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# The Internal and External Networks of Knowledge-Intensive Teams: The Role of Task Routineness

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*Using a sample of 56 science research teams, the authors examined (a) the relationships between qualities of team internal and external networks and team performance and (b) the moderating impact of task routineness on these relationships. The authors argued that the mixed empirical results of past studies investigating the relationship between internal networks and performance may be due partly to variations in task routineness and partly to the presence of curvilinear relationships between network qualities and team performance. Using an objective measure of team performance, the results revealed support for both explanations. The authors found an inverted-U relationship between internal trust relationship strength and team performance and a positive linear relationship between external work relationship strength and team performance. Furthermore, task routineness moderated these relationships, as predicted. Future scholarship and practice may be advanced by attending to the boundary conditions under which strong internal and external team networks are likely to be beneficial to the performance of knowledge-intensive teams.*

**Keywords:** *team networks; social networks; team; task routineness*

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In today's highly complex and turbulent environment, effective knowledge-intensive teamwork can contribute to firm competitiveness and survival (Jackson, Hitt, & DeNisi, 2003). In knowledge-intensive teams, the primary goal is to create and develop new and innovative products and services. Through team activities such as knowledge acquisition and knowledge sharing, employees help the firm develop the core resources and capabilities required to achieve a competitive advantage (Jackson, Chuang, Harden, & Jiang, 2006). Examples of knowledge-intensive teams encompass industrial and academic research teams, product development teams, and strategic planning teams, among others. In teams such as these, performance depends on the movement of information and knowledge through social networks that include people within as well as outside the team (Faraj & Yan, 2009; Hansen, Mors, & Løvås, 2005; Hirst & Mann, 2004; Keller, Julian, & Kedia, 1996; Nahapiet & Ghoshal, 1998; Reagans, Zuckerman, & McEvily, 2004; Rey-Rocha, Martin-Sempere, & Garzón, 2002; Wong, 2008).

Prior research has considered two forms of team networks as factors that can enhance team performance: internal networks (networking relationships among people within a team) and external networks (networking relationships between team members and people outside the team).

Drawing on Coleman's (1988) network closure perspective and the bonding view on networks (Adler & Kwon, 2002), dense internal networks in a team, where all team members are densely connected to each other, are expected to have a positive relationship with team performance (Hansen, 1999, 2002; Hansen et al., 2005; Reagans & Zuckerman, 2001; Reagans et al., 2004; Rulke & Galaskiewicz, 2000; Wong, 2008). In a densely internally connected team, the individuals are connected to each other by strong bonds, and the team develops strong norms that support collaboration and the sharing of knowledge information. Such norms motivate and guide the behaviors of the team's members.

Whereas moderately strong internal networks may prove to be beneficial to team performance, excessively strong internal networks may interfere with team performance (Oh, Chung, & Labianca, 2004). The members of a team characterized by strong bonds may spend more time maintaining their relationships with each other (Hansen, Podolny, & Pfeffer, 2001), which detracts from time spent working directly on the team task. Members of teams with dense internal networks are likely to rely on each other as sources of information (Burt, 1992) and consequently have less contact with alternative views and mind-sets that are not represented within the team (Oh et al., 2004). To date, most research on internal networks has assumed that such effects are likely to result in a negative linear relationship between the strength of internal bonds and team performance (for an exception, see Oh et al., 2004). In contrast to most prior work, we argue that these dynamics and their effects may be nonlinear. Thus, one objective of the present research is to test theoretical arguments that lead to the prediction of a curvilinear relationship between the strength of internal networks and team performance.

The nature of a team's external relations has also garnered the attention of scholars interested in understanding social networks. The acquisition of novel and essential resources and knowledge often requires team members to engage in boundary-spanning activities, which link team members to others in the organization. It follows that the presence of network ties that link team members to external resources should be positively associated with team performance (Oh et al., 2004; Reagans et al., 2004; Rulke & Galaskiewicz, 2000; Wong, 2008).

However, the extent to which internal and external networks are related to team performance may depend on differences in task demands. In particular, we examined teams working on tasks that varied in routineness. Because task routineness is associated with information-processing demands (Arrow, McGrath, & Berdahl, 2000; Gladstein, 1984), it is likely to influence interactions within a team. Although scholars often mention team task characteristics as important to consider when studying team dynamics, the literature on team internal networks has generally ignored this contextual factor.

Task routineness may play a critical role in shaping the relationship between external informational networks and team performance. Since performing less routine tasks may require team members to process complex and difficult information, teams may benefit from work relationships that reach across the team boundary. Thus, this study also examines the relationship between external team networks and team performance.

The research uses data collected from academic science research teams whose work requires substantial information processing. The major objective of these teams was to produce new knowledge that advances scholarship in their academic specialties within the broad disciplines of biology and chemistry. Therefore, we used academic publication records to assess team performance. In the following sections, we present our theoretical reasoning and develop specific hypotheses. First, we consider how team internal networks can influence team performance. Then, we consider how team external networks can influence team performance. Finally, we examine task routineness as a potential moderator of the predicted relationships between characteristics of team networks and team performance.

## **Internal Networks and Team Performance**

The bonding view on internal networks highlights the importance of the social relationships among actors within a formal boundary (e.g., team) and acknowledges the potential benefits and costs of dense internal networks (see Adler & Kwon, 2002, for a review). Following the logic of Coleman's (1988) discussion of network closure, we consider the degree to which discrete individuals are linked to others in a network (Kilduff & Tsai, 2003).

When mutually reinforcing social interactions link together members of a work team, the team's internal network approaches a state of closure. Because actors in a social unit characterized by network closure are densely connected to each other, they are less able and less likely to hide resources (e.g., information) from one another. The closure of internal networks allows team members to monitor and guide the behaviors of one another, and in so doing they develop a collective norm of cooperation and feelings of interpersonal trust (Nahapiet & Ghoshal, 1998).

### *Characteristics of Internal Networks in Teams*

Drawing on Coleman's (1988) network closure perspective, we examine two aspects of team internal networks: internal work relationship strength and internal trust relationship strength.

*Internal work relationship strength* is the degree to which team members have strong interpersonal interactions with each other deriving from their shared job activities (e.g., seeking

job-related advice and sharing work knowledge). Dense ties for sharing work-related information and knowledge may promote mutual interdependence between team members and make them aware of their roles and the sources of knowledge and information (e.g., who knows what) (Sparrowe, Liden, Wayne, & Kraimer, 2001).

*Internal trust relationship strength* is the degree to which team members trust each other. *Trust* is defined as “the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trust, irrespective of the ability to monitor or control that other party” (Mayer, Davis, & Schoorman, 1995: 712). Trust allows team members to expect social and economic exchange (conditional trust) and/or to perceive shared values and positive mood and emotions (unconditional trust; Jones & George, 1998). When they trust one another, team members are willing to accept some risk that colleagues will engage in opportunistic behaviors (Williams, 2001). A substantial body of literature suggests that trust and the trustworthy environment created by dense social networks are associated with cooperative behavioral norms (Coleman, 1988; Jones & George, 1998; Mayer et al., 1995; Nahapiet & Ghoshal, 1998; Oh et al., 2004).

These two aspects of team internal networks are similar to the theoretical constructs of structural and relational embeddedness. The structural embeddedness of social networks represents the overall form of the network connections between actors (Nahapiet & Ghoshal, 1998). A key facet of structural embeddedness is the pattern of interactions (Tsai & Ghoshal, 1998), including interactions related to work tasks. The more team members engage in work-related exchanges, the greater is the internal work relationship strength of the team’s internal network. Relational embeddedness highlights the type of interpersonal relationships cultivated through a history of social interactions (Granovetter, 1992). Trust is the key aspect of relational embeddedness (Nahapiet & Ghoshal, 1998; Tsai & Ghoshal, 1998; Zheng, 2010).

Internal work relationship strength and internal trust relationship strength are likely to co-evolve within teams and be positively correlated (Jones & George, 1998; Tsai & Ghoshal, 1998; Williams, 2001). Knowing each other’s roles and frequently engaging in work-related interactions may create feelings of psychological intimacy. Due to their close relationships, team members may expect to receive and feel obliged to repay others’ favors. Consistent with Leana and van Buren’s (1999) and Coleman’s (1988) discussions of public goods, a dense web of strong ties among team members may result in being more willing to take actions for the sake of the team. Dense work networks also allow team members to readily observe and monitor each other’s social behaviors and attitudes, contributing further to feelings of mutual trust. The trustworthiness of the social environment may allow actors to anticipate repayment of favors they extend to others, and in return, they are more likely to feel obliged to repay others’ favors (Coleman, 1988). Since it is difficult for actors to escape from their obligations, trust between actors may be quite durable.

### *How Team Internal Networks Can Influence Team Performance*

Internal work relationship strength and internal trust relationship strength may both facilitate team performance under certain circumstances. However, the potential benefits of these two aspects of a team’s internal network are not the same, as we explain next.

*Internal work relationship strength.* Internal work relationship strength is particularly critical for knowledge-intensive teams, in which the acquisition, sharing, and use of knowledge is central (Jackson et al., 2006). Dense and strong connections built on job-related issues help team members exchange tacit and confidential knowledge more easily than might otherwise occur (Hansen et al., 2001).

Scholars have typically argued that the relationship between work-related network strength and team performance is likely to be linear and positive (Baldwin, Bedell, & Johnson, 1997; Oh et al., 2004; Reagans & Zuckerman, 2001; Reagans et al., 2004; Rulke & Galaskiewicz, 2000; Sparrowe et al., 2001; Tsai & Ghoshal, 1998). If team members frequently communicate with each other about task-related issues and get work advice from each other, they may be more likely to achieve work goals and thereby improve team performance. A recent meta-analytic review (Balkundi & Harrison, 2006) also found a positive (but not strong) overall relationship between work network density within teams and team performance. Despite the appealing logic for expecting denser internal team networks to be associated with better team performance, previous research suggests that the density of work-related networks in teams does not always improve team performance. Baldwin et al. (1997) found that the density of within-team advice networks of MBA student teams was positively associated with team members' perceived team performance but not with a more objective performance measure (team grades). Sparrowe et al. (2001) and Hansen et al. (2001) also reported nonsignificant relationships between advice and knowledge network density and team performance. However, other scholars have reported that teams with flat and dense networks of work ties outperformed teams with hierarchical and sparse work networks (Cummings & Cross, 2003; Reagans & Zuckerman, 2001; Reagans et al., 2004; Rulke & Galaskiewicz, 2000).

The network closure perspective may provide an explanation for these contradictory research findings. Moderately strong job-related relationships among team members may improve team performance, but when internal bonds are too strong, the team may develop a cognitive barricade that shuts out useful information from the external world. Team members who are embedded in a network of job-related strong ties develop a strong shared view, and they may be unwilling to accept new and diverse perspectives (Burt, 1992; Ibarra, 1992; Oh et al., 2004). In addition, dense internal work networks may increase the likelihood that individuals acquire similar knowledge and information, which inhibits knowledge creation in the longer term (Burt, 1992; McFadyen & Cannella, 2004). If team members develop a strong team identity, they may be less open to interacting with external (nonteam) colleagues in their organization or profession. Thus, whereas a moderate level of internal work relationship strength may improve team performance, very strong internal work relationship strength may be associated with poorer performance. Dynamics such as these also provide an explanation for the phenomenon of "group think" (Janis, 1972).

Prior research has seldom considered the possibility of a curvilinear relationship between internal work relationship strength and team performance. However, studies of other characteristics of internal team networks are suggestive: For example, Oh et al. (2004) found a significant curvilinear relationship between the density of internal friendship ties and group effectiveness (team performance ratings). In a study of cross-functional teams, Patrashkova-Volzdoska, McComb, Green, and Compton (2003) found a curvilinear relationship between

internal communication (face-to-face and e-mail) frequencies and team goal achievement. In a sample of new product development teams, Leenders, Van Engelen, and Jan Kratzer (2003) found a curvilinear (inverted-U) relationship between internal communication frequency and team members' perceptions of creativity. Thus, we proposed the following hypothesis:

*Hypothesis 1a:* Degree of internal work relationship strength in team internal networks will have a curvilinear inverted-U relationship with team performance.

*Internal trust relationship strength.* To our knowledge, there is no empirical research on the relationship between team internal trust relationship strength and team performance. However, several studies have examined the relationships between perceived interpersonal trust and various team outcomes, and the results of those studies have indicated the potential value of internal trust relationship strength. For example, a study of Chinese professionals working in teams at a wide range of companies revealed a positive relationship between perceived cognition-based trust and team performance ratings of team leaders (Hampel, Zhang, & Tjosvold, 2009). In a study of 33 virtual teams, members' reported trust levels were positively correlated with their own perceptions of team performance but not with external managers' perceptions of team performance (Peters & Karren, 2009). On the other hand, team trust was not significantly associated with customer satisfaction in a study of geographically dispersed customer service teams (Kirkman, Rosen, Tesluk, & Gibson, 2006), and it was not associated with creativity in a study of R&D teams (Chen, Chang, & Hung, 2008). In a study of self-managing MBA student teams, Langfred (2004) found no significant relationship between team trust and team performance (the average score on the presentation of teams' case analyses by six faculty).

The mixed findings of past studies might arise due to the presence of a curvilinear relationship between perceived levels of trust and team performance, with performance being harmed when trust among teammates is either too weak or too strong. Since asking someone for knowledge and information often requires some level of trust (Abrams, Cross, Lesser, & Levin, 2003; Cross, Parker, Prusak, & Borgatti, 2001), in knowledge-intensive teams where tacit knowledge needs to be shared and transferred to improve team performance internal trust relationship strength is likely to play a pivotal role. When trust is too low, team members are not likely to freely seek out or share knowledge. Information seeking may be construed as an indication of weakness and reveals one's own vulnerability, while sharing information involves taking a risk that others will use the information for their own personal gain at one's expense. On the other hand, very high internal trust relationship strength may signal an overly strong team identity that inhibits members from sharing beliefs and perceptions that are counter to the team's accepted understanding. Moreover, in a team with a too strong internal trust network relationship, team members hesitate to monitor each other's work because doing so may be interpreted as a sign of distrust (Langfred, 2004). Therefore, we propose the following:

*Hypothesis 1b:* Degree of internal trust relationship strength in team internal networks will have a curvilinear inverted-U relationship with team performance.

## Team External Networks and Team Performance

Seldom are intact work teams isolated from their larger organizational context. Rather than having clear and impermeable boundaries, work teams are somewhat fuzzy social structures in which people interact, collaborate, and collect information and knowledge among themselves while also maintaining relationships with those situated in the broader social context (Oh et al., 2004).

External network ties can serve both instrumental/informational and expressive/social purposes (Balkundi & Harrison, 2006; Cascioaro & Lobo, 2008). In this study, we focused on the instrumental role of external team networks because we assumed instrumental external ties were most relevant to team performance. More specifically, we examined the strength of team external informational networks.

Members of work teams often perform a variety of activities and tasks in collaboration with nonteam (external) members (Faraj & Yan, 2009). To be effective, work teams need to learn about and understand other parts of the organization (Ancona & Caldwell, 1992). External networks and vigorous boundary-spanning activities appear to play a crucial role in knowledge and information transfer and acquisition and may promote team performance (see Joshi, Pandey, & Han, 2009, and Marrone, 2010, for reviews).

Prior research on team networks has found that strong external informational networks facilitate knowledge sharing and transfer (Hansen et al., 2005), reduce interunit conflicts (Nelson, 1989), and ease task coordination (Gargiulo & Benassi, 2000). Strong external ties are especially beneficial for the transfer of tacit and complex knowledge that is not easily codified (Hansen, 1999). Thus, strong external ties should aid team performance by increasing the team's access to useful but sticky information. Strong relationships with people outside the team can minimize the amount of time team members need to spend locating and interpreting information. Knowing whom to ask can reduce the time required for information search. And when the person providing the information is well known, information transfer is more efficient. Consistent with this logic, Hansen et al. (2001) and Reagans et al. (2004) found that strong external informational networks were significantly and positively associated with faster project completion. Therefore, we proposed the following:

*Hypothesis 2:* External informational network strength will be positively associated with team performance.

We note, however, that a study of student teams by Baldwin et al. (1997) found no significant relationship between external informational strength and team grades. Task characteristics may help explain such inconsistent findings. Next, we consider the role of task routineness as a potential moderator of the relationships we have just proposed.

## Task Routineness as a Moderator of Relationships Between Team Network Characteristics and Team Performance

Task routineness is widely recognized as a contextual condition that shapes information-processing activities, boundary-spanning activities, and intrateam interactions (e.g., Campion,

Papper, & Medsker, 1996; Gladstein, 1984). It is also recognized as a contextual condition that may influence the relationship between team internal networks and performance (Ahuja & Carley, 1999; Argote, Turner, & Fichman, 1989; Brown & Miller, 2000; Burt, 2000; Cummings & Cross, 2003; Katz, Lazer, Arrow, & Contractor, 2004). Put simply, task routineness is a contextual factor that may diminish or magnify the performance consequences of internal team networks.

Internal team dynamics are central to the performance of teams working on nonroutine tasks. Teams performing new and unpredictable tasks need to exchange tacit knowledge that is not easily articulated and has not been acquired through one's own experience (Hansen et al., 2001). Because nonroutine (vs. routine) tasks are likely to benefit from the use of wide-ranging information and knowledge, we expected to observe a curvilinear relationship between internal work relationship strength and team performance when studying science research teams, for their work is *relatively* nonroutine in comparison to some other types of team tasks. That is, the work of R&D teams is relatively complex, difficult, and unpredictable (Tushman, 1977). Teams working mostly on nonroutine tasks may be more likely to recognize the value of sharing their unique knowledge and expertise with colleagues and to develop strong internal networks in order to build appropriate knowledge stocks and maintain appropriate knowledge flows.

Nevertheless, the daily work activities of some R&D teams can sometimes be fairly routine. Tasks that are high on the dimension of routineness are characterized by greater repetitiveness, simplicity, and certainty (Jehn, 1995). Because routine tasks generally involve activities that are predetermined and predictable, they generally are less knowledge- and information-intensive (Brown & Miller, 2000) and they require less coordination (Van de Ven, Delbecq, & Koenig, 1976). For teams engaged in such work, acquiring and sharing a wide variety of information may be less critical to team performance, and thus characteristics of the team's social network may be less consequential. For example, R&D teams whose work involves following formal research protocols may view the tasks of collecting and analyzing data as routine, despite the high level of technical expertise required.

For routine tasks, we expected the characteristics of internal team networks to be unrelated, or only weakly related, to team performance. When the team task requires following formal and clearly communicated procedures and protocols, team members may be less motivated to develop a strong interpersonal network simply because they do not see the value of sustaining close work relationships. For scientists working on relatively routine tasks, the speed and accuracy of each person's work contributes to the team's performance, but qualities of the team's internal network may be unrelated to these aspects of performance. Based on these arguments, we proposed the following:

*Hypothesis 3a:* Task routineness moderates the curvilinear inverted-U relationship between team internal work relationship strength and performance such that the relationship is stronger for teams whose work is relatively low on task routineness and weaker for teams whose work is relatively high on task routineness.

Similarly, we expected task routineness to moderate the predicted curvilinear relationship between team internal trust relationship strength and team performance. Just as internal work

relationship strength is likely to have greater consequences for performance when the work required is less routine work, so too is internal trust relationship strength likely to have greater consequences when the work is less routine. For nonroutine tasks, moderate levels of mutual trust facilitate the transfer of knowledge, which contributes to the performance of knowledge-intensive teams. However, when the work required is more routine, knowledge flows are less critical to team performance. Therefore, we proposed the following:

*Hypothesis 3b:* Task routineness moderates the curvilinear inverted-U relationship between team internal trust relationship strength and performance such that the relationship is stronger for teams whose work is relatively low on task routineness and weaker for teams whose work is relatively high on task routineness.

The role played by external informational networks also may vary depending on the degree of task routineness. External informational networks are more likely to be beneficial to team performance when the task requires extensive or rapid information acquisition (e.g., see Katz et al., 2004; Reagans & McEvily, 2003). Nonroutine tasks and external informational network strength may have synergistic consequences for team performance: Complex information and knowledge acquired through strong external informational networks may be more valuable for the performance of teams performing nonroutine tasks.

Prior research has not directly examined the moderating role of task routineness on the relationship between external informational network strength and team performance. However, some research findings on external networks and boundary-spanning activities are relevant to this issue. In a study of product development teams, Hansen et al. (2001) found that teams with strong external ties completed projects that involved more exploration (where tacit knowledge is involved) faster than projects that involved more exploitation (where explicit knowledge is involved). In addition, Hansen (1999) found that strong interunit communication ties speeded up project completion when knowledge was complex and noncodifiable and slowed down project completion when knowledge was codifiable. Therefore, consistent with the work of Hansen, we proposed the following:

*Hypothesis 4:* Task routineness will moderate the positive relationship between external informational network strength and team performance such that the relationship will be stronger for teams whose work is relatively low on task routineness and weaker for teams whose work is relatively high on task routineness.

## Method

### *Procedure and Sample*

We collected data from biology and chemistry research teams in a university located in the eastern United States. Interviews with science professors, postdoctoral assistants, and doctoral students confirmed that many characteristics of research teams working in university science laboratories are similar to those of corporate research teams. Team members often interact with one another to learn and develop new research methods, conduct experiments,

and share resources. In addition to the work they do in their own laboratories, the members of science research teams engage in external networking to obtain information and knowledge from colleagues working in other labs on campus. In the typical science research laboratory, a professor or laboratory head is the team manager. This person is responsible for acquiring the financial and other resources needed to operate the laboratory and complete the work; she or he hires employees (e.g., research professors, research associates, technicians, postdoctoral assistants, doctoral students, and master's students), determines their compensation, and is evaluated on and rewarded for the performance of the entire science team.

We invited 216 laboratory teams to participate in the study, of which 70 laboratory teams (350 team members) agreed to participate. Following Sparrowe et al.'s (2001) suggestion, teams with less than 80% response rates were excluded in order to ensure accurate assessments of network characteristics at the team level, resulting in a sample of 58 teams (264 team members). Participating teams had large proportions of international members (especially from China, India, and South Korea). The proportion of White U.S. citizens was 26.52%.

### Measures

*Internal work relationship strength and internal trust relationship strength.* We used a sociometric survey to assess the two aspects of internal networks of interest: internal work relationship strength and internal trust relationship strength. To begin, we obtained a roster of team member names from the head of each research laboratory. We presented this roster of names to the team members to define the boundary of the team. To ensure the anonymity of study participants, we asked respondents to use the roster to fill in the first- and last-name initials of team members and use these initials as referents when completing the sociometric survey. For each member of their teams, respondents provided ratings of his or her job-based relationships and their feelings of trust using a 4-point Likert-type response scale ranging from 3 (*to a great extent*) to 0 (*not at all*). Following Burt (1992) and Sparrowe et al. (2001), job-based relationships ratings indicated, "How close is your work-related relationship (e.g., collaborate tasks, exchange job-related information) with each person?" and trust ratings indicated, "How much do you trust each person?"

Using these ratings of their relationships, we calculated network relationship strength for each team using the following formula of network density (Reagans & Zuckerman, 2001; Reagans et al., 2004):

$$Density_k = \frac{\sum_{i=1}^{N_k} \sum_{j=1}^{N_k} z_{ijk} / \text{MAX}(z_{ijk})}{N_k(N_k - 1)}, j \neq i,$$

where  $z_{ijk}$  is the relationship strength that team member  $i$  reports for team member  $j$ ,  $\text{max}(z_{ijk})$  is the possible largest tie score, and  $N_k$  is the number of team members in team  $k$ . The highest possible density score is 1, and the lowest possible density score is 0. The density of job-related relationships, defined as the mean of job-related relationships between any two

members of team  $k$  (Reagans & Zuckerman, 2001), was used as the measure of *internal work relationship strength*. Similarly, the density of trusting relationships, defined as the mean of trusting relationships between any two members of team  $k$ , was used as the measure of *internal trust relationship strength*.<sup>1</sup>

A few team network studies (Hansen et al., 2001; Hansen et al., 2005; Wong, 2008) have measured team-level network density as the number of existing relationships divided by the number of possible relations,  $N \times (N - 1)$ , where existing relationships were defined as a dichotomized value of the relationship between any two team members (e.g., 0 = *no relationship* and 1 = *existence of relationship*). This approach yields a less sensitive metric than the one we employed. In small teams such as those we studied, almost all team members can be expected to report the existence of a relationship with every other teammate. For this reason, most team-level network studies assess strength of relationships among team members, differentiating between at least three degrees of tie strength (Baldwin et al., 1997; Leenders et al., 2003; Oh et al., 2004; Rulke & Galaskiewicz, 2000; Shah, Dirks, & Chervany, 2006; Sparrowe et al., 2001). The measure of network density used in this study is similar but slightly different from this approach in that the mean strength of relations between team members was adjusted by dividing average tie strength by the strength of the network of the most extreme member,  $\max(z_{ijk})$ . This method reduces distortions that might otherwise be caused by individual differences in the tendency to report high relationship strength (Reagans & Zuckerman, 2001; Reagans et al., 2004); it also reduces distortions to the team score that are created when one or a few members are strongly connected and the others are not connected.

*External informational network strength.* We used egocentric network data to measure external networks. First, respondents listed the first- and last-name initials of up to eight people in the organization who they viewed as valuable contacts for obtaining work-related information. We did not ask team members to indicate people in their network who were not members of the organization because lab leaders and members reported during pilot interviews that most team members focused on job-related networks within the organization (the networks of lab leaders frequently extended beyond the organization's boundary, however). For each external contact listed, respondents provided ratings to answer the question, "How close is your work-related relationship (e.g., collaborating on tasks, exchanging job-related information) with each person?" using a 4-point Likert-type response scale ranging from 1 (*to a great extent*) to 4 (*not at all*). Limiting the list of possible contacts to eight people may not have allowed all members to describe their entire external network, but constraining the number of contacts listed has the benefit of making data collection more feasible (see Morrison, 2002). Only 6% of respondents listed the maximum allowed number of contacts, suggesting that placing a limit of eight contacts did not substantially restrict variation among respondents.

Following Hansen et al. (2001) and Brass (1995), *external informational network strength* was operationalized by first calculating each team member's average tie strength (sum of all network external tie ratings divided by the number of external informational relationships reported), then aggregating to the team level, and finally dividing by the number of team members. Thus, external informational network strength reflects the average strength of external relationships for members of a team.

*Task routineness.* We measured task routineness using items that reflected the past work of several other scholars (Jehn, 1995; Jehn, Northcraft, & Neale, 1999; Perrow, 1970; Van der Vegt & Janssen, 2003; Van de Ven et al., 1976). After consulting all of these sources, we selected 4 of Jehn's (1995) original 20 items to assess task routineness (Cronbach's  $\alpha = .79$ ). The measure includes "My job is very routine," "I encounter a lot of variety in my normal working day," "The methods I follow in my work are about the same for dealing with all types of work, regardless of the activity," and "I feel like I am doing the same thing over and over again." Ratings were made on a 7-point Likert-type response scale ranging from 1 (*completely disagree*) to 7 (*completely agree*). We asked respondents to describe their own work rather than the work of the team as a whole in order to maximize the likely accuracy of these self-reports. We assumed that reports might differ somewhat among members of the same team due to role differentiation within the team, yet significant differences between teams also were expected because the overall degree of task routineness reflected the nature of the team's current projects and differences in the way lab leaders managed the team's work.

To test our assumption that team members shared similar perceptions of their task environment, we conducted several statistical checks prior to aggregating individual ratings to create a team-level score. We found significant between-group variance using one-way ANOVA ( $F = 1.768, p < .01$ ) and high interrater agreement among team members ( $r_{wg} = .87$ ) using the computational procedure of James, Demaree, and Wolf (1984). While some indicators were lower than ideal, intraclass correlation coefficient (ICC) (1) = 0.18 and ICC (2) = 0.44, taken together, these results suggest that ICC (1) and ICC (2) values may be artificially low due to low within-team variance in ratings of task routineness, not because of low within-group agreement (George & James, 1993).

*Team performance.* To assess team performance, we calculated each team's publication impact factor score using participants' lists of publications for the current year, which they provided. Following McFadyen and Cannella (2004) and Stephan and Levin (1991), we obtained the Institute of Scientific Information's (ISI) impact factors for all publications on which any team member was listed as a coauthor. We did not exclude publications that included coauthors who were not members of the team, because collaboration across team boundaries was expected. Likewise, we did not require all of a team's members to be listed as coauthors of a publication; some (especially junior) team members may have participated in the work that resulted in publication but had not made sufficient intellectual contributions to justify coauthorship.

The ISI impact factor adjusts for the frequency of publications issues, the volume of journals, and the history of journals. The impact factor is generally most sensitive to variations in productivity within a field of study. However, the impact factor may also reflect the size, nature, and growth rate of a field. For example, publications in some older, well-established fields (e.g., chemistry) may have higher citations than do publications in other newer fields (e.g., environmental science). To adjust for such differences between specialties, we standardized the impact factor within the academic fields that were relevant to participants in this study. We defined academic fields of specialty using the categories identified by the ISI.

Thus, a team's performance was defined as the average weighted impact score of the publications in which team members appeared as authors. (Note that a publication was

counted only once for a team, regardless of how many team members were listed as coauthors.) The final team performance score reflected publication quantity and quality. For example, a team member with two publications in Journal A with a standardized impact factor of 4 and one in Journal B with a standardized impact factor of 1 would be assigned a weighted standardized impact factor score of  $[(2 \times 4) + (1 \times 1)] = 9$ . A team performance score was calculated by summing the team members' weighted standardized impact factor scores and dividing by the number of team members.

Our measure of team performance is context specific (Mathieu, Maynard, Rapp, & Gilson, 2008) and reflects the performance expectations for science research teams. It assumes that publications represent the cumulative effort of team members and that differences in publication scores between teams represent meaningful differences in team performance. In support of these assumptions, laboratory heads reported that publishing research results was a primary performance objective and that teams achieved this objective by working on tasks interdependently. In a survey of the laboratory heads, 82% indicated that at least 50% of their teams' work was performed interdependently. No laboratory leaders reported that team members performed their tasks solely as individuals.

*Controls.* Team size and three indicators of team human capital were included as control variables. For *team size*, we used the natural logarithm of the number of team members in a team, due to the skewed distribution of team sizes. Larger teams might perform better on difficult tasks in an uncertain and complex environment (Hülshager, Anderson, & Salgado, 2009; Stewart, 2006). Three indicators of *team human capital* were included to control for cognitive ability and other possible influences on performance: proportion of team members with a doctoral degree, average tenure of team members, and average performance of individual team members for the past three years. Teams with more talented members are likely to achieve better outcomes (see Stewart, 2006, for a meta-analytic review), and previous research has found that the average tenure of team members influences group interactions and team performance (e.g., Hülshager et al., 2009; Katz, 1982; Pelled, Eisenhardt, & Xin, 1999). For our tests of Hypotheses 2 and 4, the size of a team's external informational network (calculated as the mean number of external people listed by members of a team) also was included as a control variable as well. Larger external networks may allow teams to obtain more information, regardless of the strength of external networks (e.g., Hansen et al., 2001). Finally, in separate analyses not included here, we ran the analyses controlling for gender diversity, ethnic diversity, and diversity of educational specialty, which also have been found to be associated with performance in some teams (Jackson, Joshi, & Erhardt, 2003; Joshi & Roh, 2009). We found no significant relationships between these diversity variables and team performance, so to conserve statistical power we did not control for team diversity.

## Results

### *Descriptive Statistics*

Table 1 reports means, standard deviations, and bivariate correlations for all the variables in the model, treating teams as the unit of analysis. As expected, the two indicators of internal

**Table 1**  
**Descriptive Statistics and Intercorrelations**

	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9
1. Team performance	0.22	1.40									
2. Team size (log)	1.61	0.22	.01								
3. Team average tenure	3.18	2.32	.72**	-.06							
4. PhD proportion	34.76	30.47	.10	-.26	.04						
5. Past performance	1.02	4.80	.19	-.41**	.40**	.58**					
6. Task routineness	3.41	0.79	-.27*	.14	-.20	-.41**	-.29*				
7. Internal work relationship strength	0.71	0.28	.14	-.09	.19	.17	.17	-.25			
8. Internal trust relationship strength	0.40	0.18	-.17	.11	-.31*	.12	.01	-.02	.56**		
9. External informational network size	3.24	1.71	.17	-.16	.22	.07	.24	-.03	-.28*	-.03	
10. External informational network strength	0.45	0.11	.46**	-.05	.31*	.17	.25	-.15	.38**	-.03	-.17

Note:  $N = 56$ .

\* $p < .05$ . \*\* $p < .01$ , two-tailed tests.

network characteristics—internal work relationship strength and internal trust relationship strength—were significantly correlated ( $r = .56$ ). We also note that internal work relationship strength and external informational strength were positively correlated, suggesting that teams were able to maintain strong ties within the team while also maintaining strong ties outside the team. External informational network strength was positively and significantly correlated with team performance ( $r = .46$ ), while internal work relationship strength and internal trust relationship strength were not. In addition, the average tenure of team members was significantly correlated with team performance ( $r = .72$ ), indicating that teams with members who had worked together longer were more productive, and supporting the use of team average tenure as a control variable.

### Tests of Hypotheses

Table 2 reports results of the moderated hierarchical regression analyses conducted to test our hypotheses. Two teams judged to be outliers because they fell above the cutoff value,  $4/(n - k - 1)$ , of Cook's distance were removed from the sample. Independent variables were centered to minimize problems created by multicollinearity (Aiken & West, 1991). We introduced into a regression equation the control variables first (Table 2, Model 1), followed by the internal and external network characteristics. Controlling for team size and team human capital, neither internal work relationship strength nor internal trust relationship strength was linearly associated with team performance (Table 2, Model 2).

To test Hypotheses 1a and 1b, which predicted that work and internal trust relationship strength would have a curvilinear relationship with team performance, we entered then the quadratic terms of internal work and trust relationship strength next (Table 2, Model 3).

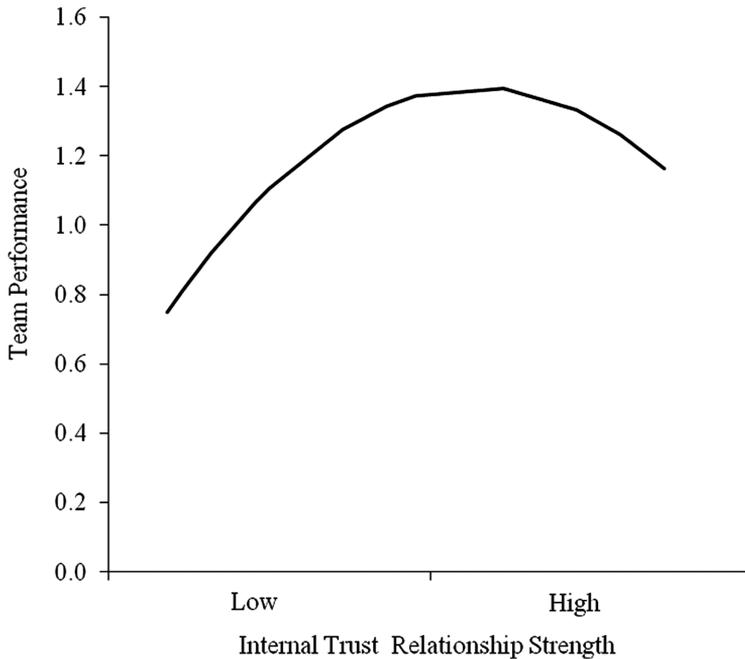
**Table 2**  
**The Moderating Role of Task Routineness on the Relationship Between Internal and External Networks and Team Performance**

Predictor	Results for Internal Work Relationship Strength			Results for Internal Trust Relationship Strength			Results for External Networks		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7		
Team size	-0.005	-0.07	-0.12	-0.14	-0.06	-0.04	-0.23***		
Team average tenure	0.81***	0.85***	0.65***	0.65***	0.63***	0.36**	0.46***		
PhD proportion	0.17	0.16	0.10	0.03	0.05	0.09	0.01		
Past performance	-0.24†	-0.32*	-0.20	-0.20	0.01	-0.08	-0.37*		
External informational network size		0.02	0.03	0.00	0.02	0.10	0.35**		
External informational network strength		0.31**	0.21*	0.23*	0.15†	0.21**	0.34***		
Internal work relationship strength		-0.25	0.06	0.03	0.00	-0.13	0.00		
Internal trust relationship strength		0.23	0.12	0.16	0.17	0.14	0.09		
Internal work relationship strength <sup>2</sup>			0.05	-0.04	0.26	0.77***	-0.03		
Internal trust relationship strength <sup>2</sup>			-0.44**	-0.41**	-0.08	-0.49***	-0.49***		
Task routineness (TR)				-0.19*	-0.66***	-0.67***	-0.31**		
TR × Internal Work Relationship Strength					-0.45*				
TR × Internal Trust Relationship Strength						0.10			
TR × Internal Work Relationship Strength <sup>2</sup>					1.08***				
TR × Internal Trust Relationship Strength <sup>2</sup>						1.00***			
TR × External Informational Network Strength							-0.48***		
$\Delta R^2$		.08	.09	.03	.11	.11	.07		
$\Delta F$		2.52†	7.54**	4.25*	15.05***	14.44***	17.40***		
$R^2$	.55	.53	.72	.74	.85	.83	.82		
Adjusted $R^2$	.51	.56	.66	.68	.81	.78	.77		
$F$	15.29***	9.82***	11.55***	11.64***	18.46***	18.99***	16.10***		

Note:  $N = 56$ .

† $p < .10$ . \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ , two-tailed tests.

**Figure 1**  
**The Relationship Between Internal Trust Relationship Strength**  
**and Team Performance**

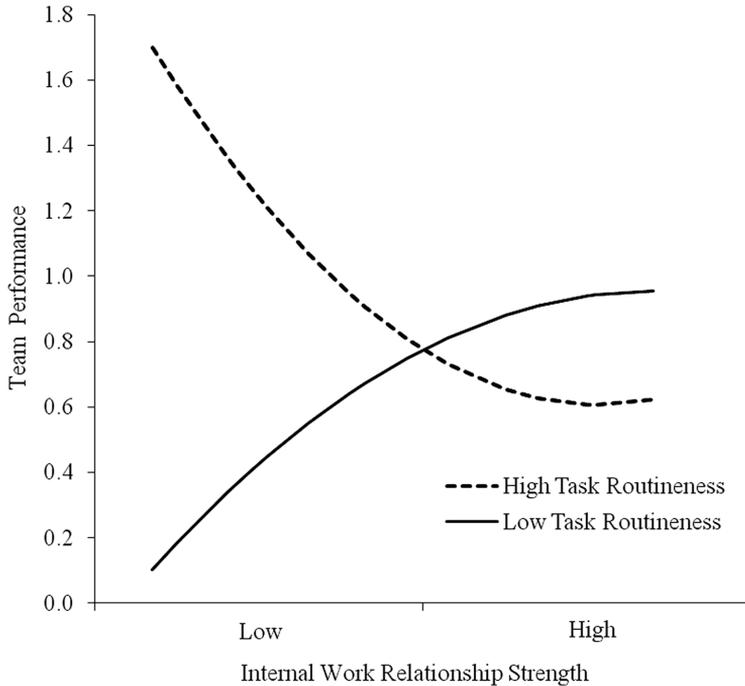


Results revealed no significant curvilinear relationship between internal work relationship strength and team performance, contrary to Hypothesis 1a. As predicted, we found a significant inverted-U relationship between internal trust relationship strength and team performance ( $\beta = -0.44, t = -3.37, p < .01$ ). This curvilinear relationship remained significant even after taking task routineness into account (Table 2, Model 4). As we expected, team performance was greater for teams with moderate levels of internal trust relationship strength compared with teams with either very low or very high levels of internal trust relationship strength (Figure 1). Thus, Hypothesis 1b was supported.

Hypothesis 2 predicted a positive relationship between external informational network strength and team performance. As shown in Table 2 (Model 3), the overall relationship between external informational network strength and team performance was positive and significant ( $\beta = 0.21, t = 2.01, p < .05$ ). The relationship remained significant and positive after controlling for task routineness (Model 4). Thus, Hypothesis 2 was supported.

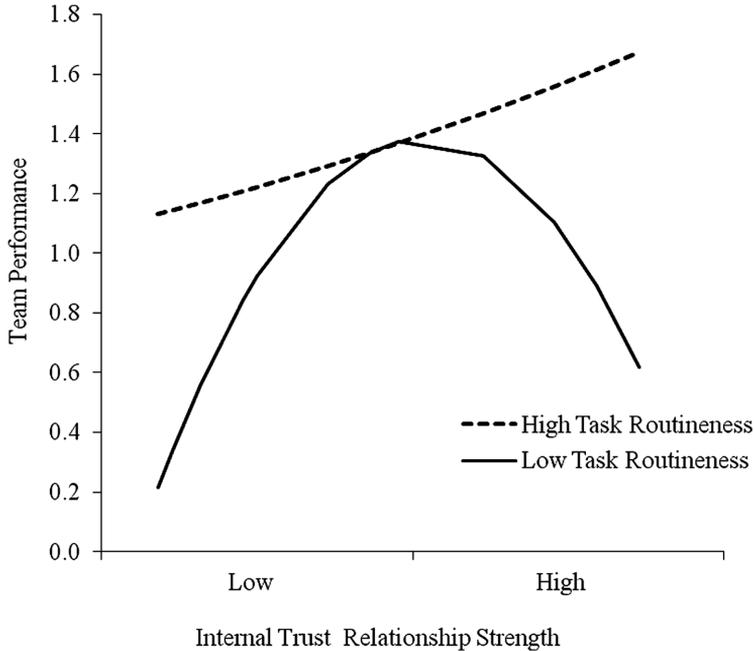
Hypotheses 3a and 3b predicted a moderating effect of task routineness on the curvilinear relationships between internal network density and team performance. Following Aiken and West (1991), we tested the moderating effect of task routineness predicted by Hypothesis 3a by regressing team performance on Internal Work Relationship Strength<sup>2</sup>  $\times$  Task Routineness,

**Figure 2**  
**Task Routineness as a Moderator of the Relationship Between**  
**Internal Work Relationship Strength and Team Performance**



controlling for all other variables (Table 2, Model 5). Consistent with Hypothesis 3a, we found a significant moderating effect of task routineness on the curvilinear relationship between internal work relationship strength and performance ( $\beta = 1.08, t = -4.79, p < .01$ ). To examine the form of this relationship, we plotted regression curves for the relationship between internal work relationship strength squared and team performance on high and low task routineness (shown in Figure 2). While the numeric results in Table 2 are consistent with our prediction, the graphic depiction of this interaction revealed that the moderating effect of task routineness was more pronounced than expected. When we estimated the curvilinear relationships depicted in Figure 2 at 1 standard deviation below the mean of task routineness (low routineness) the relationship between internal work relationship strength and team performance had a predominantly concave upward curve ( $\beta = -0.51, t = -3.05, p < .01$ ), as predicted. For teams working on routine tasks, the relationship had a predominantly concave downward curve ( $\beta = 0.91, t = 2.26, p < .05$ ), whereas we had expected this curve to be relatively flat. Finally, following Aiken and West (1991), we estimated simple slopes. First, we computed variables at the two levels of task routineness (1 standard deviation below the mean and 1 standard deviation above the mean) and the two levels of internal work relationship

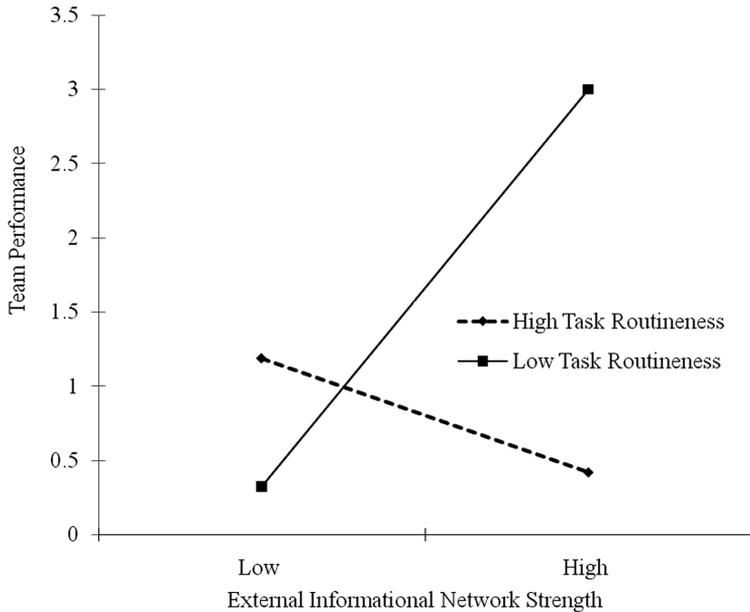
**Figure 3**  
**Task Routineness as a Moderator of the Relationship Between**  
**Internal Trust Relationship Strength and Team Performance**



strength (1 standard deviation below the mean and 1 standard deviation above the mean). Next, we computed the cross-products of these variables and conducted the regression of team performance on internal work relationship strength and internal work relationship strength squared at each level of internal work relationship strength and task routineness. Results indicated that in teams with high task routineness, the simple slope of high internal work relationship strength was nonsignificant and the simple slope of low internal work relationship strength was significant and negative ( $\beta = -1.15, t = -3.81, p < .001$ ). When task routineness was low, the simple slope of high internal work relationship strength was nonsignificant and the simple slope of low internal work relationship strength was significant and positive ( $\beta = 0.68, t = 2.04, p < .05$ ). Overall, these results support Hypothesis 3a, which stated that task routineness moderates the curvilinear relationship between internal work relationship strength and team performance.

We followed procedures to test Hypothesis 3b. As predicted, we found that task routineness significantly moderated the curvilinear relationship between internal trust relationship strength and team performance (Table 2, Model 6;  $\beta = 1.00, t = -5.84, p < .001$ ). As shown in Figure 3, for nonroutine tasks, there is a curvilinear inverted-U relationship between internal trust relationship strength and team performance ( $\beta = -1.02, t = -7.11, p < .001$ ). For

**Figure 4**  
**Task Routineness as a Moderator of the Relationship Between External Informational Network Strength and Team Performance**



teams working on routine tasks, internal trust relationship strength was not associated with team performance ( $p > .5$ ). Results of simple slope tests also confirmed the prediction. When task routineness was high, the simple slopes of the regression curve were not significantly different from zero at low or high levels of internal trust relationship strength. When task routineness was low, the simple slope of the regression curve was positive and significant ( $\beta = 1.02$ ,  $t = 7.11$ ,  $p < .001$ ) at low internal trust relationship strength and negative and significant ( $\beta = -1.47$ ,  $t = -4.67$ ,  $p < .001$ ) at high internal trust relationship strength. These results provide support for Hypothesis 3b.

Hypothesis 4 predicted a moderating effect of task routineness on an expected positive linear relationship between external informational network strength and team performance. As predicted, our results revealed a significant moderating effect of task routineness (Table 2, Model 7;  $\beta = -0.48$ ,  $t = -4.17$ ,  $p < .001$ ), providing support for Hypothesis 4. Figure 4 depicts this interaction. Simple slope test results confirmed that the form of the observed interaction was as we predicted. For nonroutine tasks, stronger job-related external network ties were associated with better team performance ( $\beta = 0.95$ ,  $t = 4.95$ ,  $p < .001$ ). On the contrary, for routine tasks, stronger external ties were negatively associated with team performance ( $\beta = -0.27$ ,  $t = -1.88$ ,  $p < .10$ ), although not at the conventional level of significance (i.e.,  $p < .05$ ). Thus, Hypothesis 4 was supported.

## Discussion

Internal and external team networks have been recognized as crucial antecedents of team performance, especially for teams that engage in knowledge-intensive work. Yet, prior research has yielded inconsistent results concerning these relationships. We attempted to broaden our understanding of how team networks might influence the performance of teams engaged in knowledge-intensive work, taking into account variations in the degree to which teams perform tasks that are more or less routine.

Overall, the results were consistent with most of our predictions. In particular, as illustrated in Figures 2, 3, and 4, task routineness was a significant moderator of the relationships between the three network characteristics and team performance. Relationships between internal and external network strength and performance were more evident for teams whose work was relatively nonroutine. Under conditions of low routineness, stronger internal work networks and external informational networks appear to enhance team performance. These results are consistent with the assumption that the effective performance of knowledge-intensive teams depends on free-flowing questioning, advice giving, and knowledge use among team members and across team boundaries. However, for knowledge-intensive team-work involving relatively routine tasks, stronger work networks appear not to enhance team performance and may actually have impeded team performance by reducing the efficiency of team members. Given that team members have limited time to perform their tasks, scientists who perform relatively routine tasks should allocate their time efficiently to maximize their productivity and avoid spending too much time engaged in unproductive networking activities.

Note, however, that even for teams working on nonroutine tasks, strong internal trust networks are beneficial only up to a point; at high levels of internal trust relationship strength, the benefits to performance begin to decline. The curvilinear relationship between internal trust relationship strength and team performance for teams whose work is non-routine fits the logic of Langfred (2004), who suggested that members of teams characterized by high trust might intentionally avoid behaviors that signal low trust. Closely monitoring the work of teammates, questioning team members' judgments, and seeking outside opinions are all behaviors that enhance team performance. Scientists might avoid such behavior in high-trust situations because they do not want their teammates to misconstrue their actions as indicating low trust. Among moderately trusting teammates, self-censoring of such behaviors may be less likely, allowing the team to reap their benefits (e.g., see West, 2004).

The divergent trends between internal work and trust relationship strength for teams engaging in routine works are also noteworthy, especially as the two internal network characteristics are correlated with each other conceptually and statistically. For teams performing routine tasks, the relationship between internal work relationship strength and team performance showed a negative trend, whereas the relationship between internal trust relationship strength and team performance was nonsignificant. Job-related ties (e.g., asking advice, seeking knowledge and information) may represent the behavioral aspect of relationships, whereas trust ties stand for the attitudinal aspect of relationships. A strong internal network of job-related ties indicates that team members are investing time in seeking advice and

knowledge from each other. When tasks are routine, such interactions merely reduce time spent focused on core tasks, so maintaining an internal team network of dense work relationships may actually interfere with the performance of teams working on relatively routine tasks. On the other hand, building and maintaining internal trust relationship strength may require no additional time investment—it may arise due to the quality (not quantity) of interactions among team members. Mutually trusting relationships may ease team members' knowledge-seeking activities, but because such activities are not central to effective team performance, internal trust relationship strength has no implications for team performance.

### *Theoretical Contributions*

This study extends current theory and research by addressing the complex dynamics that contribute to team performance in several ways. It enhances our understanding of the relationship between internal team networks and team performance, especially in knowledge-intensive settings. Drawing on network closure theory (a prevailing theory of internal team networks), prior treatments have postulated linear and positive relationships between internal team networks and team performance (Balkundi & Harrison, 2006), but the empirical results have been mixed and inconclusive. We argued that inconsistent findings might be due to the combination of advantages and disadvantages associated with strong within-team bonds as well as variation in the types of tasks performed by work teams in various settings. Our results largely support the network closure perspective while also suggesting some boundary conditions that future research should take into account. Specifically, stronger team internal networks may be more beneficial for teams working on nonroutine tasks, and the benefits of stronger internal networks may diminish above some optimal, moderate level of the internal network relationship.

To date, the contextual factors that influence the dynamics of knowledge-intensive teamwork have received little empirical attention. As others have suggested (e.g., Hansen et al., 2001; Jackson, et al., 2006; Joshi & Roh, 2009), the information-processing demands of team tasks create a context for the development of interpersonal relationships and related information flows. An information-processing perspective suggests that task routineness may regulate individual behaviors and attitudes toward job-related activities. For more complex, nonroutine tasks, team performance depends more heavily on the use of tacit and noncodified knowledge. When strong internal and external team networks facilitate the acquisition and sharing of tacit knowledge, they should also improve team performance. But for tasks that are routine, strong internal and external networks are less beneficial for team performance.

Our results suggest that teams performing routine tasks can maximize their team performance by minimizing internal work networking and external informational networking. On the contrary, teams performing nonroutine tasks can maximize their team performance by increasing internal work and trust networking relationships up to a moderate level and enhancing external informational networking as much as possible. Hence, team managers might consider two options for configuring teams to maximize performance: One option is to structure the work in ways that involve team members in relatively routine tasks and to

restrict (or at least not encourage) the development of strong internal and external networks, and the other is to eschew the intentional structuring of work into routine tasks and to encourage and support moderate internal networking and extensive external networking. Although these suggested configurations of task and network combinations must be considered tentative until additional research confirms the patterns we found, our results clearly indicate the value of aligning task requirements with practices that encourage and support appropriate patterns of networking.

The results regarding team tenure also are noteworthy. Team tenure was significantly associated with team performance even after controlling for internal and external network characteristics and task routineness (see Table 2). Producing new scientific knowledge requires persistence and collaboration over a period of time. While the passage of time undoubtedly contributes to the development of stronger network ties (Balkundi, Kilduff, Michael, Barsness, & Lawson, 2007), it may also deepen team members' understandings of each other's working styles and unique knowledge or expertise. Such understanding may make it easier for team members to work together effectively.

There may be the potential inverted-U-shaped relationship between external informational network strength and team performance. A moderate level of external networks may increase team performance. However, very strong external networks may distract team members from focusing on tasks, as they must also devote time and effort to maintaining their external networks and helping people in the networks (Hansen et al., 2001). In a post hoc examination, we found no evidence of a quadratic relationship between external informational network strength and team performance. We also found that the interaction between the squared term of informational network strength and task routineness was nonsignificant. Because team laboratories were usually separated by some physical distance, scientists may have used their time for externally networking judiciously, communicating with collaborators in other labs primarily to acquire or exchange information and knowledge or discuss work-related matters. Thus, our results reveal that the average strength of external informational relationships was less (.45) than the average strength of internal work relationships (.71; see Table 1). These results are consistent with prior research on external ties, which has found only a linear relationship between external informational network strength and team performance (e.g., Hansen et al., 2001; Reagans et al., 2004).

### *Limitations and Future Research*

We studied knowledge-intensive work teams in a single organization, and the types of work these teams engaged in was research intensive. Although the teams were similar to R&D teams in corporate settings, conclusions about how broadly these results generalize to other similar and dissimilar settings awaits further research.

Our research design does not permit us to draw inferences about causality. The research model presumes causal relationships, but the support we found for our hypotheses might arise from a different set of causal effects. For example, it is possible that leaders of underperforming teams may intentionally recruit team members with strong network ties within and outside the team in hopes of improving team performance. To address this possibility,

we controlled for team tenure and prior team performance, and we excluded newly hired team members with less than six months tenure on the team. Nevertheless, the question of how team leaders' implicit models about the performance implications of team networks influence their staffing decisions is a topic for future research.

This study provided no direct evidence about how team dynamics evolved throughout the life of the science research teams we observed. Social networks evolve and change, becoming more stable over time (Nahapiet & Ghoshal, 1998), and prior research shows that relationships among team members change over time in ways that may help explain the evolution of social networks (e.g., see Harrison, Price, & Bell, 1998; Jiang, Jackson, Chung, & Shaw, 2008). We statistically controlled for team tenure when testing our hypotheses, but additional research should examine the development of networks in knowledge-intensive work teams and the conditions under which teams succeed in maintaining optimal network structures to fit their specific tasks.

Measuring scientific performance is not an easy task. Although the impact factor has been widely used to measure the quality of publications, some scholars have questioned its accuracy and representativeness (Bollen & Van de Sompel, 2008). To address some of the criticisms, we adjusted impact factors by academy discipline. Nevertheless, this does not address the fact that the impact factor takes into account only citations for the last two years (Leydesdorff, 2008) and excludes a growing body of electronically published articles (Bollen & Van de Sompel, 2008).

### *Practical Implications*

If robust, our findings have potentially important implications for managing knowledge-intensive teams. They indicate that managing team networks effectively is more complex than simply striving for greater connectedness. Organizations that fail to take into account the nature of work performed may waste resources by investing in developing strong network ties that are unnecessary and perhaps even harmful to the performance of teams engaged in relatively routine knowledge-intensive work. Even for teams engaged in non-routine knowledge work, organizations may reap performance gains from investments in network development only up to a point, after which there is little benefit to be gained from further investments.

The practical implications of our results also extend to team staffing decisions. When selecting new team members, team leaders may find it useful to attend to the network ties of job candidates. Our interviews with managers and team members revealed that in the organization we studied, the value of external network ties was seldom recognized. Many interviewees confessed that they did not think much about the contribution that external informational networks might make to team performance. If team managers do not understand and acknowledge the worth of external informational networks, they may overlook opportunities to strengthen such networks by giving preference to job candidates with well-established network ties. Uninformed managers might also harm team performance by not providing support for activities that can help build networks (e.g., attending research talks in other departments, serving on dissertation committees outside the department).

## Conclusion

Our results suggest that the performance of knowledge-intensive work teams is likely influenced by the complex interplay of internal and external networking behaviors and task requirements. By taking into consideration task routineness, we identified some of the conditions under which internal and external team networks are more strongly associated with improved team performance. Despite the limitations of this study, the results clearly suggest that continued research on these topics has the potential to yield useful practical suggestions for organizations whose effectiveness depends on the performance of research teams.

## Note

1. We also assessed expressive ties (social relationships), but we did not use this measure because it was strongly correlated with the internal work relationship strength ( $\alpha = .79$ ). The relationship strength of work ties and social ties may sometimes be indistinguishable. The appropriation of social networks, a characteristic of network closure, means that interpersonal ties created for one purpose (e.g., socializing) can be used for other purposes (e.g., getting work done; Oh, Chung, & Labianca, 2004). Likewise, the interactions initiated for one purpose (e.g., getting work done) may naturally evolve to create a more complex relationship (socially close and interdependent for work tasks).

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