# NETWORK DIVERSITY AND SOCIAL COHESION IN CREATIVE PERFORMANCE: A VIEW OF COMMUNICATION MEDIA MIX

*Completed Research Paper*

**Yi Wu**
National University of Singapore
Kent Ridge, Singapore, 117418
wuyi@nus.edu.sg

**Klarissa Chang**
National University of Singapore
Kent Ridge, Singapore, 117418
changtt@comp.nus.edu.sg

## Abstract

*Creative performance is a fundamental form of knowledge creation in knowledge intensive organizations. While some studies emphasize the importance of diversity on creative performance, others argue for the role of socially cohesive groups with strong third-party connections. To address the gaps in the literature, this study examines the influence of three attributes of dyadic ties (i.e., network diversity, social cohesion, and communication media mix) on creative performance. From the knowledge, social and technology perspectives, we empirically tested our model using a social network methodology with dyads working on knowledge intensive tasks. The results suggest that network diversity is positively associated with creative performance, and moderate level of social cohesion is preferred for creative performance. The findings also show that the influence of social cohesion on creative performance is weakened by the degree of communication media mix. Implications for research and practice are discussed with respect to creativity in organizations.*

**Keywords:** Creative performance, network diversity, social cohesion, communication media mix

# Introduction

Creative performance is one form of knowledge creation and an organizational resource that competitors cannot imitate (Wu et al. 2012). It is reflected by the ability of individuals in organizations to generate creative ideas (Simonton 1988) and can be conceptualized as "creativity" (Amabile et al. 1996). Research on creativity has attracted much attention from an individual level, including one's network structural positions (Cattani and Ferriani 2008; Perry-Smith 2006; Tortoriello and Krackhardt 2010) and demographics (Thatcher and Brown 2010). From an organizational level, previous studies have examined the effects of team composition, network density and network range (Baer 2010). Despite the importance of individual and organizational levels, they do not provide an explanatory mechanism to determine how an individual learns from each other (Borgatti and Cross 2003). Social networks are not actual physical entities. Knowledge resources are held by network participants, and such resources flow through ties between sources and recipients at the dyadic level (Carpenter et al. 2012). While acknowledging the benefits of the network structural perspective (e.g., structural holes and bridging tie) (Burt 1992; Tortoriello and Krackhardt 2010), little attention has been given to the relational perspective of dyads in terms of the conditions where such structural positions become conducive to creativity.

From a relational perspective, one way to improve creative performance between dyads is through network diversity. Network diversity refers to the extent to which focal ties cross different knowledge domains (Reagans and McEvily 2003). Sources with greater network diversity are more likely to act as cognitive catalysts that ignite creative performance between sources and recipients. The benefits of network diversity have been emphasized (Sosa 2011; Thatcher and Brown 2010; Wu et al. 2012) because creative performance is the result of a novel combination of new and useful knowledge. From a knowledge viewpoint, network diversity facilitates the convergent process of generating creative ideas (Amabile et al. 1996) in which a pair of individuals is more likely to perform creatively when they can access diverse knowledge domains from each other (Fleming et al. 2007).

On top of the ability to leverage diverse knowledge in generating creative ideas, the willingness to devote time and effort to share knowledge should not be taken for granted in organizations. Such willingness can be formed through social cohesion, which indicates the presence of strong third-party connections around a focal dyad (Reagans and McEvily 2003). Research studies have shown that the presence of third-party connections makes it easier for individuals to generate creative ideas by enhancing knowledge transfer and shared understanding towards problems (Obstfeld 2005; Tortoriello and Krackhardt 2010). From a social viewpoint, social cohesion is beneficial for the divergent process of generating creative ideas (Ford 1996) in which individuals think about different ideas/solutions based on the shared understanding towards problems.

Network diversity focuses on the benefits associated with network connections that span distinct domains, whereas social cohesion stresses the value of overlapping ties among mutual third parties. Although both network patterns have been linked to the flow of knowledge, they are often viewed as being in opposition. The benefits of social cohesion are believed to be at the expense of the benefits from network diversity and vice versa. However, recent work indicates that the two network forms may not be inherently at odds. Instead, an optimal network combines both elements of diversity and cohesion (Reagans et al. 2004). Based on motivation-opportunity-ability theories of behavior (Blumberg and Pringle 1982), network diversity enables individuals with the abilities to generate creative ideas, and social cohesion provides the motivations for exchanging knowledge. Even with the existing of diverse knowledge between appropriately motivated recipients and sources, the process of knowledge transfer is not feasible because of the lack of opportunity to access to each other regard of temporal or spatial issues.

Technology advances have brought together pairs of individuals to work on a plethora of tasks regardless of temporal and spatial boundaries. Both synchronous media (e.g., face-to-face meeting, video conferencing) and asynchronous media (e.g., email and Google Docs) have been widely used in organizational works. The mix of different communication media is another factor that would significantly impact creative performance in dyads by providing access opportunities from technology support for transferring knowledge. Different media would exhibit different levels of media synchronicity and impact knowledge sharing differently in terms of information transmission and processing (Dennis et al. 2008). Although some research suggests that there is potential process losses when using different types of media

(Dennis et al. 2001), the process losses that occur as a result of communication media mix may actually be beneficial when the end result is a creative product. Therefore, this study deliberates the influence of communication media mix. Adapting from Thatcher and Brown (2010) and drawing on media synchronicity theory (Dennis et al. 2008), communication media mix is defined as the extent to which asynchronous communication is used relatively to synchronously communication.

In this study, network diversity provides resources from a knowledge viewpoint, social cohesion ensures the willingness to interact from a social viewpoint, and communication media mix provides opportunities for such interaction from a technological viewpoint. Arising from the knowledge gaps identified previously, we examine how creative performance is achieved in dyads from the three viewpoints by addressing the following research questions:

RQ1. How does network diversity impact on creative performance among dyads?

RQ2. How does social cohesion impact on creative performance among dyads?

RQ3. How are the relationships between network diversity, social cohesion, and creative performance contingent on communication media mix?

This research provides significant theoretical contributions. First, it helps in the understanding of creative performance between individuals in dyads by integrating different theoretical perspectives (i.e., theories of network diversity, social cohesion, dual coding and media synchronicity). Second, an extension and improvement is contributed to existing social network literature by investigating the overall strength of third-party connections in association with creativity. Third, we conceptualize communication media mix among one of the few studies based on dual coding and media synchronicity theories, and examine its moderating effects; this allows us to uncover the technological mechanism of how the attributes of dyads affect creative performance. More importantly, it calls for more significant theoretical attention to the network relational perspective at a dyadic level in studies investigating the nuances of social networks and knowledge creation in organizations.

The study also provides significant practical contributions. Organizational managers would be encouraged to form creative teams by recruiting employees with diverse expertise domains. The research findings could assist in providing insights on the configuration of team members with an appropriate level of diverse and common knowledge. The study could provide useful guidelines on team building from a social cohesion perspective in terms of sub-team cliques. In addition, organizational employees would benefit from how to utilize appropriate communication media when they seek knowledge to solve challenges in their work. Finally, technology designers could learn suggestions on how to design organizational systems from this study.

## Theoretical Foundations

### Social Networks and Creative Performance

Creativity is increasingly important for organizations not only for short-term benefits but also for development of new and interesting products and services that will enable them to survive over the long term (Oldham and Cummings 1996). Generating creative ideas is often the result of novel combinations of different perspectives that individuals are exposed to via social interaction (Allen 1977). Social interactions are defined as the transfer of information between the source who is sending information and the recipient who is receiving information (Sosa 2011).

There are three basic stages in social interaction: (1) knowledge acquisition of the recipient from the source; (2) the recipient's processing of that knowledge; and (3) the recipient's realization of the potential value of the interaction outcome (Reagans and McEvily 2003). Processing knowledge that yields creative ideas has been the subject of studies that adopt a cognitive psychology perspective in studying creativity (Simonton 1988). Within this context, creative ideas are associated with the occurrence of two distinct sets of cognitive processes: generation of creative ideas and evaluation of the generated ideas to select the ones suitable for further pursuit. This model is consistent with the "blind-variation and selection-

retention" model of creative thought by Simonton (1988). As the recipient evaluates the ideas after interacting with the source, that recipient is able to realize the novelty and usefulness of the ideas. We rely on the recipient to assess the novelty and usefulness of his/her ideas because we focus on the generating of creative ideas before the ideas are exposed to the public for further evaluation. This structure is especially pertinent to team work involving problem solving, where individuals have a common understanding of the knowledge domain. Ideas are potentially valuable, and there is a sound awareness of the criteria that would categorize an idea as novel and useful. Nonetheless, it is important to recognize that what the recipient considers potentially creative may not necessarily be considered creative by others. Therefore, the theoretical arguments and results presented in this paper must be considered in the light of the generative aspect of creativity.

In a reflection of insights from the social interaction, scholars have recently begun to identify the social network parameters that shape creativity at work (Burt 2004; Fleming and Waguespack 2007; Granovetter 1973; Perry-Smith 2006; Tortoriello and Krackhardt 2010). Past research on creativity has studied the factors that make some individuals more creative than others from structural hole theory (Burt 2004) and weak tie theory (Granovetter 1973). It is recognized that an individual's network structure influences the ability to develop creative outcomes (Sosa 2011). Several studies have examined how network structure relates to the creation and implementation of potential creative outcomes (Burt 2004; Fleming and Waguespack 2007; Granovetter 1973; Perry-Smith 2006; Tortoriello and Krackhardt 2010). While these studies contribute to existing literature on social networks, they do not provide an explanatory mechanism relating to what an individual learns about each other in knowledge transfer (Borgatti and Cross 2003). As generation of creative ideas is a process attained through social interaction (Allen 1977; Czikszentmihalyi 1996), investigating creativity from an individual perspective ignores the content differences of each interaction. Similarly, examining creativity from an organizational perspective treats each interaction as a black box. This calls for research attention by looking at each interaction that an individual conducts with another individual, i.e., a dyadic perspective.

A fast-growing body of research has shown that the characteristic of a social interaction influences an individual's ability to access, transfer, absorb, and apply knowledge. Therefore, a dyad constitutes an ideal unit of analysis to disentangle the factors that help in creativity. However, not all dyadic relationships are equally good catalysts in the generation of creative ideas. Thus, it is necessary to examine precisely how the attributes of a specific dyadic exchange affect creative performance. This study investigates creative performance by looking at three key dyadic attributes: network diversity, social cohesion and communication media mix.

## *Network Diversity and Creative Performance*

In the convergent process of creativity (Amabile et al. 1996), individuals bring diverse knowledge together to build personal thinking and solutions. The cognitive resource theory suggests that network diversity will improve creative performance, since individuals will have access to a wide array of views, skills, and information (Perry-Smith and Shalley 2003). Exposure to a wide range of perspectives is especially important when one is interested in the development of creative products and ideas (Garfield et al. 2001). Previous research on creativity has suggested that accessing diverse pools of knowledge to establish novel linkages among them is an important condition to the generation of creative outcomes (Fleming et al. 2007; Simonton 1999). Additionally, network diversity makes it possible for dyadic individuals to learn from each other, and this learning in turn enables them to generate more novel and useful ideas in the future (Fliaster and Schloderer 2010).

Individual-level analyses have emphasized the value of accessing diverse knowledge through ties with diverse groups of people, which overlooks the possibility that ties that cross diverse network may also facilitate generation of creative ideas (Sosa 2011). From a knowledge viewpoint, an individual with a portfolio of dyadic interaction that conveys diverse knowledge is expected to be highly proficient at generating creative ideas. Network diversity favors the convergent process of creative performance, in which a pair of individuals is more likely to generate creative ideas when they have access to diverse knowledge from each other.

### Social Cohesion and Creative Performance

The weak tie theory (Granovetter 1973) may predict that a weak tie performs better than a strong tie in creative work due to the access to diverse knowledge from structural networks. However, Krackhardt (1992) and Sosa (2011) emphasize the strength of strong tie in creative performance. To address the conflicting findings in past research, it is interesting to examine the situation where tie strength comes in third-party connections around a focal tie. Simmel and Wolff (1950) argued that network size does not fundamentally change the impact of a network on behavior, rather, the change from a dyad to a triad or a larger network changes an individual's behavior. Their approach argues for the fundamental importance of third-party connections around the focal dyads. Third-party connections and triads provide the contextual background that can change the meaning or importance of the dyads embedded within them.

Social cohesion, the extent to which dyads are surrounded by third-party connections (Krackhardt 1998), offers opportunities for social support, knowledge sharing across boundaries, and increased cognition of social ties and knowledge sources (Ho and Chang 2009). It facilitates the formation of mutual understanding and the pursuit of common goals by mitigating competition and self-interest. This is important because informational advantages can be limited if the parties involved act opportunistically and avoid sharing sensitive knowledge with each other (Tortoriello and Krackhardt 2010). Third-party connections increase the stability of dyadic relationships by reducing dissension and facilitating conflict resolution. The increased stability promotes the formation of common knowledge and shared understanding towards problems among the individuals involved, enabling them to overcome interpretive barriers and achieve successful integration of different perspectives (Carlile 2004).

From a social viewpoint, social support may be fostered extrinsically when dyads spend more time and energy in transferring knowledge and working together. Social cohesion can affect the motivations of an individual to transfer knowledge to a coworker, although the source of that motivation differs. The willingness to assist others is reluctant because knowledge sharing is typically beneficial to the recipient but can be costly for the source. Despite the costs, the source's willingness to share knowledge represents the cooperative behavior and reputation (Granovetter 1985). The fostering of a collaborative environment is favorable to innovation involvement (Obstfeld 2005) from the cooperative norms and reputation (Reagans and McEvily 2003). Such an environment eases the transfer of knowledge (Reagans and McEvily 2003), limits selfish behavior and promotes open knowledge sharing (Tortoriello and Krackhardt 2010), as well as fosters risk sharing of creative ideas around the focal dyad (Granovetter 1985) .

### Communication Media Mix and Creative Performance

Media synchronicity theory (MST) (Dennis et al. 2008) focuses on communication performance, particularly on the ability of the media to support synchronicity for an improved performance. Media synchronicity is defined in MST as "the extent to which the capabilities of a communication medium enable individuals to achieve synchronicity", with synchronicity being "a state in which individuals are working together at the same time with a common focus". Synchronous or asynchronous communication has long been recognized as an important factor affecting interpersonal communication. Some media are used synchronously, so that all communication participants are communicating at the same time (e.g., face-to-face communication, video conference). Others are typically used asynchronously so that participants do not work together at the same time (e.g., email, fax).

The second theoretical perspective we draw upon to understand the relationship between communication media mix and creative performance is dual coding theory (DCT). DCT posits that individuals learn and retain information through both verbal and nonverbal systems (Clark and Paivio 1991). In reality, individuals present and receive information in multiple ways; the mix of different media usage allows us to process different facets of information in a variety of ways (Massey and Montoya-Weiss 2006). Thus, receiving information through different types of media not only influences how one receives information but affects how one perceives information and influences the amount of time one engages in communication-related activities (Thatcher and Brown 2010). For instance, interaction via asynchronous media (e.g., email) allows a recipient more time to ponder the information, while communication via synchronous media (e.g., video conferencing) provides rich cues to explain/deliver knowledge, especially for diverse knowledge. However, individuals who use asynchronous media usually exert greater cognitive efforts and experience more communication ambiguity and/or information inaccuracy that lead to greater

creativity (Thatcher and Brown 2010). Creative solutions to problems have sometimes been developed as the result of accidents or misunderstandings. Moreover, studies in cognitive psychology have shown that when individuals do not have all the information they need to make a conclusion, they "fill in the blanks" based on their individual knowledge base (Kock 2007).

Creative performance is achieved through both the convergent route which requires individual thoughts, as well as the divergent route which requires shared understanding with others (Scheidel 1986). Use of both asynchronous and synchronous media might impact on the two processes of creative performance. Therefore, we conceptualize communication media mix as the extent to which asynchronous communication is used with respect to synchronous communication between individuals. Creativity does not occur in isolation, but is a result of social interaction among individuals with technological support and appropriate communication media mix. Faraj and Spoull (2000) demonstrated that work performance was a function of access to knowledge rather than the mere presence of expertise or willingness to exchange. This suggests that the presence of "who knows what" and "willingness to exchange" need to be supported by technology accessibility to obtain actual expertise.

## Model and Hypotheses

Based on the preceding foundations, this study proposes a research model (see figure 1) for investigating creative performance among dyads. The model suggests that network diversity, social cohesion and communication media mix are predictors of generation of creative ideas.

The effect of network diversity is grounded in the role of cognitive variations in generating creative ideas (Simonton 1988). As cognitive variation depends on the existence of knowledge elements that can be combined into new feasible variations in the mind of the recipient, the number and breadth of cognitive elements acquired by the recipient from the source are essential factors in the generation of creative ideas (Simonton 1999). Furthermore, diverse knowledge acquired by a recipient usually introduces ambiguity and misunderstandings to that recipient, due to the limited capacity of that recipient. Creative ideas to problems have sometimes developed as the results of accidents or misunderstandings (Thatcher and Brown 2010). Therefore, we hypothesize that:

> H1: Network diversity is positively associated with creative performance among dyads.

The benefits of network cohesion have been associated with the fostering of a collaborative environment favorable to innovation involvement (Obstfeld 2005), due to the reputation and cooperative norms (Reagans and McEvily 2003). Such an environment eases the transfer of knowledge (Reagans and McEvily 2003), limits selfish behavior and promotes open and complete knowledge sharing (Tortoriello and Krackhardt 2010), as well as fosters risk sharing around the focal dyad (Granovetter 1985). The presence of third-party connections can foster the extrinsic motivations for the individuals to engage more closely and spend more time and energy in the work interaction. This could foster the collaborative conditions to generate creative ideas (Obstfeld 2005). Furthermore, social cohesion supports to form shared understanding toward the problems and challenges in the divergent process of creative performance. Therefore, we propose that:

> H2: Social cohesion is positively associated with creative performance among dyads.

Individuals' creativity has been improved by the use of multiple communication media (Wu et al. 2012; Yuan et al. 2010). The knowledge transfer for generating creative ideas between individuals needs to be supported by technology accessibility (Faraj and Sproull 2000). Use of multiple media provides dyads with the benefits of each communication medium in an integrated way, and provides more choices for individuals in media selection (Yuan et al. 2010). Asynchronous interaction allows individuals to have more time and space to process knowledge exchanged, and such a situation makes them denote time and efforts to information processing for generating creative ideas. Otherwise, synchronous interactions via high level of synchronicity push individuals to response and narrow the space for personal thinking. Also, the ambiguity during the communication process cannot be diminished in low levels of synchronicity, because of the low feedback of media capabilities. Furthermore, individuals who use asynchronous media usually exert greater cognitive efforts and experience more communication ambiguity and/or information

inaccuracy that lead to greater creativity (Thatcher and Brown 2010). Creative solutions to problems have sometimes developed as the result of accidents or misunderstandings. Therefore, we predict that:

> H3: The degree of communication media mix is positively associated with creative performance among dyads; that is, dyads engaging in proportionally more asynchronous communication will have higher level of creative performance than dyads engaging in proportionally more synchronous communication.

Network diversity provides individuals with diverse knowledge pools. Work performance was a function of access to knowledge rather than the mere presence of expertise, it means that presence of "who knows what" needs to be supported by technology accessibility to obtain actual access to that expertise. Therefore, the impact of network diversity on creative performance is contingent on the technology accessibility.

The capability of symbol sets from synchronous media provides a number of ways to encode information, for instance, verbal and non-verbal formats (Dennis et al. 2008). Especially for diverse knowledge, the source needs to express the knowledge in multiple formats in order to convince the recipient, for example, voice, text, body gesture. Physical, visual, and verbal symbol sets from synchronous media are fast to encode, facilitating turn-taking and coordination and making interactions faster (Williams 1977). Furthermore, high capability of feedback from synchronous communication ensures that the diverse knowledge from the sources is exact what the recipients need to process for solving the challenges. Therefore, use of synchronous communication facilitates the exchange of diverse knowledge between individuals. Thus, we describe that:

> H4: The degree of communication media mix will weaken the relationship between network diversity and creative performance.

The effect of social cohesion on creative performance is the implicit assumption that social cohesion enhances exposure to knowledge that is not only different from the actor's own but that is also fundamentally different from each other. Indeed, the ability of the networks to stimulate creativity is dependent upon the ability of such networks to deliver enhanced access and exposure to diverse pockets of knowledge (Baer 2010). However, social cohesion by no means guarantees the entry into different networks. Therefore, the technology capability from communication media mix supports the access to knowledge from social cohesion.

Social cohesion fosters the extrinsic motivations for the individuals to engage more closely and spend more time and energy in the work interaction to generate creative ideas (Obstfeld 2005). The amount of social and nonverbal cues found in synchronous communication probably enhances the formation of the motivations. For instance, individuals prefer to spend more time discussing in face-to-face meeting instead of writing an email. On the other hand, individuals feel responsible to exchange and contribute more with others in a rich environment, especially for these strongly connected individuals. Therefore, we posit that:

> H5: The degree of communication media mix will weaken the relationship between social cohesion and creative performance.
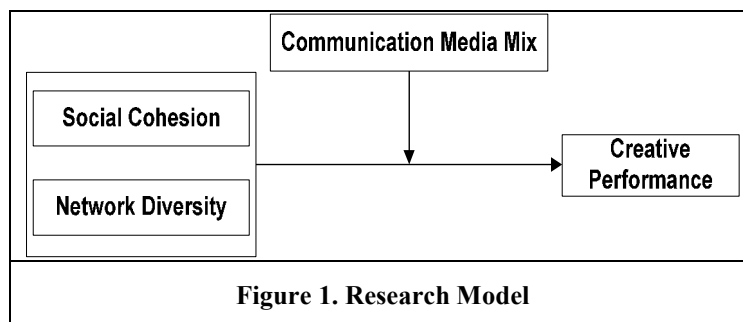


**Figure 1. Research Model**

# Methodology

## *Research Setting*

This research context includes knowledge intensive dyads in a large academic institution located at South East Asia. The participants were students in a university course, which required them to participate in knowledge intensive tasks (e.g., developing a social media application, preparing a business proposal). Preliminary interviews with the instructors, observation, and existing documentation confirmed that the tasks in this setting would suffer from a lack of creative ideas. Students could discuss work in face-to-face as well as via technology-mediated communication, e.g., email, instant message (i.e., Gtalk, MSN), and Google Docs. Since students were not constantly in physical contact, but frequently communicated with each other, it was important for them to have access to multiple communication tools.

Responses were received from 72 of 79 students with 38 males, resulting in a 91.14% response rate. With a network size of 448 complete responses, we attained more than the minimum 80% participation rate needed for network studies (Scott 2000). Demographic data was collected from their class rosters. The sample included a heterogeneous mix of educational backgrounds, with students from computer science (20%), information systems (35%), social science (10%), business (20%) and engineering (15%) departments 53% of them were males. Demographics were comparable between the sample (n=72) and the entire class (n=79). Thus, these demographic checks generally suggested that the sample was representative of the entire class and was not biased toward a particular demographical factor.

## *Survey Procedures*

Prior to data collection, the course instructors sent an email to publicize this study and encouraged the participation. This was followed by an email from the researchers to invite the students to be in the paper-based survey, along with the date for the questionnaire distribution. A reminder was sent one week later.

Network data was collected in classical sociometric techniques (Wasserman and Faust 1994). First, each student was provided with a fixed roster of contacts formed by the 79 students in the study. The full name of each student was clearly specified in the paper-based survey, and students were asked to select those they had "gone to" for interactions that significantly affected their works (Burt 1984). The name generator used an "information seeking" perspective to ensure consistency throughout the survey, because all the relational questions would be formulated from the recipient's viewpoint. In addition, the focus was on the interaction that affected works in order to concentrate the hypothesis testing on those ties that were more likely to be associated with the generation of creative ideas. This approach did not appear to lead respondents to omit a significant number of less important ties. Records related to the seven non-respondents were deleted in the data of the final survey, because we measured variables from the recipient's perspective at the dyadic level.

## *Construct Measurements*

Following the norms of social network studies (e.g., Shah 1998), this study utilized single-item measurement to capture network variables. Although there are generally well-known benefits of multi-item scales, they are not feasible in a network study where data on relationships is gathered alongside multiple dimensions for many actors in a network. Prior research has found the combination of roster methodology and single-item measurement to be reliable (Marsden 1990). Freeman et al. (1987) found network questions to be highly reliable when respondents are inquiring about typical interaction patterns. Therefore, considering the risk of respondents dropping out of our survey if there were an excessive number of relational questions, we chose to use a single item to measure each variable.

*Creative performance* captures the extent to which it is easy for the recipient to generate creative ideas associated with his/her interaction with the source in a dyad (Sosa 2011). Instead of evaluating the number of creative ideas, we focused on the recipient's ease of generating creative ideas with the source. This measurement is consistent with previous studies on knowledge transfer at the dyadic level, which relies on the recipient of the dyad to assess the ease of transferring knowledge to the source (Reagans and

McEvily 2003). The ease of generating creative ideas was captured by asking each respondent to rate, on a binary scale ("disagree", or "agree"), his/her agreement with "When I interact with this person, it is easy for me to generate new and useful solutions and/or ideas related to what I do" (Tortoriello 2005).

*Tie strength* has two components: communication frequency and emotional closeness (Granovetter 1973). Communication frequency is how frequently individuals speak with each other, and emotional closeness is the level of emotional affect associated with the interaction. Unfortunately, emotional closeness network data was not available. Thus, we follow other network researchers in using communication or interaction frequency as a measure of tie intensity (Reagans and Zuckerman 2001; Uzzi 1999), though we encourage future researchers to consider emotional closeness as well. Respondents were asked to indicate the average frequency of knowledge exchange on work-related issues with each source on a four-point scale ("rarely", "less than once a week", "once a week", and "more than once a week") (Umphress et al. 2003). We treated this communication frequency as tie intensity ($\mathbf{IN}_{ij}$: tie intensity from $i$ to $j$). Then, we measured tie strength ($\mathbf{TS}_{ij}$) as the proportion of the recipient $i$'s total interaction invested in the relationship with source $j$, both as a result of $i$'s seeking out $j$ and of being sought out by $j$. This approach is consistent with previous network studies that transform tie intensity into a proportional measure of tie strength (Reagans and McEvily 2003; Sosa 2011). This proportional measure of tie strength allows us to capture how the focal actor $i$ allocated his/her time and attention to the different people with whom she interacted on work-related matters during the interaction. Hence:

$$TS_{ij} = \left( \frac{IN_{ij} + IN_{ji}}{\sum_q (IN_{iq} + IN_{qi})} \right); i \neq j.$$

*Social cohesion* is a function that depends on the number and tie strength of third-party connections surrounding the focal dyad. Following Burt (1992) and Reagans and McEvily (2003), our indicator of social cohesion is indirect structural constraints $\mathbf{SC}_{ij}$,

$$SC_{ij} = \sum_{q=1}^{N} TS_{iq} \times TS_{qj}, q \neq j,$$

where $N$ stands for the number of third-party connections around $i$ and $j$.

*Network diversity*. We considered the importance of network diversity at the level of expertise area. Each expertise area is a distinct pool of knowledge. A tie that crosses multiple knowledge pools is exposed to more diverse knowledge. The indicator of network diversity is knowledge diversity, which is the extent to which the dyads share different types knowledge across distinct domains (Sosa 2011). It was measured: "I think the knowledge received from this person is different to me," on a four-point Likert scale ("strongly disagree", "disagree", "agree" and "strongly agree").

*Communication media mix* is to determine how often dyads engage in asynchronous communication relatively to synchronous communication. Respondents were asked to indicate the frequency at which each medium was used to communicate with each individual on a four-point scale ("rarely", "less than once a week", "once a week", and "more than once a week"). The media included face-to-face meetings, email, instant message (i.e., Gtalk, MSN) and shared documentation systems (i.e., Google Docs). For each medium usage matrix ($\mathbf{M}$), $\mathbf{M}_{ij}$ was set as "1" if individual $i$ used the medium to communicate with individual $j$ at least once a week, otherwise, it was set as "0" (Sykes et al. 2009). Following Dennis et al. (2008), email and Google Docs are categorized as asynchronous media while interactions through face-to-face meetings and instant message belong to synchronous communication. Then, we calculated communication media mix as the ratio of asynchronously media to synchronous media. In the interaction work, one medium is dominant but accompanied by complementary use of other media as (Watson-Manheim and Bélanger 2007). Face-to-face meeting is weekly used herein among individuals as a regulation from the class instruction. Therefore, the value of communication media mix ranges from "0" (i.e., all communication is taken synchronously) to "2" (all technology-mediated communication is taken asynchronously).

*Control variables*. Given the potential to confound the hypothesized relations, the following were included as control variables. First, we examined social category characteristics to induce responses such as in-group biases and conflict (Thatcher and Brown 2010) in terms of race difference and gender difference. *Race difference* as a cultural issue had been shown to influence the communication process (Cummings 2004). It was measured by the differences in nationality, where "1" indicated that individuals

in the dyad come from different races and"0" for the same race. *Gender difference* was constructed by the differences in sex, where "1" indicates that two individuals are with different sexes and "0" from the same sex. Second, we examined informational characteristics that are underlying attributes of individuals (such as work experience and education) which, although not immediately detectable, are important in the completion of a task (Jehn et al. 1997). *Education difference* was captured by the differences between their studying years in university, and the studying years include "freshman", "sophomore", "junior" and "senior". For instance, education difference between "freshman" and "senior" was coded as "3". We introduced "*work difference*" to control the effect of work efforts, and it was measured by the differences between amounts of work hours each spent together with the other on works. Finally, we treated *pre-existing networks* as a control variable, through a self-reported item, namely: "How many projects have you worked on with this person", ranging from "0" to "3".

# Empirical Results

## *Preliminary Analyses*

Network studies do not usually assess the measurement model as model variables are measured as single items and each network question addresses specific persons in a network. Table 1 provides the descriptive and correlation statistics for all variables used in our study, including the control variables. We have a sample of 448 dyads with complete information. The table consists of minimum, maximum, mean, and standard deviation values for each variable in the sample described in the survey data. It can be seen from table 1 that correlation results show significant correlations between the dependent variable (i.e., creative performance) and the key independent variables, i.e., knowledge diversity (0.16, p<0.01), social cohesion (0.26, p<.01) and communication media mix (0.18, p<.01). The high significant correlations between others variables (e.g., knowledge diversity, tie strength, social cohesion) are due to the interdependence of network variables, resulting from non-independent observations (Umphress et al. 2003).

| Table 1. Descriptive and Correlation Statistics | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **Min** | **Max** | **M** | **SD** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| 1. Gender difference | 0 | 1 | 0.39 | 0.49 | -- | | | | | | | | |
| 2. Race difference | 0 | 1 | 0.14 | 0.34 | -0.01 | -- | | | | | | | |
| 3. Education difference | 0 | 2 | 0.47 | 0.54 | 0.09* | -0.05 | -- | | | | | | |
| 4. Work difference | 0 | 18 | 3.40 | 4.10 | -0.02 | 0.05 | 0.01 | -- | | | | | |
| 5. Pre-existing network | 0 | 3 | 0.87 | 1.14 | -0.08 | -0.09 | -0.07 | -0.13** | -- | | | | |
| 6. Tie strength | 0.03 | 0.57 | 0.14 | 0.06 | -0.01 | 0.12* | -0.13** | -0.19** | 0.35** | -- | | | |
| 7. Network diversity | 1 | 4 | 3.12 | 0.78 | 0.04 | 0.04 | -0.01 | 0.01 | 0.15** | 0.21** | -- | | |
| 8. Social cohesion | 0 | 0.22 | 0.08 | 0.04 | 0.02 | 0.11* | -0.14** | -0.19** | 0.16** | 0.56** | 0.14** | -- | |
| 9. Communication media mix | 0 | 2 | 1.02 | 0.65 | -0.05 | 0.05 | -0.10* | -0.05 | 0.03 | 0.25** | 0.19** | 0.47** | -- |
| 10. Creative performance | 0 | 1 | 0.79 | 0.41 | -0.07 | -0.21** | -0.01 | -0.08 | 0.23** | 0.23** | 0.16** | 0.26** | 0.18** |
| *Notes.* *<0.05, **<0.01, (two-tailed). | | | | | | | | | | | | | |

## *Hypothesized Model*

Although we have an enough sample of 448 dyads, there are specific attributes of the observations that make the data analysis as a nontrivial task. On one hand, because the dependent is binary, a logit regression model was used as the main statistical approach. On the other hand, and more important, our unit of analysis is at the dyadic level, and so the non-independent sample violates an important

assumption underlying most regression models. Because groups of observations share the same recipient or the same source, their error terms are likely to be correlated. There are several solutions to the problem, one solution is to introduce a fixed effect for each source or recipient of a dyad (Mizruchi 1989). Following this technique, we created a dummy variable for each person who received or sent a tie within a particular dyad; the dummy variables for the focal respondent and the focal contact were set equal to one and all other dummy variables were set equal to zero. The fixed effects estimation also serves as a control for any unobserved heterogeneity among the respondents (e.g., age, education), including any tendency for respondents who rated themselves high on creative performance to inflate their popularity. Next, the fixed effects also control for unobserved differences among contacts, including their cognitive ability to absorb knowledge and diversity cognition. Finally, we estimated robust standard errors clustered by individual recipient to control the lack of independence among observations (Wooldridge 2002). Clustering standard errors by the source yields substantially similar results. This effectively models how the hypothesized effects explain variation in the dyadic dependent variable while controlling for any unobserved heterogeneity among actors (Reagans and McEvily 2003; Sosa 2011). Regression results are depicted in table 2.

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 | Model 9 | Model 10 | Model 11 | Model 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Table 2. Regression Models of Creative Performance** | | | | | | | | | | | | |
| Gender difference | 0.08 (0.26) | 0.03 (0.10) | 0.15 (0.46) | 0.08 (0.24) | 0.03* (0.08) | 0.04 (0.11) | 0.39 (1.08) | 0.38 (1.08) | 0.25 (0.72) | 0.53 (1.32) | 0.09 (0.28) | 0.51 (1.37) |
| Race difference | -1.62* (2.18) | -1.51* (2.01) | -0.80* (1.33) | -0.58 (1.13) | -0.28 (0.48) | -0.78 (1.46) | -0.74 (0.93) | -0.88 (1.04) | -1.19* (1.50) | -1.67 (1.76) | -0.51 (0.76) | -1.70 (1.75) |
| Education difference | 0.23 (0.70) | 0.51 (1.39) | 0.21 (0.72) | 0.26 (0.80) | 0.50 (1.42) | 0.40 (1.10) | 0.19 (0.59) | 0.30 (0.86) | 0.22 (0.75) | 0.30 (0.89) | 0.51 (1.44) | 0.41 (1.21) |
| Work difference† | -0.93** (3.32) | -0.86** (2.83) | -0.80** (3.12) | -0.77** (2.87) | -0.64* (2.33) | -0.76* (2.34) | -0.97** (3.69) | -0.97** (3.15) | -0.86** (3.54) | -0.93** (3.54) | -0.70* (2.53) | -0.93** (2.98) |
| Pre-existing networks | 0.42* (2.41) | 0.35 (1.86) | 0.44** (2.65) | 0.38** (2.17) | 0.32 (1.87) | 0.35* (1.89) | 0.46* (2.43) | 0.43* (2.17) | 0.50** (2.95) | 0.49** (2.66) | 0.40* (2.22) | 0.46* (2.34) |
| Tie strength | 5.33* (1.97) | 4.91 (1.74) | 4.16 (1.61) | 2.67 (1.08) | 2.08 (0.86) | 2.72 (1.10) | 0.29 (0.70) | -0.02 (0.57) | 2.72 (0.91) | -0.62 (0.21) | 0.57 (0.20) | -0.94 (0.33) |
| Network diversity† | | 0.95* (2.25) | | | 0.91* (2.51) | 1.52* (2.35) | | 1.64** (2.71) | | 0.88* (2.40) | | 1.68** (2.86) |
| Network diversity×CMM | | | | | | -1.00 (1.55) | | -0.99 (1.58) | | | | -0.92 (1.42) |
| Social cohesion | | | 9.39 (1.69) | | 4.80 (0.80) | | 18.72** (2.88) | 21.89** (3.22) | 28.30** (2.79) | -24.92 (1.41) | 20.27* (1.98) | -24.58 (1.34) |
| Social cohesion × CMM | | | | | | | -15.10* (1.97) | -16.77* (2.13) | | 26.50 (1.82) | | 26.16 (1.71) |
| Communication media mix | | | | 0.83** (3.56) | 0.71** (2.88) | 1.84** (2.91) | 1.68** (3.16) | 2.76** (3.46) | | 0.68 (1.02) | 0.66** (2.73) | 1.67 (1.88) |
| Social cohesion sq | | | | | | | | | -144.00* (2.08) | 401.76* (2.38) | -113.32* (2.15) | 432.82* (1.71) |
| Social cohesion sq × CMM | | | | | | | | | | -316.32** (3.39) | | -330.79* (3.44) |
| Pseudo R² | 0.53 | 0.55 | 0.54 | 0.56 | 0.57 | 0.58 | 0.58 | 0.59 | 0.55 | 0.59 | 0.58 | 0.61 |

*Notes.* Robust standard errors are clustered by the recipient. Models included fixed effects for each source and recipient in any dyads. T-values are in parentheses. *<0.05, **<0.01, (two-tailed).
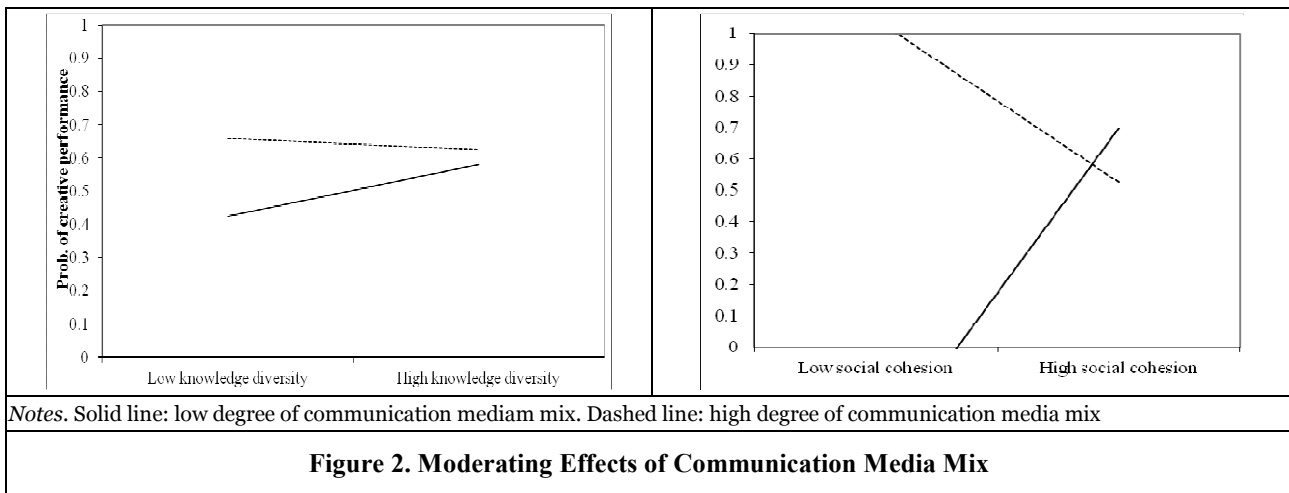CMM: communication media mix. Social cohesion sq: squared social cohesion.
†: logged values are used.

Estimates for the control variables are included in model 1. The results show that there isn't any significant relationship between gender difference, education difference and creative performance. However, individuals from different races are expected to be not good at thinking about creative solutions/ideas together. Individuals who spend almost the same efforts will be more likely to perform creative together. Pre-existing network between dyadic individuals is helpful for them to performance creatively, because it partially stands for the emotional closeness between the recipient and the source to work together. Contradictory with the prediction from strength of the weak tie theory, we found that tie strength with the source is positively related to the recipient's creative performance in dyads. One potential explanation is that tie strength is measured by the interaction frequency on the work-related issues.

Results from Model 2 ($\beta=0.95$, $t=2.25$, $p<0.05$) support hypothesis 1, so that dyads which cross distinct expertise domains are in high level of creative performance. Hypothesis 2 is tested in model 3 with a positive but not significant effect ($\beta=9.35$, $t=1.69$, $p>0.05$) of social cohesion on creative performance. Thus, hypothesis 2 is not supported. Model 4 is conducted to test hypothesis 3, and there is a significant positive relationship between communication media mix and creative performance ($\beta=0.83$, $t=3.56$, $p<0.01$). Thus, dyads engaging in proportional more asynchronous communication are in higher level of creative performance than dyads engaging in proportional more synchronous communication. To confirm the results from model 2, 3, and 4, we use model 5 to test all the hypotheses. The results confirm that hypothesis 1 ($\beta=0.91$, $t=2.52$, $p<0.05$) and hypothesis 3 ($\beta=0.71$, $t=2.88$, $p<0.01$) are supported while hypothesis 2 ($\beta=4.80$, $t=0.80 p>0.05$) is not.

In hypothesis 4, it was proposed that communication media mix would weaken the positive relationship between network diversity and creative performance. We did not find any significant evidence ($\beta=-1.0$, $t=1.55$, $p>0.05$) from model 6. Therefore, network diversity does not impact significantly differently on generating creative ideas in both asynchronous and synchronous communication. To further explore the moderating effect, we did an interaction plotting. As show in figure 2 (left side), the dashed line is always above the solid line, indicating that the impact of network diversity on creative performance is always larger at high level of communication media mix than at low level of communication media mix, but, the influence difference is not significant. Therefore, hypothesis 4 is not supported.

In hypothesis 5, it was predicted that communication media mix would weaken the positive relationship between social cohesion and creative performance. Model 7 indicates that the interaction of social cohesion and communication media mix ($\beta=-15.10$, $t=1.97$, $p<0.05$) has a significant negative impact on creative performance. We plotted the interaction effect. As show in figure 2 (right side), the highest probability of creative performance is found when social cohesion is high and communication media mix is low. Therefore, hypothesis 5 is supported, Model 8 confirms again that hypothesis 4 ($\beta=-0.99$, $t=1.58$ $p>0.05$) is not supported while hypothesis 5 ($\beta=-16.77$, $t=2.13$, $p<0.05$) is.



*Notes.* Solid line: low degree of communication mediam mix. Dashed line: high degree of communication media mix

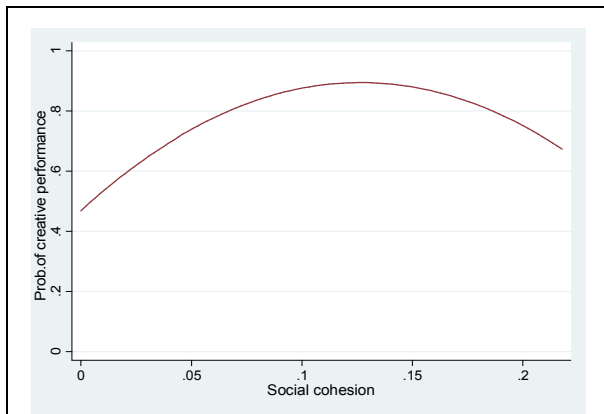**Figure 2. Moderating Effects of Communication Media Mix**

Based on these findings, it is interesting to obtain that the linear impact of social cohesion on creative performance in hypothesis 2 is not significant, whereas the interaction of social cohesion and

communication media mix (i.e., social cohesion in higher order) is significant. Furthermore, the linear impact of social cohesion becomes significant with the presence of the interaction term. Therefore, it is believed that the impact of social cohesion on creative performance follows certain concave trajectory. Theoretically speaking, social support is fostered extrinsically when the dyadic individuals experience social cohesion that encourages them to spend more time and energy to transfer knowledge and work together. However, when the social cohesion around a focal dyad is too strong, it maybe gives rise to information redundancy and imposes social constraints/pressures on individuals' divergent thinking (Tortoriello and Krackhardt 2010). Thus, we propose that there is an inverted U-shape relationship between social cohesion and creative performance among dyads.

To justify our proposition, we run model 9 by including social cohesion in both linear and quadratic terms. The linear term ($\beta$=28.30, t=2.79, p<0.05) and quadratic term ($\beta$=-144.00, t=2.08, p<0.05) are both significant. The results show that the holistic impact of social cohesion on creative performance follows an inverted U-shape trajectory in figure 3 (Aiken and West 1991). The plot depicts how the probability that the recipient agrees on whether it is easy or not to generate creative ideas after interacting with the source varies as a function of social cohesion. It shows a marginally positive effect of social cohesion on creative performance when social cohesion is no more than about 0.13; when it exceeds 0.13, the marginal effect is negative. Therefore, the moderate level of social cohesion is preferred among dyads.

Furthermore, it is necessary to consider whether the weakened moderating effect from hypothesis 5 still holds when there is an inverted U-shape relationship between social cohesion and creative performance. From model 10, the term "social cohesion sq × CMM" was significant ($\beta$=-316.32, t=3.39, p<0.05) (Aiken and West 1991). As shown in figure 4 the slope of solid line is always larger than the slope of the dashed line, meaning the marginal effect of social cohesion on creative performance is larger when in low degree of communication media mix than in high degree of communication media mix. The highest probability of creative performance of dyads is found when the social cohesion is high and the communication media mix is low. When social cohesion exceeding certain degree, it impacts more on creative performance when in low degree of communication media mix than in high degree of communication media mix. Thus the impact of social cohesion on creative performance is contingent on the degree of communication media mix among dyads. Therefore, the weakened moderating effect of communication media mix still holds when there is an inverted U-shape relationship between social cohesion and creative performance. Model 11 and model 12 together show that the results of hypothesis 1, hypothesis 3 and hypothesis 4 are stable, under the condition of inverted U-shaped relationship of social cohesion and creative performance.



**Figure 3. Social Cohesion on Creative Performance**
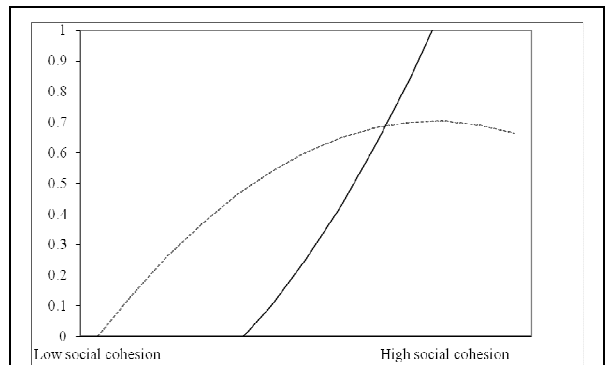


*Notes.* Solid line: low degree of communication mediam mix
Dashed line: high degree of communication media mix

**Figure 4. Moderating Effect of Communication Media Mix**

## Discussion

The results of the present study support not only the more nuanced approach to examining the arguments of network diversity and social cohesion from a relational structural perspective with respect to creative performance, but also the proposed technology support of communication media mix. The insights from

this work complement what we have learned from previous studies on creativity as a social phenomenon (Burt 2004; Fleming and Waguespack 2007; Perry-Smith 2006). According to Csikszentmihalyi (1996), creativity "does not happen inside people's heads, but in the interaction between a person's thoughts and a socio-cultural context". Instead of focusing on how the aggregated communication patterns of an individual contribute to his/her creative performance, this paper emphasizes that it becomes theoretically necessary to look at each specific interaction between individuals, and not all the dyadic interaction is equally important or useful for creative performance.

Consistent with previous research on creativity, our results show that network diversity assists in improving creative performance at the dyadic level. However, it is important to highlight that what positively influences creative idea generation is that there is diversity within the dyadic relationship itself. Having a diverse knowledge base acquired by engaging in distinct interactions with different sources does increase the generation of creative ideas (Fleming et al. 2007). Exposure to a wide range of perspectives is especially important when one is interested in the development of creative ideas (Garfield et al. 2001).

An important advantage of explicitly examining the effect of social cohesion is that it enables to examine the marginal affects that social factors have on creative performance. Instead of benefiting from increasing social cohesion, moderate level of it increases the stability of a dyadic interaction by increasing common knowledge and shared understanding (Krackhardt 1998), as well as ensures network diversity (Sosa 2011). This will be effective for individuals to generate creative ideas with the intrinsic motivations for knowledge sharing from social cohesion. However, when the focal dyad depends heavily on third-party connections to transfer knowledge between individuals, such a focal dyad may suffer from information redundancy and social pressure (Amabile 1996). The risk of receiving redundant information from the source increases to the extent that what the source knows is a function of her connections to common third parties, making the high level of knowledge similarity among them. In the extreme case, the social cohesion is such strong that everyone in the cliques are almost the same. On the other hand, social cohesion introduces social pressure to the individuals to pursuit common goals in Simmelian tie (Tortoriello and Krackhardt 2010). It makes the individuals to exploit the fastest and most efficient path to reach a solution, and hinders them to explore alternative paths to think about other creative ideas (Sosa 2011). Therefore, moderate level of social cohesion is preferred for generating creative ideas.

This study examines both the direct and moderating effects of communication media mix on creative performance. In fact, work performance benefits from technology accessibility which enables access to expertise (Faraj and Sproull 2000). By drawing on media synchronicity and dual coding theories, we acknowledge the benefits and importance to use both asynchronous and synchronous media. The integration of different communication media enables individuals to obtain different types of knowledge from different sources to generate creative ideas (Yuan et al. 2010). Receiving information through different types of media not only influences how one receives information but affects how one perceives information and influences the amount of time one engages in the activities (Thatcher and Brown 2010). Asynchronous communication allows a recipient more time to ponder the information, while synchronous communication provides rich cues and fast speed to explain/deliver knowledge. However, individuals, who use asynchronous media, usually increase creative performance from the greater cognitive efforts in thinking and experienced communication ambiguity and/or information inaccuracy (Thatcher and Brown 2010).

Further, social and technical mechanisms need to work mutually to produce optimal outputs, and a successful system is the result of a concurrent configuration of technical and social aspects of the environment (Bolstrom and Heinen 1977). The effect of knowledge presence is not contingent on level of communication media mix, instead that, the awareness and accessibility of such knowledge is supported by communication technology ability (Yuan et al. 2010). However, the social aspect of willingness to transfer knowledge is definitely interdependent on communication technology support. Extrinsic motivations and social supports from social cohesion are further enhanced in synchronous communication comparing to asynchronous communication. The amount of social and nonverbal cues found in synchronous communication probably makes individuals to collaborate more closely and interact more frequently, especially on private and sensitive issues. Strongly connected individuals will feel responsible to exchange and contribute more with others in the synchronous environment

# Conclusion

This paper examined the impacts of tie attributes on creative performance at the dyad level. From a knowledge viewpoint, increasing network diversity improves the creative performance. From a social viewpoint, increasing social cohesion favors the creative performance for low level of social cohesion, whereas increasing social cohesion hinders creative performance for high level of social cohesion. Moderate level of social cohesion is preferred by the recipient for creative performance during the interaction with the source. From a technical viewpoint, asynchronous media facilitates knowledge transferring, while synchronous media benefits information processing during the personal interaction. Therefore, a mix of asynchronous and synchronous media usage is suggested in the process of generating creative ideas.

## *Theoretical Implications*

This research provides significant theoretical contributions. It helps in the understanding of relational network aspects of creative performance between dyadic individuals by integrating different theoretical perspectives (i.e., theories of network diversity, social cohesion, dual coding and media synchronicity). Firstly, we made an extension and improvement to Simmelian tie theory by taking the overall strength of indirect connections into account. We deepened the understanding of Simmelian tie by finding that moderate level of social cohesion is perfectly preferred for creative performance between individuals. This enriches theoretical development for weak tie theory or strong tie theory. Secondly, be inconsistent from weak tie theory (Granovetter 1973), we measured tie strength by communication intensity between individuals, and propose to include emotional closes as well.

Thirdly, we explored the creativity issues by looking at the communication media used between individuals. Not only social aspect in term of tie attributes and network position influences creativity, also the technical system in terms of communication media use does. The research is one of the few studies to conceptualize communication media mix to uncover the technical mechanism of how the attributes of dyads affect work performance, based on dual coding and media synchronicity theories. Although Thatcher and Brown (2010) examined the effect of communication media mix on individual creativity, the communication media that they studied are asynchronous email, asynchronous voice mail and synchronous face-to-face meeting. The advanced technologies have enabled several media (e.g., video-meeting) to function as synchronously as face-to-face meeting. Therefore, we improve the existing literature by categorizing communication media into asynchronous and synchronous based on media synchronicity theory, and define communication media mix as the extent to which asynchronous communication is used relatively to synchronously communication.

Furthermore, creativity can be cultivated from the communication ambiguity or information inaccuracy in the asynchronous environment, as well as be improved from the building of shared understanding in the synchronous environment. Although knowledge diversity is always more helpful for generating creative ideas when knowledge is exchanged via asynchronous media than synchronous media, the influence differences are not significant. However, the impact of social cohesion on creative performance is interdependent on the communication media mix between the recipient and the source. When the recipient has more accessibility to asynchronous communication media, low level of social cohesion improve the recipient's creative performance during the interaction with the source. On the other hand, when the recipient has more accessibility to synchronous communication media, high level of social cohesion assists in generating creative ideas when the recipient interacts with the source.

Finally, this study initials the importance of the dyadic perspective in studies investigating the nuances of social networks in work teams. Individual perspective ignores the content differences of each interaction. Similarly, organizational perspective treats each interaction as a black box. Neither of them provides an explanatory mechanism relating to what an individual learns about each other in the knowledge transfer (Borgatti and Cross 2003). Therefore, a dyad constitutes an ideal unit of analysis to disentangle the factors in explaining phenomena in the social networks, because not all dyadic relationships function equally.

## *Practical Implications*

The findings provide important practical implications. For the organizational managers, firstly, they could put efforts in increasing new knowledge for the employees, for instance, organizing different training sections and workshops, to obtain knowledge diversity among them, especially for the R&D departments. One potential method, the job-rotation, is suggested for the purpose of maintaining a high level of network diversity among workers in a group. Secondly, to maintain moderate level of social cohesion, managerial guides should encourage employees to work together and form certain number of sub-team cliques, as well as spilt workload among employees to avoid too much interaction among. Accordingly, community of practice can be a useful tool to facilitate creative performance because it promotes shared contacts among the potential knowledge sources and recipients as well as the direct relationship between each dyad.

To date, organizations are relying more and more on team works, there are two main types of teams: fixed team and project-based team. In the fixed teams, because most of the team members have been working together for a certain period of time, the knowledge diversity is most likely to be low and social cohesion is probably high between any two of them. These team leaders can encourage the team members to leverage relative more proportionally synchronous communication (e.g., face-to-face meeting, video conferencing) for team work. In the project-based teams which usually exist for a short term, these team leaders should recruit team members with much diverse backgrounds and avoid high levels of co-participation among team members to retain certain level of knowledge diversity among team members. For such teams, the social cohesion between individuals is mostly at a low level, therefore, the team leaders can encourage the team workers to use asynchronous media, for example, email, fax and asynchronous message.

When it comes to the individual employee, firstly, he/she should seek knowledge or advice from those who have different expertise with him/her. Secondly, the interactions with those who share certain number of third-party connections with the focal employee will help the focal employee to solve challenges. The benefit from such an interaction will be amplified when the focal employee use asynchronous media. Finally, when the focal employee's ego network is closely connected (i.e., high level of social cohesion between the focal employee and any peer), the focal employee should use synchronous communication media to interact with others. For example, when in face-to-face meeting, individuals feel responsible to exchange and contribute more with others, especially for these strongly connected people.

Finally, this study also provides suggestions for the technology designers. Referring to the issues of communication cost, it is better for the technology designers to develop a single system with multiple options (e.g., text, voice, gesture language) for the users to choose from asynchronous and synchronous functions. An example is the implementation of intra-organizational collaborative tool. Then, employees save the time and efforts to switch among amount of media tools. Such design enables organizational employees to choose the communication functions based on justifications of knowledge diversity and social cohesion with the source when the work outcome is creative ideas.

## *Future Work*

Although this study provides important empirical evidences supporting the hypothesized arguments outlined in the theoretical framework, the nature of the data and the limitations imposed by the dyadic unit of analysis recommend caution when generalizing the findings. To name a few, we first utilized survey method to collect subjective data for network variables; there maybe are certain information losses due to response cost of network study. For example, subject may neglect some second important contacts. Therefore, a potential way to use objective data (e.g., logs of email exchanges) could be implied in future. Second, we did not measure the quality of generated ideas. We suggest that content analysis could be applied to assess the "ideas" in future work regarding of the dependent variables, such as uniqueness and diversity (Jung et al. 2012). However, our results provide some insights into the roles played by network diversity, social cohesion and communication media mix in enhancing creative performance, while also providing insights on the innovation process.

## Acknowledgments

## References

Aiken, L.S., and West, S.G. 1991. Multiple Regression: Testing and Interpreting Interactions. Sage Publications, Incorporated.

Allen, T.J. 1977. Managing the Flow of Technology. Cambridge: MIT press.

Amabile, T. 1996. Creativity in Context. West View Press, Inc., Boulder, CO.

Amabile, T.M., Conti, R., Coon, H., Lazenby, J., and Herron, M. 1996. "Assessing the Work Environment for Creativity," Academy of Management Journal (39:5), Oct, pp. 1154-1184.

Baer, M. 2010. "The Strength-of-Weak-Ties Perspective on Creativity: A Comprehensive Examination and Extension," Journal of Applied Psychology (95:3), p. 592.

Blumberg, M., and Pringle, C.D. 1982. "The Missing Opportunity in Organizational Research: Some Implications for a Theory of Work Performance," Academy of Management Review (7:4), pp. 560-569.

Bolstrom, R., and Heinen, J. 1977. "Mis Problems and Failures: A Social-Technical Perspective," Part (1), pp. 17-32.

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

Burt, R.S. 1984. "Network Items and the General Social Survey," Social Networks (6:4), pp. 293-339.

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

Burt, R.S. 2004. "Structural Holes and Good Ideas," The American Journal of Sociology (110:2), pp. 349-399.

Carlile, P.R. 2004. "Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge across Boundaries," Organization Science (15:5), pp. 555-568.

Carpenter, M.A., Li, M., and Jiang, H. 2012. "Social Network Research in Organizational Contexts a Systematic Review of Methodological Issues and Choices," Journal of Management (38:4), pp. 1328-1361.

Cattani, G., and Ferriani, S. 2008. "A Core/Periphery Perspective on Individual Creative Performance: Social Networks and Cinematic Achievements in the Hollywood Film Industry," Organization Science (19:6), pp. 824-844.

Clark, J.M., and Paivio, A. 1991. "Dual Coding Theory and Education," Educational Psychology Review (3:3), pp. 149-210.

Czikszentmihalyi, M. 1996. "Creativity: Flow and the Psychology of Discovery and Invention." New York: HarperCollins.

Dennis, A.R., Fuller, R.M., and Valacich, J.S. 2008. "Media, Tasks, and Communication Processes: A Theory of Media Synchronicity," MIS Quarterly (32:3), pp. 575-600.

Dennis, A.R., Wixom, B.H., and Vandenberg, R.J. 2001. "Understanding Fit and Appropriation Effects in Group Support Systems Via Meta-Analysis," MIS Quarterly (25:2), pp. 167-193.

Faraj, S., and Sproull, L. 2000. "Coordinating Expertise in Software Development Teams," Management Science (46:12), pp. 1554-1568.

Fleming, L., Mingo, S., and Chen, D. 2007. "Collaborative Brokerage, Generative Creativity, and Creative Success," Administrative Science Quarterly (52:3), pp. 443-475.

Fleming, L., and Waguespack, D.M. 2007. "Brokerage, Boundary Spanning, and Leadership in Open Innovation Communities," Organization Science (18:2), Mar-Apr, pp. 165-180.

Fliaster, A., and Schloderer, F. 2010. "Dyadic Ties among Employees: Empirical Analysis of Creative Performance and Efficiency," Human Relations (63:10), Oct, pp. 1513-1540.

Ford, C.M. 1996. "A Theory of Individual Creative Action in Multiple Social Domains," Academy of Management Review (21:4), pp. 1112-1142.

Freeman, L.C., Romney, A.K., and Freeman, S.C. 1987. "Cognitive Structure and Informant Accuracy," American Anthropologist (89:2), pp. 310-325.

Garfield, M.J., Taylor, N.J., Dennis, A.R., and Satzinger, J.W. 2001. "Research Report: Modifying Paradigms--Individual Differences, Creativity Techniques, and Exposure to Ideas in Group Idea Generation," Information Systems Research (12:3), pp. 322-333.

Granovetter, M. 1985. "Economic-Action and Social-Structure - the Problem of Embeddedness," American Journal of Sociology (91:3), pp. 481-510.

Granovetter, M.S. 1973. "The Strength of Weak Ties," The American Journal of Sociology (78:6), pp. 1360-1380.

Ho, Z.W., and Chang, K. 2009. "Simmelian Ties, Organizational Justice, and Knowledge Sharing in Virtual Workgroups," European Conference on Information Systems, p. Paper 152.

Jehn, K.A., Chadwick, C., and Thatcher, S.M. 1997. "To Agree or Not to Agree: The Effects of Value Congruence, Individual Demographic Dissimilarity, and Conflict on Workgroup Outcomes," International Journal of Conflict Management (8:4), pp. 287-305.

Jung, J., Lee, Y., and Karsten, R. 2012. "The Moderating Effect of Extraversion–Introversion Differences on Group Idea Generation Performance," Small Group Research (43:1), pp. 30-49.

Kock, N. 2007. "Media Naturalness and Compensatory Encoding: The Burden of Electronic Media Obstacles Is on Senders," Decision Support Systems (44:1), pp. 175-187.

Krackhardt, D. 1992. "The Strength of Strong Ties: The Importance of Philos in Organizations," Networks and organizations: Structure, form, and action (216), p. 239.

Krackhardt, D. 1998. "Simmelian Tie: Super Strong and Sticky," in Power and Influence in Organizations, R.M. Kramer and M.A. Neale (eds.). CA: Sage, pp. 21-38.

Marsden, P.V. 1990. "Network Data and Measurement," Annual Review of Sociology (16), pp. 435-463.

Massey, A.P., and Montoya-Weiss, M.M. 2006. "Unraveling the Temporal Fabric of Knowledge Conversion: A Model of Media Selection and Use," MIS Quarterly (30:1), pp. 99-114.

Mizruchi, M.S. 1989. "Similarity of Political Behavior among Large American Corporations," American Journal of Sociology (95:2), pp. 401-424.

Obstfeld, D. 2005. "Social Networks, the Tertius Lungens and Orientation Involvement in Innovation," Administrative Science Quarterly (50:1), Mar, pp. 100-130.

Oldham, G.R., and Cummings, A. 1996. "Employee Creativity: Personal and Contextual Factors at Work," Academy of Management Journal (39:3), pp. 607-634.

Perry-Smith, J.E. 2006. "Social yet Creative: The Role of Social Relationships in Facilitating Individual Creativity," Academy of Management Journal (49:1), Feb, pp. 85-101.

Perry-Smith, J.E., and Shalley, C.E. 2003. "The Social Side of Creativity: A Static and Dynamic Social Network Perspective," Academy of Management Review (28:1), Jan, pp. 89-106.

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

Reagans, R., Zuckerman, E., and McEvily, B. 2004. "How to Make the Team: Social Networks Vs. Demography as Criteria for Designing Effective Teams," Administrative Science Quarterly (49:1), pp. 101-133.

Reagans, R., and Zuckerman, E.W. 2001. "Networks, Diversity, and Productivity: The Social Capital of Corporate R&D Teams," Organization Science (12:4), pp. 502-517.

Scheidel, T.M. 1986. "Divergent and Convergent Thinking in Group Decision-Making," in Communication and Group Decision-Making, R. Y.Hirokawa and M.S. Poole (eds.). London: SAGE, pp. 113-130.

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

Shah, P.P. 1998. "Who Are Employees' Social Referents? Using a Network Perspective to Determine Referent Others," The Academy of Management Journal (41:3), pp. 249-268.

Simmel, G., and Wolff, K.H. 1950. The Sociology of Georg Simmel. Free Pr.

Simonton, D.K. 1988. Scientific Genius: A Psychology of Science. Cambridge University Press.

Simonton, D.K. 1999. Origins of Genius:: Darwinian Perspectives on Creativity. Oxford University Press.

Sosa, M.E. 2011. "Where Do Creative Interactions Come From? The Role of Tie Content and Social Networks," Organization Science (22:1), January/February, 2011, pp. 1-21.

Sykes, T., Venkatesh, V., and Gosain, S. 2009. "Model of Acceptance with Peer Support: A Social Network Perspective to Understand Individual-Level System Use," MIS Quarterly (33:2), pp. 371-393.

Thatcher, S., and Brown, S.A. 2010. "Individual Creativity in Teams: The Importance of Communication Media Mix," Decision Support Systems (49:3), pp. 290-300.

Tortoriello, M. 2005. "The Social Underpinnings of Absorptive Capacity: External Knowledge, Social

Networks, and Individual Innovativeness," in: Working paper. Carnegie mellon University, Pittsburgh.

Tortoriello, M., and Krackhardt, D. 2010. "Activating Cross-Boundary Knowledge: The Role of Simmelian Ties in the Generation of Innovations," The Academy of Management Journal (53:1), pp. 167-181.

Umphress, E.E., Labianca, G., Brass, D.J., Kass, E., and Scholten, L. 2003. "The Role of Instrumental and Expressive Social Ties in Employees' Perceptions of Organizational Justice," Organization Science (14:6), pp. 738-753.

Uzzi, B. 1999. "Embeddedness in the Making of Financial Capital: How Social Relations and Networks Benefit Firms Seeking Financing," American Sociological Review (64:4), pp. 481-505.

Wasserman, S., and Faust, K. 1994. Social Network Analysis: Methods and Applications. Cambridge ; New York: : Cambridge University Press.

Watson-Manheim, M.B., and Bélanger, F. 2007. "Communication Media Repertoires: Dealing with the Multiplicity of Media Choices," MIS Quarterly (31:2), pp. 267-293.

Williams, E. 1977. "Experimental Comparisons of Face-to-Face and Mediated Communication: A Review," Psychological Bulletin (84:5), pp. 963-976.

Wooldridge, J.M. 2002. Econometric Analysis Cross Section Panel. MIT press.

Wu, Y., Sha, X., and Chang, K. 2012. "Knowledge Diversity and Simmelian Tie in Generating Creative Ideas: The Importance of Media Multiplexity," International Conference on Information Systems, Orlando, FL, USA.

Yuan, Y.C., Carboni, I., and Ehrlich, K. 2010. "The Impact of Awareness and Accessibility on Expertise Retrieval: A Multilevel Network Perspective," Journal of the American Society for Information Science and Technology (61:4), pp. 700-714.