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RESEARCH ARTICLE

EXPLAINING EMPLOYEE JOB PERFORMANCE: THE ROLE OF ONLINE AND OFFLINE WORKPLACE COMMUNICATION NETWORKS[1]

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By distinguishing between employees' online and offline workplace communication networks, this paper incorporates technology into social network theory to understand employees' job performance. Specifically, we conceptualize network ties as direct and indirect ties in both online and offline workplace communication networks, thus resulting in four distinct types of ties. We theorize that employees' ties in online and offline workplace communication networks are ***complementary resources*** *that interact to influence their job performance. We found support for our model in a field study among 104 employees in a large telecommunication company. The paper concludes with theoretical and practical implications.*

Keywords: Online networks, offline networks, communication networks, social networks, complementarity, job performance

Introduction

Organizations continue to make huge investments to build virtual information and communication technology (ICT) platforms to facilitate employee communication and, consequently, enhance employees' job performance (Gartner 2008). The trillions of dollars spent on such ICTs serve as the major source of motivation for research that seeks to understand information systems (IS) success (e.g., Bajwa et al. 1998; Thong 1999; Thong et al. 1994, 1996, 1997; Thong and Yap 1996; Venkatesh et al. 2003). DeLone and McLean (1992, 2003) presented a holistic nomological network that related system characteristics all the way to IS success, conceptualized as downstream impacts of technologies on individuals and organizations. Prior research has made impressive strides in explaining performance impacts of ICTs at the macro-level (e.g., firm performance; Rai et al. 2006; Straub et al. 2004; Thong et al. 1994, 1996, 1997; Wareham et al. 2005). Likewise, prior IS research has made significant progress in understanding the characteristics of different communication media and how they relate to communication effectiveness under different task circumstances (e.g., Dennis et al. 2008; Hong et al. 2004; Mennecke et al. 2000; Topi et al. 2002). Yet, research related to the broader employee job outcomes, especially job performance, of technologies has been limited (see DeLone and McLean 1992, 2003; Rai et al. 2002; Seddon 1997). Therefore, research that focuses on explaining job performance will be of value to research and practice.

[1] Joe Valacich was the accepting senior editor for this paper. Ron Thompson served as the associate editor.

The appendix for this paper is located in the "Online Supplements" section of the *MIS Quarterly*'s website (http://www.misq.org).

Quite in contrast to IS research, research in management has extensively studied job performance using a variety of theoretical perspectives, such as personality (e.g., Tett and Burnett 2003), job characteristics (e.g., Fried and Ferris 1987; Hackman and Oldham 1980), and social networks (e.g., Burt 1992; Cross and Cummings 2004; Mehra et al. 2001; Sparrowe et al. 2001). Despite the progress made using each of these theoretical perspectives to explain job performance, there has been little, if any, role for technology in explaining job performance. However, prior research has incorporated technology in understanding organizational phenomena at the macro level. For instance, prior work has examined the causal structure between technology and organizational power (Jasperson et al. 2002). Also, prior research has examined firm performance by incorporating technology into social networks research (i.e., by studying digital networks; Straub et al. 2004; Wareham et al. 2005). Taken together, it is clear that neither IS nor management research has focused much attention on the role *technology plays in influencing employees' performance.*

In this work, we anchor on one particular theoretical perspective that explains job performance—namely, social networks. Social networks research mainly takes a resource view to explain job performance (e.g., Ahuja et al. 2003; Cross and Cummings 2004; Sparrowe et al. 2001). It argues that an employee's network ties play an important role in affecting access to important resources that in turn serves as a key mechanism contributing positively to job performance (Brass 1984; Sparrowe et al. 2001). Individuals who have a large number of network ties or connections would have more interactions with others in the network (Borgatti 2005; Freeman 1979) to gain access to resources (e.g., Sparrowe et al. 2001). Individuals link to other people in the network (Borgatti 1995, 2005; Freeman 1979), either through direct ties (i.e., there is a direct link between two people such that they can communicate with each other without having to go through other people) or indirect ties (i.e., there is no direct link between two people such that the two people can communicate with each other only through others).

This paper aims to incorporate technology into the nomological network relating social networks to performance, with a view toward furthering our understanding of job performance, which is a key net benefit of technology (see DeLone and McLean 1992, 2003). To capture the role of technology, particularly different communication technologies used for creating and maintaining social networks, we distinguish between an online workplace communication network (i.e., where people interact using a variety of communication technologies available to them in the workplace; see Dennis et al. 2008), and an offline workplace communication network (i.e., where people interact face-to-face). By distinguishing between online and offline workplace communication networks, we seek to understand the independent and interdependent roles of online and offline workplace communication network ties in affecting job performance. Our thesis is that employees who have a large number of ties in both networks will be able to leverage the complementary benefits of both networks while minimizing the limitations or constraints of both networks. We further distinguish between direct and indirect ties in both the online and offline workplace communication networks and explain how they enable or constrain employees' access to valuable resources.

Our work is expected to make important theoretical contributions. First, we contribute to IS research that seeks to understand the role of technology in affecting job performance. Second, we contribute to organizational behavior research, by providing a more nuanced view of the role of social networks in explaining job performance. Third, we advance social networks research by distinguishing between online and offline networks as well as direct and indirect ties, thus responding to calls for research on finer-grained conceptualizations of networks (e.g., Cross et al. 2001) and complementing other such work (e.g., Mehra et al. 2001; Yang and Tang 2003).

Background: Social Network Theory ■

A social network is

> a specific set of linkages among a defined set of persons, with the additional property that the characteristics of these linkages as a whole may be used to interpret the social behavior of the persons involved (Mitchell 1969, p. 2).

A social network approach describes patterns of interactions among people as a graph of connections (Newman 2002), with persons within a network being called nodes and relationships between actors being called ties. Nodes and ties form the structure of a social network and social network theory describes the network structure as resources for social action (Baker 1990; Bourdieu 1986; Burt 1992; Coleman 1988, 1990; Jacobs 1965; Loury 1987). Specifically, the theory seeks to understand the nature of a network (i.e., network patterns), and the antecedents and consequences of the network at different levels (e.g., interpersonal, interunit, or interorganizational; Brass et al. 2004; Butler 2001).

A wealth of research has examined different types of networks (e.g., communication) to understand how network ties affect interactions and behaviors (e.g., Baldwin et al. 1997;

Borgatti and Cross 2003; Cho et al. 2007; Obstfeld 2005; Reagans and McEvily 2003; Yang and Tang 2003). In understanding the impact of social networks on individual performance, prior research has mainly focused on examining network centrality, a structural property that contributes to the acquisition of valuable resources through direct and indirect ties. Applying such resources in completing one's job may greatly improve one's performance. Table 1 lists key prior research that examines the relationship between centrality and individual performance (i.e., either employees' job performance or students' academic performance).[2]

To further understand the distinction between direct and indirect ties, we draw on prior social networks research that discusses strong and weak ties (e.g., Granovetter 1973; Hansen 1999; Hansen et al. 2005; Haythornthwaite 2002). We illustrate this by using an example of a small workplace communication network of six people (i.e., Frank, James, Joe, Sean, Tracy, and Tony; see Figure 1). In Figure 1, a line between two people indicates there is a tie between these two people. The communication could be unidirectional (denoted by a one-way arrow) or bidirectional (denoted by a two-way arrow). For example, Tracy and James are linked by a one-way arrow that goes from Tracy to James, suggesting Tracy initiates communication. Tracy and Tony are linked by a two-way arrow, indicating both of them initiate communication. If Sean needs to communicate with Tracy, he can communicate with Tracy directly or he can choose to communicate with Tracy via Tony or via both Frank and Tony. If Tony needs to communicate with Joe, he has to go via Tracy and James. In other words, Sean and Tracy are connected via both direct and indirect ties while Tony and Joe are connected only via indirect ties. It is easier for a person to communicate with another person directly than it is for them to communicate via other people. For example, if Sean wants get some information from Tracy, he can communicate with her to get it, but if he wants to get some information from Joe, he has to communicate with Tracy who then can communicate with James. Once James communicates with Joe and gets the information, he can communicate with Tracy again who then can communicate with Sean again to provide him with the information.

Theory

We first describe the mechanisms related to resource access. Then, we present the ideas behind online and offline networks in organizations, the concept of complementarity, and the differences between online and offline networks. Finally, we explain how online and offline networks independently and interdependently affect job performance.

Mechanisms Related to Resources Access

Research on social networks and communication media, both of which speak to how people interact and share information, have discussed several mechanisms that play an important role in affecting an individual's ability to obtain the resources, particularly information, necessary to contribute positively to performance (e.g., Cross and Cummings 2004; Mehra et al. 2001; Sparrowe et al. 2001). We organize these mechanisms into two categories to correspond to each of the two theory bases respectively: (1) nature of the ties and type of information that are available (e.g., Borgatti and Cross 2003; Cross and Cummings 2004; Sparrowe et al. 2001); and (2) key media characteristics that govern the effectiveness of communication (e.g., Dennis et al. 2008) in acquiring resources (Borgatti and Foster 2003; Brass et al. 2004). In the first category of mechanisms, which are drawn from social networks research, we present *strong ties, weak ties, fast receipt of information, network reach, network homophily, information integrity, maintenance cost*, and *third-party surveillance*. In the second category of mechanisms, which are drawn from IS research (specifically, media synchronicity theory; see Dennis et al. 2008), we present r*esolving temporal and spatial constraints, transmitting contextual information, transmitting information in parallel,* and *documenting and retrieving information*.

A *strong tie* characterizes closeness and frequent interaction of a relationship between two people (Hansen et al. 2005; Levin and Cross 2004). A strong tie involves a high level of emotional closeness and reciprocity, manifested as social support and trust (Krackhardt 1992), that play a critical role in facilitating knowledge sharing and make transfer of complex knowledge easier (Ahuja 2000; Berg et al. 1982; Haythornthwaite 2002; Levin and Cross 2004). Prior research has indicated that there is a high level of ease and comfort among those who have strong ties with each other (Perry-Smith 2006) that in turn may also contribute positively to knowledge transfer. By developing relationship-specific heuristics (Uzzi 1997), employees connected via strong ties communicate more effectively (Reagans and McEvily 2003).

A *weak tie* characterizes distant and infrequent relationships (Granovetter 1973; Hansen 1999; Hansen et al. 2005; Haythornthwaite 2002; Levin and Cross 2004). A weak tie is likely to be a conduit of novel information because a weak tie is less likely to result in network closure (Hansen 1999; Levin

[2]Our search mainly focused on articles in premier management journals (e.g., *Academy of Management Journal* and *Administrative Science Quarterly*) since 1980.

Table 1. Key Prior Research on Social Networks and Individual Performance

Authors	Type of Network	Online or Offline	Network Ties	Direct or Indirect Ties	Controls	Performance DV	Major Findings
Ahuja et al. (2003)*	Communication	Online	Degree centrality	Direct	None	Job performance	Degree centrality was a predictor of job performance.
Baldwin et al. (1997)	Friendship, communication, and adversarial	ND	Closeness centrality	Both	Cognitive ability	Course grade	Communication centrality was positively related to student grades.
Barsness et al. (2005)	Familiarity	ND	Direct centrality (density)	Direct	Age, gender, and minority status	Job performance	The positive relationship between supervisor-focused impression management and performance was enhanced for subordinates with high levels of direct centrality.
Belliveau (2005)	Advice	ND	Network size and network heterophily	Direct	Human capital/student characteristics, institutional reputation, and job characteristics	Individual performance as job search outcomes	Network heterophily was positively related to number of offers received and institutional sex composition moderated the effect of heterophily on salary offers.
Bowler and Brass (2006)	Friendship	ND	Tie strength, third-party friendship, social dependence, relational, and third-party influence	Both	Job satisfaction, affective commitment, procedural justice, and demographic similarity controls (i.e., gender, age, race, education, tenure, hierarchical level, and hours worked per week)	Performance of interpersonal citizenship behavior (ICB)	Tie strength, relational and third-party influence were related to performance of ICB.
Brass (1981)	Workflow	ND	Closeness centrality	Both	None	Job performance	Job characteristics mediated the relationship between centrality and job performance.
Burt (2002)	Career	ND	Bridge	Both	Rank and tenure	Job performance as peer evaluation and log compensation	Bridges were positively related to job performance and decay in bridges was less frequent in the networks of high-performers.
Burt et al. (2000)	Multiple (information, socializing, political support, and so on)	ND	Structural holes	Both	Rank, age, function, location, sonority, minority, education	Job performance as early promotion and salary	Structural holes were positively related to performance.
Burt et al. (1998)	Entrepreneurial	ND	Structural holes	Both	None	Job performance	The relationship between structural holes and job performance was contingent on rank and gender.
Cattani and Ferriani (2008)	Affiliation	ND	Coreness (the degree of closeness of each node to a core of densely connected nodes observable in the network)	Both	Structural holes, individual/team/project characteristics	Job performance as creativity indicated by individual awards and nominations	Moderate level of coreness at both individual and team level were positively related to individual creative performance.
Cho et al. (2007)*	Friendship, collaborative learning network	Online	Degree, betweenness, closeness	Both	None	Course grade	Closeness centrality was positively related to student's grade.
Cross and Cummings (2004)	Information, awareness, adversary	ND	Betweenness centrality, boundary spanning, physical barriers, and hierarchical ties	Both	Tenure, hierarchy, gender, network autocorrelation	Job performance	Betweenness centrality in both information and awareness network was related to individual performance. Ties spanning boundary and physical barriers were positively related to performance. The relationship between ties to higher hierarchical levels and performance was partially supported.

Table 1. Key Prior Research on Social Networks and Individual Performance (Continued)

Authors	Type of Network	Online or Offline	Network Ties	Direct or Indirect Ties	Controls	Performance DV	Major Findings
Gargiulo et al. (2009)	Information	ND	Network size, density, and hierarchy	Both	Individual characteristics (gender, age, seniority, and rank), alter, and ego' mean evaluations, direct reports, knowledge diversity, and business unit fixed effects	Job performance as annual bonus received by the banker	Network closure was positively related to job performance when the individual acted as acquirer of information but was negatively related to job performance when the individual acted as provider of information. These effects were contingent on one individual characteristic (i.e., formal rank).
James (2000)	Advice and friendship	ND	Social capital (racial similarity and tie strength)	Direct	Gender, age, position, and supervisory performance ratings	Job performance as promotion rate, career-related support, and psychological support	The relationship between social capital and promotion rate was not significant. Social capital mediated the relationship between race and psychological support.
Kane and Labianca (2010)	Interpersonal network	ND	Eigenvector centrality	Both	Individual-, doctor-, and group-level controls	Job performance as patient care	Eigenvector centrality was significantly and negatively related to patient care.
Mehra et al. (2001)	Friendship, workflow	ND	Betweenness centrality	Both	Rank, tenure, gender	Job performance	Centrality in both friendship and workflow networks was positively related to individual performance.
Mizruchi et al. (2011)	Information and approval	ND	Tie strength and density	Direct	Gender, marital status, education, rank, salary, age, experience, hierarchy, and performance	Job performance as bonus received	Both strong ties and sparse network were positively related to bonus received in informational networks but not in approval networks.
Ortiz et al. (2004)	Communication	ND	Degree, betweenness, closeness, eigenvector	Both	Gender, occupation	Student academic performance	Closeness and eigenvector centralities were positively related to academic performance.
Pil and Leana (2009)	Instrumental and advice	ND	Horizontal and vertical ties' strength and closeness, team density, and team horizontal and vertical tie strength	Direct	Prior test scores, grade level, education status, attendance, socioeconomic status	Job performance as students' test scores	Individual vertical tie strength, and team horizontal and vertical tie strength were positively related to teacher performance, human and social capital interacted in their effects on teacher performance.
Rodan (2010)	Advice, task execution, idea generation, and friendship	ND	Density and alter knowledge heterogeneity	Direct	Tenure, education, gender, seniority, network size, number of key contacts, and differences between the initial sample and the snowball round	Job performance	Knowledge heterogeneity partially mediated the density-performance relationship.
Sparrowe et al. (2001)	Advice, hindrance	ND	Degree centrality	Direct	Organizational differences	Job performance	Job performance was positively related to centrality in advice networks and negatively related to centrality in hindrance networks.
Xiao and Tsui (2007)	Career	ND	Structural holes	Both	Age, gender, education, experience, tenure, affective commitment	Career performance as monthly salary and bonus	The collectivistic and high-commitment culture dampened the positive effect of structural holes on career performance.
Yang and Tang (2003)*	Friendship, advice, adversarial	ND	Degree centrality	Direct	None	Student overall academic performance	Centrality in advice network was positively related to student's performance in class.

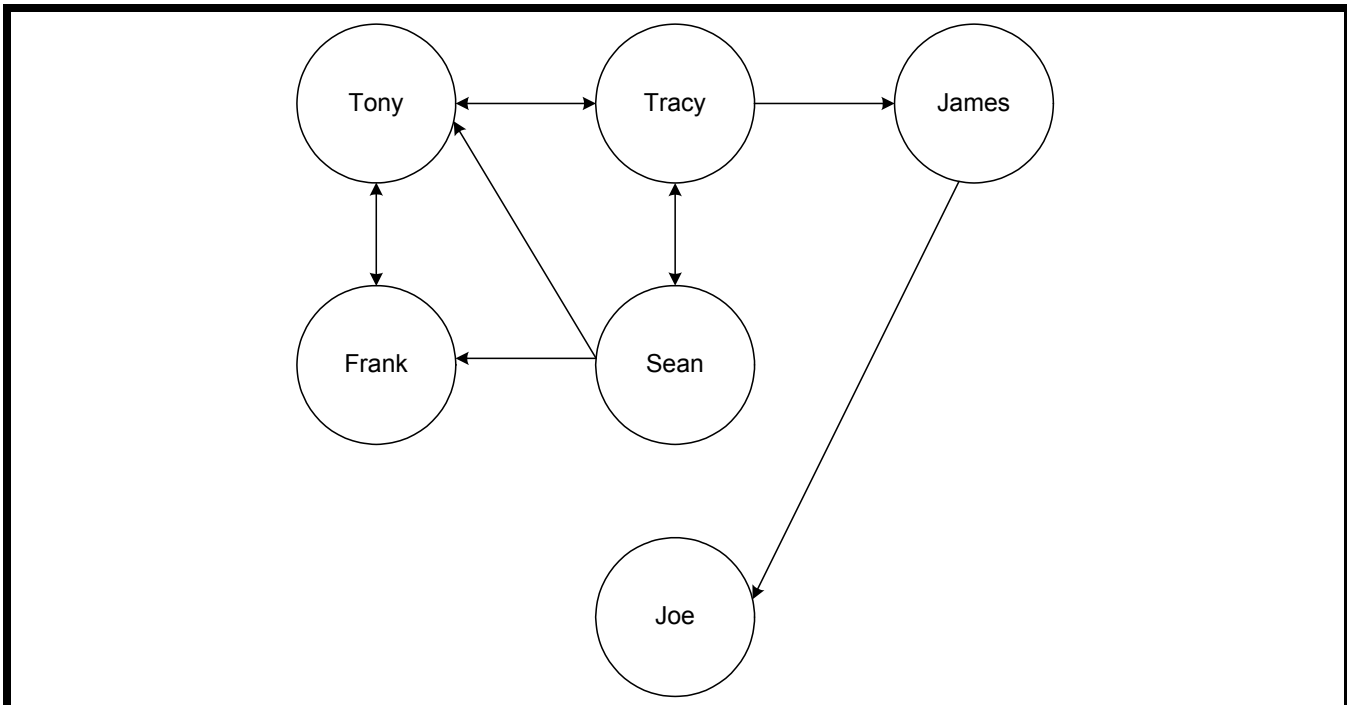


Figure 1. Visualization of a Workplace Communication Network

and Cross 2004). Access to novel information or new ideas may help better accomplish tasks in one's job because new ideas may broaden an employee's horizons such that he or she could apply different approaches or refine existing approaches to resolve problems. In the workplace, being creative, thinking outside the box and breaking traditional paradigms have been found to be effective in contributing favorably to performance (e.g., Gilson et al. 2005).

Fast receipt of information refers to how quickly an individual can receive a message transferred from another node in the network. The shorter the distance or the fewer the intermediaries, the faster the individual can receive information (Burt 1992). Prior studies have indicated fast receipt of resources affects knowledge transfer and task performance (e.g., Dihoff et al. 2004; Phye and Andre 1989). Timely access to important knowledge or advice plays a critical role in affecting knowledge seeking (Borgatti and Cross 2003) and subsequent job performance (Sparrowe et al. 2001). In today's business context, pressures of ever shorter time-to-deliver are salient (Vidgen and Wang 2009). When employees have questions about work-related problems and ask for advice from other employees, it is important for them to receive advice or knowledge in a timely fashion such that they can resolve problems and accomplish their assignments before deadline. Otherwise, their performance will suffer.

Network reach indicates the extent to which an individual is able to access others in the network (Borgatti and Cross 2003; Brass et al. 2004; Granovetter 1985). If individuals can reach many others, they are more likely to enjoy the benefit of knowledge spillover (i.e., access to the knowledge not only of their partners, but also of their partners' partners; Gulati and Garguilo 1999). In addition, every node an individual is able to reach can help the individual gather, process, and screen information, such as absorbing, sifting, and classifying information (Ahuja 2000; Freeman 1991; Leonard-Barton 1984). In contrast, if individuals have a small number of contacts or have fewer opportunities to interact with their contacts (e.g., employees who work in different places with non-overlapping hours; Cummings et al. 2009), they are less likely to reach many others and enjoy the benefits of network reach that contribute positively to job performance.

Network homophily indicates people who are similar to each other with respect to sociodemographic, behavioral, and personal characteristics are likely to bond together (Ibarra 1992; McPherson et al. 2001). These people are more likely to communicate directly with each other as well as communicate frequently with each other. Frequent communication creates more opportunities to clarify misunderstandings, thus making the transfer of complex knowledge easier. In addition, knowledge is easier to transfer between people who have

similar cognitive paradigms to resolve problems (Reagans and McEvily 2003). When people are dissimilar (e.g., have different educational backgrounds or professional experiences), they are likely to think differently or behave differently, thus making the transfer of knowledge more difficult. For instance, prior research indicates that dissimilarity makes it difficult for communication partners to develop mutually understood knowledge, one of the most important factors that facilitate knowledge transfer in an online environment (Cramton 2001).

Information integrity indicates the faithfulness or intactness of a message after it is transmitted from one node to another in a network (Baldwin et al. 1997; Nayar 1993). The shorter the distance, the more likely a message will maintain its integrity. When information needs to travel through many intermediaries, the integrity of the message will be reduced, because the more nodes in the network a message needs to pass through before it reaches the target, the more noise and interference to which it will be exposed and, consequently, the more the message will be different from the original message. When an employee requests knowledge to resolve work problems, the integrity/accuracy of the knowledge is important. If the knowledge is distorted during the transfer, it may no longer be useful in addressing the problems, thus negatively affecting the requester's job performance.

Maintenance cost refers to the time and effort an individual needs to spend on preserving a network relationship that could help the individual acquire the necessary resources (Ahuja 2000; Burt 1992; Hansen 2002). To obtain resources from a person in the network, an individual needs to establish and maintain a good relationship with the person by spending some time and effort in helping that person such that the person is willing to return the favor (e.g., providing resources to the individual, in the future; Reagans and McEvily 2003). The more time and effort an individual spends on helping others or maintaining a relationship, the less time the individual can use for his or her own work. This could jeopardize the individual's job performance. If the maintenance cost of a relationship is high, it is difficult for an individual to maintain such a relationship, thus reducing the individual's capability to leverage the relationship in obtaining resources. In contrast, the lower the maintenance cost, the easier it is for an individual to maintain a relationship and leverage it to gain access to resources.

Third-party surveillance refers to the role of certain network nodes in constraining the behaviors of other nodes. When two nodes are indirectly connected via a third node (e.g., Tracy and Joe are indirectly connected via James; Figure 1), the third node (here, James) can influence the behaviors of the other two nodes (here, Tracy and Joe). This was described as the third-party surveillance effect in prior literature (Brass et al. 1998; Reagans and McEvily 2003). The third party can serve as a conduit to spread news that affects the reputation of those who are tied to them. Prior research indicates employees are more likely to cooperate with their coworkers when strong third-party ties surround their relationships with those coworkers. If the employees do not cooperate, the third parties can spread news about their uncooperative behavior to other network members quickly and limit their ability to interact with those network members in the future (Reagans and McEvily 2003). Third-parties can also spread news to other network members about the competence and credibility of the employees to whom the third-parties are tied. When employees' reputations are dependent on whether third-parties would say good things or bad things about them, such employees are likely to be motivated to perform better so as to get favorable reviews from third-parties. In the absence of third-parties, the strength of such motivation is likely to reduce (e.g., knowledge providers would feel less motivated to provide accurate answers), thus negatively affecting knowledge recipients' job performance.

Resolving temporal and spatial constraints refers to the capability of a communication medium to overcome the temporal and spatial barriers that prevent employees from holding a meeting. Employees who work during non-overlapping hours in different locations face significant challenges in meeting each other to discuss work-related issues (Cummings et al. 2009). Even for those who work in the same location and during the same hours, finding a way to communicate is important. It is via communication that employees exchange ideas, request critical information, or learn about effective solutions, all of which contribute positively to performance. If a network tie is less restricted by the temporal and spatial constraints, employees are more likely to leverage it to gain access to resources and get their job done.

Transmitting contextual information refers to the capability of a communication medium to transmit various cues to enhance communication effectiveness and mutual understanding between the communication partners. To facilitate effective knowledge transfer, a network tie should allow the transmission of nonverbal and paraverbal cues, such as body language, facial expression, increased personal focus, and support of high velocity of feedback (Becker-Beck et al. 2005; Dennis et al. 2008). When knowledge is transferred effectively, employees are more likely to leverage it to enhance job performance. In the absence of contextual information, the communication partners will find it difficult to gain a better understanding of each other, thus increasing the difficulty in transferring complex knowledge (Becker-Beck et

al. 2005). Also, the lack of contextual information reduces attention and visibility that could translate to more favorable perceptions among employees' supervisors and coworkers who may help them obtain valuable resources to accomplish their jobs.

Transmitting information in parallel refers to the capability of a communication medium to support parallel or multi-thread conversations (Dennis et al. 2008). When a network tie supports the transmission of multiple sources of information in parallel, employees are likely to listen to or learn from different perspectives in a timely manner. This could trigger employees to think about different solutions to various work problems, thus resulting in developing new approaches that better tackle the problems and, consequently, enhancing job performance.

Documenting and retrieving information refers to the capability of a communication medium to keep track of the communication history and revisit the records whenever necessary (Dennis et al. 2008; Majchrzak et al. 2005). Knowledge exchange or transfer could be an iterative process that requires ongoing conversations between communication partners. When too much information is being exchanged, employees are likely to forget some of the information and as such lack of recall could negatively affect their job performance. If a network tie helps communication partners better store their communication history as well as easily retrieve relevant information for future work, it will make knowledge exchange and transfer easier and more effective, thus enhancing job performance.

Online Versus Offline Workplace Communication Networks

When organizations increase the extent of virtualness, in addition to the offline (i.e., face-to-face) workplace communication networks, employees are more likely to interact with each other virtually and form online communication networks (Koh et al. 2007) that are characterized by more weak ties (Wellman and Hampton 1999), democratization and equalization (Short et al. 1976; Sproull and Kiesler 1991), and a larger network of contacts (Boase et al. 2006). When both online and offline communication media are available, employees may choose different media to interact with others based on their preferences. Some may feel more comfortable using an offline medium, whereas others may prefer to use an online medium or both (e.g., Hollingshead et al. 1993; Sproull and Kiesler 1986; Walther 1995). As a result of different levels of online and offline interactions, employees may develop different network ties online versus offline. Some may have a large number of direct and indirect ties online but not offline, or vice versa, and some may have a large number of direct and indirect ties in both networks. The concept of online and offline networks has been discussed in prior research (e.g., Butler 2001; Cummings et al. 2002; Koh et al. 2007; Wellman 2001) and it has been noted that the distinction between online and offline networks may shed light on our understanding of network phenomena because online networks may not be subject to the same problems as offline networks (e.g., Butler 2001; Cummings et al. 2002). *In this paper, we focus on the workplace communication network that includes both the online communication network and the offline communication network. In the remainder of the paper, we refer to them as online network and offline network respectively*. Figure 2 presents an example of online and offline networks. Although Figure 2 captures the relationships of the same people as Figure 1 does, it provides more information about each individual's ties broken down by offline versus online networks. For example, we can see how an individual's ties are different in online and offline networks, and how different individuals' ties are different in online and offline networks.

Online and offline workplace communication networks enable access to diverse resources, such as job-related knowledge, task advice, strategic information, and social support (e.g., Ahuja et al. 2003; Baldwin et al. 1997). In the remainder of the paper, we use the term *resources* to refer to the collection of different types of resources or we refer to specific resources by name (e.g., knowledge or social support). Prior literature, rooted in the resource based view of organizations, has argued that the impact of complementary resources on performance outcomes is far beyond the simple addition of these resources such that firm performance is significantly enhanced (Milgrom and Roberts 1995). For example, when organizations adopt management practices that complement each other, firm performance is enhanced (Baird and Meshoulam 1988). Beyond the resource-based view of an organization, the concept of complementarity has been applied to different domains. In economics, this concept underscores the effect of price changes on demands for complementary goods (i.e., price change in one good or service leads to variation in demand for other goods or services; Pindyck and Rubinfeld 2001). In consumer behavior, this concept illustrates the fit of product- or feature-specific utilities into different aspects of consumers' composite needs (Chernev 2005; Lattin and McAlister 1985). With respect to the application of the concept of resource complementarity in research on technology, early work underscored the macro-level synergy among technologies (Milgrom and Roberts 1995) on the software/hardware paradigm (e.g., Katz and

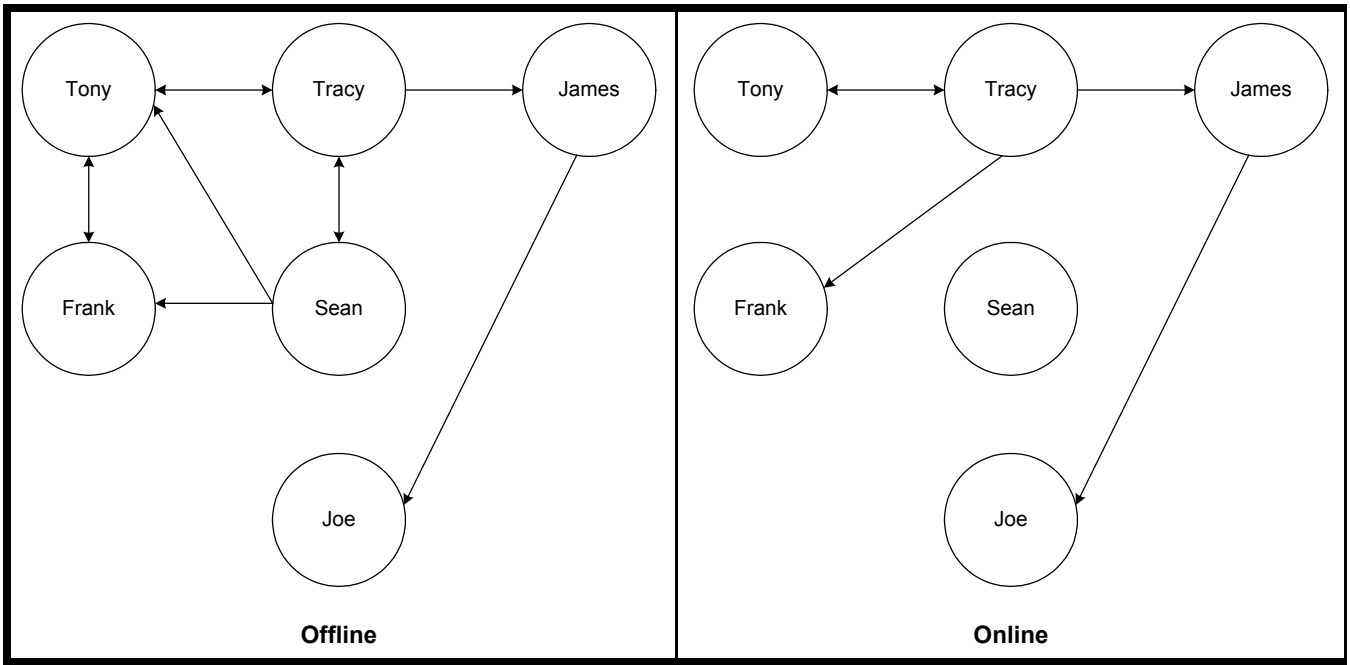


Figure 2. Visualization of Workplace Communication Networks

Shapiro 1994), such that improvement in one technology (e.g., hardware) strengthens the effect of the other (e.g., software) to increase the overall effect of the whole system (see Xu et al. 2009).

Although the concept of resource complementarity has been applied to explain macro-level phenomena in technology research, little, or no, research has examined it at the individual level. However, the concept of fit, which is similar to the concept of complementarity, has been examined in individual-level research. For example, task–technology fit (Goodhue and Thompson 1995) suggests that when a technology fits or supports the task, an individual can achieve better performance. Likewise, the management literature relates individual performance to person–job and person–organization fits (Barber 1998; Breaugh 1992; Cable and Judge 1996).

We use the theory of complementarity to explain the synergistic effect of individuals' online and offline network ties on their job performance. Given that each of the four types of ties (i.e., offline direct ties, offline indirect ties, online direct ties, and online indirect ties) have strengths and weaknesses in terms of getting access to resources, we theorize how the strengths of one type of ties can addresses the weaknesses of another. We first theorize how direct and indirect ties in the offline and online networks respectively complement each other in affecting job performance. Then, we theorize about the complementary role of online and offline ties. To access resources, individuals can use either online or offline communication media. Thus, the capabilities of accessing resources are bound by the capabilities of online and offline communication media. The role of online and offline communication media may further vary across direct or indirect ties. For example, in the offline network, direct (versus indirect) ties result in faster receipt of information (Burt 1992). But, in the online network, the time it takes to transmit resources via indirect ties may be greatly reduced because use of online communication media (e.g., mobile texting and email) may speed up the resource flow such that people communicating indirectly can acquire resources quickly, especially compared to indirect offline ties. Considering the differences between online and offline communications, we argue that network ties in online and offline networks provide access to resources that are complementary to each other, such that missing benefits of one network can be obtained from the other network and the limitations or constraints of one network can be offset by the other network.

Hypotheses Development

We develop three sets of hypotheses that relate network ties, conceptualized to contain both direct and indirect ties in online and offline networks, to job performance. The first set of hypotheses theorizes about the impact of offline ties. The

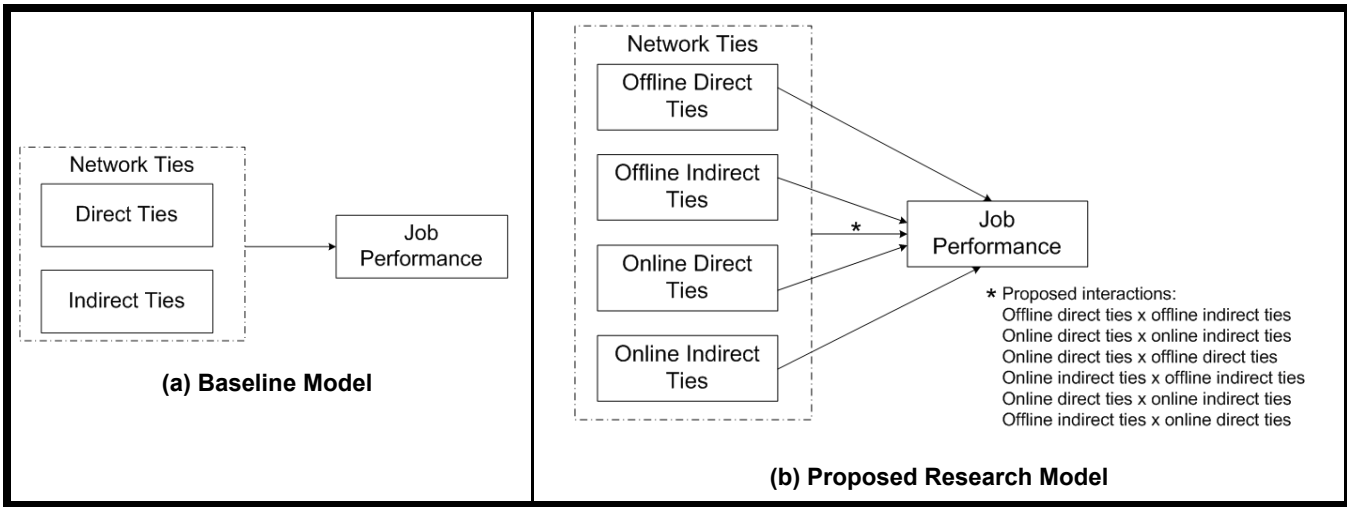


Figure 3. Research Model

second set of hypotheses theorizes about the impact of online ties. The last set of hypotheses theorizes about the interaction of online and offline ties. Figure 3(a) presents the baseline model that does not distinguish between online and offline network ties and Figure 3(b) presents our model that distinguishes between online and offline networks, and is important in understanding job performance. To explain the relationships between network ties and job performance, we incorporate mechanisms related to resource access into the hypotheses development. These mechanisms are not the constructs examined in our research model but they serve as the building blocks of the theory development in this paper. Each mechanism is rated as high, medium, or low on each type of tie to indicate their relative differences with regard to capability of accessing resources. High is associated with stronger capability, followed by medium and low.

Offline Ties

As noted earlier, there are offline (i.e., FTF) workplace communication networks—hereinafter, offline networks.

Offline direct ties. Among the various mechanisms identified, we rate fast receipt of information, information integrity, strong ties, network homophily, and transmitting contextual information as high for offline direct ties. Offline direct ties are likely to result in fast receipt of information and maintain a high level of information integrity because information needs to travel the shortest distance from the source to the target (Burt 1992). When two people communicate FTF directly, they can better clarify misunderstandings (Dennis et al. 2008), thus making communication easier. Ease of communication leads to high frequency and intensity of interactions that characterize strong ties. When people interact frequently, they are likely to know each other better, bonding to those who are similar to themselves (Ibarra 1992; McPherson et al. 2001). In other words, offline direct ties are likely to help employees develop a high degree of homophily. Given that FTF communication can transmit nonverbal and paraverbal cues, such as body language and facial expression, get personal focus, and clarify misunderstandings (Becker-Beck et al. 2005; Dennis et al. 2008), offline direct ties are good for transmitting contextual information. Each of these strengths of direct offline ties will contribute positively to job performance. Thus, we hypothesize

H1(a): Offline direct ties will be positively related to job performance.

Offline indirect ties. Among the various mechanisms identified, we rate weak ties, maintenance cost, network reach, and third-party surveillance as high for offline indirect ties. When two people are connected via intermediaries (i.e., offline indirect ties), their communication becomes less convenient because every message transmitted between these two people needs to go through the intermediaries. Such inconvenience makes it difficult for these two people to communicate often, thus resulting in low frequency and intensity of communication that characterizes weak ties. Offline indirect ties are also inexpensive to maintain because employees who are indirectly connected in the offline network do not need to spend much time and effort to communicate with each other compared to employees who are directly connected (Ahuja 2000; Burt 1992; Hansen 2002). Low maintenance cost can also lead to a higher degree of

network reach due to the low cost of expanding relationships. Employees who are connected indirectly in the offline network will go through third parties and thus are more likely to be subject to third-party surveillance (Reagans and McEvily 2003). Each of these strengths of indirect offline ties will contribute positively to job performance. Thus, we hypothesize

H1(b): Offline indirect ties will be positively related to job performance.

Offline indirect ties as a complement to offline direct ties. Among the various mechanisms identified, we rate maintenance cost, network reach, weak ties, and third-party surveillance as low for offline direct ties. Offline direct ties are expensive to maintain because employees need to spend time and effort to sustain such relationships by frequently meeting FTF with their offline contacts or helping them resolve work-related problems. Given that offline direct ties are costly to maintain, it is more difficult for employees to expand their networks by developing new relationships. Consequently, they are less likely to develop a high degree of network reach. As noted earlier, offline direct ties are typically strong ties. Given that strong and weak ties are structurally opposite, the structural benefits of weak ties (e.g., access to new and diverse resources; Hansen 1999; Levin and Cross 2004) are less likely to appear also as the structural benefits of strong ties. Although employees communicate directly in the offline network, there are no third parties and thus there is a lack of third-party surveillance. In contrast, offline indirect ties are rated higher than are offline direct ties in the mechanisms discussed above.

Offline direct ties as a complement to offline indirect ties. Among the various mechanisms identified, we rate strong ties, network homophily, information integrity, and fast receipt of information as low for offline indirect ties. As noted earlier, offline indirect ties are typically weak ties such that the structural benefits of strong ties (e.g., transfer of complex knowledge; Granovetter 1982; Levin and Cross 2004; Reagans and McEvily 2003) are less likely to be the structural benefits of weak ties. Because offline indirect ties are weak ties, people who communicate indirectly in the offline network do not interact frequently, resulting in fewer opportunities to find similar others and develop network homophily (Ibarra 1992; McPherson et al. 2001). When a piece of information is transmitted via many intermediaries in the offline network, the likelihood of it being distorted is high (Burt 1992). Offline indirect ties significantly slow down the speed of knowledge transfer given the large number of FTF meeting logistics that people need to manage. Likewise, offline direct ties are rated higher than are offline indirect ties in the mechanisms discussed above.

We demonstrate the complementary role of offline direct and indirect ties using Figure 2. Frank has two direct ties (i.e., Tony and Sean) and three indirect ties (i.e., Tracy, James, and Joe). Not only can Frank use his offline indirect contacts to reach a large and diverse base of information with minimum cost, but also he can use his offline direct contacts to transfer complex knowledge in a timely fashion while minimizing the likelihood of jeopardizing the integrity of the knowledge. Given that offline direct and offline indirect ties address each other's limitations, they complement each other in affecting job performance. Thus, we hypothesize

H1(c): Offline indirect ties positively moderate the relationship between offline direct ties and job performance.

Online Ties

As noted earlier, distinct from offline networks, there are online workplace communication networks—hereinafter, online networks. Online networks comprise employees who interact using email, mobile texting, messaging software, and audio/video conferencing (e.g., Wellman 2001).

Online direct ties. Among the various mechanisms identified, we rate fast receipt of information, information integrity, strong ties, resolving temporal and spatial constraints, transmitting information in parallel, and documenting and retrieving information as high. When employees communicate directly online, they are likely to receive information faster than they do offline because in an online network, employees do not need to spend time and effort in scheduling FTF meetings. Instead, they can spend more time interacting with other employees using different online communication media and developing stronger relationships in the online network. Online direct ties are likely to make employees receive information of high integrity because there are no intermediaries to transmit the information. Moreover, employees can directly exchange information by using asynchronous communication media, such as email and mobile texting, to overcome the temporal and spatial constraints. Some computer-mediated technologies support parallel conversation such that employees who communicate directly online can listen to or learn from different perspectives in a timely manner (Dennis et al. 2008). Online communication is good to document information because digital storage devices have larger memory capacity than humans do. Once the information is kept in a well-designed digital storage device, such as an advanced database management system, it is easier and faster for employees who communicate directly

online to navigate to the information. Each of these strengths of online direct ties will contribute positively to job performance. Thus, we hypothesize

H2(a): Online direct ties will be positively related to job performance.

Online indirect ties. Among the various mechanisms identified, we rate weak ties, maintenance cost, network reach, third-party surveillance, information integrity, resolving temporal and spatial constraints, and documenting and retrieving information as high for online indirect ties. Employees who communicate indirectly online are less likely to communicate often because it is inconvenient to communicate via intermediaries. Another reason for the low level of communication is that online communication media do not typically transmit contextual information adequately. As a result, employees may find it difficult to understand each other when communicating indirectly online. Given that weak ties characterize relationships of infrequent communication (Granovetter 1973; Hansen 1999; Hansen et al. 2005; Haythornthwaite 2002; Levin and Cross 2004), online indirect ties can be regarded as weak ties. Like online direct ties, online indirect ties are inexpensive to maintain because employees do not need to deal with FTF meeting logistics. Consequently, employees are likely to expand their network reach. Like offline indirect ties, online indirect ties link employees via third parties who are likely to perform a surveillance role. Like online direct ties, information transferred via online indirect ties can maintain high integrity because the intermediaries can simply use email to forward the message without interpreting it. Like online direct ties, online indirect ties are less bound by temporal and spatial constraints because employees can use various online communication media (e.g., email, audio or video conference) to communicate such that they do not need to meet at the same place at the same time. Such online communication media can also document all of the communication history without losing information, making it easier for future use (Dennis et al. 2008). Each of these strengths of indirect online ties will contribute positively to job performance. Thus, we hypothesize

H2(b): Online indirect ties will be positively related to job performance.

Online indirect ties as a complement to online direct ties. Among the various mechanisms identified, we rate weak ties and third-party surveillance as low for online direct ties. As noted earlier, online direct ties are strong ties that do not have the structural benefits of weak ties (e.g., access to new and diverse information). Like offline direct ties, online direct ties indicate there are no third parties between communication partners. Consequently, there is no third-party surveillance. Such limitations are addressed by online indirect ties that are rated high in terms of weak ties and surveillance.

Online direct ties as a complement to online indirect ties. Among the various mechanisms identified, we rate network homophily and strong ties as low for online indirect ties. Like offline indirect ties, online indirect ties are typically weak ties that reduce the opportunities of developing network homophily (Ibarra 1992; McPherson et al. 2001). In addition, weak ties indicate the absence of the structural benefits of strong ties (e.g., transfer of complex knowledge). Such limitations are addressed by online direct ties that are rated to be high in terms of homophily and strong ties.

We illustrate the complementary role of online direct and indirect ties by using the communication network presented in Figure 2. Tracy has three online direct ties and one online indirect tie. If she needs to request knowledge from Joe, she can enjoy the benefit of third-party surveillance performed by James. She can also leverage her direct contacts to transfer complex knowledge. Given that online direct and indirect ties address each other's limitations, they complement each other in affecting job performance. Thus, we hypothesize

H2(c): Online indirect ties positively moderate the relationship between online direct ties and job performance.

Complementarity of Online and Offline Network Ties

Our last four hypotheses examine the interaction of online and offline network ties. Considering the differences between online and offline communication, the associated networks, and the underlying network ties, we argue that employees who have a large number of ties in both networks will be able to leverage the benefits of both networks and are less constrained by the limitations of both networks. We suggest that network ties in online and offline networks convey resource benefits that complement each other and can synergistically help job performance.

Online Direct Ties and Offline Direct Ties

Online direct ties as a complement to offline direct ties. As noted earlier, offline direct ties are rated low in maintenance cost and network reach. In addition, offline direct ties are rated low in resolving temporal and spatial constraints, transmitting information in parallel, and documenting and

retrieving information. To access resources, employees who communicate directly offline must meet at the same place and at the same time. This could be difficult when employees are located in different places and work at non-overlapping hours (Cummings et al. 2009). This indicates the temporal and spatial constraints for offline direct ties are high. During a FTF meeting, only one person can speak at one time such that employees cannot listen to diverse feedback in a timely manner (Dennis et al. 2008). This indicates offline direct ties have limited support to transmit information in parallel. During a FTF meeting, employees take notes or memorize discussion topics. Notes can be incomplete or misplaced and employees may forget what has been discussed after some time, resulting in information loss or failure to retrieve critical information to resolve work problems (Dennis et al. 2008). This indicates offline direct ties have inadequate support to document and retrieve information. The strengths of online direct ties in terms of these mechanisms address the limitations of offline direct ties.

Offline direct ties as a complement to online direct ties. Online direct ties are rated low in transmitting contextual information. Most of the online communication media, such as email and audio conference, do not support transmission of multiple cues (e.g., body language, facial expression). When employees do not talk to each other FTF, personal focus is also reduced. Although video conferencing can transmit some contextual information, it largely depends on the quality of the Internet connection. For instance, an inferior quality of connection may cause information loss and delay. The strength of offline direct ties in terms of transmitting contextual information addresses such weaknesses of online direct ties.

We illustrate the complementary role of online and offline direct ties using the communication network presented in Figure 2. Tracy has three direct ties in both online and offline networks. When Tracy cannot meet FTF with her offline direct contacts, they can communicate directly using email or other online communication media not only to lower the cost of relationship maintenance, but also to better create and preserve communication records. Using an online meeting software, Tracy can receive feedback from her three online direct contacts simultaneously. Likewise, Tracy can leverage her offline direct contacts to acquire complex knowledge. Given that online direct and offline direct ties address each other's limitations, they complement each other in affecting job performance. Thus, we hypothesize

H3: Offline direct ties positively moderate the relationship between online direct ties and job performance.

Online Indirect Ties and Offline Indirect Ties

Online indirect ties as a complement to offline indirect ties. As noted earlier, offline indirect ties are rated low in fast receipt of information and information integrity. In addition, offline indirect ties are rated low in resolving temporal and spatial constraints, and documenting and retrieving information. To obtain resources via offline indirect ties, employees must meet FTF with those to whom they are directly connected (i.e., intermediaries). These intermediaries will then meet FTF with whomever they are directly connected to transfer the message. FTF meetings are bound by temporal and spatial constraints. The more intermediaries between communication partners, the more FTF meetings are required to transfer resources, creating more temporal and spatial constraints. As noted earlier, employees may not take complete notes or memorize all of the information during FTF communication. The more FTF meetings required to transfer resources, the more likely some information will be lost during transmission. Consequently, offline indirect ties have limited capability to resolve temporal and spatial constraints as well as to document and retrieve information (Dennis et al. 2008). The strengths of online indirect ties in terms of these mechanisms address the limitations of offline indirect ties.

Offline indirect ties as a complement to online indirect ties. Like online direct ties, online indirect ties are rated low in transmitting contextual information because online communication media provides inadequate support to transmit contextual information (Dennis et al. 2008). The capability of online indirect ties in terms of transmitting contextual information is even weaker than that of online direct ties because information needs to travel through additional nodes (i.e., intermediaries). The strength of offline indirect ties in terms of transmitting contextual information addresses this weakness of online indirect ties (Becker-Beck et al. 2005; Dennis et al. 2008; Maznevski and Chudoba 2000).

We illustrate the complementary role of online and offline indirect ties by using the communication network presented in Figure 2. If Tracy needs to obtain resources from Joe via James, these three people can use different synchronous and/or asynchronous online communication channels, such as email, audio conference, or video conference, so that they do not need to meet FTF. This might speed up resource access for Tracy because there will be no FTF meeting logistics that need to be managed. This is also likely to maintain information integrity because James can simply forward a message to Tracy and Joe. Moreover, all the communication history can be easily documented for future use. In times when Joe needs to transfer complex knowledge to Tracy, the more effective

method is that Joe meets James FTF and explains everything clearly to James who then meets Tracy FTF and passes on the knowledge. Given that online indirect and offline indirect ties address each other's limitations, they complement each other in affecting job performance. Thus, we hypothesize

H4: Offline indirect ties positively moderate the relationship between online indirect ties and job performance.

Online Indirect Ties and Offline Direct Ties

Online indirect ties as a complement to offline direct ties. As discussed earlier, offline direct ties are rated low in weak ties, maintenance cost, network reach, resolving temporal and spatial constraints, transmitting information in parallel, and documenting and retrieving information. The strengths of online indirect ties in terms of these mechanisms address the limitations of offline direct ties.

Offline direct ties as a complement to online indirect ties. As discussed earlier, online indirect ties are rated low in network homophily, strong ties, and transmitting contextual information. These limitations prevent the transfer of complex knowledge. The strengths of offline direct ties in terms of these mechanisms address the limitations of online indirect ties.

We illustrate the complementary role of offline direct and online indirect ties by using the communication network presented in Figure 2. Tracy is indirectly connected to Joe online such that she is likely to obtain new ideas from Joe at a low cost. If she cannot meet FTF with James to reach Joe, she can email James and the communication history will be documented for future use. When Tracy needs to acquire some complex knowledge from Joe, she can leverage her strong and direct contact in the offline network (i.e., James) and discuss the topic FTF with him. This will ease the transfer of knowledge because James and Tracy are likely to have similar cognitive patterns that make it easier for Tracy to understand James. James is also likely to spend time in helping Tracy due to their strong offline relationship, and FTF communication would help clarify misunderstandings and facilitate the transfer of complex knowledge. Given that online indirect and offline direct ties address each other's limitations, they complement each other in affecting job performance. Thus, we hypothesize

H5: Offline direct ties positively moderate the relationship between online indirect ties and job performance.

Online Direct Ties and Offline Indirect Ties

Online direct ties as a complement to offline indirect ties. As noted earlier, offline indirect ties are rated low in fast receipt of information, information integrity, resolving temporal and spatial constraints, and documenting and retrieving information. Like offline direct ties, offline indirect ties do not support transmission of information in parallel because during FTF communication (meetings), only one person can speak at any given time. The strengths of online direct ties in terms of these mechanisms address the limitations of offline indirect ties.

Offline indirect ties as a complement to online direct ties. As noted earlier, online direct ties are rated low in third-party surveillance (Brass et al. 1998; Reagans and McEvily 2003) and transmitting contextual information (Dennis et al. 2008). The strengths of offline indirect ties in terms of these mechanisms address the limitations of online direct ties.

We illustrate the complementary role of offline indirect and online direct ties by using the communication network presented in Figure 2. When Tony needs to request resources from Joe, he can communicate directly with Tracy using various online communication media and Tracy can use the same approach to reach Joe. In this way, Tony is more likely to receive information with high integrity from Joe in a timely fashion. He does not need to worry about not being able to meet Tracy FTF or recall the communication history. When Tony requests complex knowledge from James, he can leverage his offline network such that Tracy can monitor James' knowledge sharing behaviors so that James is more likely to provide useful and correct knowledge to Tony. In addition, Tracy can clearly explain to Tony what she hears from James when she meets FTF with Tony. Given that online direct and offline indirect ties address each other's limitations, they complement each other in affecting job performance. Thus, we hypothesize

H6: Offline indirect ties positively moderate the relationship between online direct ties and job performance.

Table 2 summarizes these mechanisms drawn from social networks research and literature on media characteristics used to relate network ties to job performance. In developing the hypotheses, we explained why different types of network ties are rated high or low along various mechanisms. We thus gain a better understanding of the independent and interdependent effects of different types of network ties on job performance.

Table 2. Mechanisms Related to Resources Access

Resource Characteristics	Offline Direct	Offline Indirect	Online Direct	Online Indirect
1. Maintenance cost	Low	High	Medium	High
2. Strong ties	High	Low	Medium	Low
3. Weak ties	Low	High	Medium	High
4. Network homophily	High	Low	Medium	Low
5. Network reach	Low	Medium	Medium	High
6. Information integrity	High	Low	High	High
7. Fast receipt of information	Medium	Low	High	Medium
8. Third-party surveillance	Low	High	Low	High
9. Resolving temporal and spatial constraints	Low	Low	High	High
10. Transmitting contextual information	High	Medium	Low	Low
11. Transferring information in parallel	Low	Low	High	Medium
12. Documenting and retrieving information	Low	Low	High	High

Method

In this section, we provide information about the participants, measurement, pilot study, and data collection procedure.

Participants and Data Collection

Our study was conducted in a Fortune 500 telecommunications company in the United States. Participants were knowledge workers, including software engineers, analysts, and technical leads from one business unit. Out of 120 questionnaires distributed, 104 were returned for a response rate of 87 percent, which is above the 80 percent response rate threshold in network studies (Kleiner 2002; Lesser and Prusak 2004). Of the respondents, 34 were women, with age ranging from 25 to 60 (M = 38.55 years, SD = 10.22 years). We checked for nonresponse bias and found no significant differences in demographics between respondents and nonrespondents.

We asked the manager of the business unit to give us the names of all the employees in the business unit to create a roster that was then used to collect the social network data. Specifically, we asked employees to respond to questions about other employees on the roster. Such a roster-based approach to social network data collection is common and is the preferred method to ensure that the respondents can readily remember all members of the network (Wasserman and Faust 1994). In addition, we used a whole network design to improve the reliability of network data (Marsden 1990; Scott 2000; Venkataramani and Dalal 2007). Data were collected during normal business hours and the participants were asked to return the completed survey within a week. Reminders to complete the survey were sent to all of the participants every day throughout the week. Also, the company allowed participants to fill out the survey during the work day. The average time to fill out a survey was about an hour (including additional filler questions, such as various personality traits). Incentives of $50 for completed survey responses were offered to all participants to maximize response rate. Supervisor-rated job performance of the respondents was obtained from organizational archives.

Measurement

Online and Offline Network Ties

We capture an employee's direct ties by counting the number of immediate contacts the employee has in the communication network in the business unit. With respect to indirect ties, we counted the number of contacts to whom an employee was tied at path distances (i.e., count of the minimum number of ties between two employees) of two or greater, accounting for the weakening or decay in tie strength between two employees as the path distances grow (Ahuja 2000; Burt 1991). In the Appendix, we explain the details related to the calculation of direct and indirect ties. Using a roster of all employees, we separately measured each employee's overall communication network ties (i.e.,online network ties and offline network ties). Online communication refers to any

communication via email, instant messenger, mobile text messaging, audio conference, or video conference. Offline communication refers to face-to-face communication. One item was used to gather data about each network because using multiple items would be too demanding and would result in respondent fatigue and poor response rate (e.g., Marsden 1990; Venkataramani and Dalal 2007). Online communication was measured using the question: "On average, I communicate with this person online…" Offline communication was measured using the question: "On average, I communicate with this person offline…" Participants were asked to respond to these questions using a Likert-type scale ranging from 1 to 5 (1 = less than once a month, 2 = once a month, 3 = once a week, 4 = once a day, 5 = many times a day). Participants were asked to skip individuals with whom they did not interact. Although we used a five-point scale, social network analysis generally uses dichotomous ties within a network (i.e., 0 = no tie; 1 = tie) based on communication frequency. A tie exists if there is regular interaction between two individuals. If communication frequency is 3 or greater, there is a tie, and no tie otherwise. The cutoff point of 3 indicates communication at least once a week and can be regarded as a regular activity of the employee (Scott 2000).

Job Performance

Job performance was obtained using a five-item scale that was used in the organization (see Appendix). The scale is adapted from prior research (e.g., Kraimer et al. 2005; Welbourne et al. 1998) to focus on overall effectiveness. The data were gathered from the supervisor of each of the participating employees. The use of supervisor rating of employee job performance is consistent with prior research (e.g., Cross and Cummings 2004; Sparrowe et al. 2001). The supervisor ratings on these five items were aggregated and reported as a final rating ranging from excellent (7), very good (6), good (5), acceptable (4), needs improvement (3), to varying levels of probation (2, 1).

Control Variables

We included gender (coded as men = 0), organizational tenure, rank, computer experience (i.e., years of using computer), computer self-efficacy, and conscientiousness as control variables (see Appendix). Gender, organizational tenure, and rank have been included in prior social network research that examines individual performance (Cross and Cummings 2004; Mehra et al. 2001). We include computer experience and computer self-efficacy because they may influence individuals' ability to leverage their online network resources to accomplish their jobs. We include conscientiousness because this personality trait is a consistent predictor of individual performance (Tett and Burnett 2003). We used a four-item, seven-point scale computer self-efficacy measure adapted from Venkatesh et al. (2003). We used a short (five-item) version of the ten-item, seven-point scale conscientiousness measure developed by Gosling et al. (2003).

Pilot Study

We conducted a pilot study among students. Although it would have been ideal to conduct the pilot study (also) in an organization, the major practical constraint facing all primary social network studies (i.e., need for a site where we could obtain a response rate over 80 percent to a network survey) precluded the same. Participants in the pilot study were sophomores in an undergraduate biology course. We invited all 55 students in the class to participate and 52 (24 women, between 17 and 23 years of age) of them filled out our surveys for a response rate of 95 percent, which is above the 80 percent response rate threshold necessary for network studies (Wasserman and Faust 1994). We checked for nonresponse bias and found no significant differences in demographics between respondents and nonrespondents.

We coordinated with the instructor of the class to obtain the names of the students to create the roster. Data were collected toward the end of the semester but before the final exam. To increase participation, we offered incentives of $10 for participation. In the pilot study, we examined students' course performance, which is an index of individual performance in this context, as the dependent variable. Course performance was measured using students' course grades (measured on a 100-point scale) provided by the instructor of the course. As the study proceeded without any problems, the pilot study provided evidence that our data collection procedure was appropriate, and the questionnaire was clear and understandable. It took a little over an hour, on average, to complete the survey and, based on the feedback we received from participants, we concluded that it was important to communicate the time it takes to complete the survey to set appropriate expectations about the time commitment, especially because our survey was longer than a typical survey. In their open-ended comments regarding the survey, participants noted that they appreciated the honesty about the survey length compared to other surveys that promised a reward but took much longer than suggested. In terms of results, the pattern of correlations among variables was as expected and our model was supported.

Results

We examined reliability, convergent validity, and discriminant validity of the scales. Results of the principal component analysis with oblimin rotation indicated that the loadings of multi-item scales (i.e., computer self-efficacy, conscientiousness, and job performance) were adequate because loadings were greater than .70 and cross-loadings were .20 or less, supporting convergent validity and discriminant validity. Table 3 shows the loadings and cross-loadings. Table 4 presents the Cronbach's alphas, descriptive statistics, and correlations. As shown in Table 4, offline direct ties, offline indirect ties, online direct ties, and online indirect ties were significantly correlated with job performance in the expected direction. Overall network ties measured without differentiating online and offline networks (i.e., direct ties and indirect ties) were significantly correlated with job performance.

We tested our model using hierarchical regression analysis. The results of the baseline models are presented in Table 5. Direct network ties ($\beta = .16$, $p < .05$) influenced job performance but indirect network ties did not ($\beta = .04$, $p > .05$). The inclusion of network ties explained more variance in job performance compared to a model with control variables only ($R^2 = .15$ versus .20), thus supporting the idea that network ties explain variance in job performance beyond what is explained by individual characteristics (i.e., gender, tenure, rank, computer experience, computer self-efficacy, and conscientiousness).

Table 6 presents the results of our model test (i.e., distinguishing online and offline networks). A main effects model that incorporated control variables (i.e., gender, tenure, rank, computer experience, computer self-efficacy, and conscientiousness) and main effects (i.e., offline direct ties, offline indirect ties, online direct ties, and online indirect ties) explained 25 percent of the variance in job performance. Specifically, offline direct ties ($\beta = .23$, $p < .001$), online direct ties ($\beta = .14$, $p < .05$), and online indirect ties ($\beta = .13$, $p < .05$) predicted job performance. But the relationship between offline indirect ties and job performance was not significant ($\beta = .02$, $p > .05$). Thus, hypotheses 1(a), 1(b), and 2(a) were supported but hypothesis 2(b) was not supported. Compared to the model without differentiating online and offline networks (model 2, Table 5), the model differentiating between online and offline networks (model 2, Table 6) explained more variance in job performance ($R^2 = .25$ versus .20).

To test the hypothesized interaction effects, we created interaction terms. Following guidelines outlined by Aiken and West (1991), offline direct ties, offline indirect ties, online direct ties, and online indirect ties were standardized prior to creating the interaction terms to reduce collinearity between the main effects and interaction terms. We checked for multicollinearity of our predictors and the VIFs were all less than 5, indicating there were no significant multicollinearity problems. As Table 6 indicates, all interaction effects, except offline direct ties × online indirect ties ($\beta = -.07$, $p > .05$) and offline indirect ties × online direct ties ($\beta = -.03$, $p > .05$), were significant. Thus, hypotheses 1(c), 2(c), 3, and 4 were supported but hypotheses 5 and 6 were not supported. The variance explained by the interaction model was 40 percent, an increase of 15 percent over and above the main effects model, thus indicating that the interaction model explained substantially more variance in job performance than the main effects only model did.

To better understand the pattern of the interaction between four types of network ties, we plotted the significant interactions by following Aiken and West's guidelines. Figure 4 shows the plots of the four significant interactions. As we can see, the best scenarios (i.e., highest performance) were (1) having a large number of direct and indirect ties in the offline network, shown in Figure 4(a); (2) having a large number of direct and indirect ties in the online network, shown in Figure 4(b); (3) having a large number of direct ties in both the online and offline networks, shown in Figure 4(c); and (4) having a large number of indirect ties in both the online and offline networks, shown in Figure 4(d). In the first scenario, we tested the slopes of the lines representing offline indirect ties at one standard deviation below and above the mean. Based on a t-test, both slopes were found to be significantly different from zero and the difference between the two slopes was also significant, indicating job performance varied across employees with a different number of direct and indirect offline ties. We did the slope test for the other scenarios and the pattern of the results was similar in that the slopes were different from zero and different from each other.

Discussion

This research seeks to advance our understanding of the impact of technology on employee job performance. We drew from social network theory and specifically examined how network ties, conceptualized as direct and indirect ties, in online and offline workplace communication networks influence job performance. The impact of technology is demonstrated by separating an employee's workplace communication network into offline and online networks that respond to suggestions in prior research that such a distinction may be

Table 3. Factor Loadings

	1	2	3
CSE1	**.84**	.10	.13
CSE2	**.83**	.04	.17
CSE3	**.80**	.03	.13
CSE4	**.74**	.08	.15
CON1	.08	**.82**	.14
CON2	.03	**.71**	.12
CON3	.04	**.77**	.12
CON4	.02	**.74**	.04
CON5	.09	**.80**	.03
PER1	.13	.03	**.80**
PER2	.14	.04	**.75**
PER3	.12	.02	**.71**
PER4	.12	.07	**.73**
PER5	.20	.05	**.86**

Notes: CSE = computer self-efficacy; CON = conscientiousness; PER = job performance.

Table 4. Descriptive Statistics and Correlations

	Mean	S Dev	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Gender (0: men)	.33	.47	NA												
2. Tenure	8.44	4.20	-.23***	NA											
3. Rank	3.20	1.15	-.29***	.34***	NA										
4. Comp. experience	8.24	4.21	-.13*	.17*	.15*	NA									
5. Comp. self-efficacy	4.22	1.11	-.19**	.19**	.16*	.30***	.82								
6. Conscientiousness	4.31	1.18	-.09	.15*	.20**	.05	-.02	.71							
7. Direct ties	9.44	4.66	.14*	.13*	.07	.07	.06	.05	NA						
8. Indirect ties	16.01	7.98	.18**	.14*	.04	.05	.08	.04	.14*	NA					
9. Offline direct ties	10.26	4.20	.17*	.13*	.02	-.14*	-.15*	.03	.20**	.13*	NA				
10. Offline indirect ties	16.42	7.75	.20**	.15*	.05	-.13*	-.16*	.04	.12*	.21***	.19**	NA			
11. Online direct ties	8.61	5.12	.13*	.13*	.06	.22***	.25***	.02	.19**	.10	.17*	.08	NA		
12. Online indirect ties	15.60	8.20	.15*	.12*	.03	.23***	.23***	.07	.13*	.22***	.08	.17*	.22***	NA	
13. Job performance	5.13	1.09	-.19**	.15*	.14*	.10	.05	.17*	.25***	.23***	.31***	.13*	.20**	.20**	.74

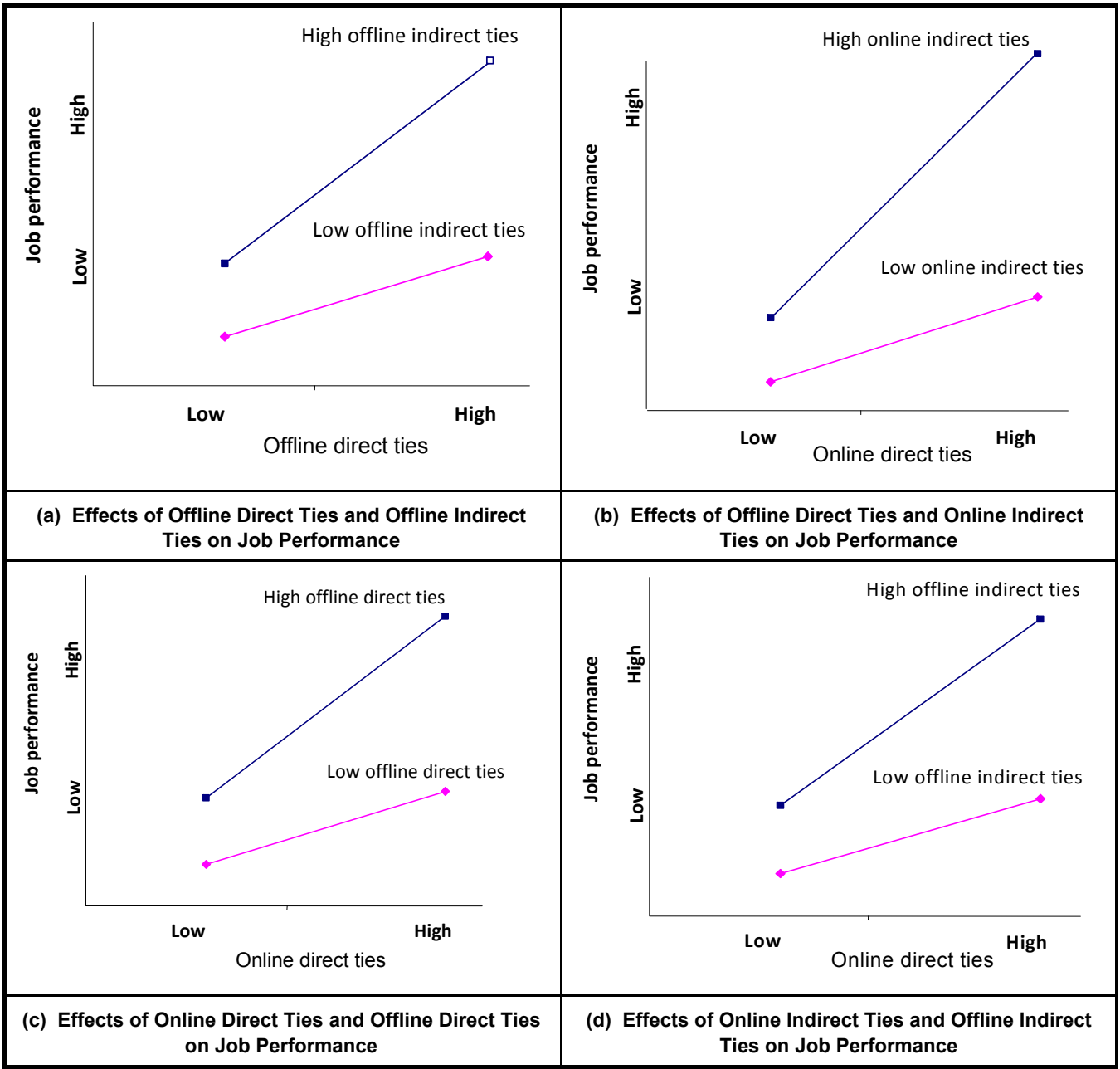
Notes:
1. n = 104.
2. Cronbach's alphas are shown on the diagonal.
3. *p < .05; **p < .01; ***p < .001

Table 5. Explaining Job Performance: Baseline Models		
	Model 1	**Model 2**
R^2	.15	.20
ΔR^2		.05*
Control variables		
Gender	-.13*	-.11*
Tenure	.02	.04
Rank	.06	.03
Computer experience	.06	.01
Computer self-efficacy	.04	.01
Conscientiousness	.30***	.14*
Network ties main effects		
Direct ties		.16*
Indirect ties		.04

Notes: *p < .05; **p < .01; ***p < .001

Table 6. Explaining Job Performance: Proposed Model Test			
	Model 1	**Model 2**	**Model 3**
R^2	.15	.25	.40
ΔR^2		.10**	.15***
Control variables			
Gender	-.13*	-.10*	-.07
Tenure	.02	.01	.01
Rank	.06	.02	.01
Computer experience	.06	.01	.01
Computer self-efficacy	.04	.01	.00
Conscientiousness	.30***	.13*	.10*
Main effects			
Offline direct ties		.23***	.11*
Offline indirect ties		.02	.02
Online direct ties		.14*	.06
Online indirect ties		.13*	.03
Interaction effects			
Offline direct ties × offline indirect ties			.15*
Online direct ties × online indirect ties			.16**
Online direct ties × offline direct ties			.14**
Online indirect ties × offline indirect ties			.17**
Online indirect ties × offline direct ties			-.07
Online direct ties × offline indirect ties			-.03

Notes: *p < .05; **p < .01; ***p < .001



(a) Effects of Offline Direct Ties and Offline Indirect Ties on Job Performance

(b) Effects of Offline Direct Ties and Online Indirect Ties on Job Performance

(c) Effects of Online Direct Ties and Offline Direct Ties on Job Performance

(d) Effects of Online Indirect Ties and Offline Indirect Ties on Job Performance

Figure 4. Interaction Plots

of theoretical and practical importance (see Butler 2001; Cummings et al. 2002; Koh et al. 2007; Wellman 2001). We found that online direct, online indirect, and offline direct ties were significantly related to job performance. It is important to note that distinguishing between network ties in online and offline networks explained more variance in job performance compared to a unitary conceptualization of network ties, thus indicating that a nuanced conceptualization of network ties (i.e., distinguishing between online and offline networks) is better than the traditional, unitary conceptualization of network ties. We also found support for four of the six proposed interaction effects, thus underscoring the importance of complementarity across the different types of network ties in predicting job performance. Our proposed model, which included interaction terms to represent the complementarities across online and offline networks, explained 40 percent of

the variance in job performance, a 15 percent improvement over the main effects only model and a 20 percent improvement over the model that employs a traditional unitary conceptualization of network ties.

Theoretical Implications

This work contributes to research in several ways. First, this work adds to the body of knowledge related to IS success (DeLone and McLean 1992, 2003; Rai et al. 2002). Although individual-level net benefits have been studied in prior research, much of this work has focused on task-level performance (e.g., Hong et al. 2004) or individual job satisfaction (e.g., Joshi and Rai 2000). Our research examines the impacts of technology on job performance and thus expands our understanding of IS success. This responds to continuing calls in much prior research to extend the nomological network beyond the techno-centric outcomes typically studied in IS research (see Thong 1999; Venkatesh et al. 2003; Venkatesh et al. 2012). Specifically, we used social network theory to enrich our understanding of the impact of ICTs on job performance. The incorporation of social network theory helps better understand the impacts of technology on job performance. Social networks act as conduits for resource exchange such that the more network ties employees have, the more likely they can leverage ICTs to enhance job performance. By integrating social network theory into IS research, we open the black box of understanding the interdependent role of social factors and technology factors in affecting job performance. Our paper demonstrates how the interplay of technology and social networks affects job performance. Future research should further explore the interdependent role of technology and social factors by examining different social and technology factors (e.g., the interdependent role of management support and technology use in affecting job performance) to advance both IS and management research.

Related yet distinct from the first contribution is the second contribution of this work: to enrich our understanding of ICT impacts on performance. Prior research on ICTs has mainly focused on understanding performance differences between FTF and virtual communication, mostly in the context of teams performing certain types of tasks (e.g., Alge et al. 2003; Galegher and Kraut 1994; Straus and McGrath 1994; Tan et al. 1998; Weisband et al. 1995). Specifically, the communication effectiveness of both channels has been compared along various dimensions of communication capabilities (e.g., support of synchronicity) and different communication requirements (Dennis et al. 2008). Likewise, researchers have focused on ICT impacts at the macro-level (e.g., Devaraj and Kohli 2003; Rai et al. 2006; Straub et al. 2004; Thong et al. 1997; Wareham et al. 2005). Complementing prior work that has examined performance at the team and firm levels, this research examines the broader impacts of ICTs on individual-level job performance. This paper illustrates how ICTs affect employees' job performance, underscoring the importance of understanding the intersection of technology and social networks that could be further explored by future researchers. For example, future research should examine how technology can be designed to affect other social network properties, such as tie strength and awareness of others' areas of expertise. When organizations understand how ICTs affect job performance, they are likely to develop better strategies related to ICT investment and utilization. Overall, examining job performance enriches our understanding of the downstream impacts of ICTs, which is of great value to both researchers and practitioners.

Third, this research brings insights from complementarity theory to extend our understanding of social network theory in explaining job performance. Although prior research found a relationship between the extent to which an individual is connected to others in a network and job performance (e.g., Cross and Cummings 2004; Sparrowe et al. 2001), it did not distinguish across the broad type of media and consequent types of communication networks (online and offline). Drawing on complementarity theory and adapting the same to understand an individual-level phenomenon, this paper explains how individuals' different online and offline network ties can be viewed as complementary resources that affect job performance. The idea of distinguishing between direct and indirect ties as well as online and offline networks can be applied to gain a better understanding of other important organizational behaviors. The complementary role of direct and indirect ties and online and offline networks suggests future research should conceptualize their independent and interdependent effects in understanding other organizational behaviors, such as employee job satisfaction, organizational commitment, knowledge sharing, and socialization. For example, it may be that having a larger number of offline direct ties would make employees more satisfied with their jobs than having a large number of offline indirect ties because contextual information, such as emotions, can be better transferred via FTF meetings and gaining adequate emotional and social support is likely to make employees more satisfied with their jobs.

Finally, the current research provides a nuanced conceptualization of networks to gain a better understanding of network phenomena. This research identifies and underscores

the conceptual differences between direct and indirect ties in online and offline workplace communication networks. A rich understanding of the conceptual differences between direct and indirect ties in online and offline communication networks were key to understanding how they are related to job performance through different mechanisms that play an important role in affecting an individual's capability to obtain the resources in online and offline workplace communication networks. Distinguishing between different types of network ties also provides future researchers with an opportunity to develop an in-depth understanding of various phenomena. Future research may further explore the interdependent role of the four network ties by examining their three-way or even four-way interactions to gain an understanding of the best network structure.

Limitations and Future Research

First, although this research indicates the importance of incorporating technology into social networks research to understand job performance, our understanding of the impact of technology can be refined. In this research, we consider technology as a whole without differentiating across various communication technologies that could, in practice, play out differently in terms of effects on job performance. Therefore, future research should examine how the effects of different technologies (e.g., synchronous versus asynchronous) would vary so as to further our understanding of the impact of technology (see Dennis et al. 2008) on job performance. Future research should also study job performance in times of organizational change as a result of technology implementations, for example, knowledge management system (KMS) implementation. As an example, we can apply the network paradigm (Borgatti and Foster 2003; Lin 2001) to understand how social networks affect KMS use and subsequent job outcomes, such as job performance and job satisfaction. Such an understanding using a social network lens would be an important contribution to the IS, organizational change, and social networks literatures. With regard to offline communication, we only consider FTF communication and exclude telephone communication, which has sometimes been considered to be akin to offline communication (e.g., Wellman et al. 2001). We chose to omit it because it is also noted to be different from FTF communication in terms of capabilities of transmitting multiple cues and supporting personal focus (Dennis et al. 2008). It is also possible that telephone communication could be online communication because it is technology-mediated. Thus, there is some lack of clarity regarding how to categorize telephone communication. Regardless, telephone communication is important and we acknowledge this limitation and call for future work to investigate this. One approach to address this limitation will be to draw on frameworks related to communication media (e.g., Dennis et al. 2008; Maruping and Agarwal 2004) to study the impacts of different types of networks based on different media.

Second, we only examined one structural property of the network (i.e., direct and indirect ties) on job performance. There are other structural properties, such as structural holes and network constraints, that could affect job performance. Likewise, we only studied employees' communication networks. There are other types of networks, such as friendship networks, that could affect job performance. A friendship network indicates mutual liking or similarity of attitudes between individuals (Mehra et al. 2001). For example, if two employees are close friends, it is likely that they can offer timely assistance to each other. An awareness network indicates the extent to which individuals know whom to seek out for information or expertise relevant to their tasks (Cross and Cummings 2004). Not knowing other employees' expertise may result in accessing information that is not useful. Therefore, future studies should include other types of networks and compare their differential effects on job performance.

Finally, future research should apply a more sophisticated approach (not only communication frequency) to collect network data. For example, future research can examine various types of communication, such as work-related advice or social support. Likewise, future research should collect data about how employees leverage different networks, especially for those who are central in both online and offline networks. Do they make complementary use of both networks or treat both networks as just alternatives for communication? This will result in a richer understanding of the complementary or substitutive role of both networks. Although our study found a significant correlation between network ties and job performance, it is perhaps premature to conclude a causal relationship between network ties, especially the nuanced conceptualization, and job performance because the relationship is not necessarily unidirectional. Future research should employ a longitudinal approach or a qualitative approach to gain further insights about the causal structure related to network ties and job performance.

Practical Implications

As organizations rely more and more on ICTs for distributed work, they must leverage ICTs effectively and maximize the

benefits it can bring, such as enhancing job performance. Although organizations find it difficult to truly reap the benefits of ICTs, limited research has sought to solve this puzzle. Our research provides explanations regarding how the impact of ICTs on job performance is transferred via communication networks in that employees who have a large number of direct and indirect contacts in both online and offline networks are more capable of acquiring and leveraging useful resources to enhance their job performance. In light of this understanding, organizations should consider the role of social networks in maximizing the benefits of ICTs. When employees develop their offline networks, they may want to expand their online networks as well because employees may not be able to resolve all the problems using FTF meetings. In this case, employees may switch to online communication, an approach that is unbounded by the temporal and spatial constraints. When interacting with others via online networks, employees are more likely to leverage the benefits of ICTs. However, using only online networks may not be sufficient. Although using online networks provides a lot of benefits, such as fast receipt of information and information integrity, it may not be adequate for employees to understand complex knowledge that is likely to be transferred via offline networks. Therefore, to truly realize the benefits of ICTs, employees need to develop both online and offline networks. The implication for organizations is that they should encourage employees to create more ties so as to leverage the benefits of ICTs. Organizations should promote the creation and sustenance of both online and offline workplace communication networks by encouraging employees with no or a small number of ties to interact with other employees through socialization activities. This complements prior social networks research that has made useful suggestions for organizations to enhance job outcomes (e.g., nurturing value-creating interactions or engaging employees through community efforts; Cross et al. 2006), because our study helps organizations understand the differences between different types of networks (i.e., online and offline networks) and the strengths and weaknesses of different types of network ties in terms of accessing resources. Also, managers should attend to employees with few or no ties because these employees may not be able to take advantage of ICTs to access information and resources. Such employees should be particularly targeted to receive more formal support, such as personalized training, that is designed to enhance their job performance.

Our research also informs employees striving to enhance their job performance. Our study indicates that it is important that employees are well connected both in the online and offline workplace communication networks because these networks provide channels for them to access valuable resources. More importantly, online and offline networks provide channels to access resources that are complementary. Leveraging the complementary resources will achieve the best performance. If organizations can train or educate employees to reflect on their network structures (e.g., how well they are connected in online and offline networks and the benefits and limitations of their network ties), employees are more likely to alter their network structures in a way that will help them better leverage resources. We illustrate this using Figure 2(b). If Sean can be helped to understand the limitations of not being connected in the online network, he is more likely to develop online ties that can then contribute positively to his job performance. Understanding the different mechanisms underlying the impacts of the four types of network ties would help organizations educate their employees to develop more effective strategies to enhance job performance. For example, employees can increase the number of offline direct ties by expanding their direct offline contacts because the increased direct ties are likely to ease the transfer of complex knowledge. Likewise, employees can develop communication structures (e.g., use of online direct or indirect ties) that reduce the time to receive assistance or feedback when needed. An effective network structure not only allows individuals to get access to useful resources, but also makes them receive such resources without delay that can together contribute favorably to job performance.

As an emerging organizational form to reduce costs and achieve competitive advantage, virtual teams, distributed teams, and telecommuting have become increasingly popular. These organizational forms intensively use technologies to accomplish one or more organizational tasks. However, growing evidence indicates that meeting strategic or operational objectives in virtual environments is tremendously challenging. Prior research has indicated the inadequacies associated with online communication and the importance of FTF meetings for virtual workers to function effectively (Hill et al. 2009; Maznevski and Chudoba 2000). Our research provides further insights from the social network perspective to help such workers as well. We not only acknowledge the importance of both online and offline communication media, but also illustrate the strengths and limitations of different types of online and offline network ties, thus gaining a better understanding of how to leverage different types of network ties to enhance performance. For example, when employees need to transfer complex knowledge, it could be more effective if they leverage their online direct ties because employees communicating directly generally have a high degree of homophily and stronger relationships that ease the transfer of complex knowledge. When employees work on projects that require innovation, it could be more effective if they leverage

their online indirect ties that could help them get access to diverse and new information, which is key to innovation (e.g., Ahuja 2000).

Conclusions

Our study contributes to research that seeks to understand the impact of technology on employees' job performance. Drawing from social network theory and complementarity theory, we develop a better understanding of the role of technology in explaining job performance by distinguishing between online and offline workplace communication networks. In particular, this paper conceptualizes online and offline workplace communication network ties as resources and theorizes about the complementary effect of these resources on job performance. We thus enrich our understanding of how the network mechanisms (i.e., accessibility to and control over resources) affect job performance. Further, our research advances social networks research by bringing insights from complementarity theory, and developing a more nuanced conceptualization of communication network ties and their independent and interdependent effects on job performance.

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RESEARCH ARTICLE

EXPLAINING EMPLOYEE JOB PERFORMANCE: THE ROLE OF ONLINE AND OFFLINE WORKPLACE COMMUNICATION NETWORKS

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Appendix

Measures

Online and offline network ties (adapted from Baldwin et al. 1997)

Please answer the following questions about your interactions with your coworkers.

In general, which of the following persons in the list do you contact for help or advice with your work (related to your work tasks and not administrative activities). Please leave the row blank if you do not interact with that person at all. Online communication refers to any communication via e-mail, instant messenger or mobile text messaging, audio or video conference. Offline communication refers to face-to-face communication.

	On average, I communicate with this person **online…**					On average, this person communicates with me **online…**				
	Less than once a month	Once a month	Once a week	Once a day	Many times a day	Less than once a month	Once a month	Once a week	Once a day	Many times a day
Name 1	1	2	3	4	5	1	2	3	4	5
…	1	2	3	4	5	1	2	3	4	5
Name N	1	2	3	4	5	1	2	3	4	5

	On average, I communicate with this person **offline…**					On average, this person communicates with me **offline…**				
	Less than once a month	Once a month	Once a week	Once a day	Many times a day	Less than once a month	Once a month	Once a week	Once a day	Many times a day
Name 1	1	2	3	4	5	1	2	3	4	5
…..	1	2	3	4	5	1	2	3	4	5
Name N	1	2	3	4	5	1	2	3	4	5

Computer self-efficacy (seven-point Likert Scale) (Venkatesh et al. 2003)
I could complete a job or task using the system…
- ○ if there was no one around to tell me what to do as I go.
- ○ if I could call someone for help if I got stuck.
- ○ if I had a lot of time to complete the job for which the software was provided.
- ○ if I had just the built-in help facility for assistance.

Conscientiousness (seven-point Likert Scale) (Gosling et al. 2003)
I…
- ○ am always prepared.
- ○ pay attention to details.
- ○ make plans and stick to them.
- ○ waste my time.
- ○ find it difficult to get down to work.

Job performance (seven-point Likert Scale) (adapted from Kraimer et al. 2005; Welbourne et al. 1998)
Please rate your subordinates along the following dimensions:

Quality of work.
Quantity of work.
Technical competence.
Working as part of a team or work group.
Help others when it is not part of his/her job.

Computer experience (Venkatesh et al. 2003)
Please indicate amount of computer experience you have in years: _____

Rank (Mehra et al. 2001)
Which of the following best describes your position in this company:
1. junior manager
2. middle manager
3. senior manager
4. non-managerial employee

Tenure (Cross and Cummings 2004; Mehra et al. 2001)
Please indicate the number of years you have been working for this company: _____

Gender (Cross and Cummings 2004; Mehra et al. 2001)
Male ☐ Female ☐

Network ties
A communication network can be seen as a set of employees and the ties or linkages between them, where the ties represent communication between employees. The online network examines employees' online communication and the offline network examines their offline communication. The frequency of communication is indicated by values ranging from 1 to 5, where 1 indicates minimum communication (less

than once a month) and 5 indicates maximum communication (many times a day). Social network analysis is generally concerned with dichotomous ties within a network, either being present (1) or absent (0). In order to illustrate actual communication networks and not incidental contact with other members of the company, we only show the existence of a link (1) between two individuals when the strength of their communication is 3 or above. A score of 3 indicates communication at least once a week and can be regarded as a regular activity of the employee (Scott 2000).

Direct ties (Freeman 1979)
Direct ties were calculated using the UCINET 6.0 software used in network analysis (Borgatti et al. 2002) for online and offline networks respectively. Direct ties measure the number of employees with whom an individual is directly connected (Freeman 1979). The focal individual can either be the source or object of the connection. In-degree ties include only those links in which the focal individual is the object of the connection. In other words, only when other employees indicate that they would communicate with the focal individual, such links/ties would be counted. To reduce self-report bias, we use in-degree ties that were operationalized as the number of times an individual was chosen by coworkers on the communication roster. The in-degree ties of a focal individual k can be denoted as:

$$C_D(P_k) = \sum_{i=1}^{n} a(P_i, P_k)$$

where $a(P_i, P_k) = 1$ if and only if are connected by a line and 0 otherwise.

Indirect Ties (Ahuja 2000)
The number of contacts an individual has in the communication network with path distances greater than one, accounting for the weakening or decay in tie strength between two individuals that are connected by increasingly large path distances. A weight factor will be assigned to each indirect tie based on the number of steps in-between the indirect ties such that larger weight will be assigned to an indirect tie with fewer steps. The weight factor is expressed as: $1-[f_i/(N+1)]$, where f_i is the total number of contacts an employee can reach at path distance i, and N is the total number of contacts an employee can reach in any number of steps. For example, if an individual has 2 direct ties, 3 two-step ties and 5 three-step ties, the weight factor for each direct tie will be 1-2/11 = 9/11 (N=10, i.e., 2+3+5), 1-3/11 = 8/11 for each two-step ties and 1-5/11 = 6/11 for each three-step ties. Therefore, the weighted count of indirect ties for this hypothetical individual is 3(8/11) + 5(6/11) = 54/11.

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