations depend on the development of effective communication networks of individuals that span teams, departments, and formal lines of authority.

Interpersonal networks often emerge from informal collaboration and lateral coordination among individuals within organizations (Berry et al. 2004; Isett et al. 2011). Research on networks within organizations has examined the importance of social processes, such as reciprocity and transitivity, as well as the effect of individuals’ position in social networks (Krackhardt and Hanson 1993; Contractor and Leondardi 2018). Being at the periphery of a network is associated with negative attitudes toward one’s work (Porter et al. 2019), whereas being in a position that bridges organizational sub-groups is correlated with positive outcomes (Maroulis 2017). With regard to knowledge networks, research similarly emphasizes the importance of informal network structure. Better connected individuals are able to leverage more organizational knowledge (Oparaocha 2016; Paruchuri and Awate 2017; Tasselli 2015).

In this article, we take different perspective on knowledge networks. In line with previous work, we employ a network-based conceptualization of communication – that is, forming ties for the purpose of information search. Unlike most other work we do not focus only on drivers of tie formation based on network structure or attributes of individuals. In fact, we argue quite the
opposite: The *formal* structure of the organization and its hierarchy shape *informal* communication networks in important ways that have been neglected in the literature. This suggests that we can improve our understanding of intra-organizational networks by accounting for the underlying – but often neglected – hierarchies within organizations. Even seemingly lateral communication may differ based on individuals’ formal roles, positions, and responsibilities, especially in public bureaucracies. We propose a model that explores the impact of formal-structural factors, including departmental hierarchy, power proximity, supervisory status, and underlying lines of permission on the informal information search network of government employees.

This article models these effects using exponential random graph modeling on a sample of 143 employees (reflecting a response rate of 92%) across multiple departments in a small city government. We estimate the effects of formal-structural factors while controlling for a set of social-structural network variables as well as important cognitive variables including the perception of organizational commitment, trust, and self-efficacy. The results suggest that structure has important shaping effects on information search. Tie formation in the information search network is both constrained and driven by several aspects of organizational structure. The results have important implications for scholars and practitioners concerned with understanding the antecedents of information search in public organizations, suggesting that organizational design and interventions associated with formal structure may stimulate the emergence and maintenance of robust communication networks necessary to perform work tasks in the local government context.
In this section, we first provide a brief overview of the literature on intra-organizational networks in public administration. While certainly growing, this body of research is still underdeveloped, especially compared to the work on inter-organizational networks. Next, we review the literature on information searching and sharing in public organizations to synthesize the state of research and identify our research gap. Finally, we develop hypotheses about the importance of organizational structure for shaping information search in social networks.

Intra-Organizational Networks in Public Administration

The study of social networks within and between public organizations is an emerging subject in public administration research. During the latter half of the 20th century, scholars developed methods for analyzing social relations between individuals in terms of graph theory and networks. The term “network” first appeared in the titles, abstracts, and keywords of articles in Public Administration Review in the mid-1980s. However, the substantive application of network analysis did not begin to occur until much later, with agenda setting work (e.g. O’Toole 1997) appearing in the mid to late 1990s (Hu, Khosa, Kapucu 2016). Since then, a great deal has been uncovered about the resolution of public problems through social and organizational networks (Provan and Milward 2001; Berry et al. 2004; Provan and Kenis 2008; Isett et al 2011). For example, the concepts of policy networks, collaborative networks, and network governance emerged to provide theoretical explanation for the increasingly complex patterns of interaction.

1 A Web of Science search ((SU="public administration") AND (TS="network analysis")) show the term network analysis did not appear in the searchable text of a general public administration journal until 1997.
between numerous actors around public programs, policies, or problems (Kapucu, Hu, and Khosa 2017).

Much of the research on networks in public administration has occurred at the inter-organizational level, and relatively little research has explored *intra*-organizational social networks between individuals with public organizations. Kapucu, Hu, and Khosa (2017) suggest that merely 14% of public administration network studies have used the individual as the level of analysis. Similarly, Isett et al. (2011) state that informal interpersonal networks are an understudied area. Information seeking networks of individuals are categorized as informal networks, as opposed to formal hierarchical relations or formal inter-organizational relations that involve some contractual exchange of resources.²

Intra-organizational networks are often defined in terms of the relationships between individuals within organizations. Such networks emerge as a result of complex communication patterns between individuals, where the exchange of information or resources is the generic criteria for quantification of a relationship (tie) between two individuals in a network (Monge and Contractor 2003). As the number of ties increases between individuals, and as secondary ties begin to form between their partners, a network structure begins to emerge. Network structure can vary in terms of size, density, diameter, and centralization, etc. with consequences for the flow of information and resources in a network (Wasserman and Faust 1994). As networks increase in size and density, they often begin to form a core-periphery structure, where the distribution of ties is concentrated around a few very well-connected individuals or groups (Borgatti, Everett, and Johnson 2015). A ubiquitous phenomenon known as preferential attachment characterizes highly skewed distributions of network ties concentrated among few

² A topic search for intraorganizational or intrapersonal network within the subject category of public administration yielded only 24 results in the Web of Science data base (accessed 01/23/2020).
very well-connected nodes, observed in numerous types of networks across physical, biological, and social networks (Barabasi and Alber 1999; Newman 2001).

An individual’s position within the network has important influences on access to resources and perceptions of social status within the network. For example, individuals that occupy central positions in the network often benefit from enhanced access to information, resources, and the popularity and prestige that derive from the social capital associated with such access (Lin 1999). Further, as routines of exchange develop among network actors, mechanisms of social interaction emerge to safeguard and maintain the structure and functioning of the network (Jones, Hesterly, and Borgatti 1997). Thus, Coleman (1994) posits a reciprocal process between structure and actor, where social structure has a downward influence on individual actor-level behavior, but actor-level behavior has upward influence back on structure, i.e. Coleman’s Boat.

While the literature on intra-organizational and interpersonal networks within public organizations is limited, there are several important studies that examine the effects of such networks on variables of interest to management and organizational behavior scholars, including turnover intention (Moynihan and Pandey 2008), organizational commitment (Siciliano and Thompson 2018), resource sharing (Fusi, Welch, and Siciliano 2019), innovation (Nisar and Maroulis 2017; Zandberg and Morales, 2019), and individual performance outcomes (Siciliano 2017).

Among others, this research has shown that organization-internal networks act as “sticky webs” that keep people in the organization, while external networks act more like “trampolines” to the next organization (Moynihan and Pandey 2008). Further, it has documented the social dependencies between individuals that shape perceptions and attitudes as well as differential
effects in advice versus friendship networks (Siciliano and Thompson 2018). In a study of performance outcomes of schools, including network measures significantly improved the variance in scores explained by the models for reading as well as mathematics scores (Siciliano 2017).

**Information Searching and Sharing in Public Organizations**

Studies on information seeking and sharing in public organizations highlight the importance of interpersonal networks in facilitating the flow of knowledge for the accomplishment of work tasks. Binz-Scharf, Lazer, and Mergel (2012) apply the knowledge-based view (KBV) of organizations (Grant 1996) to analyze resource exchanges in an interpersonal network of forensic laboratory workers. The KBV treats knowledge as a resource critical to the performance of organizations. As Nonaka (1994:15) suggests, information and knowledge can be distinguished in the following manner: “information is a flow of messages, while knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder.” In this sense, information provides the material basis for the construction of theory with the pragmatic aim of guiding some action. However, because knowledge is often tacit rather than explicitly codified in organizational files, employees expend considerable effort on information search activities (Nonaka 1994; Polanyi 1996). Interpersonal communication networks facilitate the sharing of both tacit and explicit knowledge for the completion of work tasks. As Binz-Scharf, Lazer, and Mergel (2012) show, interpersonal networks are critical to the functioning and performance of knowledge-intensive public organizations. This research suggests that elements of the knowledge-based view of the firm may be generalized to public organizations.
While several studies have examined the effects of networks on outcomes of interest in the workplace, fewer studies have examined the antecedents of intraorganizational and intrapersonal network formation. Nisar and Maroulis (2017) studied information seeking in interpersonal communication networks of teachers in a public high school. Their results suggest that street-level bureaucrats tend to seek out information from individuals that use their discretion to experiment with new innovative practices in the workplace. Siciliano (2016) examines advice networks of teachers in five schools. His results suggest that the expertise of individuals becomes an important factor in being sought out for advice, specifically when the domain of activity is knowledge explicit. Conversely, he found the opposite to be true in less knowledge intensive domains of activity.

While the drivers of information sharing in public organizations are manifold (Yang and Maxwell 2011), we notice a predominance of individual-level factors, particularly cognitive variables, in social network studies. One such factor is trust. Mayer and colleagues provide the seminal definition of trust in organizations, as “the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other” (1995, p. 712). Trust figures prominently into research on information exchange at the individual (Levin and Cross 2004), intra-organizational (van de Bunt, et al, 2005), and inter-organizational levels (Tsai and Ghoshal 1998; Shazi, Gillespie and Steen 2015). The most common explanation for trust and information exchange focuses on trust in information sources, where sharing is facilitated if the information source is perceived as reliable (Levin and Cross 2004; Shazi, Gillespie and Steen 2015). Trust can also foster information sharing due to reducing transaction costs between sender and receiver (Dawes, Cresswell, and Pardo 2009). As Yang and Maxwell (2011) suggest, when
information is viewed as an asset within a broader organizational power game, withholding it from others is often a rational strategy for competitive advantage. Similarly, Dawes, Cresswell, and Pardo (2009), citing Jones, Hesterly, and Borgatti (1997), suggest that transactions costs associated with interpersonal communication increase when trust is low. Thus, trust substitutes for more costly organizational structures designed to prevent exploitation by increasing monitoring and oversight controls.

Another factor is self-efficacy, which is an individual’s belief in their own capabilities given a specific domain of interest, such as in the performance of work tasks (Lunenburg 2011). Self-efficacy has been examined as an antecedent for various outcomes of interest in several articles in public administration, most of which have been published in the last ten years (George et al. 2018; Jacobsen and Andersen 2017; Wright 2004). Self-efficacy effects on information search may materialize via two opposing logics: Individuals high in self-efficacy are less concerned with appearing incompetent to others due to confidence in their own abilities, suggesting that individuals higher in self-efficacy may be more willing to seek out knowledge from their coworkers. Conversely, individuals lower in self-efficacy may hesitate to reach for the costs of doing so, such as reputation damage and loss of self-esteem (Johnson, et al, 1995). Alternatively, it may be that individuals who have higher self-efficacy may feel themselves less likely to require advice or information from others. Siciliano (2015, 2016, 2017) examined the effects of self-efficacy on knowledge seeking activities in a set of network studies, and he overall documents mixed and null findings. However, Siciliano’s results may be contingent on the context of the public-school workplace, where teachers have considerable autonomy and independence in the accomplishments of day-to-day teaching responsibilities. Analyzing self-
efficacy in settings where employees require more interaction to accomplish work tasks may yield different results.

A third cognitive factor that is known to shape behaviors such as information sharing and search is employees’ organizational commitment. This term is widely understood as “the affective attachment to the organization, perceived costs associated with leaving the organization, and obligation to remain with the organization” (Meyer and Allen 1991, 64). We suspect that commitment will foster social exchange around information. Both behaviors – searching for information and providing it when others reach out – will require additional effort from the employee, which can be more likely expected of committed workers. In many instances, information search constitutes a type of extra-role behavior, where employees need to look outside of the formal hierarchy to obtain information required to solve nonroutine problems. Similarly, helping others when they search for information is often comparable to organizational citizenship behavior, which employees committed to the organization’s mission will engage in. Siciliano (2017) shows that commitment is a consequential variable in education networks. Research also suggests that public employees’ identification with their organization fosters the effectiveness of knowledge sharing but had no impact on the knowledge-sharing intensity (Willem and Buelens 2007). Overall, we believe that organizational commitment will reinforce information seeking behaviors.

The Role of Hierarchical Structure

A general ontological principle of social networks is that they constitute complex phenomena that emerge from local processes of self-organization between individuals, rather than emerging purely from formal organizational structure (Comfort 1994; Miller and Page
However, organizational structure remains an important element in the development and shape of social networks (Agranoff 2006; Eglene, Dawes, and Schneider 2007). Organizational structure in this respect pertains to the social architecture that arranges individuals and groups and delineates relationships between them (Tolbert and Hall 2009, 20; Hall 1999, 47). Structure is formal in that it is explicitly developed and sanctioned by the organization (Pugh, Hickson and Vinings 1968). While structure can constitute an array of elements such as centralization (the upward locus of authority), formalization (the extent to which rules, regulations and procedures are written), and complexity (including the extent of both hierarchical and lateral differentiation) (Rainey 2014, 217), we focus on the role of hierarchy in altering information search in intra-organizational networks, which (along with other forms of organizational structure), is an understudied topic in social networks (Johnson, et al. 1995).

Hierarchy is a well-established means of controlling information flow within organizations. Organizational scholarship in the 1950s suggested that hierarchy would facilitate communications by running information though centralized individuals, who would convey information back down the hierarchy on an as-needed basis (Bavelas 1950). But hierarchies have been shown to undercut both bottom-up and top-down communications as well (Anderson and Brown 2010). From a top-down perspective, hierarchy distorts messages that are passed down from the highest echelons (Athanassiades 1973). From a bottom-up perspective, hierarchy reduces psychological safety by creating fears of retribution experienced by lower-level organizational members (Kish-Gephart et al., 2009). Steeper hierarchical structures are also thought to impede communications laterally, by discouraging peer-to-peer communications that potential disrupt the status quo (Hage 1965) or involve acting outside one’s functional
boundaries (Burns and Stalker 1961). Thus, we hypothesize that hierarchical structure will influence the search for information ties. Specifically:

**Hypothesis 1:** Steeper hierarchical structures will be associated with fewer information search ties whereas flatter hierarchical structures will be associated with more information search ties.

While the research on information searching and sharing has emphasized the social, informal dynamics behind such behaviors, we argue that organizational structure creates spaces in which these interactions occur. Departments, one type of organizational structuring, have been shown to be important prisms through which employees view the entire organization (Kroll, DeHart-Davis, Vogel 2019). Employees within the same department function within the same operating environment, and thus are more likely to have shared understandings of workplace norms, values and expectations (Ginsburg et al 2009; Schaubrook, et al, 2012). Furthermore, organizations are typically structured in ways that place task-interdependent individuals in work units (Thompson 1967; Galbraith 1974), making it highly likely that they turn to each other when they need information rather than look outside. Since departments impose order on lateral communication, we infer more specifically that departmental membership should also play a critical role in guiding information search (Cross, Rice and Parker 2001). In support of this argument, Johnson and colleagues (1995) found that individuals with an interpersonal dependence on others, which is a logical feature of individuals within a department, were more likely to seek information from others. As Kleinbaum et al. put it, “structure itself induces a great deal of interaction,” and accordingly found higher levels of communication among dyads within the same business units.
In the social network literature, this is conceptualized as a type of actor-attribute based homophily, where a node is more likely to form ties with nodes that share the same attribute (McPherson, Smith-Lovin, & Cook, 2001). Accordingly, we expect that:

**Hypothesis 2:** Individuals are likely to seek information relevant to the performance of job tasks within their own departments.

Given the organizationally dependent nature of information search within public organizations, it is reasonable to question how formal authority, both upwards and laterally, influences information search. As Krackhardt (1990) suggests, those in higher positions of formal authority interact with more individuals and deal with more issues, often acting as bridges between disconnected others in a network. As he proposes, formal power influences informal network power, the cognitive accuracy with which others perceive the network, and the reputational power of others in the network. Powerful individuals are likely to have access to information relevant to the completion of work tasks both within and between departments (Kahn and Kram 1994). They also are likely to have the “last word” (decision-making authority), so that employees reaching out can be more certain the information they receive is final or has been vetted and approved (Galbraith 1974).

While hierarchical structure is intended to funnel information search through a chain of command (Simpson 1959), there are limits on how far up the hierarchy individuals can go to interact (Zahn 1991). Under these circumstances, peers can be an important source of information. Cross and colleagues (2001) argue that seeking information from those with roughly the same hierarchical power incurs less risk from showing one’s ignorance to upper
management. And Morrison observed that peers played a particularly important role in the ability of newcomers to seek information, particularly social and normative information (Morrison 1993). Again, in the social networks literature, the potential for peer information seeking amounts to a type of actor-attribute homophily regarding the effect of actor’s position within the formal hierarchy on the probability that two nodes form information ties (McPherson, Smith-Lovin and Cook 2001).

Based on the role of formal authority in hierarchies and their implications for information seeking, we formulate two complementing hypotheses:

_Hypothesis 3: Individuals are likely to seek information from those with greater formal authority._

_Hypothesis 4: individuals are likely to seek information from those with the same level of formal authority._

Finally, social network research has suggested that networks often exhibit _multiplexity_, where, for example, networks based on advice ties are often dependent on other sorts of underlying relations such as friendship ties (Lazega and Pattison 1999). As Siciliano suggests (2015:551) “Multiplexity is an important concept in the literature on intraorganizational networks given the tendency for formal roles (e.g., status, position) to overlap with informal roles.” Extending this logic to the present case, we hypothesize that the information search relationships may depend to some extent on existing organizational authority, such that individuals will tend to seek out information from those with whom they also have existing permission-based relations. If an individual frequently has contact with another in order to gain
permission for a given work task, then they may also be more likely to seek that person out for
information more generally. Further, such individuals may hold positions of authority precisely
because they have information relevant to the effective completion of particular tasks. Thus, we
advance the following hypothesis.

\[ \text{Hypothesis 5: Individuals are likely to seek out information from those with whom they depend on for permission to complete job tasks.} \]

\[ \text{Research Design} \]

Data Collection

To test the relationship between formal structure, social dynamics and tie formation/information search, we emailed a Qualtrics survey link to all 155 employees of a small coastal local government in a Southeastern state. The survey was administered in October 2020 and remained open for two weeks. The response rate was 92 percent (n=143/N=155). Two individuals only partially completed the survey, which is why their scores were imputed based on the median values of the sample. The survey sample represents the city workforce in age, gender, and departmental representation.

The survey instrument used the roster method to generate social network data (Wasserman and Faust 1994; Wald 2014; Perry, Pescosolido, Borgatti 2018). The small city government context is useful for addressing the network boundary specification problem by restricting potential network actors to the common characteristic of employment within the
organization (Nowell et al. 2018). Thus, the survey asked about the occurrence and nature of interactions between survey participants and the full roster of every other employee in the city.

Variables

The exact wording of all survey items can be found in appendix 1. To identify network interactions between organizational members, survey participants were asked to indicate whether they sought out each organizational member for “information from this person to do my job.” The survey item about seeking information established interactions between employees based on acquiring knowledge about specific day-to-day work tasks. The language “seek out” was used to establish directionality to the network ties. For ease of survey readability, organizational members were divided into sections by department. This survey item provided the basis for constructing the information search network, where information ties within the network serves as our dependent variable.

Organizational trust was measured using three items related to supervisor, team, and organization specific trust, which were adapted from Kroll, DeHart-Davis, and Vogel (2019). The scale responses ranged from 0 (Strongly Disagree) to 6 (Strongly Agree). Cronbach’s alpha for the items is 0.92. Organizational commitment was measured using three items, including turnover intention (a derivation of continuance commitment), guilt about leaving the organization (normative commitment), and happiness regarding the prospect of remaining with the organization (affective commitment). The Cronbach’s alpha for these items is 0.85. Self-efficacy (the perception that goals are achievable despite difficulties) was measured using three items from Chen, Gully and Eden (2001). The scale responses ranged from 0 (Strongly Disagree) to 6 (Strongly Agree). Cronbach’s alpha for the items is 0.92. Each set of variables was
aggregated into principal components for use in the models; all three principal components produced eigenvalues above one, and the analysis produced a single component for each variable set. When factor analyzing all nine items together, they load on their original three factors with no significant cross-loadings.

Our structural variables, which are also listed in in appendix 1, were constructed based on administrative data to avoid issues related to common-source bias. We identified departments based on the city budget document for FY2019-2020 and used department membership as a node attribute to identify assortative mixing, e.g. homophily, between individuals. We calculate the level of departmental hierarchy by counting the administrative levels in the department up to the top level found in the city organizational chart. We employ two variables to tap into the concept of authority. Similar to departmental hierarchy, administrative data allowed us to calculate the power distance for individuals, defined as the number of steps to the top position (in this case, the city manager). The variable was then reverse coded to account for proximity rather than distance. The administrative data also permitted identifying whether individuals had supervisory status. As an additional test of the effect of formal structure on informal networks, the study generated a separate permission network alongside the information network, which asked participants to identify the individuals they seek out when they need “permission” to complete work tasks. The analysis includes the effect of tie formation in the permission network on tie formation in the information network by including an edge covariate in the analysis (edgecov).

The analysis also includes a number of variables specific to the network analysis. These include dyadic terms for each variable of interest that account for assortative mixing, including homophily and heterophily (nodematch and absdiff). We include structural network terms to account for the density of the network (edges), reciprocity in tie formation (mutual), transitivity
(GWESP), the geometrically weighted in-degree distribution (GWIDegree), and a fixed out-degree term (ODegree) that accounts for out-degrees of 0 to 5. This last term was used to account for an uneven out-degree distribution. A description of these variables is provided in Table 1.

Table 1 – Description of Network Variables

| Variable    | Description                                                                                                                                                                                                 | Level of Variable                      |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| Edges       | Density of the network                                                                                                                                                                                    | Social network process effect on tie formation |
| Mutual      | Reciprocity of ties in the network                                                                                                                                                                       |                                        |
| GWESP       | Geometrically-weighted edgewise shared partner distribution. Transitivity in the network. For directed networks, this is outgoing two-path, i.e. “a friend of my friend also becomes a friend.”                              |                                        |
| GWIDegree   | Geometrically-weighted in-degree distribution. Models the distribution of incoming ties in the network, i.e. popularity spread.                                                                        |                                        |
| ODEGREE(0:5)| Distribution of outgoing ties in the network, i.e. activity spread. Fixed at the first five values in the out-degree distribution, between zero to five.                                                        |                                        |
| Edge.Cov    | Multiplexity effect of a tie formed in a separate network on the probability of a tie forming in the current network.                                                                                       | Dyadic edge attribute effect on tie formation |
| Absdiff     | Effect of the absolute difference between two nodes of a given node attribute (continuous variable), on the probability of a tie forming between a sender and receiver pair. Negative is homophily. Positive is heterophily. | Dyadic, paired-nodes attributes effect on tie formation |
| Nodematch   | Effect of the similarity of two nodes of a given node attribute (categorical variable), on the probability of tie formation. Positive is homophily. Negative is heterophily. |                                        |
| Receiver.Cov| Covariate effect of a node attribute (continuous variable) on the probability of receiving a tie.                                                                                                                                 | Individual node attribute effect on tie formation |
| Sender.Cov  | Covariate effect of a node attribute (continuous variable) on the probability of sending a tie.                                                                                                                                 |                                        |
| Receiver.Factor| Effect of a node attribute (categorical variable) on the probability of receiving a tie.                                                                                                                                 |                                        |
| Sender.Factor| Effect of a node attribute (categorical variable) on the probability of sending a tie.                                                                                                                                 |                                        |

**Method**

To investigate the effects of the variables on information and advice seeking behavior, we used exponential random graph modeling (ERGM). ERGM was developed to explore the factors that lead to the emergence of networks, permitting the inclusion of structural, dyadic, and actor-level attributes as predictors of tie formation in networks. In basic terms, the ERGM using
Markov Chain Monte Carlo simulation to produce a probability distribution of simulated networks based on the observed network, providing estimates for model parameters. ERGM permits modeling the probability of tie formation, where the parameter estimates can be interpreted in a manner similar to logistic regression analysis. However, the advantage of ERGM is that it accounts for network dependency in probability of tie formation, which violates the assumption of independence of observations in the logistic regression setting. The ERGM model takes the following mathematical formulation (Robbins 2007).

\[
Pr(Y = y) = \left(\frac{1}{k}\right) \exp \left\{ \sum_A \eta_A g(y) \right\}
\]

Actor attributes, dyadic homophily effects, and network structure effects are contained in \(g_A(y)\). Structural effects control for dependencies in the network and can be thought of as standard network control variables that model properties of self-organization in the network. The model parameters are contained in \(\eta_A\). The parameters undergo an iterative estimation and updating process until they effectively model the distribution of simulated networks. ERGM models converge when the observed network is probable given the simulated distribution of networks (Lusher, Koskinen and Robins 2013).

**Results**

The results of the analysis begin with a brief examination of descriptive network statistics and visualization of the information search network within the city government. Figure 1 shows a directed network of 143 nodes (individuals) and 1778 edges (information search ties), with a density of 0.09 and an average degree of 12.4. The network is color coded by department and uses the Kamada-Kawai force directed layout to space the nodes and edges. The nodes are sized
according to their in-degree. The visualization shows a robust and dense network of directed information search ties with strong departmental clustering. On visual inspection, apparent departmental clustering suggests that formal organizational structure affects the formation of the information search network, warranting further analysis.

**Figure 1 – Information Search Network**

*Figure Notes:* The network visualization shows a directed network of individuals who listed others as individuals whom they seek for information to complete work-related tasks. The node color is based on the department. Node size is based on in-degree. Kamada-Kawai force directed algorithm was used for the network visualization layout. Two isolates were removed from the graph. Edges have arrows representing the directionality of the information search.
Table 2 presents the results of the exponential random graph models. We introduce the models in a stepwise manner to show the comparative effects of the perceptual-cognitive and organizational structure variables on the probability of ties forming between individuals in the network. Model 1 shows the effects of cognitive variables. Model 2 shows the formal organizational structure variables, and Model 3 includes both simultaneously. Model 4 adds three network control variables that account for the in-degree (GWIDegree), out-degree (ODegree), and edgewise shared partner (GWESP) distributions. These added network terms substantially improve the goodness-of-fit for the final model. However, we included these only in Model 4 because ERGMs tend to be very sensitive to model degeneracy under changing variable specifications. All models account for the density (edges) of the network and reciprocity (mutual) between individuals.

Model 1 begins with principal components for self-efficacy, trust, and organizational commitment. Estimates for the variables are interpreted as the logged odds of a tie forming between two individuals. Each principal component includes a sender effect, a receiver effect, and the effect of the difference between the two (absdiff), where a positive sign indicates heterophily and a negative sign indicates homophily.\(^3\) The model suggests that organizational commitment is positively and significantly associated with sending an information search tie, while the organizational commitment of the receiver is non-significant, the difference between sender and receiver pairs is significant and negative, indicating positive value homophily for commitment. Similarly, trust also has a positive significant effect on sending an information search tie. There is a negative but non-significant receiver effect of trust and absolute difference

\(^3\) Network studies analyzing directed social networks include both a sender and a receiver effect to capture the two-way interaction between individuals. Absdiff is also commonly utilized to capture the likelihood of ties forming between individuals based on shared similarities or differences.
effect between the sender-receiver pair. Self-efficacy has a negative and significant effect on information tie formation both for the sender and receiver and the absolute difference between the two. In summary, Model 1 provides support for the effect of well-known variables of interest on information search.

Model 2 estimates the effects of formal organizational structure on the formation of information search ties in the network. Supporting H1, departmental hierarchy appears to have important effects on information search. Individuals who reside in departments with taller hierarchies have a lower probability of sending ties, while conversely being more likely to be the receiver of information search ties. Further, the absolute difference (absdiff) of department hierarchy between sender-receiver pairs is positively associated with tie formation, indicating that ties tend to form across the organization between members of different departmental heights. Supporting H2, there appears to be very strong departmental homophily (nodematch) in the information search network, indicating that individuals tend to seek information within their own departments. Supporting H3, individuals tend to seek out information from supervisors, and they tend to seek out information from those with higher proximity to power, i.e. positive significant receiver effects for supervisors and power proximity. Supporting H4, differences in power proximity appear to be negatively associated with tie formation, indicating power proximity homophily. Finally, supporting H5, ties in the permission network are strongly positively associated with tie formation in the information search network (edge.cov), suggesting that information search tends to be channeled through formal lines of authority.

Model 3 adds all the variables from Model 1 and 2 together. It shows a few notable changes. When controlling for formal organizational factors, the sender effect of commitment is weakened, while the sender effect of trust appears to be strengthened. The absolute difference in
commitment between sender-receiver pairs is also strengthened, indicating that when controlling for organizational structure, individuals with similar levels of commitment tend to form ties. The self-efficacy effects also appear to be stronger in the presence of variables accounting for organizational structure. Further, when including the perceptual-cognitive variables with the organizational structure variables, the sender effects of supervisory status and hierarchy become only marginally significant.

Model 4 takes all variables from Model 3 and includes three network controls that substantially improve both the information criteria (AIC, BIC, and Log Likelihood) and the ERGM specific goodness-of-fit statistics (see Appendix 2). These include GWESP which models the edge-wise shared partner distribution, or triangles between three nodes in a network, often interpreted as a transitivity effect; GWIDegree which models the in-degree distribution, interpreted as the popularity effect in the network; and ODegree(0:5), which was included to account for an uneven out-degree distribution, interpreted as a network activity effect. Including these network terms weakens the estimates and significance of several variables of interest but improves the accuracy of the model by accounting for well-know social processes ubiquitous in social networks. Regarding the perceptual-cognitive variables, accounting for both formal organizational structure and social network structure renders all but the sender effect of trust and the homophily effect of commitment insignificant. Regarding the formal organizational structure variables, the pattern of effects appears mostly to remain intact. However, the estimate on the sender effect of power appears to reverse becoming negative. This indicates that social network processes may account for a larger proportion of variance in perceptual-cognitive variables than for formal organizational structure.
Table 2 – Exponential Random Graph Models

|                        | Model 1          | Model 2          | Model 3          | Model 4          |
|------------------------|------------------|------------------|------------------|------------------|
| Self.Eff - Receiver.Cov| -0.179*** (0.035)| -0.245*** (0.043)| -0.117** (0.038) |                  |
| Self.Eff - Sender.Cov  | -0.098** (0.036) | -0.165*** (0.043)| -0.027 (0.031)   |                  |
| Self.Eff - Absdiff     | -0.141*** (0.033)| -0.146*** (0.043)| -0.031 (0.032)   |                  |
| Trust - Receiver.Cov   | -0.003 (0.037)   | -0.020 (0.044)   | -0.083* (0.038)  |                  |
| Trust - Sender.Cov     | 0.212*** (0.037) | 0.259*** (0.043) | 0.095** (0.030)  |                  |
| Trust - Absdiff        | -0.061 (0.033)   | 0.021 (0.041)    | 0.045 (0.030)    |                  |
| Commitment - Receiver.Cov | 0.059 (0.034)   | -0.028 (0.037)   | -0.063 (0.034)   |                  |
| Commitment - Sender.Cov| 0.169*** (0.034) | 0.120** (0.037)  | 0.026 (0.027)    |                  |
| Commitment - Absdiff   | -0.073* (0.032)  | -0.234*** (0.039)| -0.144*** (0.031)|                  |
| Department - Nodematch | 3.035*** (0.093) | 3.128*** (0.097) | 1.575*** (0.078) |                  |
| Hierarchy - Receiver.Cov| 0.056 (0.031)   | 0.069* (0.032)   | 0.057* (0.028)   |                  |
| Hierarchy - Sender.Cov | -0.109*** (0.033)| -0.067* (0.034)  | -0.147*** (0.024)|                  |
| Hierarchy - Absdiff    | 0.166*** (0.031) | 0.176*** (0.031) | 0.072** (0.022)  |                  |
| Permission - Edge.Cov  | 0.988*** (0.118) | 0.981*** (0.120) | 0.647*** (0.108) |                  |
| Supervisor - Receiver.Factor | 0.595*** (0.070)| 0.567*** (0.072)| 0.403*** (0.068) |                  |
| Supervisor - Sender.Factor | 0.197** (0.072)| 0.142 (0.074)    | -0.091 (0.053)   |                  |
| Supervisor - Nodematch | 0.045 (0.055)   | 0.031 (0.057)    | 0.053 (0.056)    |                  |
| Power.Prox - Receiver.Cov | 0.511*** (0.031)| 0.535*** (0.032)| 0.329*** (0.032) |                  |
| Power.Prox - Sender.Cov| 0.300*** (0.034) | 0.296*** (0.034)| -0.052* (0.025)  |                  |
| Power.Prox - Absdiff   | -0.161*** (0.025)| -0.182*** (0.025)| -0.130*** (0.019)|                  |
| Density - Edges        | -2.610*** (0.061)| -6.558*** (0.354)| -6.623*** (0.366)| -8.123*** (0.276)|
| Reciprocity - Mutual   | 2.398*** (0.084) | 1.013*** (0.101) | 0.974*** (0.103) | 0.261* (0.105)   |
| Transitivity - GWESP.75|                  | 2.262*** (0.096) |                  |                  |
| Popularity - GWIDegree.75|               | 4.424*** (0.410) |                  |                  |
| Activity - ODegree(0:5)|               | 4.424*** (0.410) |                  | FIXED*** (FIXED) |

Table Notes: Dependent variable is the probability of a tie between two nodes in the network for all models. ***p < 0.001, **p < 0.01, *p < 0.05; Standard errors are in parentheses; ERGM controls include seed=101; MCMC.samplesize=5120; MCMC.interval=5120; MCMC.burnin = 81920. Goodness-of-fit plots for model 4 are shown in Appendix 2. GWESP and GWIDegree both included fixed alphas at 0.75. ODegree is fixed at 0 through 5, and each term is significant (abbreviated as FIXED). For an explanation of each model term see table 1.
By adding variables that capture formal organizational structure, the AIC, BIC, and log likelihood shrink by roughly 20% between Model 1 and 2. Further, there appears to be little effect of including perceptual variables on the information criteria between models 2 and 3. Indeed, comparing Model 1 to a null model that includes only an edge term produces an AIC of 11959, indicating a marginal decrease by including these common perceptual-cognitive variables. Finally, Model 4 shows a sizeable decrease in the AIC and BIC from Model 3, suggesting that social network processes are indeed an important determinant of information search. ERGM specific goodness-of-fit-statistics form Model 4 are presented in Appendix 2.

In summary, the results from Table 2 suggest that formal organizational structure has important effects on the formation of information search networks within city government, while controlling for perception-based factors as well as social network processes. The results suggest broad support for all five hypotheses.

**Discussion**

The research purpose of this article is to develop and test theory regarding the effects of formal organizational structure on the development of informal social networks within public organizations. The results showed broad support for the subject-line expectation, providing empirical support for a number of measures of formal organizational structure. To summarize, we found that departments with tall hierarchies tend to constrain information search, individuals tend to seek information within their own departments, they tend to seek out managers and those closer to power in organizations, and they tend to form information ties with individuals whom they also seek out for formal permission for job tasks. At the same time, we found that
accounting for formal structure had important consequences for existing perceptual-cognitive variables. The results suggested that trust is strongly associated with information search regardless of the model specification, while organizational commitment appears to lose its relevance when controlling for variables that capture organizational structure and social network processes.

Scholars have argued that hierarchy should have a waning influence over information seeking, presumably due to organizations becoming flatter, less layered, thus creating the need for organizational members to actively seek information outside chains of command. In support of this argument, Cross, Rice and Parker (2001) found that being at the same hierarchical level did not influence information benefits, nor did colocation in the same office. Yet our findings suggest the hierarchy significantly shapes information flows within organizations, constraining them both vertically and horizontally. Thus, public organizations wishing to foster information flow and stimulate collaboration across departments should consider how their hierarchies can be flattened to foster such activity. Given the role of departments in constraining information flow, public managers should consider explicitly encouraging cross-departmental information exchange that will diminish silos.

While a great deal of research on information search and knowledge sharing has been concerned with the bridging of organizational silos and facilitating lateral communication, our findings point to one additional consideration: If department membership is still one of the main factors for explaining effective information exchange, then one way to further improve communication is through well-developed relations within work units. This finding is in line with research that has argued that the development of social capital within teams can benefit the organization as a whole (Kroll et al. 2019). Information sharing within teams or departments
could be fostered if members are encouraged to speak up and listen to each other and feel safe to take risks (Edmondson and Roloff 2008).

The fact that managers high up in the hierarchy are likely to be sought out for information emphasizes a dilemma: While supportive managers may want to play this role and provide insights and feedback to employees, organizations need to establish structures that prevent managers from being overburdened or creating a bottleneck. One way to do this would be through establishing staff positions, which could serve as a filter for all coordination and communication related inquiries. A second possibility would be the creation of learning forums around themes such as improving performance or visualizing impact (Moynihan 2005), which would allow managers to interact with a cross-section of employees, while being focused on specific issues for a limited time period.

Our finding for the permission network has two implications. First, the lines of permission matter a great deal even for the social and largely informal phenomenon of information seeking. Second, while permission lines are one important structural factor, it is not the only one. Put another way, even after controlling for the permission network, all other structural-formal factors, including hierarchy, authority, supervisor status, departmental membership, still show significant, independent effects. This finding confirms our point that the structural side of organizations has many facets, and many of them come into play at the same time.

Like other research, our study is prone to some limitations. First, the analysis is cross-sectional and does not account for change over time. Rather, the study utilizes ERGM to analyze a snapshot of a social network to test hypotheses regarding the formation of social ties. Future research could extend the study to account for temporal dynamics. Second, the study includes
only one organization. Hence, we cannot generalize the findings far beyond the present context. However, we take a different philosophical approach, emphasizing the current study as an instrumental case for the development of theory and its illustration, rather than generalizing to a broader population. Analysis of public sector organizations with different department structures, of different sizes, in different geographic locations, may produce valuable additional insights. Future research could extend the study to account for more organizations. Third, we were unable to completely control for the hierarchical nature of the organizational structure, e.g. including department fixed effects (e.g. node(i/o)factor) overspecifies the model. Recently developed, multilevel ERGMS could be used to control for departmental clustering in intraorganizational networks (see Stewart et al. 2019).

**Conclusion**

The vast majority of research on public sector networks has focused on the antecedents and consequences of inter-organizational networks, often neglecting intra-organizational social networks. Those studies that have examined intra-organizational networks have tended to focus on the effect of informal dynamics of social structure, cognitive-perceptual variables, and the attributes of individuals, such as commitment, trust, and self-efficacy. As a result, the function of formal organizational structure in determining the shape of informal intra-organizational networks has been relatively neglected. The current study addresses this lacuna by developing theory and testing hypotheses regarding the effects of formal structure on information search within a small city government. The results suggest strong effects of formal structure on constraining and enabling information search across and within departments, as well as
interesting relative effects of commitment and trust in the presence and absence of formal structural variables.

While we argue that structure matters even for informal networks, we do not suggest that it is more important than other vectors in equations trying to predict information search. Rather, our point is that we are able to draw on established theory to make a strong case for a structural perspective, and that disregarding such variables would be a missed opportunity. As we showed in our modeling: accounting for a set of structural variables also helped to tease out more nuanced cognition effects. We found, for example, that organizational commitment likely promotes information search across departments but may not be as salient as trust within departments. We think that our argument about structure is even more valid for the context of public bureaucracies. Considering that bureaucracies are known for their reliance on tall hierarchies, formal authority, and routine processes, we suggest that these factors will also be influential in shaping more informal, social interactions. If one’s research interest is in understanding behaviors within public organizations, then the mere use of variables that are widely employed in the analysis of firms (such as network position, work attitudes, or demographic attributes) may be insufficient. Overall, our study provides a practical starting point for the unification of formal and informal network structure within public sector intra-organizational network studies.
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Appendices

Appendix 1 – Interview Items

The table below shows the exact language used for each survey item. Each variable was measured on a 1-7 Likert scale.

Table A.1 – Interview Items

| Variable                   | Questionnaire Text                                             | Operationalization                                                                 |
|---------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Information Search Tie    | “I seek information from this person to do my job”              | Dependent Variable – Serves as edge between two nodes in information search network |
| Self-Efficacy 1           | “I am confident that I can perform effectively on many different tasks.” Likert 1-7 | Independent Variable – Self-Efficacy Factor                                         |
| Self-Efficacy 2           | “Even when things are tough, I can perform quite well.” Likert 1-7 |                                                                                   |
| Self-Efficacy 3           | “Compared to other people, I can do most tasks very well.” Likert 1-7 |                                                                                   |
| Trust 1                   | “In my department, employees trust supervisors.” Likert 1-7      | Independent Variable – Trust Factor                                               |
| Trust 2                   | “In my department, supervisors trust their subordinates.” Likert 1-7 |                                                                                   |
| Trust 3                   | “In my department, employees trust supervisors to make good decisions.” Likert 1-7 |                                                                                   |
| Commitment 1              | “I would feel guilty if I left this organization now.” Likert 1-7 | Independent Variable – Commitment Factor                                          |
| Commitment 2              | “I would be very happy to spend the rest of my career with this organization.” Likert 1-7 |                                                                                   |
| Commitment 3              | “I am thinking about leaving this organization.” Likert 1-7      |                                                                                   |
| Permission search tie     | “I seek permission from this person to do certain tasks” Likert 1-7 | Independent Variable – Serves as edge between two nodes in permission search network |
Appendix 2 – Goodness of Fit Statistics for Table 2, Model 4

The package *statnet* in R produces the goodness-of-fit plots, presented in Figure A.2 for Model 4 in Table 2. The model converged to produce reliable parameter estimates. The figures show how well the distribution of simulated networks models observed distributions of interest, including the in-degree distribution, out-degree distribution, edgewise shared partner distribution, network distance, and model parameters. The figures show a reasonably good fit given the unevenness of the in-degree and out-degree distributions. The ODegree term was useful for fixing the distribution between 0 and 5 degrees where drastic changes were observed in the distribution. We were unable to increase the GWESP fixed alpha value or include another triangle term such as GWDSP without model degeneracy.
Figure A.2 – ERGM Goodness-of-Fit Diagnostic Plots, Model 4, Table 2

Figure Notes: The plots include an in-degree distribution, an out-degree distribution, an edgewise shared partner distribution, a distance distribution, and a set of model parameter box plots. The solid line in each figure represents the observed distributions, while the box plots represent the simulated distributions based on observed network characteristics and model terms. The degree to which the box plots encompass the black line indicates the goodness-of-fit for the model for the given parameter.