IS HIGH PERFORMANCE CONTAGIOUS AMONG KNOWLEDGE WORKERS?

Completed Research Paper

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Abstract

This study investigates the peer effects of worker productivity among knowledge workers who interact through digital communication channels. We draw on social and developmental network research to examine the performance of 248 knowledge workers and their 1,027 email contacts. The average performance of contacts in a digital communication network relates positively to employee performance: Interacting with high performing coworkers benefits the employee's performance, though no evidence indicates that interacting with low performers harms it. Consistent with preferential attachment and direct reciprocity explanations, high performing employees benefit most from the performance of employees in their network. Social network researchers should consider both structure and resources to determine the effects of networks.

Keywords: Social networks, performance, email, resource access, collaboration

Introduction

Workforce performance remains a central concerns for teams, organizations, industries, and economies, because the rate at which individual workers transform resources into outputs likely determines success or failure. In addition, workers' performance influences the performance of their peers, so whether introducing high performing employees into a work environment improves the performance of other workers has been the focus of considerable recent research (Mas and Moretti 2009). However, previous research investigating these peer influences has focused on traditional production settings, including supermarket checkers (Mas and Moretti 2009), farm workers (Bandiera et al. 2005), letter stuffers (Falk and Ichino 2006), and cosmetics salespeople (Chan et al. 2010). Knowledge is an increasingly valuable resource for firms (Grant 1996); work in contemporary organizations frequently involves knowledge work and the active use and development of information. Understanding performance by knowledge workers thus represents a critical frontier (Drucker 1999), though comparatively little research has investigated whether peer influences on performance extend to knowledge work.

Important differences exist between production and knowledge work that may affect the nature of peer influence on employee performance. First, the outputs of production workers and knowledge workers differ considerably. Performance in production work tends to be defined in terms of quantity (e.g., more fruit picked, more letters stuffed, more customers helped), but knowledge work performance requires quality assessments (Drucker 1999). High performing employees in production settings may set an example for their peers to work longer or faster, but it is not clear whether working longer or faster similarly improves performance among knowledge workers. Second, contemporary knowledge workers typically interact through digital communication technologies, such as email. Online communication networks are thought to provide less rich information than face-to-face networks (e.g., Daft et al. 1987), particularly the types of social information that individuals are likely to look for improving their performance (Miranda and Saunders 2003). These technologies also undermine the theoretical mechanisms by which peer influence is believed to occur. Researchers have empirically demonstrated that peer influence occurs because workers can observe the performance of their coworkers (Chan et al. 2010; Mas and Moretti 2009). Observation will fundamentally differ in electronic communication. If co-located, an employee may observe that a coworker is engaging in knowledge work (e.g., typing on a computer) but likely cannot observe the most salient aspects of what that coworker is doing. If not co-located, these technologies limit the ability to observe the interactions between people with whom one is not communicating directly.

Our research examines whether knowledge workers influence the performance of their peer contacts when interacting through digital communication networks. We study the email networks and yearly performance levels of 248 knowledge workers and their 1,027 contacts. We hypothesize that the performance of an employee's contacts positively influences his or her own work performance. Even after controlling for structural features of the network, we find that the influence of employee performance in a digital communication network relates positively to performance changes from year to year. Nevertheless, the nature of this influence is ambiguous, as it is not clear whether high performing employees raise the performance of their contacts or whether low performing employees drag it down. We theorize that the performance of an employee's network exerts a positive, rather than a negative, influence on performance. We find that high performers improve the performance of their contacts, but find no evidence that low performers worsen the performance of their peers. Finally, we study whether performance of one's contacts influences all employees equally. Consistent with explanations of preferential attachment, high performing employees benefit more from high-performing contacts than do low performing employees.

This study makes a number of important contributions. Although there have been many studies focusing on the performance implications of social networks (Borgatti and Foster 2003), most of these studies focused primarily on the structural features of the network. In contrast, our study establishes that the characteristics of the people in one's social network influence performance *in addition to* these structural features. This finding is particularly important in relation to digital communication networks because – unconstrained by geographic or temporal boundaries – digital networks are likely more malleable than traditional ones. The data generated by digital communication networks also provides opportunities to analyze the structure of the network, allowing managers to cultivate mentoring-like relationships via these digital channels between high and low performing employees. Furthermore, if the characteristics of the

individuals in a network influence performance above and beyond its structural aspects, it may encourage organizations to shift toward newer generations of digital communication technologies (e.g. social media technologies, Boyd and Ellison 2007) that make the characteristics of and resources of individuals in the network more transparent to others in the network.

Theoretical Background

Organizations have long sought to encourage employees to enhance one another's performance. Perhaps the most explicit example is mentoring (c.f., Kram 1985; Levinson et al. 1978; Ragins and Kram 2007), in which colleagues cultivate a relationship expressly to transfer wisdom and knowledge. Mentoring increases organizational commitment, reduces turnover (Payne and Huffman 2005), enhances personal learning and skill development (Lankau and Scandura 2002), and improves work performance and promotion rates (Scandura and Schriesheim 1994). Traditional mentoring relationships involve a single dyad, in which a more experienced and hierarchically superior mentor imparts wisdom to an individual protégé, who is both less experienced and hierarchically inferior.

More recent research advocates shifting away from this traditional dyadic view to consider *developmental networks* (Higgins and Kram 2001, p. 268), defined as "the set of people a protégé names as taking an active interest in and action to advance the protégé's career by providing developmental assistance." By combining a traditional view of mentoring with a social network perspective, a developmental network approach advocates multiple relationships that provide diverse sources of knowledge and wisdom. The relationships are 1) not top-down but rather involve mutuality and reciprocity; 2) engage not a single mentor but an entire "constellation" of people; and 3) need not be traditional or explicitly established but instead can be opportunistic and entrepreneurial (Higgins 2000; Higgins and Kram 2001). Yet developmental networks still should produce many of the same consequences as traditional mentoring relationships, such as improved job performance, personal learning, and organizational commitment. Researchers have found that this networked model of developmental networks also extends to electronic and virtual mentoring relationships (Ensher et al. 2003; Hamilton and Scandura 2003).

Research on developmental networks builds upon the substantial research investigating the relationship between social network structure and work performance. Because a social network structure provides social capital (Adler and Kwon 2002; Nahapiet and Ghoshal 1998), employees gain advantages related to the combination and exchange of knowledge, which they can use to improve their work performance. For example, structural holes that allow connections across otherwise disparate groups offer a particularly advantageous network structure in that the people who occupy the structural holes receive vast, timely information by brokering the knowledge across otherwise unconnected groups (Burt 1992). Thus social network structures can affect work performance and produce various benefits, including promotions (Burt 1992; Podolny and Baron 1997), positive managerial evaluations (Cross and Cummings 2004; Sparrowe et al. 2001), and bonuses (Mizruchi et al. 2011).

These performance implications extend to digital communication networks, where the network structure reflects the messages exchanged on a particular platform. The structural features of this communication network structure have been found to be associated with both online and offline performance. Online, the structure of a digital communication network might improve individual worker productivity (Ahuja et al. 2003) and the output quality produced by a group (Grewal et al. 2006). Offline, it relates to managerial evaluations of in-role performance (Wasko and Faraj 2005) or the amount of revenue generated (Aral and Van Alstyne 2010).

Like much of the social network literature, however, much of this previous work on online and offline networks has focused predominantly on the network *structure* as a source of social capital. Social network researchers, however, have increasingly emphasized the additional role of the *resources* to which the network provides access as an important determinant of social networks and performance (Borgatti and Foster 2003; Kane and Borgatti 2011; Lin 1999). Different nodes provide access to different resources, so the properties of nodes to which the network provides access might be influential beyond the simple structure of the network. For example, certain nodes might possess better information, superior skills, or more available time and thereby render seemingly identical network positions more or less valuable. We argue that networks that contain higher-performing employees contribute to an employee's performance beyond the performance benefits realized by the structural features of that network.

Is Performance Contagious in Digital Communication Networks?

According to social information processing theory, people rely on their social environments for valuable information about attitudes, perceptions, and behaviors (Salancik and Pfeffer 1978). An employee might use such social information to improve performance. For example, peers might provide explicit performance feedback, or coworkers could react favorably or unfavorably to behaviors; people then can use that information to inform their future choices. Such social information also might help a person identify which aspects of the work environment are most salient for effective performance. For example, if employees observe that their peers believe positive customer feedback is a critically important aspect of effective performance (or not), they likely adjust their performance to match these values, which could result in improved performance. This social information also helps them understand how to identify or interpret important events or actions in the workplace; coworkers are referents for employees' own performance, which helps them determine what their "needs, values, and requirements should be" (Salancik and Pfeffer 1978 p. 230).

Furthermore, research on practice diffusion indicates that novel work practices spread through social and developmental networks (Abrahamson 1991; Attewell 1992; Rogers 1995), because the characteristics of practices diffuse through the network and influence performance (Ansari et al. 2010; Oliver 1992). *Cultural characteristics* refer to organization-specific expectations of effective work (Katz et al. 1963; Rogers 1995). Knowing cultural performance standards can help employees adjust their work practices to achieve better performance, such as by determining whether supervisor appraisals or customer assessments are more important in the firm. *Political characteristics* instead refer to the individualities of coworkers (Cyert and March 1963; Davis and Thompson 1994), which can help employees learn how to interact effectively. For example, knowing how and from whom to obtain valuable information likely is critical to knowledge work (e.g., Borgatti and Cross 2003). Finally, *technical characteristics* refer to domain-specific behaviors or knowledge required to perform a job (Rogers 1995; Tornatzky and Klein 1982). An accountant can learn valuable knowledge about the job by working with high-performing accountants.

Thus, the performance of an employee's contacts should influence his or her future performance, even if we control for the structural aspects of the network. A network composed of higher performing contacts can help employees evaluate the effectiveness of their existing work practices, as well as provide a source for new, potentially more effective practices. When the digital communication network contains higher performing contacts, it likely provides more valuable feedback and richer sources of new practices. We thus hypothesize:

> *Hypothesis 1: Controlling for the structural features of the network, the performance of one's contacts in a digital communication network relates positively to improvements in the employee's performance.*

Positive or Negative Influence?

The effects of the performance of an employee's contacts on his or her performance are not clear. Do effective and ineffective practices disseminate equally? Although we argue that high performing employees improve the performance of their contacts, it is possible that low performing networks negatively influence performance by their contacts. The metaphor of contagion, to describe how virulent diseases spread, reminds us that detrimental or virulent practices also may be disseminated through networks (Morris 1997). The negative effects of performance even could be the dominant mechanism, according to some social network research that theorizes that the negative effects of social networks are more influential than the positive effects (Labianca and Brass 2006). A network of low performers thus might hinder the performance of employees, more than a network of high performers helps it (c.f., Sparrowe et al. 2001)

If instead, effective practices diffuse across a network more than negative ones, the performance of one's contacts should have beneficial effects for networks composed of high performers but little effect in those marked mainly by low performers. How might this occur? Social network research, particularly that focused predominantly on network structure, may fail to account for agency of the individual members of the network (Borgatti et al. 2009; Emirbayer and Goodwin 1994) by assuming that information and resources flow through the network, with members as merely passive recipients. The resource-based view

of social capital that we employ partially avoids these critiques by recognizing individuals as rational actors who adopt network resources (Ansari et al. 2010; Williamson 1979).

In literature on practice diffusion, individuals selectively adopt practices that they expect to be beneficial. A similar rationale applies in models of organizational learning (Fang et al. 2010; Kane and Alavi 2007; March 1991), in which people make adoption decisions based not on the value of adopting but rather on the actions of others whom they perceive as more knowledgeable. A comparable mechanism may help people evaluate feedback received from the network, particularly if it is conflicting. If someone has difficulty determining which feedback is more valuable, an effective heuristic could be to weight information provided by high performers more heavily but discount feedback from low performers.

This predicted uniform, positive effect of peer performance also appears in empirical studies of traditional production environments. In a randomized experimental trial, working with peers consistently raises performance, compared with work on the same task in isolation (Falk and Ichino 2006). The result is not average performance between the high and low performers or lower performance by one member of the pair, as might be predicted by a free ridership rationale. Similarly, Mas and Moretti (2009) find that introducing high performing supermarket workers raises the performance of low performing coworkers, whereas the introduction of low performing coworkers has little effect on their high-performing counterparts.

These arguments lead us to predict that the performance of an employee's contacts have a mainly positive effect on employee performance. As employees draw on the resources they find in their network, they can make rational decisions about which practices to adopt and which social information represents the most salient feedback. Networks with higher performing employees then exert positive effects on performance, beyond the influence of the network structure. In contrast, networks with lower performing contacts should have little or no effect—not a negative effect—on an employee's performance, beyond the influence of the network structure. Formally,

Hypothesis 2: Networks consisting of high performing contacts have greater influence on changes in employee performance than do networks with low performing contacts.

Are All Employees Influenced Equally?

The resources provided by performance networks also may not have an equal influence on all employees. Certain employees may benefit more from the resources contained in the networks than others. Some rationale might support the perspective that low performers may benefit more from performance networks than high performers, simply because they have more to learn. The marginal value of new information may be lower for people who are already performing well (March 1991). If high performers already possess adequate technical, cultural, and political knowledge to perform their work, additional knowledge may have little incremental value for their performance. Low performers may benefit more from the resources available in the network, simply because they have greater need for these resources. This argument, however, assumes that the technical, cultural, and political knowledge necessary for effective performance is relatively stable over time, an unlikely scenario for most knowledge workers today. If the value of knowledge changes, it may be necessary employees continually draw new resources from the network to perform effectively.

In this case, high performers are better able to take advantage of the resources in the network for effective performance. The network literature is replete with examples in which "rich get richer", suggesting that high performers will benefit from the resources found in the network than the low performers. Several dynamics may work together to explain why higher performers might benefit disproportionately from the resources available in the network.

Network researchers argue that people tend to seek out the people who have or who can provide access to valuable information (Perry-Smith and Shalley 2003). It is logical that when people need resources from the network, they will likely seek out high performers as a likely source of those resources. Being sought out by others in the network confers a number of benefits. First, these exchanges allow high performers learn more about others in the network, improving their knowledge of the other people in the network and the resources they possess. Also known as *transactive memory*, this knowledge of who knows what in a network is critically important for effectively using the resources available in a network (Borgatti and Cross 2003). Second, electronic communication networks also exhibit *direct reciprocity* (Faraj and

Johnson 2011; Wasko and Faraj 2005). People tend to help those in the network to whom they have provided help in the past or who will likely be able to provide help in the future. People helped by the high performers are more likely to help the high performers in the future. Thus, if high performers are sought out more by others in a network, they are more likely to be aware of the resources available in the network and better able to access those resources when needed.

Additionally, these dynamics favoring high performance may also reinforce themselves. Networks have been shown to exhibit a tendency toward *preferential attachment* (Barabâasi et al. 2003), which suggests that people tend to seek out people in a network who are already sought out by others. This property of networks reduces the need of first-hand knowledge of an employee's performance to confer benefits to high performers. Even if an employee does not know personally whether someone is a high performer, the employee may seek our high performers simply because others have sought them out in the past. Also called *herding behaviors*, these tendencies have been documented in online communication networks and are particularly strong for networks, like intra-organizational communication networks, that have few external options (Oh and Jeon 2007). Preferential attachment also makes the network's tendency to benefit high performers robust with respect to short-term variations in performance. Even if an employee's performance dips in the short-term, people will continue to seek them out simply because others have sought them out in the past.

Taken together, these network tendencies suggest that networks are likely to disproportionately benefit high performers than low performers. Thus, we hypothesize.

> *Hypothesis 3: The performance of one's contacts in a digital communication network has a greater influence on high performers than on low performers.*

Research Method and Setting

To test our hypotheses, we collected data from partners and senior associates of a regional division of a large professional services firm. The firm's global client list spans numerous industries. Two aspects of this context make it particularly well suited to our research questions. First, the services offered by the firm are entirely knowledge related, such that employee performance is independent of any physical production. This feature serves to isolate our research question from previous work that occurred in production settings. Second, as a professional services company with a global client list, employees are rarely co-located. They communicate virtually exclusively through email communications, with the possible exception of one day per week that they work in their home office. Furthermore, these high-level employees rarely work with each other on the same on-site project, as they typically serve as the on-site supervisors of the project teams. For these reasons, the employee email network represents the dominant communication network employed by these individuals in the firm.

We selected all employees that worked in the regional division, though it was not clear how salient such boundaries were for governing work. Within the region, employees could belong to various service areas, in which setting they interacted with employees from other regions. Because it was unclear just how to define the network boundaries, we adopted an ego network strategy, which is less sensitive to the researcher's definitions of the boundary than other methods (Scott 2000). Beginning with all 248 senior managers and partners in the regional division, we obtained a complete record of email communications between these focal employees and 1,027 senior managers and partners throughout the organization with whom they communicated during a three-month period (September–November 2009). The resulting data set contained 1,048,576 emails, including information about the sender, recipient, and date and time the message was sent but excluding the content of the email.

We selected this three-month period for two reasons. First, organizational contacts indicated that it was representative of their typical work efforts (i.e., excluding summer months and holidays). Second, it immediately preceded the yearly performance evaluation process, so it was temporally proximate to evaluations. The firm eliminated any personally identifying information from the data, using a randomly assigned number that uniquely identified senders and recipients. Thus, neither the identities of the recipients nor the content of the messages were available to or discernible by the researchers.

Dependent Variable

The firm evaluates employee performance on a yearly basis, using both objective performance measures and subjective evaluations by superiors and colleagues. The use of secondary performance data from company records avoids problems of common method bias that is often associated with traditional psychometric survey-based methods of performance. These multiple data sources are qualitatively evaluated and assigned a single yearly performance rating on a four-point scale, on which 1 indicates the highest performers and 4 the lowest. For our analysis, we reverse-coded the numbers to facilitate intuitive interpretations of our results (i.e., higher scores are better). We obtained fiscal year (FY) 2010 evaluations for all 1,027 senior managers and partners with whom our focal 248 employees sent or received email communications during the analysis period. In addition, we obtained FY2009 evaluations for all 248 employees.

We considered two specifications of the dependent variable. First, we evaluated the models using absolute FY2010 performance metrics as the dependent variable (both controlling for and not controlling for previous period performance). Second, we subtracted FY2009 performance from FY2010 performance to measure change in performance over the period represented by our email data. By focusing on performance change for individual workers, we could control for unobserved, individual-level characteristics. The hypothesis testing results are robust to the precise formulation of the dependent variable; we focus on change in performance, which should provide the most conservative estimation. These robustness checks of both absolute performance and the change in performance help rule out alternative explanations, such as that our results might stem purely from homophily, where people with similar performance associate with one another (Aral et al. 2009).

Independent Variables

We constructed our three independent variables using the performance data from each employee's network. First, to test whether the performance of an employee's contacts positively influences his or her individual performance, we averaged the performance levels of all employees with whom that employee communicated during our period of analysis. To calculate the aggregate network performance, we added the performance ratings of all direct email contacts in the focal employee's network, and then divided the result by the size of the network. Aggregating ordinal data is not straightforward. Our method could introduce error by implicitly assuming weights to performance ratings. However, given the large volume of email and network size, any measurement error should be small; we confirm this through alternative specifications described in the results section.

Second, we tested the differential effects of high and low performers in the network by splitting the sample into two separate networks: one with above-average performing contacts and another with below-average performing contacts. We analyzed each subsample separately.

Third, to determine whether networks provided more benefits for high or low performers, we created an interaction term according to whether the focal individual was a high performer (i.e., top two performance categories, = 0) or a low performer (i.e., bottom two performance categories, = 1). We multiplied this dummy variable with the average network performance variable. Accordingly, our hypothesis that high performers benefit more from the network would receive support if we found a negative relationship between the variable and performance (i.e., low performers benefit less from the performance of their contacts).

Structural Network Variables

Because we hypothesized that the performance of one's contacts influences performance independently of the structural aspects of the network, we controlled for various aspects of the network structure. Using UCINet 6.359 (Borgatti et al. 2002), we generated network statistics. With our ego network strategy, we employed a suite of ego network measures that should be associated with performance, including network size, constraints, efficiency, and hierarchy (Burt 1992). *Network size* reflects the number of unique people with whom the focal employee communicates. It relates positively to performance, because more connections offer additional potential sources of knowledge and information. However, the value of

additional contacts diminishes if new contacts are already connected to one another, in which case they represent redundant information (Burt 1997). Thus, we use an adjusted measure of network size, *effective network size* that controls for the degree of redundancy in the network.

In contrast with the widespread agreement about the influence of network size, the relationships of other network structures with performance outcomes remain subject to some debate (Borgatti et al. 2009). Some researchers argue that dense, interconnected networks are superior for performance (Coleman 1988), whereas others consider sparse networks of non-redundant contacts superior (Burt 1992). Most studies also acknowledge that the precise relationship depends on environmental conditions (Burt 1992; Reagans and McEvily 2003; Rowley et al. 2000; Walker et al. 1997). Because we merely need to control for the structural dimension of the network, not test particular relationships, we avoid predicting any particular relationships between these controls and network outcomes. *Constraint* is the degree to which someone's contacts also communicate with one another. *Efficiency* reflects the number of total people available in the network, divided by the number of network ties the focal member possesses. *Hierarchy* captures the extent to which network constraints are concentrated in a few nodes. Together, these metrics control for various relevant structural aspects of an employee's ego network, such that we isolate the effects of the resources available.

Other Control Variables

We used additional variables to control for alternative possible explanations of performance and network formation. First, we controlled for two aspects of employees' history with the firm: tenure and direct admission. *Tenure* with the firm, measured by the number of years the employee has worked for the company, might affect performance, in that the firm retains high performers, whereas low performers leave. We also noted whether employees were *direct admits* to the company, which indicated whether they worked their way up or were subject matter experts who had been recruited from specific industries or other professional services firms. Because employees' entry points might affect networking behaviors, we determined whether employees worked their way up in the firm (0) or were hired from outside the company (1).

Second, we controlled for organizational level with a dummy variable that assessed whether an employee was a partner or a senior manager. This distinction might influence networking behavior and performance, because the incentive structures and responsibilities of each employee class differ considerably.

Third, we controlled for two aspects of organizational structure: office and industry. *Office* refers to the location to which the employee was assigned. Most employees in our sample travelled nearly constantly, but their home office provided support staff and, up to one day per week, served as an office for the employee. Thus, a particular office could influence networking or performance in ways not otherwise captured in our data. It also offers a proxy for face-to-face network communication. Employees in the region could be assigned to one of 10 possible offices, and we used a separate indicator variable to control for each. We then captured the *industry* in which the employee worked, such as financial services or healthcare. Employees represented six distinct industry categories, each with a separate dummy variable. These measures also help control for aspects of the interpersonal network that may not be captured by electronic communication channels. For example, people are more likely to interact personally with others who share the same office or work in the same industry, so these measures help control for the performance effects of these unobserved networks.

Fourth, because our models refer to the change in performance, we controlled for FY2009 performance levels, using a series of indicator variables. The model scale was bounded, so the degree to which an employee's performance can change also is bounded in part by previous performance. Controlling for previous performance enabled us to control as well for unobserved individual differences.

Data Analysis and Results

We used ordinal logit regression (R) for our data analysis. Ordinal regression is appropriate when there is a progressive relationship within a categorical dependent variable, but the magnitude of difference

between categories is unclear. For example, fans might know which athletes win Olympic gold, silver, and bronze medals without knowing their exact final scores. Because we know the rank order of the performance categories but not the margin of separation between them, we used ordinal regression. Table 1 includes the descriptive statistics of our data.

Table 1: Descriptive Statistics

	Minimum	Maximum	Mean	Std. Dev.
Current Performance	1.00	4.00	2.86	0.87
Prior Performance	1.00	4.00	2.71	0.90
Effective Size	2.15	175.34	45.29	32.34
Efficiency	0.54	1.01	0.91	0.06
Constraint	0.07	1.10	0.27	0.15
Hierarchy	0.18	0.79	0.46	0.12
Tenure	1.00	35.00	11.75	6.64
Partner	0.00	1.00	0.73	0.45
Direct Admit	0.00	1.00	0.29	0.45
Average Performance of Network Contacts	1.25	2.70	2.11	0.19

The correlation matrix (Table 2) indicates slightly high correlations between some network variables, which is not surprising, considering that we have taken multiple measurements of a single network. Nevertheless, to ensure multicollinearity is not a significant concern, we calculated the variance inflation factor for all variables included in our models. We found no evidence of problematic multicollinearity; the variance inflation factors for all network variables were well below 5, which is a moderately conservative threshold (Neter et al. 1990).

Table 2: Correlations

	1	2	3	4	5	6	7	8	9
1. Current Performance	1.00								
2. Prior Performance	0.59	1.00							
3. Effective Size	0.31	0.33	1.00						
4. Efficiency	0.14	0.19	0.47	1.00					
5. Constraint	-0.20	-0.21	-0.67	-0.73	1.00				
6. Hierarchy	0.15	0.16	0.11	-0.15	0.33	1.00			
7. Tenure	0.05	0.04	0.10	0.01	0.01	-0.07	1.00		
8. Partner	0.18	0.08	0.32	0.22	-0.32	0.02	0.16	1.00	
9. Direct Admit	-0.12	-0.20	-0.03	-0.01	0.01	0.10	-0.64	-0.03	1.00
10. Average Performance of Network Contacts	0.21	0.21	0.11	0.02	0.04	0.08	0.09	0.17	-0.04

Table 3 displays the results of our analysis. We find support for our hypotheses. Specifically, we argued that the average performance of contacts positively influences performance; in support of Hypothesis 1 ($\beta = 0.348$, $p < 0.01$), we found that the average performance ratings of contacts related positively to a change in performance ratings for the focal employee, even after we controlled for the network's structural features. We focus on the models using performance change as the dependent variable since they better control for unobserved individual characteristics. However, because these models examine changes to an ordinal variable, we were concerned that unobserved threshold differences in the ordinal values could affect the results. For example, a performance difference of "plus 1" could mean something

different if the performance changed from level 2 to level 3 than if performance changes from level 3 to level 4. Therefore, we also examined models based on absolute ordinal performance after controlling for prior performance as an independent variable; models that use absolute performance exhibit almost identical results. Furthermore, the aggregation of performance levels to create the "average performance level of the network" could introduce error by implicitly assuming weights to performance ratings. However, given the large volume of email and network size, any measurement error should be small. To confirm this, we examined an alternative measure for the average performance. Instead of the single average value, we created four distinct network measures (with one for each of our four performance levels) and entered all four into the regression. In this way, no implicit weighting of performance levels are assigned. The results of this alternative analysis are consistent with the aggregate measure. We focus on the aggregate measure in our results because it is more parsimonious and it is straightforward and intuitive to interpret later interaction analysis.

Table 3: Ordinal Logit Regression on Performance Change

	Model 0	**Model 1**	**Model 2 (Low)**	**Model 2 (High)**	**Model 3**
Office	Indicators	Indicators	Indicators	Indicators	Indicators
Organizational Unit	Indicators	Indicators	Indicators	Indicators	Indicators
Prior Year Performance	Indicators	Indicators	Indicators	Indicators	Indicators
Effective Size	0.318* (0.189)	0.316* (0.191)	-0.329 (0.364)	0.457 (0.279)	0.332* (0.192)
Efficiency	-0.227 (0.201)	-0.318 (0.206)	-0.566* (0.297)	-0.023 (0.360)	-0.340 (0.208)
Constraint	-0.421 (0.275)	-0.574* (0.289)	-0.505 (0.386)	-0.991* (0.564)	-0.589* (0.290)
Hierarchy	0.323* (0.168)	0.352* (0.170)	0.348 (0.251)	0.455 (0.286)	0.327* (0.170)
Tenure	0.018 (0.028)	0.014 (0.028)	-0.068 (0.044)	0.034 (0.050)	0.004 (0.029)
Partner	0.470 (0.341)	0.341 (0.347)	1.094* (0.493)	0.391 (0.663)	0.337 (0.346)
Direct Admit	0.128 (0.400)	0.085 (0.402)	-1.327* (0.607)	1.212* (0.688)	-0.005 (0.405)
Average Performance of Network Contacts		0.348** (0.144)	0.265 (0.318)	0.745* (0.397)	0.676*** (0.215)
Average Performance of Network Contacts × Low Performer					-0.585* (0.280)
N	248	248	121	127	248
AIC	540.476	536.486	292.478	245.445	534.065
Log-likelihood	-240.238	-237.243	-117.239	-93.723	-235.032
R^2: Cragg and Uhler	39.6	41.3	51.6	53.7	42.5

We then argued that high value networks should have a greater influence than low value networks and raise the performance of the employee beyond the effects of structural aspects of the network. In support of Hypothesis 2, the performance of one's contacts network related significantly and positively to performance in the subsample with high value networks ($\beta = 0.745$, $p < 0.05$), but the link was not significant in the subsample with low value networks. That is, we found no evidence of a negative effect of low value networks. Combined with the previous findings, these results indicated that the overall positive

influence of the one's contacts primarily accrued from the positive influence of high performers, not the negative influence of low performers.

Finally, we investigated for whom the performance of one's contacts had a greater influence. The negative coefficient of the interaction term showed that low performers received disproportionately lower benefits from the performance of contacts than high performers ($\beta = -0.585$, $p < 0.05$), in support of Hypothesis 3. However, it should not be misinterpreted to imply that low performers did not benefit from the performance of one's contacts; they simply benefitted less than high performers. It appears that the rich get richer with respect to the benefits of contact's performance, because high performers know how to take advantage of available resources.

Additional Results

Some results related to the control variables are interesting as well. Consistent with previous research, three of the four structural measures of the network related significantly to performance improvement in models that use the full data set and the focal independent variables. Only network efficiency did not relate significantly to performance. This general support for the relationship between the structural aspects of the network and performance lends credence to our argument that the performance of contacts demands consideration in addition to, not instead of, structural network aspects.

Consistent with previous research (Burt 1992; Carroll and Teo 1996), we found that the effective size of the network related significantly and positively to performance improvement: More contacts in a network provide a more robust source of information. Similarly, network constraints significantly and negatively related to performance in the complete models. Despite some controversy in prior literature (e.g., Reagans and McEvily 2003), we found that people perform better when their contacts are not connected to one another.

Network hierarchy related positively to performance. Although the role of network hierarchy has been debated, this finding still is contrary to what we might expect. Burt (1992) argues that hierarchy should relate negatively to performance in situations in which constraint also exhibits a negative relation. We interpret our finding about hierarchy as a reflection of the political reality of the organization. In their partnership, the employees in this study enjoy considerable autonomy regarding what they work on and with whom. Nevertheless, some members of organizations, such as managing partners or practice area leaders, should be more influential. Thus, it may be a good general rule for employees to maximize the structural diversity of their contacts but still pursue advantages from connections to key players, even if those links create some constraint in the network.

In addition, network efficiency related significantly and negatively to the performance of employees in low value networks. Network efficiency captures the total number of people accessible in an extended network, divided by the number of direct ties. People who maintain highly efficient networks rely on their contacts to pass along or broker information in the wider network (Burt 1992). The finding that network efficiency has a negative effect only in low-value networks suggests that a network of low performers cannot perform the important role of information brokerage. Perhaps these low performers do not know which information to pass along, or their contacts may not trust them with valuable information. This interesting effect of network efficiency in the low-value is worthy of further exploration.

Discussion and Conclusions

This research examines whether knowledge workers' performance depends on the performance of the people with whom an employee communicates using digital channels. We tested three hypotheses using data from the email communications of 248 employees of a large professional services firm and their 1,027 contacts over a three-month period. We hypothesized that contacts' performance influences an employee's performance, beyond the effects of other structural features of the network. We also hypothesized that the mechanism for this effect was positive rather than negative, such that high performers help their peers more than low performers drag them down. We also argued that high performers would benefit more from the resources in the digital communication network than would low performers. We found strong support for our hypotheses. The performance of one's network contacts

strongly influences employees' performance, over and above the performance effect of structural features of the network. This influence mechanism is positive rather than negative, so associating with higher performers improves performance, but associating with lower performers does not harm it. Finally, consistent with the preferential attachment argument, high performers benefit more from the performance of their network contacts than do low performers, even though the low performers might need the resources more.

Theoretical Implications

Our research contributes to theory related to both social and developmental networks. First, knowledge workers influence one another's performance, even when they interact primarily through digital communication channels. Economic literature has convincingly demonstrated peer production effects in traditional production work (e.g., Mas and Moretti 2009), but the fundamentally different context of knowledge work requires further investigation. We have established that peer production effects extend to knowledge work settings, even though workers cannot observe the work of their peers in a traditional sense. Rather, they obtain explicit feedback and learn important social cues about effective work practices through electronic channels, then use this information to improve their own performance.

Second, our research departs from the dominant focus on network structures and instead considers the resources provided by the network. The performance of one's network contacts is particularly influential on employee performance, which is not to suggest that network structure is not important. Quite the contrary, we find that three of the four structural measures in our model relate significantly to performance. Nevertheless, an exclusive focus on the structural aspects of the network cannot tell the complete story about the influence of social networks on employee performance. The resources provided by the network represent an important benefit of social and developmental networks. Additional studies should explore how the combination of structure and resources together influence the outcomes of networks (Kane and Borgatti 2011).

Third, the effects of the performance of one's contacts are not the same for all employees. High performers benefit more from network resources than do low performers. Other social network research has explored similarly differential effects; for example, Mehra, Kilduff, and Brass (2001) note that people with self-monitoring characteristics can better navigate and benefit from network structures. We add that some employees benefit more from the resources thus provided by the network. Further research should continue to explore differential effects in other networks, such as whether developmental networks are more influential among newer or older members or if networks might be more beneficial for certain tasks.

Managerial Implications

This study also offers implications for managerial practice. Most important, we provide convincing evidence that performance in organizations can be contagious. Therefore, managers should think about workplace relationships differently and find ways to create opportunities for high performers to influence others. Traditional mentoring relationships and intentionally established developmental networks provide one solution, but such formal relationships may not be necessary. Creating opportunities for employees to interact with high performers in shared work or informal events may be sufficient to establish connections and allow information to flow. It also appears sufficient if employees gain exposure to the work practices of high performers, as preserved in and conveyed through digital communication channels. New generations of digital communication channels, such as (micro)blogs, wikis, and electronic social networks (i.e., social media), provide greater transparency regarding users' communication activities. On these platforms, a person can "observe" others' communication activity, even if they do not explicitly receive the message. This transparency then might facilitate the flow of work practices and social feedback, resulting in an even greater speed of adoption than we find in email networks.

Limitations and Further Research Directions

We were not able to observe the offline relationships of our network members, which make it difficult to assess the relationship between electronic communication and face-to-face networks. Although we cannot

rule out explanations that involve face-to-face networks, but our background work on the organization and our discussion with its leaders suggests that the diverse nature and location of projects demand digital communication channels, as the most common and predominant means of communication. We therefore believe the explanations we have forwarded are the most salient and likely ones for network effects of performance through digital communication networks. Furthermore, we do not actually examine the content of the email exchanges, so we only know that information is flowing but can offer no substantive insight on what information is flowing. Additional work should determine how digital communication networks and interpersonal relational networks work together to influence employee performance.

Although we collected extensive data for our three-month study period, other network behaviors might occur outside this window of analysis. A longer data window might reveal additional network dynamics, as well as clarify how the network changes over time. Instead, we can only create a relatively static snapshot of the network at a single point in time. This criticism is common to social network analysis; we hope the expanding adoption of digital tools eventually will allow for richer pictures of networks over time (e.g., Ransbotham et al. 2012).

Conclusion

By testing the influence of network resources, in addition to the structural features of the network, we demonstrate that more than the simple structure is at play when it comes to the performance effects of social and developmental networks. We contribute to growing research that explores a unified view of networks, which are valuable in terms of both their structure and the resources they provide. By showing that knowledge workers can influence the performance of their contacts, we recommend greater awareness among managers about the importance of effective social networking.

References

Abrahamson, E. 1991. "Managerial Fads and Fashions - the Diffusion and Rejection of Innovations," *Academy of Management Review* (16:3), Jul, pp 586-612.

Adler, P.S., and Kwon, S.W. 2002. "Social Capital: Prospects for a New Concept," *Academy of Management Review* (27:1), Jan, pp 17-40.

Ahuja, M.K., Galletta, D.F., and Carley, K.M. 2003. "Individual Centrality and Performance in Virtual R&D Groups: An Empirical Study," *Management Science* (49:1), Jan, pp 21-38.

Ansari, S.M., Fiss, P.C., and Zajac, E.J. 2010. "Made to Fit: How Practices Vary as They Diffuse " *Academy of Management Review* (35:1), Jan, pp 67-92.

Aral, S., Muchnik, L., and Sundararajan, A. 2009. "Distinguishing Influence-Based Contagion from Homophily-Driven Diffusion in Dynamic Networks," *Proceedings of the National Academy of Sciences (PNAS)* (106:51), pp 21544 –22154.

Aral, S., and Van Alstyne, M.W. 2010. "The Diversity-Bandwidth Tradeoff," *SSRN eLibrary*).

Attewell, P. 1992. "Technology Diffusion and Organizational Learning - the Case of Business Computing," *Organization Science* (3:1), Feb, pp 1-19.

Bandiera, O., Barankay, I., and Rasul, I. 2005. "Social Preferences and the Response to Incentives: Evidence from Personnel Data," *Quarterly Journal of Economics* (120:3), Aug, pp 917-962.

Barabâasi, A.L., Gann, D., and Salter, A. 2003. *Linked: How Everything Is Connected to Everything Else and What It Means for Business, Science, and Everyday Life*. New York: Plume.

Borgatti, S., Everett, M.G., and Freeman, L.C. 2002. "Ucinet 6 for Windows: Software for Social Network Analysis." Harvard, MA: Analytic Technologies.

Borgatti, S., and Foster, P.C. 2003. "The Network Paradigm in Organizational Research: A Review and Typology," *Journal of Management* (29:6), p 991.

Borgatti, S.P., and Cross, R. 2003. "A Relational View of Information Seeking and Learning in Social Networks," *Management Science* (49:4), Apr, pp 432-445.

Borgatti, S.P., Mehra, A., Brass, D.J., and Labianca, G. 2009. "Network Analysis in the Social Sciences," *Science* (323:5916), February 13, 2009, pp 892-895.

Boyd, D.M., and Ellison, N.B. 2007. "Social Network Sites: Definition, History, and Scholarship," *Journal of Computer-Mediated Communication* (13:1), pp 210-230.

Burt, R.S. 1992. *Structural Holes: The Social Structure of Competition*. Cambridge, Mass.: Harvard University Press.

Burt, R.S. 1997. "The Contingent Value of Social Capital," *Administrative Science Quarterly* (42:2), Jun, pp 339-365.

Carroll, G.R., and Teo, A.C. 1996. "On the Social Networks of Managers," *Academy of Management Journal* (39:2), Apr, pp 421-440.

Chan, T.Y., Li, J., and Pierce, L. 2010. "Compensation and Peer Effects in Competing Sales Teams," *SSRN eLibrary*).

Coleman, J.S. 1988. "Social Capital in the Creation of Human Capital," *American Journal of Sociology* (94), 1988, pp 95-120.

Cross, R., and Cummings, J.N. 2004. "Tie and Network Correlates of Individual Performance in Knowledge-Intensive Work," *Academy of Management Journal* (47:6), Dec, pp 928-937.

Cyert, R.M., and March, J.G. 1963. *A Behavioral Theory of the Firm.* Englewood Cliffs, NJ: Prentice-Hall.

Daft, R.L., Lengel, R.H., and Trevino, L.K. 1987. "Message Equivocality, Media Selection and Manager Performance: Implications for Information Systems," *MIS Quarterly* (11:3), pp 355-366.

Davis, G.F., and Thompson, T.A. 1994. "A Social-Movement Perspective on Corporate-Control," *Administrative Science Quarterly* (39:1), Mar, pp 141-173.

Drucker, P.F. 1999. "Knowledge-Worker Productivity: The Biggest Challenge," *California Management Review* (41:2), Win, pp 79-+.

Emirbayer, M., and Goodwin, J. 1994. "Network Analysis, Culture, and the Problem of Agency," *American Journal of Sociology* (99:6), pp 1411-1454.

Ensher, E.A., Heun, C., and Blanchard, A. 2003. "Online Mentoring and Computer-Mediated Communication: New Directions in Research," *Journal of Vocational Behavior* (63:2), Oct, pp 264-288.

Falk, A., and Ichino, A. 2006. "Clean Evidence on Peer Effects," *Journal of Labor Economics* (24:1), Jan, pp 38-57.

Fang, C., Lee, J., and Schilling, M.A. 2010. "Balancing Exploration and Exploitation through Structural Design: The Isolation of Subgroups and Organizational Learning," *Organization Science* (21:3), May-Jun, pp 625-642.

Faraj, S., and Johnson, S.L. 2011. "Network Exchange Patterns in Online Communities," *Organization Science* (22:6), pp 1464-1480.

Grant, R.M. 1996. "Toward a Knowledge-Based Theory of the Firm," *Strategic Management Journal* (17), Win, pp 109-122.

Grewal, R., Lilien, G.L., and Mallapragada, G. 2006. "Location, Location, Location: How Network Embeddedness Affects Project Success in Open Source Systems," *Management Science* (52:7), Jul, pp 1043-1056.

Hamilton, B.A., and Scandura, T.A. 2003. "E-Mentoring: Implications for Organizational Learning and Development in a Wired World," *Organizational Dynamics* (31:4), pp 388-402.

Higgins, M.C. 2000. "The More, the Merrier? Multiple Developmental Relationships and Work Satisfaction," *Journal of Management Development* (19:4), pp 277-296.

Higgins, M.C., and Kram, K.E. 2001. "Reconceptualizing Mentoring at Work: A Developmental Network Perspective," *Academy of Management Review* (26:2), Apr, pp 264-288.

Kane, G.C., and Alavi, M. 2007. "Information Technology and Organizational Learning: An Investigation of Exploration and Exploitation Processes," *Organization Science* (18:5), pp 796-812.

Kane, G.C., and Borgatti, S.P. 2011. "Centrality-Is Proficiency Alignment and Workgroup Performance," *MIS Quarterly* (35:4), pp 1063-1078.

Katz, E., Levin, M.L., and Hamilton, H. 1963. "Traditions of Research on the Diffusion of Innovation " *American Sociological Review* (28:2), pp 237-252.

Kram, K.E. 1985. *Mentoring at Work*. Glenview, IL: Scott, Foresman.

Labianca, G., and Brass, D.J. 2006. "Exploring the Social Ledger: Negative Relationships and Negative Asymmetry in Social Networks in Organizations," *Academy of Management Review* (31:3), Jul, pp 596-614.

Lankau, M.J., and Scandura, T.A. 2002. "An Investigation of Personal Learning in Mentoring Relationships: Content, Antecedents, and Consequences," *Academy of Management Journal* (45:4), Aug, pp 779-790.

Levinson, D.J., Darrow, C.N., Klein, E.B., Levinson, M.H., and McKee, B. 1978. *The Seasons of a Man's Life* New York: Knopf.

Lin, N. 1999. "Social Networks and Status Attainment," *Annual Review of Sociology* (25), pp 467-487.

March, J.G. 1991. "Exploration and Exploitation in Organizational Learning," *Organization Science* (2:1), Feb, pp 71-87.

Mas, A., and Moretti, E. 2009. "Peers at Work," *American Economic Review* (99:1), Mar, pp 112-145.

Mehra, A., Kilduff, M., and Brass, D.J. 2001. "The Social Networks of High and Low Self-Monitors: Implications for Workplace Performance," *Administrative Science Quarterly* (46:1), Mar, pp 121-146.

Miranda, S.M., and Saunders, C.S. 2003. "The Social Construction of Meaning: An Alternative Perspective on Information Sharing," *Information Systems Research* (14:1), pp 87-106.

Mizruchi, M.S., Stearns, L.B., and Fleischer, A. 2011. "Getting a Bonus: Social Networks, Performance, and Reward among Commercial Bankers," *Organization Science* (22:1), Jan-Feb, pp 42-59.

Morris, M. 1997. "Sexual Networks and Hiv," *AIDS* (11), pp S209-S216.

Nahapiet, J., and Ghoshal, S. 1998. "Social Capital, Intellectual Capital, and the Organizational Advantage," *Academy of Management Review* (23:2), Apr, pp 242-266.

Neter, J., Wasserman, W., and Kutner., M.H. 1990. *Applied Linear Statistical Models: Regression, Analysis of Variance, and Experimental Designs.* Homewood, IL: Irwin.

Oliver, C. 1992. "The Antecedents of Deinstitutionalization.," *Organization Studies* (13), pp 563-588.

Payne, S.C., and Huffman, A.H. 2005. "A Longitudinal Examination of the Influence of Mentoring on Organizational Commitment and Turnover," *Academy of Management Journal* (48:1), Feb, pp 158-168.

Perry-Smith, J.E., and Shalley, C.E. 2003. "The Social Side of Creativity: A Static and Dynamic Social Network Perspective.," *Academy of Management Review* (48:1), pp 158-168.

Podolny, J.M., and Baron, J.N. 1997. "Resources and Relationships: Social Networks and Mobility in the Workplace," *American Sociological Review* (62:5), Oct 1997, p 673.

Ragins, B.R., and Kram, K.E. 2007. *The Handbook of Mentoring at Work*. New York: Sage.

Ransbotham, S., Kane, G.C., and Lurie, N. 2012. "Network Characteristics and the Value of Collaborative User-Generated Content," *Marketing Science* (31:3), pp 387-405.

Reagans, R., and McEvily, B. 2003. "Network Structure and Knowledge Transfer: The Effects of Cohesion and Range," *Administrative Science Quarterly* (48:2), Jun, pp 240-267.

Rogers, E.M. 1995. *The Diffusion of Innovations*, (4th Edition ed.). New York: Free Press.

Rowley, T., Behrens, D., and Krackhardt, D. 2000. "Redundant Governance Structures: An Analysis of Structural and Relational Embeddedness in the Steel and Semiconductor Industries," *Strategic Management Journal* (21:3), Mar, pp 369-386.

Salancik, G.R., and Pfeffer, J. 1978. "Social Information-Processing Approach to Job Attitudes and Task Design," *Administrative Science Quarterly* (23:2), pp 224-253.

Scandura, T.A., and Schriesheim, C.A. 1994. "Leader-Member Exchange and Supervisor Career Mentoring as Complementary Constructs in Leadership Research," *Academy of Management Journal* (37:6), Dec, pp 1588-1602.

Scott, J. 2000. *Social Network Analysis: A Handbook*, (2nd ed.). London ; Newbury Park: Sage Publications.

Sparrowe, R.T., Liden, R.C., Wayne, S.J., and Kraimer, M.L. 2001. "Social Networks and the Performance of Individuals and Groups," *Academy of Management Journal* (44:2), Apr, pp 316-325.

Tornatzky, L.G., and Klein, K.J. 1982. "Innovation Characteristics and Innovation Adoption-Implementation - a Meta-Analysis of Findings," *IEEE Transactions on Engineering Management* (29:1), pp 28-45.

Walker, G., Kogut, B., and Shan, W.J. 1997. "Social Capital, Structural Holes and the Formation of an Industry Network," *Organization Science* (8:2), Mar-Apr, pp 109-125.

Wasko, M.M., and Faraj, S. 2005. "Why Should I Share? Examining Social Capital and Knowledge Contribution in Electronic Networks of Practice," *MIS Quarterly* (29:1), Mar, pp 35-57.

Williamson, O.E. 1979. "Transaction-Cost Economics - Governance of Contractual Relations," *Journal of Law & Economics* (22:2), pp 233-261.