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On the "missing link" between formal organization and informal social structure

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Abstract

Over the last 40 years, organizational scholars have repeatedly called for more research to reconcile formalist and social network approaches to the intra-organizational structure. The former has primarily been concerned with the reporting relationship which manifests as the chain of command while research on the informal social structure relegates the reporting relationship to a wide and varied range of instrumental and affective relationships such as advice-seeking, knowledge-sharing, trust, and friendship which span the boundaries that the chain of command defines. In this study, we employ the *chain of command distance*—the length along the chain of command of a path connecting a pair of organizational actors—as the basis for formulating and testing hypotheses about how the formal organization and the informal social structure influence one another. First, we argue that whereas the formal structure affords only one, often very lengthy, path between any pair of actors, the *combination* of formal and informal structures results in a greater number of significantly shorter paths between actors. Next, we consider one effect of the formal organization on the informal social structure. In particular, we argue that there is an inverse relationship between the chain of command distance and the likelihood of a social or informal connection forming between a pair of actors. We test our hypotheses with demographic data collected from a public sector provider of health, education, and welfare services in rural Norway.

Keywords: Organization structure, Social structure, Informal structure, Organization design, Formal structure, Social network, Network analysis, Social network analysis, Organizational network analysis, Quadratic assignment procedure

Introduction

Over the last 40 years, organizational scholars have repeatedly called for more research to reconcile two competing, yet complementary, notions of the intra-organizational structure—one based on formally defined roles and responsibilities, often referred to as the "formal" organizational structure and another based on repeated patterns of interaction, often referred to as the "informal" or "social" or "network" structure (Tichy & Fombrun, 1979; Simon, 1981, Krackhardt, 1994; Gulati & Puranam, 2009; McEvily, Soda, and Tortoriello, 2014; Hunter 2015). That such a reconciliation is both advisable and achievable is not in dispute. The two perspectives do, after all, have overlapping conceptual vocabularies (Hunter, 2016), common theoretical foundations (Gulick & Urwick, 1937), and a

shared concern with patterns of interactions which, in practical terms, manifest in a variety of similar "relationships" (Tichy, Tushman, & Fombrun, 1979). According to McEvily, Soda, and Tortoriello (2014), the "missing link" is "an integrated theoretical understanding of organizational functioning in which the formal organization and the informal social structure are conceived of not in isolation, but in combination" (p. 303).

Traditionally, the more formalist approach—perhaps best typified by the *information processing* (Galbraith, 1974; Daft & Lengel, 1986), *configurational* (Miles, Snow, Meyer, & Coleman, 1978), and *structural contingency* approaches to organizational design (Lawrence & Lorsch, 1967; Burton & Obel, 1998, Klaas, Lauridsen, Hakonsson, 2006)—is primarily concerned with the reporting relationship which manifests as the chain of command and which establishes the vertical and horizontal boundaries that define subgroups of organizational actors. To the degree that the formalist approach considers informal or social structures at all, it is primarily in their role or capacity as "integrating mechanisms" such as "direct contact", "liaison roles", and "hierarchical referral" (Galbraith, 1974, pp. 29, 33), each of which lies along the chain of command and/or spans the boundaries that it defines.

Research on the informal social structure reverses this ordering. Here, the reporting relationship is typically relegated to a wide and varied range of instrumental and affective relationships such as advice-seeking, knowledge-sharing, trust, and friendship. These relationships form networks that connect actors that are adjacent in the chain of command, as well as those that are widely separately by it. In this research stream, the formal structure is typically treated as a control variable and is atomized, that is to say, treated as a set of discrete units—hierarchical levels, departments, roles, etc.—rather than as an integrated whole. The "disconnect" in the literature is waiting to be bridged by research that takes "a systematic approach to analyzing the interplay between the formal organization and the informal social structure" and thereby deepens our understanding of how "formal and informal elements are related" (McEvily, Soda, & Tortoriello, 2014, p. 303). It is to this end that this study is explicitly directed. Our starting point is a concept that both approaches necessarily acknowledge—the chain of command. Specifically, we use the "chain of command distance" (Zahn, 1991)—the length along the chain of command of a path connecting a pair of organizational actors—as the basis for formulating and testing hypotheses about how the formal organization and the informal social structure influence one another.

The remainder of this paper is organized as follows. In the next section, we first consider the influence that informal social structure has on the length and distribution of paths that connect pairs of actors in the formal structure. We argue that whereas the formal structure affords only one, often very lengthy, path between any pair of actors, the *combination* of formal and informal structures results in a greater number of significantly shorter paths between actors. Next, we consider one effect of the formal organization on the informal social structure. In particular, we argue that there is an inverse relationship between the chain of command distance and the likelihood of a social or informal connection forming between a pair of actors. The next section describes the data that we collected from the sample organization—a public sector provider of health, education, and welfare services in rural Norway—and the methods used to test our hypotheses, all of which are confirmed. The final section contains a discussion of our conclusions and their implications for the extant literature.

Literature review and hypotheses

As noted above, the two perspectives on an intra-organizational structure consider the same basic elements but place relatively different emphasis upon them. Daft, Murphy, & Willmott (2010) definition of an organizational structure, which is typical of the formalist perspective, includes (1) the "formal reporting relationships including the number of levels in the hierarchy and the span of control of managers and supervisors", (2) the division of labor, i.e., "the grouping together of individuals into departments", and (3) integrating mechanisms, i.e., "the design of systems to ensure effective communication, coordination, and integration of efforts across departments" (Daft, Murphy, & Willmott 2010; p. 94). He continues, noting that

> These three elements of structure pertain to both vertical and horizontal aspects of organizing. For example, the first two elements are the structural framework which is the vertical hierarchy. The third element pertains to the pattern of interactions among organizational employees. An ideal structure encourages employees to provide horizontal information and coordination where and when it is needed (ibid, p. 95).

Clearly echoing Fayol (1949), the "vertical hierarchy" to which the definition refers is represented by the "vertical lines on an organizational chart" that link all subordinate groups, units, and individuals to their superiors in an "unbroken line of authority" (Daft, Murphy, & Willmott 2010; p. 108). The "departments" can, of course, include sub-groupings of many different sizes, from groups to entire business units or subsidiaries. The integrating mechanisms are of two basic varieties—vertical and horizontal. The former "are used to coordinate activities between the top and bottom of an organization and are designed primarily for control" (ibid, p. 99). Again, echoing Fayol (1949), one of the most commonly employed vertical integrating mechanisms is "hierarchical referral" which involves the use of the "hierarchy or the chain of command" to resolve problems that cannot be resolved at lower levels—perhaps because of disagreement or perhaps because of a lack of knowledge or resources." Daft adds that when "… the problem is solved, the answer is passed back down to lower levels…(and thus) the lines of the organization chart act as communication channels" (ibid, p. 99).

The other class of integrating mechanisms are horizontal or lateral. They are "designed for coordination and collaboration, which usually means reducing control" (Daft, Murphy, & Willmott 2010; p. 96). Horizontal integrating mechanisms include but are not limited to the use of "direct contact", the creation of interdepartmental task forces and cross-functional teams, and creation of new formal roles such as inter-unit liaisons and full-time integrators (Galbraith, 1974; Burton & Obel, 1998). Fayol (1949) famously referred to "direct contacts" as "gangplanks". In his later work, Galbraith (1994; p. 44) extended his original typology of integrating mechanisms to include "network-building practices" and "design actions" specifically intended "to create a voluntary lateral organization", also known as "the informal organization". Those mechanisms included interdepartmental rotation, physical co-location, information technology networks, interdepartmental events, and "mirror-image" departments.

Figure 1 below depicts a prototypical organizational hierarchy. It has four levels and a span of control of three which together give rise to three major departments, with 13

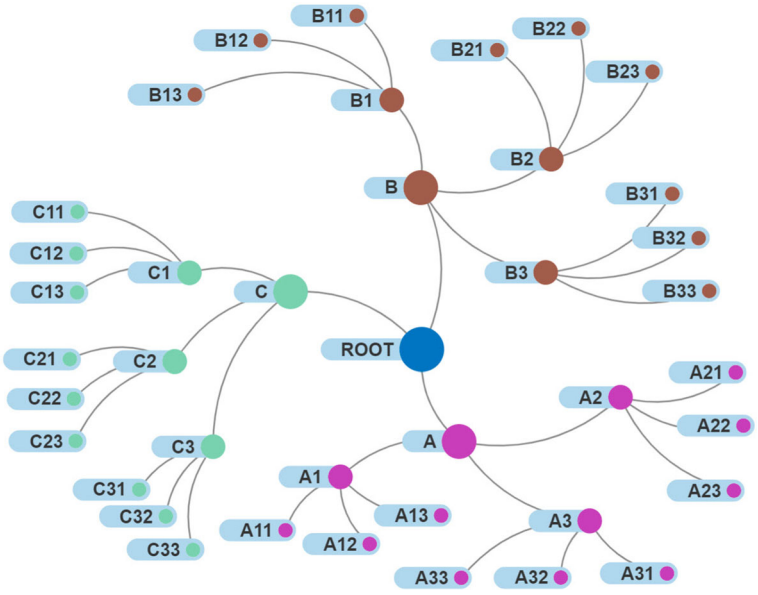

Fig. 1 Prototypical formal organizational structure with four hierarchical levels and span of control of three

members each, and 9 work groups, with 4 members each. It also delineates the horizontal boundaries that define the three 13-member departments, each of which is headed by A, B, and C (large squares) and includes all three of their direct reports (triangles) and nine indirect reports (small boxes), respectively. It also defines the nine work groups (triangles and small boxes, e.g., B1, B11, B12, and B13) which are found at the lower two levels of the hierarchy.

One distinctive feature of formal hierarchies is that there is only one path between any pair of actors—a path that runs along the chain of command. We hereafter employ the term "chain of command distance" (Zahn, 1991) to enumerate the number of steps by which any pair of actors are separated in the formal structure. In Fig. 1, Actors C and C2 are separated by one step, A and A33 by two steps, and B23 and A11 by six steps. Figure 2 below depicts the formal structure from Fig. 1 with an additional ten (10) randomly placed direct contacts or gangplanks which connect actors across, rather than along, the chain of command.

Three things are noteworthy concerning the "multiplex" network formed by the combination of the chain of command with these horizontal integrating mechanisms. First, recall that in the formal organizational structure, there is exactly one path connecting every pair of actors. When the integrating mechanisms are added, then there is more than one path between any pair of nodes. For example, consider actors B13 and C11, both of which occupy the lowest hierarchical levels in Departments B and C, respectively. The chain of command distance (D_C) between them is six steps in length: C11 ➔ C1 ➔ C ➔ Root ➔ B ➔ B1 ➔ B13. The path between them passes along the chain of command through five intermediate actors, each of which belongs to a different hierarchical level, department, and/or group. The gangplank between C11 and B13 represents a second and more direct path between them. This is the case, more generally, with all other pairs connected by direct contact or a gangplank. Specifically, whereas in the formal structure there is only one path between any pair of actors, when horizontal integrating mechanisms are present, there are more paths.

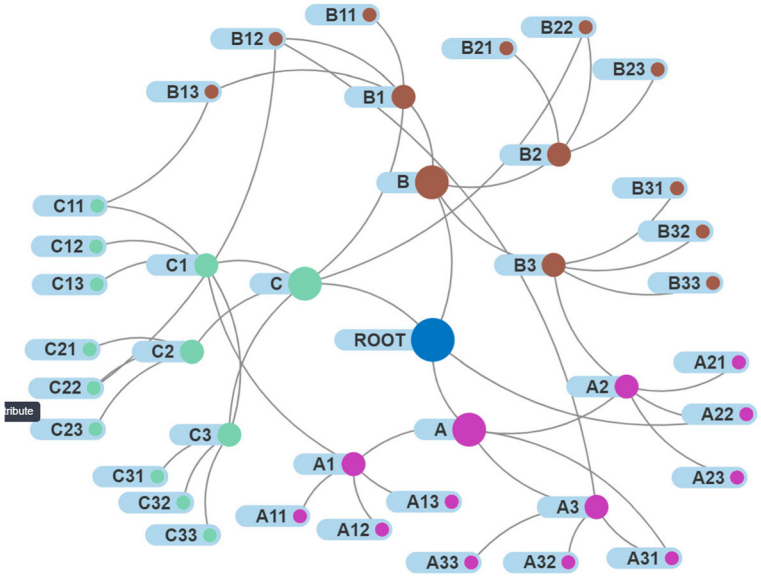

Fig. 2 Prototypical formal organizational structure from Fig. 1 with the addition of ten (10) randomly generated "gangplanks"

Secondly, recall that by definition, D_C between non-adjacent actors is at least two steps. As such, the distance over a path created by an integrating mechanism is always shorter than D_C. Also, for many other pairs of actors, the shortest path between them will now include the integrating mechanism rather than the chain of command alone. For example, while the chain of command distance between B11 and C12 is six steps, the linkage between C11 and B13 offers another path which, we see, is one step shorter. Figure 3 compares the frequency distribution of chain of command distances in the formal organizational structure to the distribution of shortest lengths of paths in the combined (multiplex) network presented in Fig. 2. Notably, the latter appears to have a lower mean, due in large part to the 81% reduction in the number of the longest paths, paths which are six steps in length and connect actors at the lowest level of different

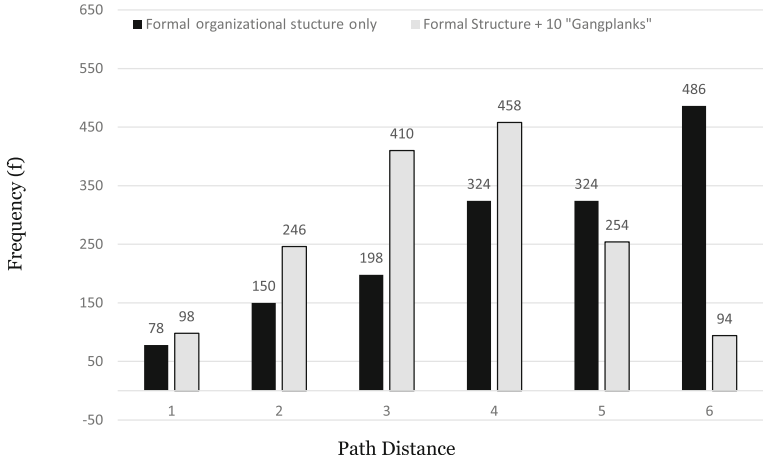

Fig. 3 Frequency distribution of path distances for formal organizational structure and formal structure with gangplanks

departments. Notably, the latter distribution appears to be much less skewed and far more normally distributed than the former.

We are aware of no prior research that explicitly tests or confirms the geometry underlying the above observations. As such, we formally offer the following testable hypotheses concerning the influence of the informal social structures in relation to the formal organizational structure:

H1: The *number of paths* between actors in the combined (multiplex) network, i.e., formal plus informal social structure, is greater than that in the formal structure alone
H2: The *average length of the shortest paths* between actors in the combined (multiplex) network *is shorter* than that in the formal structure alone

Formal structure as an antecedent of social structure

The social or informal perspective on the intraorganizational structure takes as its starting point the very obvious fact that human beings are "social creatures" whose "embeddedness" in "networks of relations" with others is instrumental to the accomplishment of "many of life's tasks", both within and outside of formal organizational settings (Kilduff & Krackhardt, 2008, p. 1). By this view, it is both the "formal relations of authority" and the "informal links…across departmental and hierarchical boundaries" that hold "business organizations" together and permit them to accomplish their tasks (ibid). Among the "informal links" of concern to this perspective are those based on several interpersonal relationships or ties between co-workers, as well as the network formed thereby. Those ties and relationships include, but are not limited to, *information-seeking* (Cross, Rice, & Parker, 2001; Borgatti & Cross, 2003), *advice-seeking* (Lazega & van Duijn, 1997; Gibbons, 2004), *workflow* (Hinds, Carley, Krackhardt, & Wholey, 2000), *work-related communication* (Allen, 1970; Zahn, 1991; van de Bulte & Moenaert, 1998), *friendship* (Gibbons & Olk, 2003), social and emotional support (Hite, Williams, & Baugh, 2005), *job-related affect* (Totterdell, et al., 2008), *trust* (Ferrin, Dirks, & Shah, 2006), *respect* (Fernandez, 1991), and "*energy*" (Casciaro & Lobo, 2015; Daly, Liou, & Brown, 2016).

Every empirical study of this kind of which we are aware treats some vertical or horizontal aspect of formal structure as control and/or independent variables and, thus, as determinants of informal structure. These include, but are not limited to, superior–subordinate ties, membership in the same department or other formally defined subgroupings, occupants of the same hierarchical level, and occupants of the same formal role. We next consider each, in turn.

Superiors and subordinates

In a study of advice relations among employees of a Dutch Housing Corporation, Agneesens and Wittek (2012) reported that supervisor–subordinate pairs "exchange advice significantly more often than dyads with peers…" and thus concluded that "communication and advice relations reflect that formal hierarchical structure". Because "individuals typically approach their direct supervisors for problem-solving assistance", Brennecke (2019) controlled for the "supervisor–supervisee" relationship in her examination of the antecedents of problem-solving ties among aerospace engineers. As expected, the relationship had a positive and statistically significant effect. In their study

of trust relations among top managers of an Italian yacht builder, Lusher, Robins, Pattison, and Lomi (2012) reported that the supervisor–subordinate relation had a positive and significant effect on tie formation. In a study of three organizations, Fernandez (1991) found that formal reporting relationships positively predicted respect relations, an affective relationship. In their study of a high-end distributor of adult beverages in Europe, Casciaro and Lobo (2015) also reported a positive and significant effect of superior–subordinate relations on task-related ties. Similarly, Contractor, et al. (2012) found a positive and significant effect on the likelihood of task-related communication between supervisors and subordinates in a large public works division on a large, American military base. We are aware of no studies that found a positive but insignificant—let alone negative or negative and significant—impact on tie formation among supervisor–subordinate pairs. The theoretical motivations and explanations for these findings are all species of social capital arguments, each of which emphasize the real and/or perceived differences in interdependence (Casciaro & Lobo, 2015), legitimate authority (Fernandez, 1991; Lusher et al., 2012), social status and rank (Agneesens & Wittek, 2012), or reward and coercive power (Brennecke, 2019) that generally attend to the superior–subordinate relationship.

Same hierarchical level

Results from studies of another vertical aspect of the formal structure—hierarchical level—on the informal social structure are more equivocal. For example, similarity of level has been shown to have a positive and significant effect on the formation of "energy" relationships among school administrators (Daly, Liou, & Brown, 2016), on tie strength among Brazilian manufacturing employees (de Oliveira Maciel & Netto, 2018), and on cross-unit, advice-seeking ties among senior leaders in a Fortune 200 agribusiness company in America (Gray, Bunderson, et al., 2019). Among studies reporting a negative and significant effect of hierarchical similarity on social structure are Marineau, Hood, and Labianca's (2018) examination of advice-seeking relations in a 75-person, life sciences firm in the midwestern USA. Among those reporting negative and non-significant effects are a study of knowledge-sharing networks in an American engineering organization (Poleacovschi & Javernik-Will, 2019), one of cooperative relationships among top executives in two German multinationals (Rank & Tuschke, 2010), another on advice relations among senior executives of an Italian yacht builder (Lomi, et al., 2014), and also one on advice-seeking relations after an acquisition (Mirc & Parker, 2019). Finally, Agneesens & Wittek (2012) reported a positive but insignificant effect from hierarchical similarity on advice relations. Because the similarity of level is almost always treated as a control variable in such studies, there is little, if any, theory offered to explain its effect within a given study.

Same Group Membership

A number of studies have reported positive and significant effects of formally delineated sub-groupings on the formation of social or informal ties in organizations. For example, Marineau, Hood, and LaBianca (2018) reported a positive and statistically significant effect on advice-seeking ties when both members of a dyad reported to the *same supervisor*. Other sub-groupings reported to have positive and significant effects include membership in (a) the *same department* on collaboration formation among

investigators in an American medical school (Kabo, et al., 2014; Kabo, et al., 2015), (b) the *same department* on tie strength in a Brazilian engine manufacturer (de Oliveria Maciel & Netto, 2018), (c) the *same subsidiary* on advice relations across "five separate, quasi-independent" units of an Italian yacht builder (Lomi, et al., 2014), (d) the *same unit* in a study of advice, creative, and friendship relations in a South Korean advertising agency (Lee & Lee, 2015), (e) the *same office* on advice relations in a corporate law firm in New England (Lazega & van Duijn, 1997), (f) the *same clinical directorate* on advice relations in a community of Italian physicians (Mascia, et al., 2015), (g) the *same legacy firm* on advice relations after the merger of two recruiting consultancies (Mirc & Parker, 2019), (h) the *same subject group* on advice-seeking ties among educators at six English secondary schools (Ortega, Boda, Thompson, & Daniels, 2020), and (i) the *same unit* on knowledge acquisition ties among scientists in the R&D division of a large multinational technology company (Tortoriello, Reagans, & McEvily, 2012). It is the principle of homophily—the notion that individuals form social ties in accordance with perceived similarity of others (McPherson, Smith-Lovin, & Cook, 2001)—that investigators most often invoke to motivate and explain these findings.

Same formal role

While similarity of role is frequently considered as an antecedent of social ties, when that role is associated with formal leadership responsibilities, there is no consensus in the literature about the direction of the effects. Typical of studies reporting a *positive and significant* impact are an examination of affective and instrumental ties in a South Korean advertising agency (Lee & Lee, 2015), of knowledge transfer ties among R&D department employees in a South Korean manufacturer of semi-conductors (Kang & Kim, 2017), of information-seeking ties among Italian government workers (Zappa & Robins, 2016), and of advice relations among Italian physicians (di Vincenzo & Mascia, 2017). *Positive and non-significant* results were reported in a study of advice-seeking relations in an American life sciences company (Marineau, et al., 2018) and advice- and information-seeking relations among secondary school teachers in Belgium (Geearts, et al., 2018). Notably, Ortega et al. (2020) reported a *negative and insignificant* effect on advice-seeking ties among educators in several English secondary schools. In a study of Italian physicians, Mascia, et al. (2011) reported a *negative and significant* effect on collaboration ties associated with the same managerial role. In their analysis of informal leadership ties among members of an R&D division of a pharmaceutical company, Chrobot-Mason, Gerbasi, and Cullen-Lester (2016) reported that while those in formal leadership positions were more significantly more likely to be seen by co-workers as "a source of direction, alignment, and commitment", they also significantly less likely feel that way about others, including other formal leaders. Spillane, Kim, & Frank (2012) examined the impact of formal leadership roles on information- and advice-seeking ties among English and mathematics teachers in a mid-sized US public school. They reported a positive and significant effect associated with leaders as providers of advice but not as receivers. Finally, Tasselli (2015) examined the impact of formal leadership positions on the "ease of knowledge transfer" and the "perceived receipt of useful knowledge" among 118 doctors and nurses in the same hospital department. He reported a negative and insignificant effect from occupancy of a formal

leadership role on the former. But when it came to "perceived receipt of useful knowledge", a formal leadership role was found to have a positive and insignificant effect overall (doctors and nurses), a negative and insignificant effect for doctors alone, and a positive and significant effect for a network of nurses.

To summarize, across a number of relationship types, the effect on the formation of social ties from *supervisor–subordinate* pairs, as well as from *subgroups* like departments and work groups, is uniformly positive and highly significant statistically. In marked contrast, the effect associated with *same hierarchical level* and *same formal role* are equivocal, i.e., sometimes positive, sometimes negative, sometimes statistically significant, and sometimes not. As shown in Table 1 below the most equivocal results are associated with the two sub-groupings that have the largest, intragroup chain of command distances (D_C) in a prototypical organizational hierarchy—like Fig. 1—where h equals the number of hierarchical levels. There is cause, we think, to conclude that this is not accidental.

As we conceive of it, every step in the chain of command represents the transgression of a formal boundary. As such, the greater the chain of command distance is, the greater the number of these vertical and horizontal boundaries there are. Prior research has already shown such distance-based measures to be associated with organizational outcomes and processes. For example, in a study of 45 members of a manufacturing organization, Zahn (1991) reported that the chain of command distance was negatively associated with exposure, i.e., opportunities for face-to-face communication. In a study of an internal crowdfunding initiative at Siemens, the likelihood of a positive evaluation was negatively associated with the hierarchical distance between an idea's creator and its evaluator (Schweisfurth, et al., 2017). And in a study of research scientists, information centrality—which assigns greater weights to shorter paths—was positively and significantly associated with the formation of inter-unit knowledge acquisition ties (Tortoriello, Reagans, and McEvily, 2012). The underlying logic of the chain of command distance's negative association with the formation of social ties is this: the greater the distance, the more likely the social actor is to encounter other actors with different "stocks of knowledge, information, and frames of reference", actors with "more divergent knowledge and expertise and potentially conflicting ways of seeing the world" (Tortoriello, Reagans, and McEvily, 2012; p. 1027), actors who identify with social foci whose boundaries are governed by different rules, incentives, and "resource allocation policies" (Lomi, et al., 2014), and actors with different "status orderings" or "cognitive categories" (McEvily, Soda, & Tortoriello, 2014). As such, we propose that the magnitude of the effect of the above sub-groupings on the formation of social ties varies inversely with the maximum value of the chain of command distance within the grouping. The following

Table 1 Effects of formal structure sub-groupings on formation of social ties, ordered by intragroup chain of command distance

Formally defined sub-groupings	Results from extant literature	Chain of command distance ($\boldsymbol{D_C}$)
Superior–subordinate	Positive, significant	$D_C = 1$
Same work group	Positive, significant	$1 < D_C < 2$
Same supervisor	Positive, significant	$D_C = 2$
Same department	Positive, significant	$1 < D_C < 2 * (h\text{-}2)$
Same role	Equivocal	$1 < D_C < 2 * (h\text{-}1)$
Same hierarchical level	Equivocal	$2 < D_C < 2 * (h\text{-}1)$

h number of hierarchical levels

four hypotheses formalize this expectation with regard to the following sub-groupings—(1) *supervisor–subordinate pairs*, (2) *work groups*, i.e., superiors and their direct reports, (3) *subordinates of the same superior*, (4) *members of the same department*, (5) occupants of the *same hierarchical level*, and (6) occupants of the *same role*. Specifically,

H3: With a chain of command distance of exactly one step, the *superior–subordinate pairing* is the strongest of the formal structure antecedents of the informal social structure.
H4: With a maximum chain of command distance of two steps, *similarity of work group* (supervisor plus direct reports) and *similarity of superior* (direct reports of the same superior) are the second strongest of the formal antecedents of the informal social structure.
H5: With a maximum chain of command distance of 2 * (h-2) steps, where h is the number levels in the hierarchy, *similarity in department* is the third strongest of the formal antecedents of the informal social structure.
H6: With maximum chain of command distances of 2 * (h-1) steps, s*imilarity of role*, where *role* is defined by the possession of supervisory responsibilities, and *similarity in hierarchical level*, are the weakest formal antecedents of the informal social structure.

Methods and data

All network data used in this study were collected from a public sector provider of health, educational, and welfare services in a non-urban, Norwegian *kommun*, one of 356 in the country. At the time of data collection, the agency had employees organized into five major departments—Office of the CEO (OC), Central Administration (CA), Health & Welfare (HW), Youth & Culture (YC), and Environment & Technology (ET). Among the agency served a local population of approximately 4000 people spread over 705 km^2. Among its 525 employees, 26 were managers whose number of direct reports ranged from a low of 1 to a high of 64, the average being 18.6 subordinates and a median of 11. As shown in Table 2 below just over 78% of the workforce was female, there were significant differences among the four departments. Specifically, females comprised 45% of Central Administration and 53% of Environment &Technology but 80% of H&W, and 84% of

Table 2 Comparative statistics for five departments of the sample organization

Department	Size	Hierarchical levels	% Male	% Foreign	% Full-time	Supervisory ratio	Common job titles
Office of CEO	7	1–3	43%	0%	100%	43%	CEO, chief of HR, chief of legal affairs, communications consultant, planning & development manager
Central admin	11	2–4	55%	9%	100%	33%	Archivist, secretary, advisor, accountant
Environment & technology	36	2–4	47%	22%	69%	5.5%	Technician, cleaner, caretaker, surveyor, agricultural advisor, forestry director
Health & welfare	221	2–5	20%	16%	40%	3.6%	Nurse, case manager, school nurse, care giver, child welfare specialist, midwife, secretary
Youth & culture	189	2–5	16%	4%	93%	5.3%	Teacher, educator, secretary, teaching assistant, child/youth worker, librarian
Total	464	1–5	22%	11%	66%	5.6%	

Y&C. Foreign-born and ethnic minority individuals comprised 11% of the workforce, 34% of which was part-time. The most common job titles by department were technician, cleaner, caretaker, surveyor, and agricultural advisor in *Environment & Technology*; archivist, advisor, and consultant in *Central Administration*; and teacher, educator, and child/youth worker in *Youth & Culture*; and nurse, midwife, and caregiver in *Health & Welfare*.

Data on one affective relationship (social support) and one instrumental relationship (expert advice-seeking) were gathered via a survey administered to all 525 employees in February of 2018. The survey was administered in Norwegian. The English translations of the two relevant survey questions are as follows

- Who do you go to when you need *information* about something important to you in a job context?
- Who do you trust will help you overcome *adversity* as you struggle with problems, frustrations, obstacles, and unwelcome changes (on the job)?

Following both questions were the following instructions, again translated from Norwegian:

- Choose from 1–7 people. Search by name list, surname or first name, start with 2–3 letters, click to add colleagues. You must select at least one person to advance. If you do not have any people you want to add, find yourself and move on.

A total of 464 surveys were completed giving a response rate of 88%.

A third network was constructed, extracted from logs from the first 6 months in which the agency deployed an enterprise social network known as *Workplace by Facebook* (WFB). That six-month period began 2 months *after* the above survey was administered—May through October of 2018. While not connected to user's personal Facebook accounts, *WFB* incorporates much of the same functionality such as groups, direct messaging, as well as many other functions designed to enhance engagement, communication, collaboration, and productivity (Facebook, 2019). For our purposes, a link was said to exist between two workers if, during the six-month period, either of them had either (a) commented on one or more of the other's *WFB* posts or (b) if one had tagged the other in his/her own post and/or in a post made by a third member of the agency. Table 3 below compares seven

Table 3 Descriptive network statistics for formal organizational structure, three informal social structures, and combinations thereof

Network/structure	Avg. deg	Density	Connectedness	Avg. geodesics	Avg. dist.	SD distance	Diameter
Formal	2.00	0.43 %	1.00	1.00	4.76	1.33	8
Support-seeking only	2.23	0.54 %	0.32	1.09	4.93 (9.09)	1.64 (2.97)	10 (11)
Information-seeking only	3.39	0.83 %	0.34	1.56	3.88 (7.90)	1.26 (3.00)	9 (10)
Workplace only	2.50	1.29 %	0.16	0.56	2.80 (6.31)	0.79 (1.59)	6 (7)
Formal + info-seeking	4.79	1.26 %	1.00	4.33	3.89	1.12	7
Formal + support-seeking	3.78	0.98 %	1.00	2.53	4.21	1.17	7
Formal + enterprise social network	4.10	1.72 %	1.00	2.71	3.30	0.79	5

networks—formal, information-seeking, support-seeking, and Workplace-mediated, as well as each of the latter three combined with the first—along several metrics—average-degree centrality, density, components, connectedness, average and standard of geodesic distance, and diameter.

Because of the non-independence of independent and dependent variables, standard methods of regression analysis such as OLS regression are inappropriate for use on network data (Krackhardt, 1988). Among the many alternative methods that have been developed, we chose the Logistic Regression Quadratic Assignment Procedure (LRQAP) to test the aforementioned hypothesized relationships between independent and dependent variables (Dekker, Krackhardt, & Snijders, 2007)

Dependent variables

The three dependent variables in this study are 464 × 464 matrices, each one representing one of three social networks. The first of these was the information-seeking network where cells *ij* and *ji* were both coded "1" if there was an *information-seeking* linkage directed from actor i to actor j and/or directed from actor j to actor i and coded "0" otherwise. The second matrix was for the *support-seeking* network and like the information-seeking network, cells i and j were coded "1" if there was a support-seeking linkage directed to/from actor i to/from actor j and coded "0" otherwise. The third matrix was for the enterprise social network, Workplace by Facebook. Here, cells ij and ji were coded "1" if actors i and j commented on one another's post(s) and/or tagged one another on a third actor's post in Workplace by Facebook during the first 6 months of its availability and coded "0" otherwise.

Independent variables

The five independent variables are 464 × 464 matrices, each of which represents a formally defined subgroup of workers. In the first, named *Same level*, cell ij was coded "1" when co-workers i and j occupied the same hierarchical level in the sample organization and coded "0" otherwise. As its name suggests, in the second matrix, cell ij was coded "1" if co-workers i and j belonged to the *Same department* and coded "0" otherwise. Recall that departmental membership was defined by a direct or indirect reporting relationship to one of the six direct reports of the Chief Administrative Officer. In the third matrix, *Same superior*, cells ij and ji were coded "1" when co-workers i and j reported to the same superior and coded "0" otherwise. The fourth matrix represented membership in the *Same work group* where "work group" was defined as a superior and all of his or her direct reports. Because membership in work groups could overlap—a superior in one group could be a subordinate in another—we included only work groups where supervisors belonged to the third hierarchical level and their subordinates to the fourth level. There were twenty (20) such work groups in our sample. In this matrix, cell ij was coded "1" when both workers i and j belonged to the same work group and coded "0" otherwise. In the fifth matrix, entitled *Supervisor–subordinate*, cells ij and ji were coded "1" when the co-workers i and j formed a supervisor-superior tie in the formal structure and coded "0" otherwise. In the sixth and final matrix, entitled *Same role*, cells ij and ji were coded "1" when both actors occupied the same formal role—supervisor or non-supervisor—and were coded "0" otherwise.

Control variables

We controlled for three additional antecedents of social structure in the sample—gender, nationality, and employment status. In the former, *Same gender*, cells ij and ji were coded "1" if both workers were female and "0" otherwise. In the second, *Same nationality*, cells ij and ji were coded "1" if both workers listed their country of origin was "Norway" and "0" otherwise. Finally, for *Same employment status*, cells ij and ji were coded "1" for full-time and "0" for part-time status. The quadratic assignment procedure (QAP) function within UCINET (Borgatti, Everett, & Freeman, 2002) was used to the calculate bivariate correlations among all independent, dependent, and control matrix variables that are presented in Table 4 below.

Results

Table 4 below contains comparative data for the four networks under consideration in this study—the formal structure alone plus three multiplex networks formed by the formal structure plus information-seeking network, the support-seeking network, and the enterprise social network, respectively. Recall that our first hypothesis (H1) concerned the number of paths between actors in the formal structure versus the multiplex or combined structures. By definition, there is exactly one path between a given pair of actors in the formal structure, a path which necessarily adheres to the chain of command. The data in the left panel of Table 4 indicates that there were 4.33, 2.53, and 2.71 paths per pair of actors in the three multiplex networks, specifically the formal plus information-seeking, plus support-seeking, and plus enterprise social network, respectively. The t-statistics for all three tests of means with different variance are statistically significantly at levels well below $p < 0.0001$. Thus, H1 is strongly supported.

The second hypothesis (H2) concerned the average length of the paths in the formal structure versus those in the three multiplex networks. As indicated in the right panel of Table 5, the average path distance in the formal structure alone was 4.76 with a standard deviation of 1.33. In the three multiplex networks, the average distances were 3.89, 4.21, and 3.30 for the formal plus information-seeking, plus support-seeking, and plus enterprise social network, respectively. The t-statistics from two tests of means with equal variance and one with unequal variance were all highly significant ($p < 0.0001$). Thus, H2 is strongly supported.

Figure 4, below, displays the frequency distribution for the chain of command distance in the formal organizational structure alone, as wells as for the average path distances for the formal organizational structure plus each of the three informal social structures. The former has a mean of 4.76 and a standard deviation of 1.33. It appears highly non-normal and the visual intuition is supported by the fact that approximately 57% of the observation are outside of the range defined by the mean minus and the mean plus one standard deviation—almost double the 31.7% that is found in a normal distribution. The latter has an average of 3.80 and a standard deviation of 1.02. Notably, in the combined networks, the longest paths in the formal, which were eight steps in length, have been eliminated and only 0.32% of the paths are seven steps in length. A post-hoc test of mean information centrality for all 464 actors was not only highly significant but also bimodal and non-overlapping. Specifically, in each of the three multiplex networks, all information centrality scores were not just higher for every actor than in the formal structure alone, the lowest score in the combined network was

Table 4 Quadratic assignment procedure (QAP) correlations

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
[1] Information-seeking	1.00 [a]											
[2] Support-seeking	0.654[a]											
[3] Enterprise social network	0.181 [a]	0.160 [a]										
[4] Same nationality	0.025 [a]	0.020 [a]	0.030 [b]									
[5] Same gender	0.004	0.012 [b]	0.004	− 0.003								
[6] Same employment status	0.051 [a]	0.038	0.038 [a]	0.097 [a]	− 0.010							
[7] Same level	− 0.030 [a]	− 0.019 [a]	− 0.050 [a]	− 0.087 [b]	0.073 [b]	− 0.068 [a]						
[8] Same role	− 0.054 [a]	− 0.042 [a]	− 0.063 [a]	− 0.046	0.052 [d]	− 0.056 [a]	0.407 [a]					
[9] Same department	0.066 [a]	0.060 [a]	0.015 [b]	0.016	0.063 [a]	0.184 [a]	0.131 [a]	0.056 [a]				
[10] Same superior	0.122 [a]	0.118 [a]	0.027 [a]	− 0.004	0.019 [c]	0.120 [a]	0.175 [a]	0.074 [a]	0.349 [a]			
[11] Same work group 1	0.174 [a]	0.124 [a]	0.084 [a]	0.022 [b]	0.005	0.043 [a]	0.019 [b]	− 0.070 [a]	0.067 [a]	0.163 [a]		
[12] Same work group 2	0.124 [a]	0.122 [a]	0.027 [a]	− 0.007	0.021 [c]	0.113 [a]	0.149 [a]	0.052 [a]	0.349 [a]	0.948 [a]	− 0.017 [a]	
[13] Superior–subordinate	0.248 [a]	0.201 [a]	0.153 [a]	0.014 [d]	0.011	0.014 [b]	− 0.105 [a]	− 0.180 [a]	0.073 [a]	− 0.014 [a]	0.119 [a]	0.185 [a]

[a] $p < 0.001$; [b] $p < 0.01$; [c] $p < 0.05$; [d] $p < 0.10$; all two-tailed

Table 5 Number of paths (geodesics) and average geodesic distance of paths in four networks

	H1: number of paths (geodesics)				H2: geodesic distance of paths			
	Avg.	St. dev.	t-stat	*p* value	Avg.	St. dev.	t-stat	*p* value
Reporting only	1.00	0.00			4.76	1.33		
Reporting + information-seeking network	4.33	3.06	41.0	< 0.0001	3.89	1.12	− 31.1	< 0.0001
Reporting + support-seeking network	2.53	0.88	35.3	< 0.0001	4.21	1.17	− 21.1	< 0.0001
Reporting + enterprise social network	2.71	0.84	40.2	< 0.0001	3.30	0.79	− 55.6	< 0.0001

larger than the highest in the formal structure alone. Thus, even actors that forged no informal social ties were brought closer to other actors in the organization.

Data relevant to H3 through H6 are contained in Table 6 which contains the results of several QAP logistic regressions of the information-seeking network on several subgroupings in the formal structure—supervisor–subordinate pairs (H3), members of the *same work group* and subordinates of the *same supervisor* (H4), members of the *same department* (H5), and occupants of the *same hierarchical level* and *same formal role* (H6).

The first model presents results of the baseline model—the intercept plus beta coefficients for the three controls—*same nationality*, *same gender*, and *same employment status*. In each table, Models 1–6 each include the baseline model plus one of the structural sub-groupings as an independent variable. Odds ratios appear in parentheses underneath each coefficient. As expected, the magnitude of the beta coefficients and of the odds ratios varies inversely with the intragroup chain of command distance. Specifically, the beta coefficient (4.19) and the odds ratio (65.85) for *supervisor–subordinate pairs* are larger than those for *same work groups* ($\beta = 2.24$, odds = 9.37) which is essentially the same as those for subordinates of the *same superior* ($\beta = 2.20$, odds = 9.01) which, in turn, are larger than that for the *same department* ($\beta = 1.60$, odds = 4.92) which, in turn, is greater than those for occupants of the *same hierarchical level* ($\beta = -0.59$, odds = 0.56) and *same formal role* ($\beta = -1.13$, odds = 0.32). Although the ordering of effect sizes is as expected in the four hypotheses, the large difference between the effect of same hierarchical level and same formal role (H6) was expected to be smaller. Notably, all coefficients are highly significant ($p < 0.001$), positively so for the short-distance sub-groupings (H3, H4, and H5) and negatively so for the longer distances (H6).

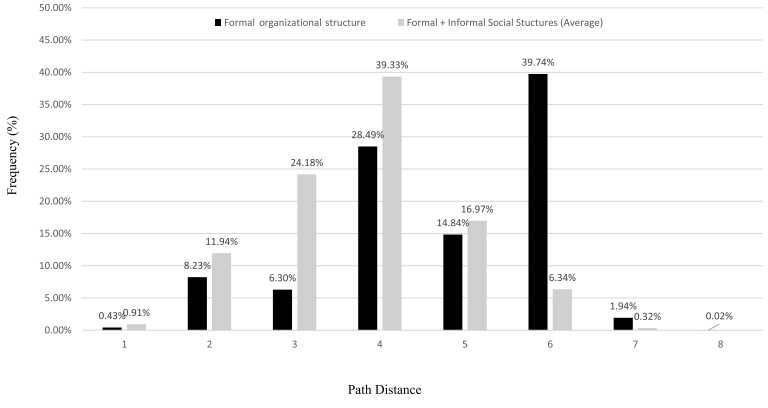

Fig. 4 Frequency distribution of path distances in formal structure and three combined (multiplex) networks

Table 6 Logistic regressions (QAP) of information-seeking network on formal organizational structure

	Baseline	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	− 6.860***	− 6.924***	- 7.178***	− 7.148***	− 7.557***	− 6.416***	− 5.789***
Same nationality	0.950*** (2.59)	0.866*** (2.38)	1.027*** (2.79)	1.017*** (2.76)	0.963*** (2.62)	0.871*** (2.389)	0.879** (2.409)
Same gender	0.162 (1.176)	0.105 (1.111)	0.077 (1.080)	0.084 (1.087)	0.027 (1.027)	0.207# (1.230)	0.228# (1.255)
Same status	1.427*** (4.167)	1.412*** (4.102)	1.122*** (3.070)	1.111*** (3.308)	1.148*** (3.152)	1.388*** (4.005)	1.369*** (3.932)
H3: supervisor–subordinate pair		4.188*** (65.85)					
H4: same work group			2.244*** (9.37)				
H4: same superior				2.197*** (9.01)			
H5: same department					1.598*** (4.92)		
H6: same hierarchical level						− 0.588*** (0.56)	
H6: same role							− 1.131*** (0.323)
Log likelihood	− 4466	− 4065	− 4075	− 4092	− 4265	− 4434	− 4382
Δ log likelihood vs. baseline	--	401	391	374	201	32	84
R^2	0.3%	7.0%	1.8%	1.9%	0.7%	0.4%	0.7%
Δ adj-R^2 vs. baseline	--	6.7%	1.5%	1.6%	0.4%	0.1%	0.4%

Non-standardized coefficients; *N* (obs) = 107,416
#$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; all one-tailed

Figure 5 is a graph of the beta coefficients for each of the three social structures versus above structural sub-groupings. The lines representing the information- and support-seeking networks are so strongly correlated in terms of coefficient values and slope that data labels are appended only for the former. The line representing the ESN decreases in a more monotonic fashion than the other two. Taken together the results strongly support H3–H6.

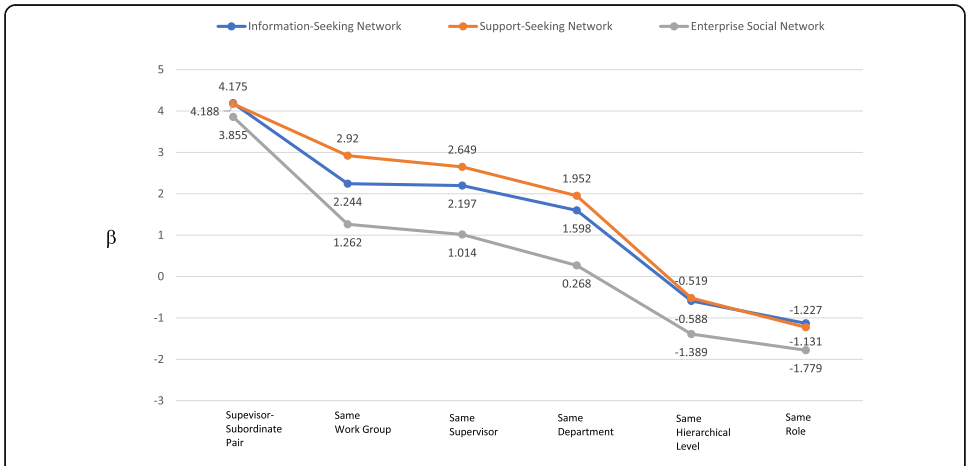

Fig. 5 Beta coefficients for QAP linear regressions of three social structures on formal structure

Discussion and conclusions

Our hypotheses were in two sets—the first about the effect of the informal social structure on the formal organizational structure while the second concerned the contrary. The first specifically considered the effect of lateral integrating mechanisms like direct contact and gangplanks on the formal structure, specifically the chain of command distance between pairs of organization actors. As expected, we found that the addition of instrumental social ties like direct contact, liaison roles, and gangplanks to the formal organizational structure significantly increased the number of paths between organizational actors (H1) and significantly reduced the average length of the shortest paths between them (H2).

The second set of hypotheses concerned the influence of formal organizational structure on the informal social structure. Specifically, we argued that the chain of command distance by which two organizational actors are separated affects the probability or odds that they will forge an informal social tie. To test this proposition, we identified six aspects of formal organizational structure—supervisor–subordinate pairs, work groups, subordinates of the same superior, members of the same department, occupants of the same hierarchical level, and occupants of the same formal role—and ordered them according to the maximum intragroup chain of command distance. As expected, we found that the formation of informal social ties varied inversely with the chain of command distance within each subgroup (H3–H6). Specifically, the formation of informal social ties in three networks—information-seeking, support-seeking, and enterprise social media—was most common among actors separated by the shortest chain of command distance and increasingly less common as that distance grew.

Taken together, the results contribute to the extant knowledge on the relationship between the formal organization and the informal social structure. We frame these contributions briefly in terms of McEvily, Soda, and Tortoriello's (2014) four "building blocks for linking formal and informal" structures (p. 314)—formal structure as a "control" variable, formal structure as a "boundary" that contours informal social structure, formal and informal structures as "joint effects" on outcomes, and formal and informal as "reciprocal influences" on one another.

Concerning the former, those authors note that "the most prevalent approach to addressing the link between the formal organization and the informal social structure is to assign conceptual primacy to the role of the informal social structure and relegate the role of the formal organization" (p. 314). They continue, adding that there is "typically little explicit theorizing devoted to explaining the extent to which formal structures enable or constrain informal relationships" and "rarely specific predictions made regarding the effects of formal structures on the outcomes of interest" (p. 315). The results of this study confirm their observation and further suggest that the chain of command distance can be used as a control variable in studies of the antecedents of the informal social structure, either alongside of or in place of other measures of formal structure. Either way, the inclusion of chain of command distance would allow for a very specific prediction—that the formation of ties would vary inversely with that distance.

The second building block concerned the manner in which formal boundaries "circumscribe the opportunity set for informal interactions to occur and restrict the locus of effects of informal patterns of relationships" (p. 317). In this study, we examined the

effect of several formal boundaries on the informal social structure and showed that all such boundaries are not created equal. The difference, we showed, is a better indicator of the chain of command distance by which actors on opposite sides of the boundary were separated than the nature of the boundary itself.

The third building block concerns "understanding how the interplay between formal and informal elements has *joint effects* on organizational outcomes and assessing their relative influence" (p. 319, italics in original). One possible contribution of our findings concerns the joint effect of the formal organization and the informal social structure on performance. This study showed that organizational actors are separated by a chain of command distance in the formal organizational structure but separated by a much shorter distance in the combined or multiplex structure, i.e., when informal social ties are included. Actors will differ in the degree to which they forge those social ties and the degree to which they benefit from the social ties created by others. They can also be compared on the basis of the (average) distance by which they are separated from others *in the multiplex structure*. Any effect that this average distance has on organizational outcomes like performance, for example, could be understood as a joint effect of the two structures. That is because, due to their having subordinates, formal managers will on average have shorter average distances between themselves and others in the organization. That said, there will be actors whose average distances will be comparable to or even lower than those of formal managers. Distance over the multiplex structure could, then, give insight into how an "actor's formal hierarchical status interacts with their informal social network in determining their influence" on organizational outcomes (p. 320).

The results of this study also speak directly to the fourth and final building block which concerns reciprocity, i.e., "the extent and nature of influence that formal and informal elements potentially have on each other" (p. 322). Recall that our first group of hypotheses concerned the influence of informal social on the formal organizational structure. Recall further that in the formal organizational structure, pairs of actors are separated by a single path which follows the chain of command. The length of that path was what we termed the chain of command distance. As expected, we showed that instrumental informal social ties both increase the number of paths between paired actors and shorten them. The second group of hypotheses considered the reverse, i.e., how the formal structure affects the informal. As expected, we found that as the chain of command distance increases, informal social ties are forged with decreasing frequency. The reciprocity is evident: informal social structure shortens the distance by which actors are formally separated—the chain of command distance—but that same distance, circumscribes or restricts the opportunities for those informal social ties to be forged.

Finally, we would note another analytical approach to the question of reciprocity, one that we chose not to pursue. It involves the use of exponential random graph models (ERGMs), a statistical model for social network data that differs in important ways from the logistic regression QAP models used in this study (Lusher, et al., 2013). Importantly for our purposes, ERGMs allow "the specification and estimation of specific sources of dependence" among actors, sources that include endogenous effects like *entrainment* (the degree to which superiors also seek support or information from their subordinates), *exchange* (the extent to which subordinates also seek information or support

from their superiors), and *closure* (the tendency for subordinates of the same superior to form informal social ties) as well as exogenous (nodal and dyadic) effects like gender, group membership, and even chain of command distance (Lomi, et al., 2014). The three endogenous effects are, at present, under-theorized and consequently poorly understood. Our future research will examine these and other effects with the specific intent of rediscovering the "missing link" between the formal organization and informal social structure.

Authors' contributions

JT and HB collected and organized the data needed for the study. SH, JT, and HB participated in the design of the study. SH and HB analyzed the data, including statistical analysis and the generation of graphics/figures. The authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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