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Exploring the Adaptive Function in Complexity Leadership Theory: An Examination of Shared Leadership and Collective Creativity in Innovation Networks

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EXPLORING THE ADAPTIVE FUNCTION IN COMPLEXITY LEADERSHIP THEORY:

AN EXAMINATION OF SHARED LEADERSHIP AND COLLECTIVE CREATIVITY IN

INNOVATION NETWORKS

By

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Leadership, creativity, and innovation are becoming increasingly important to the sustainability of organizations. Facing ever more complex environments, traditional views embodied in the individual are being augmented by theorizing which views leadership and creativity as a property of the collective, enabling emergent "grassroots" processes. With theoretical grounding in complexity leadership theory, this dissertation leverages the emerging constructs of shared leadership and collective creativity from a network perspective to provide empirical understanding of the adaptive function of complexity leadership. Social network hypotheses were advanced positing that shared leadership and collective creativity comprise the adaptive function, and that the adaptive function is related to innovation. Results of research conducted in a small regional non-profit organization found collective creativity and shared leadership relate positively with innovation. Occurrence of the adaptive function was found to relate to 93.5% of all innovation in the organization. Further, in examining the components of collective creativity individually, while advice exchange occurred most frequently, reflective reframing was found to relate most directly to innovative outcomes. Reinforcing did not relate to

innovation on its own, but appeared to act in combination with advice and reframing to predict innovation. In addition, heterogeneity between individual experiences and abilities moderated the relationship between the adaptive function and innovation, with more heterogeneity and the adaptive function positively associated with innovation. An unexpected finding was that homogeneity in educational experiences moderated the relationships of the adaptive function and innovation, with more homogeneity and the adaptive function positively associated with innovation. The moderating role of collective psychological capital was also explored, but no significant relationship was found. However, collective PsyCap was found to relate negatively to organizational tenure, suggested burnout among the longest-serving members of the organization. This study is one of the first empirical explorations of the adaptive function of complexity leadership and its relationship to innovation. Findings demonstrated the decentralized nature of creativity, leadership, and innovation within an organization's social network. Innovative outcomes were more decentralized than either creativity or leadership. Further research is recommended to better understand this growing area of research.

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CHAPTER ONE: INTRODUCTION TO THE STUDY

Problem

Organizational leadership theories have traditionally assumed top-down, bureaucratic

models of influence (Bass, 1990). This underlying assumption is a product of the industrial era,

and is well-suited for environments where tasks are simple and repetitive, or where high degrees

of uniformity, control, and efficiency are needed (Gronn, 1999). However, the assumption of

top-down leadership is outmoded for knowledge-era organizations facing a hypercompetitive

landscape where networked creativity and innovation are required (Ilinitch, D'Aveni, & Lewin,

1996; Lichtenstein, Uhl-Bien, Marion, Seers, Orton, & Schreiber, 2006; Osborn, Hunt, & Jauch,

2002). A new paradigm is needed to more fully account for the complex problems facing these

organizations (Davenport, 2001). For leadership research to remain relevant in this more

connected era, we need a conceptualization of leadership that allows for multiple models of

networked influence and enables the flow of creative ideas and emergence of innovation

(Lichtenstein et al., 2006).

Complexity leadership theory (Uhl-Bien, Marion, & McKelvey, 2007) addresses this

need by conceptualizing leadership as networked and dynamic. Rooted in complexity theory

(Miller & Page, 2007), complexity leadership theory adds a view of leadership as a process

through which leadership emerges from the networked interactions of organizational members.

This theory extends beyond traditional leadership research, where leadership was viewed

primarily as the traits and behavior embodied in the individual heroic leader (for a thorough

review, see Yukl, 2010), to include a perspective of leadership that occurs in the connections

between actors in organizational networks (Meyer, Gaba, & Colwell, 2005). Complexity

leadership theories describe emergent organizational innovation as an outcome of the patterns by

which leadership is shared, and creativity occurs collectively, based on the agentic actions of individuals (Lichtenstein & Plowman, 2009; Tsoukas, 1996).

Within complexity leadership theory, the core leadership processes are the administrative and adaptive functions. The administrative function refers to the more traditional conception of leadership, as a process of hierarchical control and efficiency in exploiting organizational resources (Uhl-Bien et al., 2007). The adaptive function involves collective leadership processes that emerge through interactions of individual organizational agents as they work creatively to further both organization and self interests; they do this through exploration and adaptation to the local environment (Uhl-Bien & Marion, 2009).

The focus of this dissertation is on providing empirical insight regarding this adaptive function of complexity leadership. The adaptive function consists of distributed leadership, creative interaction, and innovation (Uhl-Bien et al., 2007). A key to testing the adaptive function is understanding networks of interaction and how they generate creativity and innovation.

An emerging concept in the creativity literature that can provide insight into this adaptive interaction is collective creativity (Hargadon & Bechky, 2006). Collective creativity rests on the assumption of a collective mind, which is a property of the mindful interaction of individuals within a social system (Weick & Roberts, 1993). In contrast to most creativity research, collective creativity views the creative moment as a property of the collective as opposed to the individual (Hargadon & Bechky, 2006). Emerging work in collective creativity can be used to help inform the study of the adaptive function of complexity leadership theory by describing creativity as occurring in the relational space between individuals (Bradbury & Lichtenstein, 2000).

Another emerging area of research compatible with the complexity perspective is shared leadership (Pearce & Conger, 2003). In describing leadership as a process of interactive and dynamic influence in reaching collective goals, shared leadership offers a distributed form of leadership consistent with the adaptive function of complexity leadership theory.

Within complexity leadership theory, certain enabling conditions are identified as conducive to the adaptive function. One such condition is heterogeneity (Rodan & Galunic, 2004). Heterogeneity of backgrounds and experiences within groups is believed to be a key enabling condition due to the different perspectives individuals bring to the interaction (Pearce, Perry, & Sims, 2001). Another condition is the characteristics of individual adaptive leaders (Uhl-Bien & Marion, 2009). An individual's intrinsic propensities for agentic behavior and intrinsic motivational factors provide a foundation for adaptive interaction to occur (Uhl-Bien & Marion, 2009; see also Amabile, 1983; Amabile, 1996; Amabile, Schatzel, Monetam & Kramer, 2004; Tierney & Farmer, 2002; Zhou, 2003). In this research I propose that a key factor associated with the capacity to engage in adaptive leadership is psychological capital, or PsyCap. PsyCap is a positive state of psychological development that has been found to correlate with both leadership (Luthans, Avolio, Avey, & Norman, 2007; Walumbwa, Peterson, Avolio, & Hartnell, in press) and creative behaviors (Sweetman, Luthans, Avey, & Luthans, in press). Thus, both heterogeneity and psychological capital may help provide insight into enabling conditions to the adaptive function of complexity leadership theory.

To date, little empirical work has been published to examine the role of these potential enabling conditions or the broader adaptive function of complexity leadership theory (cf. Uhl-Bien & Marion, 2009). Further, virtually no work has been done to refine this theory from the perspective of interpersonal social network analysis within the organization (cf. Schreiber &

Carley, 2008). By building on the foundation of current research on shared leadership and collective creativity, it may be possible to gain greater insight into the networked adaptive function of leadership from a complexity perspective.

Purpose of the Study

The purpose of this study is to investigate collective creativity and shared leadership as a proxy for the adaptive function of complexity leadership. Specifically, this study investigates the networked interactions by which shared leadership relates to the emergence and integration of creative ideas from throughout the organization. Further, potential enabling conditions to collective creativity and shared leadership – heterogeneity and psychological capital – are considered. This dissertation advances a theoretical model which tests and explores the relationship of this heterogeneity, psychological capital, shared leadership, collective creativity, and innovation.

The goal of this research is to contribute to the understanding of the adaptive function of complexity leadership theory. Social network analysis will be used to understand the patterns of shared leadership interactions, collective creation of knowledge, and potential innovation (Krackhardt & Brass, 1994; Mizruchi & Galaskiewicz, 1994; Schreiber & Carley, 2008). Hypotheses will be developed and tested based on social network theory. The results have the potential to contribute to a growing body of knowledge that suggests innovation within organizations is created and disseminated through distributed leadership and emergent "grassroots" processes (Lichtenstein & Plowman, 2009; Marion & Uhl-Bien, 2001).

Significance of Study

This study is significant in a number of ways. Overall, the study will refine the application of complexity theory – in particular the adaptive function - to the field of

organizational leadership. The interpersonal social network analysis will provide a detailed empirical understanding of the relationship patterns of shared leadership, collective creativity, and innovation. Moreover, extant network literature generally examines only structural properties; by also examining individual characteristics of PsyCap, this study contributes to a growing body of literature that examines the interaction of network structure and individual characteristics (Klein, Lim, Saltz, & Mayer, 2004; Mehra, Kilduff, & Brass, 2001). To date, the application of complexity theory to organizational leadership has been criticized as being rich in theory and analogy while being relatively poor in data and results (Avolio, Walumbwa, & Weber, 2008). This study will add to the small, yet growing body of literature that empirically examines complexity theory as it relates to organizational leadership.

Further, this study empirically refines the construct of collective creativity. Using social network analysis to enhance understanding of this construct is significant, as research to date has only explored this collective construct qualitatively (i.e., Hargadon & Bechky, 2006). Creativity has been explored to date primarily as an individual-based phenomenon. This study purports that creativity also occurs in the connection, or space between individuals (Bradbury & Lichtenstein, 2000).

Structure of the Dissertation

This is the conclusion of Chapter One, which provided an introduction to the study. Chapter Two includes hypotheses for this study as well as a relevant review of supporting theoretical and empirical literatures. Chapter Three describes study methodology. This includes background on participants, overall study design, social network data collection methods, and a detailed discussion of the operationalization of all variables of interest. This is then be followed by a description of the data analysis procedures utilized to explore the research questions and test

the hypotheses of this study. Next, Chapter Four presents the results of the analysis described in the previous chapter. Finally, Chapter Five concludes this dissertation with a discussion of the theoretical contributions and practical implications of this study, as well as strengths, limitations, and opportunities for future research.

CHAPTER TWO: LITERATURE REVIEW AND HYPOTHESES

Knowledge workers today are faced with increasingly interdependent and interactive work environments (Perry-Smith, 2002). In this environment, creativity and influence require a complex network of interactions (Brass, 1995; Simonton, 1984). As articulated by Hargadon and Sutton, "ideas and innovation are the most precious currency in the new economy… and, without a constant flow of ideas, a business is condemned to obsolescence" (2000: 157). Leading in this dynamic environment requires adaptive structures where the broad capacities and experiences of the organizational network can be drawn upon to respond a constantly changing environment (Hazy, Goldstein, & Lichtenstein, 2007).

Adaptive Function

Fundamentally, adaptation is the ability to enact change in response to new challenges (e.g., Plowman, Baker, Beck, Kulkarni, Solansky, & Travis, 2007). This is a collective effort, involving "coordinated interdependence" in orchestrating response through either an existing repertoire of responses, or inventing a new and novel response (Kozlowski, Gully, Nason, & Smith, 1999). Thus, adaptation involves components of both leadership and creativity (Burke, Stagl, Klein, Goodwin, Salas, & Halpin, 2006). Complexity leadership theory offers a framework for understanding this intersection of leadership and creativity through the adaptive function (Uhl-Bien & Marion, 2009).

Complexity Leadership Theory

Complexity leadership theory posits that leadership is an emergent process that can occur through the interactions of individuals, not just top-down bureaucratic influence (Uhl-Bien et al., 2007). This theorizing is based on broader work in complexity theory. Complexity theory came

to be known formally as such in the 1960's, where it emerged from studies in the hard sciences including physics, biology, and chemistry (Waldrop, 1992). Complexity is the study of interacting agents, who act with limited information (bounded rationality; Simon, 1955) and whose resulting interactions can produce qualitatively different outcomes than a simple sum of the component parts (Miller & Page, 2007). A goal of complexity theory is to discover the "deep sameness of being" which exists across behavior in a variety of disciplines (Miller & Page, 2007). The broad cross-disciplinary foundation of complexity theory provides a solid basis for complexity leadership theory.

Applying the concepts of complexity theory to the study of leadership has resulted in the study of complexity leadership, which suggests a radically new paradigm for leadership. The core leadership processes posited within this theory are the administrative and adaptive functions. As described earlier, the administrative function centers on efficiency and control whereas the adaptive function is emergent leadership based on the complexity notion of interacting agents producing a qualitatively different result than the sum of their parts (Uhl-Bien et al., 2007). From the broader complexity literature, a classic example of this "qualitatively different" phenomenon is a flock of geese. When they fly together, each goose has a simple set of "rules" for its distance, speed, etc. in relation to the other geese. These individual behaviors on the part of all the geese lead to the formation of a "V" of the overall flock – something qualitatively different than the sum of the individual parts (Kauffman, 1995). Likewise, in adaptive leadership, the combination of each individual's adaptive actions is posited to lead to organizational outcomes that are beyond the scope of any one individual.

Adaptive leadership is not tied to any specific organizational position, and can occur at any level and in any role in the organization. It is comprised of shared leadership and creative

interaction that lead to innovation (Uhl-Bien et al., 2007). A key issue in moving beyond

theorizing and into empirical testing of complexity leadership theory is in understanding the

process by which individuals engage in socially networked interaction to generate creativity and

innovation. Social network analysis is the analytic tool that can provide that understanding.

Social Network Analysis

A social network pertains to a bounded set of individuals (actors) and one or more of

numerous relational ties which can exist between them (Wellman, 1988). Complexity leadership

theory and network theory both emphasize connections among individuals (Uhl-Bien et al.,

2007; Scott, 2000). Social network analysis will be the analytic tool to explore the network

structure of relational ties pertaining to adaptive function, shared leadership, creativity, and

innovation, given the inherently relational nature of these concepts as posited in complexity

leadership theory (Uhl-Bien et al., 2007). This analysis will be informed through social network

theory, which relates to the meaning derived from conducting analysis of social networks

(Wasserman & Faust, 1994).

Social network analysis is a set of relational methods for systematically describing

connections among actors in a network. Through networks of relationships, social network

analysis provides numerous concepts to describe and analyze the overall network, sub-groups

within the network, and individuals relative to their relational ties to the network (Scott, 2000).

For example, social network analysis can identify the degree to which relational ties within a

network are centralized around few key actors or distributed equally amongst all network

members. Social network analysis can also explore the nature of correlation between different

types of relational ties between actors (e.g., leadership vs. creativity relational ties) and how

actor attributes (i.e., individual differences) relate to patterns of relationships (e.g., individual

tenure in the organization and how that relates to that individual's number of creativity ties; Wasserman & Faust, 1994). Additionally, social network analysis can be used to explore the impact of heterogeneity of organization actors (e.g., how differences in educational background between actors influence the relational ties of creativity between those actors; Scott, 2000). These relational tie networks will now be explored in greater detail, beginning with the creative relationship.

Creativity

A creative product has been defined as novel or original as well as useful, doing something for the first time or creating new insights (Amabile, 1996; Ford, 1996; Mumford & Gustafson, 1988; Woodman, Sawyer, & Griffin, 1993). Creativity provides an enduring competitive advantage for organizations because it enables adjustment to the changing environment and the ability to take advantage of emergent opportunities (Shalley, Zhou, & Oldham, 2004).

Within the creativity literature, most research focuses on individual attributes and abilities along with their presumed relation to creative outcomes (for meta-analyses, see Damanpour, 1991; Shalley et al., 2004; Hulsheger, Anderson, & Salgado, 2009). Our understanding of creativity thus centers almost exclusively on the special qualities of the exemplar individual creatives (Montuori & Purser, 1996). Although this approach remains dominant, studies are now also examining the importance of social factors. Over fifteen years ago, Amabile (1995) demonstrated the influence of social environment on individual creativity. Further, Woodman and colleagues (1993) assert the collective organization is the context in which creativity occurs. Meeting the challenges of a constantly changing environment requires the ability to combine heterogeneous knowledge, abilities, and perspectives (Brown &

Eisenhardt, 1998). For example, the innovative work of Frank Gehry's architecture rests on collaborative design practices (Yoo, Boland, & Lyytinen, 2006) and seminal academic research occurs as a result of collaborative efforts (Barabási, 2005). Creativity research has begun to examine the social network as a source of this diversity (Brass, 1995; Burt, 2004; Perry-Smith, 2006) and recognize the need to conceptualize creativity beyond the individual.

Collective Creativity and Innovation

The construct of collective creativity was introduced by Hargadon and Bechky (2006), who qualitatively examined collective creativity that is generated in moments of interaction at the group level. According to this perspective, creativity is not the product of individuals, but is at the juncture of the individual and the social system, occurring at "the interaction between a person's thoughts and a sociocultural context" (Csikszentmihályi, 1996: 23). Formally defined, collective creativity is "a moment when individuals come together to find, redefine, and solve problems that no one, working alone, could have done as easily, if at all" (Hargadon & Bechky, 2006: 487).

Hargadon and Bechky (2006) have advanced a model identifying four key behaviors of collective creativity: help seeking, help giving, reflective reframing, and reinforcing. Where help seeking and help giving refer to behaviors which lead to the flow of knowledge in creative exchanges, reflective reframing is a process of refining the question being asked. Finally, reinforcing provides a foundational context for the collective creativity process through both affirming contributions and creating the environment for this interaction to occur. Each of these behaviors is now examined in turn.

Help seeking. This component of collective creativity involves actively soliciting the assistance of others. The patterns of interaction surrounding this behavior are often fluid, where

formal structures are used and informal networking is leveraged. This creates the information exchange and idea-building necessary for creativity to occur beyond the individual level (Hargadon & Bechky, 2006).

When considering the network of knowledge flow in organizations, help seeking, also known as advice seeking, is often examined (Cross, Borgatti, & Parker, 2004; De Lange, Agneessens, & Waege, 2004; for reviews, see Borgatti & Foster, 2003; Brass, Galaskiewicz, Greve, & Tsai, 2004). While these advice seeking creative interactions may occur in a planned and structured environment, an important distinction made by Hargadon and Bechky (2006) is that help seeking behavior does not occur within a fixed set of individuals. Rather, it is fluid to the context, depending on such happenstance events as who may be walking by in the hallway and pulled into the collective creative process as it is occurring. Further, these interactions often may not result in a collective "solution" per se, but could generate further interactions with a larger group of individuals ultimately producing a collective "solution" through a unique and unexpected path of contributions (Hargadon & Bechky, 2006). This corresponds to the complexity leadership theory notion of adaptive leadership, where knowledge is not created by the individual, but emerges in the interaction between individuals.

Help giving. Successful help seeking behavior relies on the assumption of the other in the interaction being willing to give help. This help giving represents a willingness to devote both time and attention on the part of the giver of help (Hargadon & Bechky, 2006). Further, the help giving must be timely. In order for a moment of collective creativity to occur, both the help seeker and help giver must be mindfully engaged in the problem at hand (Hargadon & Bechky, 2006). Such actions provide a foundation for adaptive leadership by actively integrating prior knowledge and information into new adaptive practices.

While the processes of advice seeking and advice giving are different from the perspective of the individual, from the perspective of network interaction between individuals, it can be readily recognized that these behaviors are opposite sides of the same exchange (Borgatti & Foster, 2003). When one person is engaged in seeking advice, there is another person(s) then giving advice. For the purposes of this study advice seeking and advice giving will be considered one type of social network which encompasses both types of behaviors. While it is possible for someone to seek advice without being given advice, this potentiality will not be considered, as the purpose of this study is to examine actual interactions of collective creativity, not potential ones.

Reflective Reframing. Part of the creative process involves actively reframing issues to generate broader thinking and searching across heterogeneous individuals for a solution (Schank & Abelson, 1977). The process of reflective reframing is one in which this heterogeneity generates a new way of thinking about the "problem" at hand, the realm of potential "solutions," and whether a better question could be asked (Getzels, 1975). Reflective reframing involves respectful attention and building upon comments and behaviors of others in the interaction (Weick & Roberts, 1993). Collective creativity occurs in moments where contributions to the creative process both shape the subsequent contributions as well as make new sense and new meaning of previous contributions (Hargadon & Bechky, 2006). By reframing the problem, individuals shift the frame of reference of others, making still other framing of the problem accessible (Fiske & Taylor, 1991). These multiple approaches to a "problem" enable insights to emerge that, rather than the providence of the individual, are a property of the collective.

Reinforcing. Reinforcing provides the relational foundation upon which the other three activities – help seeking, help giving, and reflective reframing – are built. Through actions to

promote, further, and help to transact the process of collective creativity, members of the organization demonstrate that such behaviors are valued within the organization. Two types of reinforcing behaviors were found in Hargadon and Bechky's (2006) research. The first is the product of positive experiences in help seeking, help giving, and reflective reframing. Such positivity increases the likelihood of future occurrence (i.e., classical conditioning, Pavlov, 1927). The second type of reinforcing behaviors relate to the climate or culture of the organization. This is comprised of enduring values and beliefs that promote collective creativity within the organization (Hargadon & Bechky, 2006). Reinforcing behaviors are especially effective in a heterogeneous environment where the collective may not share the same underlying expectations (Orlikowski, 1993).

Collective creativity is related to innovation. Innovation is the process by which creative ideas become recognized as a valuable product, process, or service and implemented in the organization (Dhanaraj & Parkhe, 2006; Taylor & Greve, 2006). This process of creativity is especially critical in complex and interdependent work (Drazin, Glynn, & Kazanjian, 1999). A broad base of multidisciplinary research has established a clear and strong linkage between creativity and innovation (for meta-analytic reviews, see Damanpour, 1991; Hulsheger et al., 2009; Scott, Leritz, & Mumford, 2004). The relationship is intuitively straightforward: generating creative ideas and alternatives is the first step in introducing these innovative ideas in the organization, and more creativity relates to a greater and more developed pool of ideas to consider (Amabile, 1996; West, 2002; Woodman et al., 1993). In other words, the distinction between creativity and innovation is that creativity involves generating ideas for new and different ways to accomplish a goal. Innovation, on the other hand, involves taking those ideas and carrying them through to implementation within the organization.

While extant research has primarily explored individual creativity and its relation to innovation, a similar relationship should be expected when creativity occurs at the collective level, as recently qualitatively explored by Hargadon & Bechky (2006). Therefore, I propose that:

> ***Hypothesis 1:*** *If actors have a collective creativity tie, they will be more likely to also have an innovation tie compared to actors without a collective creativity tie.*

Collective Creativity and Networks

Having proposed a relationship between collective creativity and innovation networks, I will next consider the structure of the collective creativity network in more detail. Based on Hargadon and Bechky's (2006) initial inquiry, this section leverages social network analysis to further refine the understanding of collective creativity as a construct. From a social network perspective, each of the components of collective creativity represents a potential type of relationship tie that can exist between individuals. For example, in addition to a reflective reframing relationship, a relationship could also exist along the dimension of reinforcing or advice exchange between any pair of individuals.

The three elements of the collective creativity relationship "appear in combination and activate one another" (Hargadon & Bechky, 2006: 494). When examining the collective as a whole, it is not necessary that they all occur between any two individuals. For example, considering a network of individuals, some individuals may provide more advice, while other individuals provide reflective reframing, and still others provide reinforcing. Therefore, a collective level of analysis will be used to examine collective creativity.

In the following sections, I will more fully explore these ideas and hypothesize the network pattern of relationships for these components of collective creativity. As collective

creativity is comprised of advice, reflective reframing, and reinforcing ties, each will be discussed as related to collective creativity overall.

Centrality and Centralization. Centrality provides an individually-based perspective of network position, whereas centralization provides an analogous network-based perspective of network structure (Wasserman & Faust, 1994). Centralization is the degree of difference in individual centrality within the network (Wasserman & Faust, 1994). For example, when considering the network of US cities and how they're connected by flights, there is high centralization, with relatively few major hubs having connections to most cities, but most cities connecting only to these hub cities. Conversely, when considering how US cities are directly connected by expressways, there is relatively low centralization, with each city directly connected to roughly the same number of neighboring cities. This section will first explore individual centrality and then build into a hypothesis related to network centralization.

One of the great controversies in the social network literature is the value of an individual having a highly central position within advice and information exchange networks, versus a position of low centrality (Uzzi & Spiro, 2005). In early studies at MIT, it was found that a balance of centrality was associated with the greatest social power and influence (Bavelas, 1950; Leavitt, 1951). Such a network position provides greater access to valuable information exchange (Perry-Smith, 2002) and the ability to synthesize disparate knowledge from across the organization (Cross & Cummings, 2004). This centrality is a product of individual expertise (Ericsson, 1996), with well-connected expert individuals having high centrality (Wasserman & Faust, 1994).

Centrality in these advice and expertise networks is, in turn, associated with greater creativity (Perry-Smith, 2006; Perry-Smith & Shalley, 2003). In her study of a multidisciplinary

research laboratory, Perry-Smith (2006) found limited support for the association of advice exchange centrality and creativity, suggesting a curvilinear relationship. Similar to advice exchange, the reflective reframing component of collective creativity is enabled through sharing knowledge and insights to refine an idea (Scott & Bruce, 1994; Zhou & George, 2001) and generate evaluation of its merit (Leenders, van Englen, & Kratzer, 2003; Perry-Smith & Shalley, 2003). This viewing of an issue from different perspectives or providing alternative explanations furthers the creative process (Amabile, Conti, Coon, Lazenby, & Herron, 1996). As stated by Kanter, "contact with those who see the world differently is a logical prerequisite to seeing it differently ourselves (1988: 175)," suggesting that the heterogeneity often found through weak ties is critical for generating effective reframing.

Finally, reinforcing networks are a form of expressive ties, or an affective-based relationship (Lincoln & Miller, 1979). As creativity involves risk, highly central individuals are more likely to take those creative risks due to the social support and reinforcement of occupying a central location in the network (Brass, 1984; Ibarra & Andrews, 1993). These ties are potential sources of social support that enable creativity to flourish; having a large support network of reinforcing ties positively relates to creative output (Isen, Daubman, & Nowicki, 1987; Madjar, Oldham, & Pratt, 2002).

Given that collective creativity is network-based, centralization, as opposed to individual centrality, will be explored. While the centrality of advice, reframing, and reinforcing ties is predicted to be high for individuals engaged in creativity, the pattern of centralization is different between them. The three elements of collective creativity fundamentally represent two types of relational ties: instrumental and expressive (Brass & Burkhardt, 1993; Lincoln & Miller, 1979). Instrumental ties relate specifically to task performance, often involving the exchange of advice

or ideas (Ibarra, 1993). Expressive ties, on the other hand, involve affective exchange and commonly relate to the perpetuation of organizational values and providing of social support (Ibarra, 1993). Given these definitions, I propose that the advice exchange and reflective reframing components of collective creativity can be categorized as instrumental ties. These exchanges involve the specific exchange of advice or technical information relevant to creative outcomes (Amabile, 1996; Deci, Connell & Ryan, 1989). Reinforcing, on the other hand, provides social support and can be considered an expressive tie. Reinforcing contributes to creativity through the exchange of social support and control (Amabile, 1996; Deci, Connell & Ryan, 1989).

Instrumental ties demonstrate higher centralization in the network overall than affective ties (Ibarra, 1993). As an example, an expert on a particular topic develops a reputation within the entire network as such, and being sought as such leads to high centralization within the network. That is, a large proportion of members of the network will turn to that individual for a particular type of advice. However, in the case of social support, this support occurs locally in the network, suggesting lower centralization of affective ties such as reinforcing (Ibarra, 1993). Social support often occurs in smaller sub-groups within the network, such as within a workgroup or small group of friends within a larger department (Lincoln & Miller, 1979).

Given this difference in centralization for instrumental and affective network ties, I hypothesize:

Hypothesis 2a: *Centralization will be higher within advice and reframing networks as compared to the reinforcing network.*

Clustering. In addition to centralization, another way to examine network structure is clustering, or sub-group cohesion (Wasserman & Faust, 1994). It is common for networks to

possess some degree of sub-group cohesion, often as related to formally defined workgroups or informally based on expertise or some common background (Webber & Donahue, 2001). Sub-group cohesion relates to frequent communication in a group and the regular sharing of advice and ideas (Mumford & Gustafson, 1988). However, as described earlier, such instrumental ties within a group for advice exchange and reflective reframing lead to assimilation of thoughts and ideas, decreasing the potential for novel outcomes (Patrashkova & McComb, 2004). Said differently, when confronted with novel problems, similarly-thinking group members provide little help. As a result, creative advice exchange is likely to occur outside of the sub-group, leading to low sub-group cohesion for collective creativity. This suggests collective creativity occurs under conditions where clustering within the instrumental ties of advice and reframing networks are low. If, on the other hand, sub-group cohesion were high, then the clusters would be susceptible to groupthink, and as a result, creativity of the group would be minimized (Janis, 1982).

However, affective-based ties, such as reinforcing ties, form relatively dense networks, generating trust, developing norms, and imposing sanctions within a cohesive group (Ibarra, 1993). A network dense in expressive ties provides the foundation for information exchange and creative outcomes (Hargadon & Bechky, 2006; Zhou, Shin, Brass, & Choi, 2009). While no empirical research has examined reinforcing ties specifically, qualitative findings of Hargadon and Bechky (2006) suggest reinforcing ties exhibit similar properties as expressive ties more generally, forming strong cohesion sub-groups. Taken together, these findings suggest the following hypothesis:

> **Hypothesis 2b:** *Sub-group cohesion will be higher within reinforcing network as compared to the advice and reframing networks.*

Having explored and elaborated the emerging concept of collective creativity, I now build upon that foundation by proposing the combination of collective creativity and shared leadership that comprise the adaptive function of complexity leadership theory.

Shared Leadership and the Adaptive Function of Complexity Leadership Theory

Complexity leadership theory posits the adaptive function is a process whereby creativity and leadership are dynamic and iterative, resulting in bottom-up innovations spreading throughout the organization (Uhl-Bien & Marion, 2009). Creativity and leadership research have found that such broad-base adoption of creative ideas throughout the organization is associated with successful new product launches (Sutton & Kelly, 1997). As such, innovation results from an intricate process of leadership and creativity in managing ideas, opportunities, processes, and tools to offer enhanced products and services (Subramaniam & Youndt, 2005).

At a fundamental level, leadership behaviors can support creative efforts by creating the conditions conducive to enabling creative outcomes (Amabile et al., 2004; Shalley & Gilson, 2004; Tierney & Farmer, 2004; Zhou & George, 2003). Complexity leadership theory broadens this perspective to posit leadership not only enables creative outcomes, but also is intertwined with the creative process itself. Given this intertwined nature of creativity and leadership in producing innovation, and creativity as occurring within a collective, leadership is thus a shared, collective process (Day, Gronn, & Salas, 2004; Ensley, Hmieleski, & Pearce, 2006). Through this fluid, mutual process, individuals who possess the most relevant knowledge are able to provide the most relevant leadership to championing the creative initiative through shared leadership (Ensley et al., 2006; Pearce, 2004).

The core of the complexity leadership theory paradigm is that leadership is a distributed and shared phenomenon. This perspective is compatible with that of shared leadership (Pearce & Conger, 2003). Formally, shared leadership is defined as "a dynamic, interactive influence process among individuals in groups for which the objective is to lead one another to the achievement of group or organizational goals or both. This influence process often involves peer, or lateral, influence and at other times involves upward or downward hierarchical influence" (Pearce & Conger, 2003: 1). Shared leadership is broadly distributed within a group of individuals and is not centralized in a single individual who exerts downward influence on subordinates (Pearce & Conger, 2003).

In this emerging conceptualization, leadership is described as a collective-level outcome (Day et al., 2004; Ensley et al., 2006). It is an interactive, mutual process of influence through which both formal and informal leaders emerge (Pearce, 2004). Through this conceptualization of leadership, conversations flow to the individual who possesses the knowledge most relevant to the specific problem at the specific moment (Ensley et al., 2006). This process is embedded within the networked dynamics of a social system (Dachler, 1992). As described further by O'Connor and Quinn, "when leadership is viewed as a property of the whole system, as opposed to solely the property of individuals, effectiveness in leadership becomes more a product of those connections or relationships among the parts than the result of any one part of that system (such as the leader)" (2004: 423).

While organizational behavior and leadership scholars may purport this is a "newer" form of leadership, the concept of team members mutually influencing each other has been comprehensively research in sociology, being first articulated by Mary Parker Follett in 1924. Gibb (1954) provided further elaboration, conceiving "distributed leadership" as a group quality,

with leaders being identified in terms of frequency and multiplicity or "pattern of functions" that are performed. Pearce and Conger (2003) provide a comprehensive historical review of the evolution of this concept. Despite a history that began over 80 years ago, it is only recently that the concept has gained traction in mainstream leadership literature, and there remain few empirical studies on the topic (Ensley et al., 2006).

According to Day, Gronn, & Salas (2004), shared leadership capacity is an "emergent state" – something that is dynamic and develops throughout team lifespan, varying due to the inputs, processes, and outcomes of the team. It produces "patterns of reciprocal influence" which reinforce and develop further relationships between team members (Carson, Tesluk, & Marrone, 2007). As suggested by Mayo, Meindl, and Pastor (2003), this networked dynamic of shared leadership lends itself to a social network perspective.

Ensley and colleagues (2006) provide a framework of four types of shared leadership team members may share: directive, transactional, transformational, and empowering. Directive involves simple give-and-take structure in interaction and initiatives. Next, transactional shared leadership also involves the establishment of performance metrics and shared rewards based on those metrics. Transformational shared leadership involves collective establishment of vision and inspiration to excel. Lastly, collective empowering behaviors include shared support and encouragement, and participative goal-setting activities.

Shared leadership can occur at any level of the organization, or across levels of the organization. It may be distributed across levels of the organizations with the recognition that those in senior positions don't always posses the relevant skills and information, and those at lower levels may be more capable of providing effective leadership and quicker decision-making in the fast-changing and complicated world (Pearce & Cogner, 2003). Carson, Tesluk, and

Marrone (2007) found teams which rely on multiple members for leadership outperformed those which were guided by external, hierarchical leadership.

The intertwined process of collective creativity and shared leadership in the network enables individuals to legitimize innovations and provide the necessary visibility to be recognized (Cattani & Ferriani, 2008). In conducting a qualitative study of psychological flow in research and development teams, Hooker and Csikszentmihalyi (2003) found evidence relating shared leadership to the production of creative outcomes as well as team member confidence in their abilities to generate these outcomes. This suggests a link between shared leadership and creative process. This emergent, shared leadership in the context of working creatively to further both organizational and self interests is the adaptive function of complexity leadership theory (Uhl-Bien & Marion, 2009). From a network perspective, an adaptive function tie will thus be defined as the existence of both collective creativity and shared leadership in a given relationship between two actors in the network. A high level of participation from throughout the network increases innovation (Carsten & West, 2001). This link between team leadership, creativity, and innovative outcomes was supported in a recent meta-analytic review of innovation at work (Hulsheger et al., 2009). Considering the adaptive function tie as comprised of the combination of a shared leadership tie and collective creativity tie between a given set of individuals, I propose the following:

> **Hypothesis 3:** *If actors have an adaptive function tie, then they will be more likely to also have an innovation tie when compared to actors without an adaptive function tie.*

Enabling Conditions of the Adaptive Function

Having explored the processes of shared leadership and collective creativity together as a proxy for the adaptive function and its relation with innovation, I now turn to the contextual conditions that are proposed to enable this adaptive function to flourish. The hypotheses in the previous sections suggest network structure impacts the adaptive function and innovation. This perspective is important, as it extends both creativity and leadership theories beyond the individual (cf. Hargadon & Bechky, 2006; Pearce & Conger, 2003). However, it must also be considered that individual characteristics and their combinations may create conditions to enable adaptive behaviors and interaction within the network. That is, both the network relationships between individuals as well as the characteristics of the individuals themselves influence innovation. Specifically, I will explore the individual enabling conditions of heterogeneity and psychological capital.

Amabile's componential model of creativity (Amabile, 1995) suggests creative behavior is the confluence of domain-relevant skills, creativity-related skills, and task motivation. As previously established in the discussion of collective creativity, domain-relevant and creativity-related skills involve a heterogeneous combination of skills and experiences between members of the collective (Watson, Kumar, & Michaelsen, 1993). Task motivation involves the psychological capital to be hopefully optimistic and efficacious in participating in the creative process, as well as resiliently bouncing back when confronted with obstacles to the creative process (Sweetman et al., in press).

Heterogeneity

Heterogeneous experiences and worldviews enable the collective creativity process to be meaningful beyond individual creativity (Hargadon & Bechky, 2006) and for higher performance leadership in addressing complex and novel issues (Denis, Lamother, & Langley, 2001, Ensley et al., 2006; Watson et al., 1993). To take an extreme example that underscores the importance of heterogeneity to shared adaptation, if all members of a group had exactly the same experiences and perspectives of the world, there would be no variation in ideas, and thus the process would be as effective individually as collectively (cf. Chiles, Meyer, & Hench, 2004).

Heterogeneity is a property of the connection between individual actors, not of the actors. For connected actors to be heterogeneous requires the actors within that network to possess differing characteristics. This network diversity enables both new, creative combinations of ideas as well as faster adoption of creative ideas and innovation (Tuomi, 2002; Rodan & Galunic, 2004). To enable a detailed understanding of the impact of heterogeneity, I will examine heterogeneity at the most fundamental level of connection within the network: between pairs of actors (cf. Hulsheger et al., 2009).

Heterogeneity is often looked at along multiple dimensions, including background diversity and personal experiences/abilities diversity. Background diversity refers to those stable demographic traits which an individual generally cannot change, such as age, race, and gender (Milliken & Martins, 1996). Because background differences do not generate cognitive resource diversity, they have generally not been found to impact the creative process (Webber & Donahue, 2001). This notion received strong empirical support in a recent meta-analysis examining the predictors of innovation and creativity at work (Hulsheger et al., 2009).

As such, factors other than background diversity are more important when it comes to heterogeneity as it relates to creative network ties. For example, results of a meta-analysis indicate personal experiences and abilities generate significant cognitive resource diversity (Webber & Donahue, 2001). Such thought diversity is conducive to creativity, as the differing perspectives and insights between pairs of actors in the creativity network enable cognitive processes related to creativity (Perry-Smith, 2006). Specifically, differences in education and work responsibilities have both been found to relate positively to creative outcomes (Amabile et al., 1996; Rodan & Galunic, 2004; Woodman et al., 1993). In a heterogeneous pair, the likelihood that the pair possesses the needed knowledge or ability to acquire the knowledge is increased relative to homogenous pairs. This heterogeneous pair is more likely to be exposed to different and unusual ideas. Similarly, the likelihood of this collective possessing the differing perspectives for reflective reframing is increased. Strong support for this notion of the positive relationship of heterogeneity to creative outcomes was provided in Hulsheger and colleague's (2009) meta-analysis of predictors of innovation and creativity.

I propose the combination of collective creativity and shared leadership – the adaptive function - will be similarly impacted by the heterogeneity of personal experiences and abilities between pairs of actors in the network, leading to the following hypotheses:

> ***Hypothesis 4:*** *Heterogeneity in the experience and abilities of pairs of actors moderates the relationship of the adaptive function to innovation such that greater heterogeneity and greater levels of the adaptive function are related to higher levels of innovation compared to pairs of actors with lower levels of the adaptive function and lower heterogeneity.*

Psychological Capital

A foundation of the adaptive function is the individual agency necessary to identify and act upon adaptive challenges to the organization (Heifetz & Laurie, 2001). As described by Uhl-

Bien and Marion (2009), the adaptive function of complexity leadership theory can be

considered leadership due to "intentional, local acts of influence to create change" on the part of

individuals throughout the organizational network (p. 638). Agency involves an individual's

beliefs to exert control over the environment of one's life (Bandura, 1982), and is a catalyst to

innovation (Anand, Gardner, & Morris, 2007). Such agentic psychological resources have been

cited by Amabile (1983; 1996; Amabile et al., 2004) and others (e.g., Rodan & Galunic, 2004;

Tierney & Farmer, 2002; Zhou, 2003) as intrinsic motivational factors key to achieving creative

outcomes. For example, in recent studies of multinational consulting firms (Teigland & Wasko,

2009) and healthcare professionals (Binnewies et al., 2007), creativity was highly related to

personal initiative. An intrinsically motivated person finds such knowledge generation

inherently interesting and satisfying (Amabile, 1996). Csikszentmihalyi (1996) found inherent

joy and deep curiosity to be predictive of creativity. Intrinsic motivation also enables persistence

when faced with the challenge of determining multiple pathways to achieve creative goals (Frese

& Fay, 2001). Research suggests these intrinsic motivational propensities, or psychological

capital (PsyCap), positively influence creativity (Sweetman et al., in press).

Psychological capital (PsyCap) is a second order construct consisting of agentic

psychological resource dimensions that, taken together, are considered as intrinsic motivational

propensities (Luthans, Avolio et al., 2007). PsyCap is formally defined as: "an individual's

positive psychological state of development characterized by: (1) having confidence (efficacy) to

take on and put in the necessary effort to succeed at challenging tasks; (2) making a positive

attribution (optimism) about succeeding now and in the future; (3) persevering toward goals, and

when necessary, redirecting paths to goals (hope) in order to succeed; and (4) when beset by

problems and adversity, sustaining and bouncing back and even beyond (resilience) to attain

success" (Luthans, Youssef & Avolio, 2007: 3). The common theoretical thread of the second-order PsyCap construct is the "positive appraisal of circumstances and probability for success based on motivated effort and perseverance" (Luthans, Avolio et al., 2007: 550).

Such motivation and perseverance are required to confront the challenges of creatively adapting to a changing environment (Amabile, 1983). Creativity is generally a high-risk activity, as novel and useful ideas often fail (Carmeli & Schaubroeck, 2007). This failure is compounded when working in a collective, where such "failures" are not held individually, but are known and shared by the collective. Not only do the agentic psychological resources of PsyCap enhance motivation, they also enable a more creative approach to problem solving (Phelan & Young, 2003). PsyCap has been found to be related to the production of individual creative outcomes (Sweetman et al., in press) as well as effective individual leadership (Norman, Avolio, and Luthans, 2010; Walumbwa et al., in press) and follower effectiveness (Avey, Avolio, and Luthans, in press).

However, when collectively creating and sharing leadership, a referent shift approach (Chan, 1998) is appropriate to instead examine collective agency. Individual agency is unlikely to impact group performance except under low interdependence (Gully, Incalaterra, Joshi, & Beaubien, 2002). Given the interdependent challenges facing collectives, a collective approach to agency is necessary. In a study in a large financial institution, collective PsyCap was recently introduced as a "shared psychological state" and found to mediate between leadership behaviors and collective outcomes (Walumbwa, Luthans, Avey, & Oke, 2009: 3). Collective PsyCap is built on the idea of collective efficacy as not a simple sum of individual efficacy, but "the product of the interactive and coordinative dynamics of its members; interactive dynamics create an emergent property" (Bandura, 1997: 477-478). This is a prospective judgment of group

capabilities and influences the management of resources, plans, strategies, and efforts of the

collective (Bandura, 1997). Research suggests this prospective judgment relates to a wide range

of performance outcomes, including creative problem solving (see Gully et al., 2002 for a meta-

analysis; Tasa & Whyte, 2005). Furthermore, when working in a collective, it is not only the

individual's view of the collective that matters, but also the collective's view of collective.

Analogous findings at the individual level combined with the idea that agentic psychological

resources are foundational to the work of the collective lead to the final hypothesis of this

dissertation:

> ***Hypothesis 5:*** *Collective psychological capital moderates the relationship of the adaptive function to innovation at the dyadic level, such that higher levels of collective psychological capital and greater levels of the adaptive function are related to higher levels of innovation compared to pairs of actors with lower levels of collective psychological capital and lower levels of the adaptive function.*

Summary

The theoretical propositions of this dissertation are summarized in figure 1. Shared

leadership and collective creativity, enabling conditions, and outcomes are the central

relationships being explored. With the literature review and hypothesis formation complete, I

now turn to study design in order to detail the mechanics of how research questions will be

examined and study hypotheses tested.

Insert figure 1 about here

CHAPTER THREE: STUDY DESIGN AND METHODOLOGY

Sample

The setting for this study was a 60-person non-profit that provides leadership development programs and curriculum for high school and college students in the Midwestern United States. Despite the recent economic downturn and its detrimental impact on many NGO's, they have thrived thanks to creative changes both internally and externally-facing. Additionally, in serving some relatively impoverished areas, the organization finds that program participants do not have the means to pay. Hence, financial resources are a constant struggle for the organization. Despite these conditions, the organization is actively sought in the communities it serves due to its high-quality program offerings. Since a collective approach is of key interest in this study, it was important to find a site where such emergent innovation occurs. Through initial inquiry with this organization, it was found that this organization has a high base rate of both collectivity and innovation. Therefore, it was selected as an appropriate site for this research.

All members of the organization were asked to participate in the study. This includes a total of 60 individuals and represents a complete network. The boundary of this network was defined using the positional technique, where the network contains individuals associated with an organization or unit (Marsden, 2005). Responses were received from 49 of 60 possible staff, resulting in a 81.7% response rate, achieving the recommended minimum 80% participation needed for this network study (Scott, 2000). The sample included a heterogeneous mix of backgrounds including educators (43.2%), management (20.5%), retail (15.9%), engineering (6.8%), financial services (6.8%), and other (6.8%). Sub-unit designation with the organization included corporate board (29.8%), seminar activities (54.4%), and alumni outreach (15.8%).

Educational background included bachelors (37%), masters (11.1%), high school (18.5%), and some college (33.4%). The high percentage of high school only is highly correlated with age (average age is 25.4); many staff are currently pursuing a bachelors degree. Respondents were 73% female. The sample was 97% Caucasian. Mean tenure with the organization was 6.79 years (s.d. 4.7 years), and mean tenure in current position was 2.73 years (s.d. 2.39 years).

Demographics were comparable between the sample (n=49) and the entire organization (n=60). Average age within the organization as a whole was 24.9 and 73% of organizational members are female. Tenure in organization averaged 6.8 years (s.d. 4.7 years) for the overall organization while tenure in current position averaged 2.7 years (s.d. 2.4 years). Thus, these demographic checks suggest, taken as a whole, the sample is representative of the entire organization and is not biased toward a particular demographic.

Procedures

Data were collected with a web-based survey using Qualtrics. See appendix A for a full copy of the survey. Demographic data were collected from organizational records. Names, e-mail addresses and telephone numbers for all organization members were provided by an organization contact. Prior to data collection, the president of the organization sent an e-mail to introduce this study and encourage participation. This was followed by an email from the researcher with an individualized survey link to each person completing the online survey. A reminder was sent one week later. Two weeks later, the organization president followed up via e-mail to the entire organization informing them of the current response rate and encouraging non-respondents to complete the survey. The researcher also followed up with those non-respondents individually via telephone. See appendix B for full details of contact scripts.

Per consultation with organization administration, a $150 donation was offered to the organization as a token of appreciation for participation in this survey as well as an additional $150 if at least an 80% response rate was achieved. This incentive was designed to enhance response rate while not being so large as to have a negative impact on response rate (Chromy & Horvitz, 1978).

Measures

Web-based surveys were administered. A full copy of the survey can be found in Appendix A. The roster method was used (Marsden, 1990). The three individuals who have left the organization in the past two years were also included in the roster as to provide a complete listing of all staff during the two-year timeframe examined. Comparing this group with current staff of the organization, they had a very minor number of network connections. For example, the ex-staff members were most connected in the reframing network. However, their connections in this network were less than one-fourth that current staff (an average of 7 connections versus 28.1). Additionally, since an innovation tie is defined as both individuals specifying the tie, this would not be possible since individuals who are no longer staff members did not complete the survey, and could result in misleading results. As such, these three individuals were dropped from further analysis.

The specific ties examined in this study were shared leadership, advice-seeking, reflective reframing, reinforcing, and innovation. Each relationship tie was collected as valued asymmetric data (Wasserman & Faust, 1994). This means data assessing the direction and strength of the relationship were collected (in contrast to non-valued symmetric network data, where simple dichotomous data are collected on the presence of the relationship, regardless of

relationship direction). By collecting data on strength and direction, a more nuanced understanding or relationships within the network is possible. The items are measured on a 5-point Likert-type scale (not at all, not much, somewhat, regularly, and very often). Each of the ties were measured by the actor who is acquiring the content of the tie (e.g., being led, receiving advice, etc.). This directionality measures actual behavior as opposed to hypothetical behavior, which is in line with the focus of this study. Further, a receiver focus was chosen as it is assumed the individual ultimately receiving and potentially using the outcome of the tie is in the best position to determine whether or not the relationship existed. For example, someone may provide advice without even realizing advice is being provided. Conversely, someone may feel they are providing leadership to a person when they are not. Each of the specific types of ties is described below.

Shared Leadership. Shared leadership is measured using a network measure of shared leadership adapted from the work of Carson, Tesluk, and Marrone (2007): "To what degree do you rely on this person for leadership? Here by leadership I mean a dynamic, interactive influence process to lead one another to achieve group or organizational goals." Per recommendation via personal communication with the authors of this measure, the item was adapted to include a succinct definition of leadership in order to further clarify the question to respondents (Carson, 2010). The definition of leadership from Pearce and Conger was leveraged: "a dynamic, interactive influence process among individuals in groups for which the objective is to lead one another to the achievement of group or organizational goals" (2003: 1). This definition acknowledges a collective and interactive view of leadership consistent with the present research.

Advice. The seeking of advice is a relatively common measured tie in organizational network research (for reviews, see Borgatti & Foster, 2003; Brass et al., 2004). De Lange and colleagues (2004) offered a comparison of a number of such measures. Chief among considerations in selecting this measure is the degree to which the question captures the underlying construct of interest. In particular, for the present research, actual advice exchange is of interest – not projective or desired advice exchange. With this in mind, the following item was adapted from De Lange and colleagues (2004): "Think of times you have been confronted with work-related problems for which you couldn't find a solution yourself. To what extent have you gone to this person for advice due to their relevant expertise?"

Reflective Reframing. No previously-published network measure of reflective reframing could be found for use in this study. Therefore, a one-item network measure was created. Item wording was based on the conceptualization of reflective reframing as a component of collective creativity as defined by Hargadon and Bechky (2006): "Think of times when you have sought help in thinking through a problem and looking at it from a different perspective. To what extent have you relied on this individual to provide that help in thinking through problems?"

Reinforcing. As with reflective reframing, no previously-published network measure of reinforcing could be found for use in this study. Therefore, a one-item network measure was created based on the conceptualization of reflective reframing as a component of collective creativity as defined by Hargadon and Bechky (2006): "Think of times when you are looking for confirmation if idea is good or not. To what extent have you relied on this individual to provide that confirmation?"

Collective creativity. Collective creativity is the combination of advice exchange, reframing, and reinforcing. It was analyzed as an additive combination these three components. Specifically, a binary adjacency matrix was created for each of the three components, with a value of "regularly" or "very often" constituting existence of each individual tie. Next, a binary adjacency matrix was created for collective creativity. The adjacency matrix includes one row and one column for each actor in the network. The existence of collective creativity in this matrix will be operationalized as the existence of any one of the three components (1) versus none of the components (0). Collective creativity will be analyzed as a symmetric adjacency matrix. That is, the value for actors j & k will be the same in row j, column k as it is in column j, row k. Specifically, the adjacency matrix is maximally symmetrized, meaning only one of the two actors (or both) needed to denote the existence of the tie for a tie to exist. While inconsistent with the asymmetric, directional nature of the individual components of collective creativity (e.g., advice exchange in a pair can flow either, both, or neither way between two actors), when collective creativity as a whole is considered, there is no concept of the "giver" or "receiver" of collective creativity. Rather, the network relationship is that collective creativity exists between individuals. Hence, a maximally symmetrized adjacency matrix will be used. While hypotheses will be tested using the maximally symmetrized matrix, a minimally symmetrized version for each network will also be included in correlation tables to enable more detailed exploration of the nature of the relationships.

Adaptive function. The adaptive function is the combination of collective creativity and shared leadership. Given that the addition of shared leadership is what differentiates the adaptive function from collective creativity, the adjacency matrix for

the adaptive function includes conditions where both collective creativity and shared leadership occur within the same dyadic relationship. The same cut-off values were used as in collective creativity for created this binary adjacency matrix. Also, as with collective creativity, a maximally symmetrized adjacency matrix will be used.

Formal leadership. Formal leadership refers to the formal reporting relationships that exist within the organization. This data was collected from organizational records to form a binary adjacency matrix of formal reporting relationships. This matrix was maximally symmetrized to be consistent with the shared leadership matrix.

Innovation. Following the example of Tsai (2001) and using the definition of innovation provided by Taylor & Greve (2006), participation in innovation with others was measured over the most recent two-year time period via the item: "To what extent have you innovated with this person to produce changes (big or small) within the organization? By innovation I mean the process by which creative ideas become recognized as valuable and implemented in the organization. For example, introducing a new segment to the seminar program or finding a way to reach out more effectively to alumni or sophomores during the recruitment process."

While such a question is subject to recall bias (Golden, 1992), there are a number of factors which serve to lessen this possibility. First, innovation produces salient outcomes, with such salient innovation being less subject to recall bias (Crutcher, 1994). Second, innovation represents positive performance, which is much less susceptible to recall bias than poor performance (Golden, 1992), as recalling positive performance is not image enhancing behavior (Feldman & March, 1981; Salancik & Meindl, 1984). Thirdly, bias is reduced by the recall of facts and behaviors as opposed to beliefs,

intentions, or possible relationships (Golden, 1992). Finally, both parties potentially

involved in the innovation need to denote involvement with each other to produce

innovation, using multiple respondents to determine innovative relationships (Dearborn

& Simon, 1958, Schwenk, 1985). Innovation was thus operationalized using a minimally

symmetrized adjacency matrix. This is different from the other adjacency matrices,

which were maximally symmetrized. This decision was made because, while an

individual may provide leadership, advice, reframing, or reinforcing to another without

realizing it, the resulting innovation is something both parties should understand and

acknowledge. While the method of symmetrization was different, the matrix is binary,

consistent with other matrices in the study. While hypotheses will be tested using the

minimally symmetrized matrix, a maximally symmetrized version for each network will

also be included in correlation tables to enable more detailed exploration of the nature of

the relationships.

Following the accepted norms of social network studies (e.g., LaBianca, Brass, & Gray,

1998; Shah, 1998), this study utilized single-item measures in measuring relationships.

Although there are well-known benefits of multi-item scales in general, they are not feasible in a

network study where relationship data are gathered along multiple dimensions for many actors in

a network. Prior research has found the combination of roster methodology and single-item

measures to be largely reliable (Marsden, 1990). Additionally, meta-analysis has provided

support for using single-item measures where situational constraints, such as those of network

analysis, limit the feasibility of multi-item scales (Wanous, Reichers, & Hudy, 1997). This is

especially true when the construct of interest is clearly defined (Sacket & Larson, 1990). To

provide further clarity, detailed explanation and example was provided for each survey item

(Cross & Cummings, 2004; Ferrin, Dirks, & Shah, 2006). To further provide for reliability, questions were phrased regarding typical patterns of interaction (Freeman, Romney, and Freeman, 1987), as it is much more difficult to accurately recall interactions involving specific times (Bernard, Killworth, Sailer, 1982).

 Collective Psychological Capital. Collective psychological capital was measured using the 8-item Psychological Capital Questionnaire (PCQ; Walumbwa et al., 2009). In this study, the scale demonstrated internal reliability ($\alpha = .88$), higher than the coefficient alpha of .79 reported for the collective PsyCap scale by Walumbwa and colleagues (2009). This scale was adapted from the original 24 item individual-focused version (Luthans, Avolio et al., 2007). As discussed earlier, the adapted version was chosen given the collective (as opposed to individual) focus of this study. Specifically, given the interdependent nature of workflow and challenges within the studied organization, a collective approach to PsyCap is necessary (Gully et al., 2002). While the questions in this measure focus on the collective, the respondent is the individual. Thus, individual perceptions about collective PsyCap are being examined. Items are measured on a 6-point Likert scale ranging from "strongly disagree" to "strongly agree." Representative items include: Members of this group ''... confidently contribute to discussions about the group's strategy'' and "are optimistic about what will happen to them in the future as it pertains to work.''

 To transform this individual perception into a relational variable, an adjacency matrix was created as the product of individual PsyCap measures. While a number of methods to create this measure of dyad-level PsyCap were explored (maximized, minimized, average, sum, and product), the product was chosen as it most accurately operationalizes theory that posits

collective PsyCap as not a simple sum across actors, but as the dynamic product of interactions (Bandura, 1997).

Heterogeneity. Within the survey, a variety of individual attribute data were collected and from these data measures of relational heterogeneity were created. This includes professional affiliation (e.g., educator, social worker, engineer, etc), sub-unit designation (corporate board, seminar activities, or alumni outreach), previous participation in the organization's programs, educational background (high school, some college, bachelor, master, etc), tenure with the organization (in years), and tenure in the current position (in years). All of these variables were gathered via survey (see Appendix A for a complete copy of the survey, including question wording). Each of these dimensions represents potential heterogeneity in experience and abilities, which has been found to contribute to innovative outcomes (Hulsheger et al., 2009). Additionally, race (White/Caucasian, African American, Hispanic, Asian, Native American, Pacific Islander, and other), gender (1 = male, 0 = female), and age (year born) were also collected. Dissimilarity matrices (n x n) were created for the categorical dimensions of heterogeneity (professional role, sub-unit designation, previous program participant, educational background, race, and gender), where similarity in an attribute across the dyad equals "0" and a difference in the attribute across the dyad equals "1". Dissimilarity matrices for age and the two tenure variables were created by taking the absolute value of the difference in number of years between each individual (Zagenczyka, Scott, Gibney, Murrell, Thatcher, 2010). Heterogeneity was then analyzed at the dyadic level using each of these matrices, as described in greater detail in the analysis section.

Measures created through social network analysis. Measures of degree centrality, betweeness centrality, Bonacich eigenvector centrality, corresponding centralization, and the

clustering coefficient for each network relationship (leadership, creativity, etc) were all derived from survey data using social network analysis. Centrality, centralization, and clustering coefficient measures were created using binary, symmetrized (i.e., undirected) adjacency matrices. The calculation of each is described in greater detail below.

Degree Centrality. Unstandardized degree centrality refers to the simple count of number of direct connections an individual has with other actors in the network (Nieminen, 1974). Standardized degree centrality for each actor in the network is then calculated as unstandardized degree centrality of the actor divided by total number of possible ties (Wasserman & Faust, 1994). Unstandardized degree centrality is reported.

Betweeness Centrality. Betweenness refers to the condition where one actor lies on the shortest path between two actors without a direction connection. Beginning with the set of all potential pairs of connections in the network, the shortest path between each pair is determined, and the unstandardized betweeness centrality for an actor is the number of instances where the actor is on the shortest path between two actors without a direction connection. The standardized betweeness centrality is the unstandardized divided by the total number of pairs in the network (Hanneman & Riddle, 2005).

Bonacich eigenvector centrality. Eigenvector centrality measures the importance of an actor in the network. A relative score is calculated for each actor where connections to more highly scored actors results in a higher scoring. It is calculated as a proportion of the sum eigenvector scores for all actors to which the actor is connected (Carrington, Scott, & Wasserman, 2005).

Centralization. Centralization for the network overall is calculated based on each of the centrality measures above, resulting in the corresponding centralization measure (standardized

degree centralization, standardized betweeneess centralization, and eigenvector centrality).

Given a network consisting of g total actors where $C_A(n^*)$ is the largest centrality value of any

actor in the network and $C_A(n_i)$ is the centrality of the ith actor, centralization C_A is calculated as:

$$C_A = \Sigma^g[C_A(n^*) - C_A(n_i)] \quad / \quad max(\Sigma^g[C_A(n^*) - C_A(n_i)])$$

Centralization ranges from 0 to 1 where a value of 0 indicates all actors have exactly the

same centrality and 1 indicates a single actor dominates in centrality over all others (Wasserman

& Faust, 1994).

Clustering coefficient. This measures the degree to which actors in the network tend to

form tightly connected groups relative to others in the organization. It is calculated as the

average of the density of the open neighborhood of all actors (Hanneman & Riddle, 2005).

Analysis

Network analysis was conducted using UCINET to calculate network statistics, QAP

correlations, and QAP regressions. NetDraw was used to visually represent the network data.

An example of an adjacency and heterogeneity matrices is provided in Appendix C. Details on

how data were transformed from Qualtrics to an adjacency matrix are provided in Appendix D.

QAP correlation was used to calculate dyadic-level correlations (Carrington, Scott, &

Wasserman, 2005). QAP is used widely within the social network literature and is a non-

parametric method of analysis robust against the issue of non-independence inherent in dyadic

data. The QAP procedure correlates network matrices, repeatedly runs permutations on the data,

and then assesses the number of times the correlation is equal to or larger than the base

correlation, offering a much more conservative estimate of significance when compared to the

more widely used Pearson correlation method. Despite these differences from a Pearson

correlation, QAP correlation coefficients appear similar, with a range from -1 to 1, with a value of 1 indicated complete correlation, 0 indicating no correlation, and -1 indicating complete correlation in the opposite direction.

Hypotheses 1 and 3 (collective creativity and the adaptive function as antecedents to the independent variable of innovation) are dyad level hypotheses. Using QAP correlation, I explored the association between having a collective creativity tie (H1) or an adaptive function (H3) and an innovation tie. Hypotheses 2a and 2b (centralization and sub-group cohesion of the collective creativity components) are network level hypotheses. Symmetrized binary adjacency matrices of collective creativity components denoted the existence of these collective creativity components. This dataset was analyzed using degree and betweenness centralization (H2a) and clustering coefficient (H2b) statistics. Given the exploratory nature of these hypotheses, a number of methods for calculating centralization and clustering were analyzed and compared.

Hypothesis 4 (heterogeneity moderating) is a dyadic level hypothesis. Using QAP regression, I explored the direct effects of the adaptive function matrix and each similarity matrices (one at a time) on the innovation matrix. Then, I explored the interactive effects by multiplying the adaptive function matrix to the similarity matrix (creating a third n x n matrix for each aspect of heterogeneity).

The Double Dekker Semi-Partilalling MRQAP regression technique was used in this analysis. While this form of QAP regression is relatively new, analysis has shown this method to be commensurate with the standard semi-partialling method under normal circumstances with additional benefit under circumstances involving non-normal or skewed data (Dekker, Krackhardt, & Snijders, 2005). For categorical variables, the interaction value was "0" unless both the adaptive function and heterogeneity were present, in which case it was "1". For

continuous variables, the adaptive function and heterogeneity matrices were multiplied. Then
including this resultant matrix into the QAP regression, I tested whether or not heterogeneity
moderated the effect of adaptive functioning on innovation. A separate series of regressions
were performed for each aspect of heterogeneity (professional affiliation, sub-unit designation,
tenure in organization, tenure in position, previous participation, and education), with the
heterogeneity matrix, the adaptive function matrix, and the corresponding interaction matrix all
predicting the innovation matrix. Additionally, the potential moderating impact of demographic
heterogeneity of gender, age, and race were similarly analyzed.

Hypothesis 5 (PsyCap moderating) is a dyadic level hypothesis. The moderating impact
of collective PsyCap on the adaptive function and innovation was then tested using the Double
Dekker Semi-Partilalling MRQAP regression in a similar manner as the heterogeneity tests in
Hypothesis 4.

In addition to the dyadic level analyses described above, sub-group analysis was
attempted to further examine hypotheses 1, 3, 4, and 5. Faction analysis was used to determine
mutually exclusive sub-groups from collective creativity (H1) and adaptive function (H3, H4,
H5) network adjacency matrices (Wasserman & Faust, 1994). Analysis was performed for
mutually exclusive factions ranging in size from seven to fifteen. In all cases, the majority of the
factions consisted of only one actor and one or two factions constituted the remainder of the
actors. For example, the faction analysis for 14 factions produced 12 factions consisting of one
individual each, one faction representing a group of five, and all 43 other members of the
organization were in the final faction. Exploring collective processes when the majority of
groupings are individuals does not make sense. Faction analysis of collective creativity networks

therefore did not produce meaningful sub-groups and no further analysis will be conducted on collective creativity sub-groups.

Similar results were obtained when attempting to create sub-groups of the adaptive function. Theoretically, the model with 10 adaptive function factions produced the "best" results (zero single-member factions, eight two-member factions, one faction of four actors, and the remaining 40 actors in the final faction). However, a faction of forty is not theoretically meaningful in the analysis of shared and collective process of the adaptive function. Due to these data driven results, sub-group analysis will not be conducted.

CHAPTER FOUR: RESULTS

The purpose of surveying staff at the non-profit organization was to gain a greater understanding of the relationship between the adaptive function, shared leadership, collective creativity, psychological capital, heterogeneity, and innovation. This section will report on the results of the analyses conducted on these data. Analyses include descriptive statistics of the sample population, correlations between study variables, and tests of the hypotheses proposed.

Descriptive Statistics and Correlation of Variables

This study includes data at the individual, dyadic, and network levels. Descriptive statistics are summarized in Table 1 for individual attributes. This includes minimum, maximum, mean, and standard deviation values of study variables for the sample of 49 staff that completed the survey. Network degree ties relate to the number of direct relationships each individual has with other actors in the network. While individual data were collected and presented, no hypotheses were tested at the individual level. Rather, these individual data were used to created dyadic network matrices that signified the similarity or combined impact of these variables. Both minimally and maximally symmetrized versions of each adjacency matrix were reported.

Individual-level correlations were calculated using Pearson correlations. Correlations were generally in the expected direction, including a positive correlation between all network ties. Innovation was highly correlated with the adaptive function (.58, $p < 0.001$), collective creativity (.67, $p < 0.001$), and shared leadership (.59, $p < 0.001$). Collective creativity was calculated as a function of advice, reframing, and reinforcing networks and adaptive function as

a function of collective creativity and leadership. This explains the extremely high levels of correlation (.92 to .95, p < 0.001) between these variables. The only individual difference significantly correlated with innovation was a person's previous participation in the organization's programs (0.28, p < 0.05). This means having been a participant in the programs of the organization results in a greater likelihood of innovation than staff members who did not. An unexpected correlation was the negative relationship between collective PsyCap and a person's tenure in the organization (-.29, p < 0.05). This signifies that the longer someone is part of the organization, the lower their sense of collective PsyCap regarding the organization.

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Insert Table 1 about here

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Descriptive statistics and correlations for dyadic-level study variables are summarized in Table 2. This includes minimum, maximum, mean, and standard deviation study variable values for the sample of 3,540 ties described in the survey data. This table was calculated using adjacency matrices that describe relationships, not values at the individual level. Data relates to ties between individuals, not individuals. The average value for shared leadership ties was 0.40, indicating that 4 out of 10 relationships in the organization involve the exchange of leadership. A value of one in the heterogeneity variables indicates two actors are different (e.g., different educational backgrounds), whereas a value of zero indicates homogeneity on the variable (e.g., both belong to the same sub-unit in the organization). The number of ties is much greater than the sample size (49) because the dyadic tie analysis examines the potential relationship of every

member of the organization to every other member. Similar to the individual-level, both minimally and maximally symmetrized matrices were reported.

Results of QAP correlations show significant correlations of the dependent variable of innovation with the key independent variables of the study - collective creativity (.36) and adaptive function (.28) networks (both significant at p < 0.001). Thus, having either collective creativity or adaptive function ties is associated with also producing innovation.   Further, the relatively high correlation between the three elements of collective creativity (ranging from .68-.70, p < 0.001) supports the notion that these three elements form a common collective creativity construct.

There were some interesting correlations between innovation and heterogeneity of actors in the network. To be clear, this heterogeneity analysis deals with whether two individuals are similar or different on a particular attribute (such as gender), not the value of the attribute (in the example of gender, male-female is treated as a heterogeneous tie, whereas male-male and female-female are analyzed together as homogenous ties). The largest positive correlation (0.16, p < 0.001) was between innovation and sub-unit designation. This indicates that individuals working together from different sub-units were more likely to generate innovation than those from the same sub-unit. Another higher correlation between innovation and heterogeneity was in previous program participation (0.13, p < 0.005). This means relationships that produce innovations were more likely between pairings of individuals who did and did not participate in this organization's programs as high school students. While sub-unit and previous participation heterogeneity were positively correlated with innovation, heterogeneity in age and educational background were each negatively correlated with innovation (-0.11 and -0.13, p < 0.01 in both

cases). In other words, individuals of similar age or educational backgrounds were more likely

to generate innovations than individuals of different ages or educational backgrounds.

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Insert Table 2 about here

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Values for network-level variables are presented in Table 3. Given only one network was

studied, it is not possible to present summary statistics or correlations of these data. The overall

network structure is depicted in sociograms: collective creativity (figure 2-4), shared leadership

(figure 5-7), adaptive function (figure 8-10), and innovation (figure 11-13). In each figure, nodes

are arranged by geodesic distance, such that connected nodes are located near each other in the

visualization. Generally speaking, this results in the most well connected nodes tending toward

the center of the diagram and the least-connected nodes tending toward the outskirts of the

diagram. Each of the three diagrams presents a different type of centrality: degree, betweenness,

and eigenvector, respectively, with the size of the nodes relating to each actor's centrality. Table

3 and the sociograms show leadership network was more centralized (59.8%) than the creativity

network (47.6%). As degree centrality can range from 0-100%, where 0% means centrality is

distributed evenly and 100% means there is one central actor in the network, these results mean

individuals in the creativity network are similarly central in the network whereas there is more

disparity in prominence of network location in the leadership network. Said differently,

individuals in the network are more likely to be distinguished from each other along the

dimension of leadership than of creativity. The innovation network is characterized by even

lower degree centralization (29.8%). This suggests one actor is it not primarily involved in all innovations and that numerous actors innovate, with innovation occurring across the organization.

The innovation network was the only network that contained isolates, meaning it was the only network where some staff were not connected to any other staff member in the organization along the dimension of innovation. This was due to a measurement artifact related to non-response. Specifically, innovation was the only network operationalized as a minimally symmetrized adjacency matrix where both parties involved in the relationship needed to denote the relationship existed. Therefore, no non-respondents had an innovation tie, as they did not complete the survey and specify any such relationship. Conversely, for the other networks (such as leadership), a maximally symmetrized adjacency matrix was used where only one party in the relationship needed to denote the relationship existed for it to be denoted as occurring. In all other networks (advice, reframing, reinforcing, and leadership), all individuals were connected directly or indirectly to every other individual through one large network component. This means that it was possible for every member of the network to reach (directly or indirectly) every other member of the network through the connections that existed. Considering innovation as a maximally symmetrized network produces no isolates in this network. The maximally symmetrized versions of all network measures are included in Tables 1 & 2 for comparison.

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Insert Table 3 about here

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Insert Figures 2-13 about here

Tests of Hypotheses

A summary of all hypotheses and study findings is provided in Table 4. Hypotheses were

tested using minimally symmetrized innovation network data as the dependent variable.

Insert Table 4 about here

Hypothesis 1 predicted that collective creativity was positively related to innovation. To

test this hypothesis, QAP correlation was used to correlate the collectivity creativity adjacency

matrix with the innovation adjacency matrix. As shown in Table 2, results show a correlation of

0.36, which is significant at $p < 0.001$. Thus, hypothesis 1 was supported. As shown in the

figure, innovation is most likely to occur with the most central members of the creativity

network, meaning that individuals with the greatest number of total collectivity ties are also more

likely to be involved in innovation ($r = 0.67$, $p < 0.001$). The majority of innovation occurs

when all three elements of collective creativity (advice, reflective reframing, and reinforcing)

exist together in a relationship (79.3% of all innovation). Of the remaining innovation, reflective

reframing was the component of collective creativity with the most frequent predictor, correlated

with over half (10.8%) of the innovation ties either alone or in conjunction with one of the other

two relationship types. Only 2.7% of all innovation involved solely an advice relationship while

no innovation involved only a reinforcing tie. While reinforcing alone was not related to

innovation, it occurred in conjunction with advice and/or reflective reframing in 85.6% of all

innovation ties. Interestingly, 5.4% of all innovation ties occurred in the absence of any

collective creativity ties. The occurrence of innovation by collective creativity component is

represented visually in the Venn diagram in figure 14. The relative size of each circle, and its

degree of overlap with other circles, signifies the approximate proportion each type of collective

creativity occurred.

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Insert Figure 14 about here

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Where hypothesis 1 examined the relationship of collective creativity with innovation,

hypotheses 2a and 2b examine the components of collective creativity in more detail as they

relate to each other. Specifically, hypotheses 2a and 2b predicted that centralization would be

higher in advice and reframing networks when compared to reinforcing networks (2a) and that

sub-group cohesion would be higher in the reinforcing network when compared to advice and

reframing networks due to the affective-based nature of reinforcing networks (2b). As shown in

Table 3, degree centralization is highest in the advice network (0.505), followed by reframing

(0.406) and reinforcing (0.386) networks. As the advice network had higher degree centralization

(over 50%) when compared with the reinforcing network (38.6%), this means reinforcing

network connections are more evenly distributed between all network members whereas advice

network had greater disparity in degree centrality between actors in the network. Thus,

hypothesis 2a was partially supported. Also shown in Table 3, the clustering coefficient in the

advice network (0.605) is similar when compared to the reinforcing (0.563) and reframing

networks (0.556). In other words, the density of an actor's open neighborhood is similar across

these three networks types. This means that reinforcing, advice, and reframing exchanges

between individuals in the network all occurred in relatively cohesive sub-groupings within the larger network. Thus, hypothesis 2b was not supported.

The collective creativity network is comprised of a mix of the three elements of collective creativity. As shown in figure 15, only 46.9% of the collective creativity network is comprised of relationships where all three components occur in conjunction with each other. Of the remaining ties that comprise the collective creativity network, advice exchange is the most frequently occurring component, occurring in 31.9% of relationships. Reinforcing-only relationships account for 10.5%, 5.9% are reflect-reframing only, and the remaining 4.8% involve a combination of reinforcing and reflective reframing.

Insert Figure 15 about here

Hypothesis 3 predicted that the adaptive function is positively related to innovation. Similar to hypothesis 1, this hypothesis was tested using QAP correlation by correlating the adaptive function adjacency matrix with the innovation adjacency matrix. As shown in Table 2, results found a correlation of 0.28 significant at the $p < 0.001$ level. Thus, hypothesis 3 was supported. This finding supports the core hypothesis of this dissertation that the adaptive function of complexity leadership is positively related to innovation. Individuals with the greatest number of adaptive ties are also more likely to be involved in innovation ($r = 0.58$, $p < 0.001$). As shown in figure 16, nearly all innovation (93.5%) occurs when the adaptive function (shared leadership and collective creativity) exist in a relationship. Only 4.9% occurred with only collective creativity, 1.5% with only shared leadership, and the remaining 0.1% of

innovation occurring in the absence of shared leadership or collective creativity. Unlike

collective creativity where any one of the three components can exist to be considered collective

creativity, with the adaptive function both components need to exist in conjunction with each

other. Examining all instances where either a shared leadership or collective creativity tie

occurs, as shown in figure 17, it was found that the two exist in conjunction with each other in

60.6% of relationships that contain at least one of these components, with leadership ties

occurring in the absence of creativity ties in 31.4% of relationships, and creativity occurring in

the absence of leadership only 8% of the time.

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Insert Figures 16 & 17 about here

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Hypothesis 4 builds upon hypothesis 3 by examining the moderating impact of

heterogeneity between the adaptive function and innovation. Hypothesis 4 predicts that

heterogeneity in experiences and abilities moderates the relationship of the adaptive function and

innovation such that greater heterogeneity and adaptive function result in higher levels of

innovation. Unlike hypotheses 1 and 3 where QAP correlation could be used, this hypothesis

was tested using QAP regression to understand the interaction of the adaptive function and

heterogeneity in predicting innovation. With nine dimensions of heterogeneity to test (including

demographic dimensions), nine different regressions were individually analyzed, one for each

dimension of heterogeneity.

The results of these regressions are shown in Tables 5-10, one for each heterogeneity

matrix. Standardized beta coefficients are reported. Standardized coefficients were chosen to

enable comparison of the magnitude of impact of variables into the regression equation, with the coefficient being measured in standard deviations. Interactions are depicted in Figures 18-23, one for each heterogeneity variable. The following dimensions of heterogeneity achieved significance in the hypothesized direction: sub-unit designation (0.209, $p < 0.01$) and participation in the organization's programs as a student (0.186, $p < 0.01$). The heterogeneity dimensions of professional affiliation (-0.003), tenure in organization (-0.013), and tenure in position (0.033) each failed to demonstrate significant moderating impact between the adaptive function and innovation. These results provide mixed support for heterogeneity moderating the relationship between the adaptive function and innovation, demonstrating that differences in the sub-unit to which an individual belongs and differences in whether or not an individual participated in the organization's programs as a youth predict innovation above and beyond the adaptive function alone. Of interesting note is that moderation by educational heterogeneity was also significant, but in the opposite direction (-0.102, $p < 0.05$). That is, *homo*geneity of educational background moderates the relationship between the adaptive function and innovation such that homogeneity and high levels of the adaptive function lead to high levels of innovation, as shown in Figure 23. Taken together, results provide partial support for hypothesis 4 in that some aspects of heterogeneity moderate the relationship between the adaptive function and innovation.

Additionally, the demographic variables of race, gender, age and their potential moderating impact on the relationship between the adaptive function and innovation were also analyzed using QAP regression, as shown in Tables 11-13 and in the interaction plots in Figures 24-26. These relationships were not hypothesized, as prior research has found such background differences to not be related to innovation (c.f., Hulsheger et al., 2009). Consistent with prior

research, gender (-0.033, 0 > 0.05) and race (0.093, p > 0.05) did not have a significant impact, and while age did not have a significant main effect (-0.054, p > 0.05), it had only a slight negative moderating impact (-0.075, p < 0.05). However, age is highly correlated with educational background (0.28, p < 0.05), and regressing the adaptive function with both educational background and age demonstrated significant impact of educational background (-0.088, p < 0.05), but not age (-0.043, p > 0.05).

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Insert Tables 5-13 about here

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Insert Figures 18-26 about here

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Similar to Hypothesis 4, Hypothesis 5 predicts that collective PsyCap moderates the relationship of the adaptive function and innovation such that greater collective PsyCap and adaptive function result in higher levels of innovation. As in Hypothesis 4, this hypothesis was tested using QAP regression to understand the interaction of the adaptive function and PsyCap to innovation. As shown in Table 14, and in the interaction plot in figure 23, there was not significant interactive impact of PsyCap and the adaptive function (0.036, p > 0.05). Thus, Hypothesis 5 is not supported.

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Insert Table 14 about here

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Insert Figure 27 about here

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CHAPTER FIVE: DISCUSSION

Discussion

Leadership, creativity, and innovation are needed to sustain organizations confronted with the need to adapt to a changing environment (Ilinitch et al., 1996; Lichtenstein et al., 2006; Osborn et al., 2002).   The purpose of this study was to learn more about the adaptive function of complexity leadership by investigating the relationship of collective creativity and shared leadership with innovation. Examining the enabling conditions of heterogeneity and psychological capital added to a nuanced understanding of the relationship of the adaptive function to innovation.

The results contribute to a growing body of knowledge that suggests innovation within organizations is created and disseminated through shared leadership and emergent "grassroots" creative processes (Lichtenstein & Plowman, 2009; Marion & Uhl-Bien, 2001). This study helps complexity leadership to begin to move beyond theorizing and into empirical testing. Five key findings emerged to provide a more nuanced understanding of the process by which the adaptive function leads to organizational innovation.

First, collective creativity was empirically shown to relate to innovation. While this could be viewed as a simple extension of extant individual-level research, it is an important paradigm shift as it challenges the traditional wisdom of creativity as embodied in the individual, and instead demonstrates creativity as a property of the collective. The present research serves to empirically validate and reinforce the initial qualitative work of Hargadon and Bechky (2006). Specifically, their work posited collective creativity as comprised of advice giving, advice seeking, reflective reframing, and reinforcing components. These components were measured individually and found in the present research to comprise a collective creativity construct that

was then related to innovation. While advice exchange has been studied extensively (for

reviews, see Borgatti & Foster, 2003; Brass, Galaskiewicz, Greve, & Tsai, 2004), advice

exchange is not generally regarded as a proxy for creativity, nor reflective reframing or

reinforcing relationships (Hargadon & Bechky, 2006). Hence, it is a significant contribution to

find these components constitute collective creativity. While it could be suggested that this is a

mere case of mono-method multi-collinearity, these components of collective creativity had

significantly greater correlation with each other than the other network measures in this study.

The relatively high centralization of advice exchange is consistent with prior research and

signifies that individuals develop specialized expertise within the organization and are actively

sought by others in the organization for the expertise (Borgatti & Foster, 2003). However, the

relatively similar network centralizations of reflective reframing and reinforcing was unexpected.

In considering instrumental (knowledge-based) versus expressive (affective-based) ties, one

potential explanation is that this designation may not be a simple dichotomy. Rather, reflective

reframing may also have elements of an expressive tie, rather than solely an instrumental tie

(Ibarra, 1993). That is, by engaging in reflective reframing, one is engaging in both instrumental

knowledge exchanges of alternative views of an idea as well as affective-based interactions

where the merit of an idea is acknowledged through the process of reflective reframing.

The overall high sub-group cohesion across all three components of collective creativity

provides empirical validation of the collective nature of these creative interactions, with such

cohesion being associated with innovative outcomes (Hulsheger et al., 2009). The lack of

difference in sub-group cohesion between components of collective creativity was surprising and

may be explained by the relatively small size of this organization. In larger organizations where

it is not possible for every staff member to have a relationship with every other staff member,

then greater differences in sub-group structure would be expected between instrumental and expressive ties (Ibarra, 1993).

The fact that only 46.9% of collective creativity relationships possessed all three components suggests the components are distinctive. However, the fact that 79.3% of all innovation occurred in this 46.9% of ties suggests the three components acting in conjunction with each other relate most strongly to innovation. Considering the components individually, while advice occurred the most frequently (78.7% of all collective creativity ties), it was reflective reframing that was most directly related to innovation, with 90% of all innovation involving a reflective reframing tie. This is further underscored by the fact that nearly 5% of innovation ties occurred with reflective reframing as the only component of collective creativity (compared to 2.7% for advice and none for reinforcing). While reinforcing by itself did not relate to innovation, it occurred in 85.6% of all collective creativity relationships. This suggests that, while it doesn't relate to innovative outcomes by itself, reinforcing behaviors are an important component of collective creativity. Taken together, this nuanced understanding of collective creativity serves an important foundation to empirically investigating the adaptive function.

Second, findings regarding shared leadership and collective creativity and their relationship to innovation supports the premises of the theory of the adaptive function in complexity leadership. Specifically, with 93.5% of all innovation relating to the adaptive function, this study demonstrates that shared leadership and creative interaction predict innovation (Uhl-Bien et al., 2007). While leadership and creativity each have been studied broadly as related to creativity, they have rarely been studied in conjunction with one another as collective and shared processes (cf. Lichtenstein & Plowman 2009). Regarding the relative

contribution of shared leadership and collective creativity to the adaptive function, when considering all relations where only shared leadership or only collective creativity occurred (i.e., not in combination with each other), shared leadership occurred more than four times as often as collective creativity. However, that portion of collective creativity was related with over three times the amount of innovation as shared leadership. This suggests a collective creativity relationship is more than twelve times as likely to predict innovation than shared leadership. While this is not surprising given the demonstrated relationship between creativity and innovation (cf, Hulsheger et al., 2009), a contribution of this study is the finding that the adaptive function is 4.6 times more likely to be related to innovation than is collective creativity alone. Through this detailed understanding of the relationship of shared leadership, collective creativity, and innovation, this study lays a foundation for future research to explore the adaptive function more fully as it relates to the administrative and enabling components of complexity leadership, which were not examined in this study.

Third, the overall patterns of centralization of leadership, creativity, and innovation networks demonstrated that innovation is a relatively decentralized phenomenon. Implicit in shared leadership and collective creativity predicting innovation is the notion that innovation itself is also shared and collective. A surprising finding in this study was that innovation was even more decentralized in the network - at 30% degree centralization - than either creativity (48%) or leadership (60%). Another way to consider this finding is that the standard deviation in number of network connections per individual was much lower for the innovation network (4.9) than it was for any of the other networks (8.4-13.3). This underscores that innovative outcomes are not the providence of a handful of creative leaders, but of the overall network. While not analyzed for this study, information regarding specific innovations was also collected from each

member of the organization. Many of the roughly 100 innovations identified were relatively localized in nature, supporting this finding of decentralized innovation. For example, fundraising teams introducing highly successful new donation campaigns or the seminar planning team developing new roles and processes to expand program content.   Relatively few innovations had a scope that included the entire organization.

Similar to prior research, the high centralization of leadership in the network can be explained in part as an organizational artifact – the organizational bureaucracy had a slight correlation with the leadership network, meaning both formal and informal leaders were reflected in the organizational leadership network (Carson, Tesluk, & Marrone, 2007; Hooker & Csikszentmihalyi, 2003). For example, key directors of the organization possessed a disproportionately high degree of leadership connections. However, these connections were not confined to the portion of the organization for which they are responsible. Likewise, there were individuals in the organization who, although not formal leaders, possessed a high number of leadership connections.

Advice exchange was the most frequently occurring component of collective creativity and was a somewhat centralized phenomenon, with a large number of individuals seeking unique experts increasing the centralization of collective creativity overall (Perry-Smith, 2006; Perry-Smith & Shalley, 2003). However, the actual production of innovations was much more strongly related to decentralized reflective reframing rather than centralized advice and leadership exchange. This suggests that innovation is more a grassroots process of emergence as opposed to a top-down process (Gupta, Tesulk, Taylor, 2007; Plowman et al., 2007; Chiles, Meyer, & Hench, 2004).

Fourth, certain aspects of heterogeneity moderate the adaptive function's influence on innovation. These potential relationships were explored by building on analogous individual-level research related to creativity. While the findings related to heterogeneity were significant, they were inconsistent across types of heterogeneity. A pattern that emerged from these inconsistencies was that more fine-grained types of heterogeneity related to a person's experiences in the organization (for example, the staff member's current sub-unit designation) were related to innovative outcomes while broad-level differences (for example, overall tenure or professional career affiliation) were not. This suggests that innovative outcomes are most dependent on immediate differences in individual's daily work experiences and relevant perspectives the individual brings (Milliken & Martins, 1996). These more salient and immediate differences may resist social influence pressures that lead to conformity or other group constraints, thus contributing to a more creative output (Janis, 1982). Further research is needed to better understand the unique intersection of both creativity and leadership that is the adaptive function, and why different forms of heterogeneity may augment that process' relationship with organizational innovation.

Another unexpected finding was that *homo*geneity in education related to innovation. Exploring this in greater detail revealed that, in particular, those with bachelor degrees frequently innovated with each other and so too individuals currently pursuing bachelor degrees frequently innovated with each other. This produced the overall homogeneity effect with education and innovation in this study. However, those individuals with a master degree, associate degree, or high school diploma only innovated with other individuals of a different educational background - most often with those who have a bachelor degree or are currently one. Extant creativity and innovation literature is surprisingly sparse with regarding to the impact of level of education on

creativity or innovation at this level of detail. Tierney and Farmer (2002) found a positive

association between education level and creativity. However, their sample did not include post-

bachelor degrees. Similarly, the education literature has consistently found linkages between

creativity and education level within K-12 samples (Fasko, 2001). While traditional wisdom

would lead us to believe more education leads to more creativity, the data in the present study

suggest there could potentially be a curvilinear relationship between education and creativity

with a peak at the bachelor level. More research is needed.

Fifth and finally, this study brings attention to the relationship of shared leadership and

collective creativity networks to human potential as measured via psychological capital. The

lack of a significant relationship between PsyCap and creativity in this study was surprising,

given its support in prior research at the individual level (Sweetman et al., in press). However,

this may have been due to the operationalization of collective PsyCap as a dyadic-level variable.

This is only known study that has operationalized PsyCap as such, and a more collective level

analysis may have been appropriate.

Another potential explanation for the lack of PsyCap findings relates to the unexpected

negative relationship between collective PsyCap and tenure in the organization. This finding

suggests the newer someone is to the organization, the greater their collective efficacy belief in

the organization and, conversely, the longer someone is with the organization the less their

efficacy belief in the organization. Sweetman and Luthans (2010) proposed a relationship

between PsyCap and work engagement, with higher levels of psychological capital relating with

greater work engagement. Taken together with these findings and feedback from organizational

members, this suggests staff with longer tenure in the organization may be experiencing the

antipoth of work engagement: burnout (Bakker & Leiter, 2010). Staff who have been with this

small non-profit organization the longest tend to feel the weight of the organization's future rests of their shoulders, often taking on unpleasant tasks to ensure the ongoing viability of the organization. This is a condition experienced by other non-profit organizations as well (Srinivas, 2002; Thompson, 1993; Wiltfang & MacAdam, 1991). The cause of the burnout is the depletion of staff energies without commensurate replenishment (Diener, Larsen, Levine, & Emmons, 1985). More research is needed to better understand the relationship between psychological capital, tenure, and other influencing variables in non-profit organizations specifically.

A unique aspect of this organization is that many staff members participated in the life-changing programs offered by this organization while they were in high school. This creates a unique form of self-categorization and social identity grouping in the organization between individuals who have had that experience first-hand and those who have not (Tajfel & Turner, 1979). In the context of this organization, it was therefore very interesting to find that innovative outcomes were more likely in heterogeneous combinations of individuals who have and have not previously participated in this organization's programs. Taken more generally, this finding is congruent with prior research in the creativity literature that has found the combination of a nuanced "inside" view combined with a more objective "outside" view is the most conducive to generating innovative outcomes (cf. Hulsheger et al., 2009).

Faction analysis failed to create meaningful data-driven sub-groups for further analysis. The lack of meaningful factions was potentially attributable to the overall size and nature of the specific network studied. Specifically, although there are formal divisions and structure with the organization, with only 60 staff members, roles often blur and individuals form both working and personal relationships across the entire organization. This is an organization where staff states that the culture feels more like a family than a formal organization. Given this close-knit nature

of the organization, it is not surprising that clear factions failed to emerge. While this resulted in the inability to conduct sub-group analysis, this lack of clear sub-groups is also of interest. It speaks to organizational cultural dynamics that inhibit such sub-groups from forming. Future research should explore these dimensions across multiple organizational networks to understand the impact of faction level on the adaptive function of complexity leadership.

Strengths and limitations

As with any study, the design and analysis of this study included different considerations and constraints. This led to some tradeoffs, producing both strengths and limitations of the study. Chief among the strengths are the multiplex network measures, which included a total of five distinct measured relationships between individuals (advice, reframing, reinforcing, leadership, and innovation), two additional network relationships derived from those five (collective creativity and the adaptive function), and one relationship provided through organizational records (formal reporting structure). The majority of network studies examine only one or two network relationships. The multiplex examination of five measured relationships provided much more nuanced detail beyond the simple existence or non-existence of a relationship, enabling a rich and nuanced understanding of the social network as related to shared leadership, collective creativity, and innovation.

An additional strength of this study was the size of the network data collection as well as the examination of multiple relationships. Especially given the nature of the self-reported relational measures collected through the roster method, a network size of 60 is somewhat large by the standards of previous interpersonal organizational network analysis (Wasserman & Faust, 1994). This large data set enabled a deeper understanding of patterns of relationships across an

organizational network. Further, the multi-source data collection afforded by leveraging network analysis data collection greatly mitigated the potential of single source bias.

While the relatively high level of correlation between network measures could indicate a method effect, the high correlation is not surprising as different types of relationship commonly overlap (Scott, 2000). Alternatively, this could also indicate similarity between the constructs – most notably advice exchange and leadership - which have been used interchangeably in some previous network studies (cf. De Lange et al., 2004). Extant measures of creativity focus on creativity as an individual-level characteristic (e.g., many common measures include individual performance on creative tasks). This makes it difficult to draw analogies between operationalization of individual-level measures and this relationship-focused measure of creativity. More research is needed to understand the differences between individual and collective creativity.

Respondents were asked to specify relationships for all 60 individuals in the network across five different relationship types, plus respond to twenty additional individual questions, for a total of 320 items; this large size could have introduced respondent fatigue in completion of the survey (e.g., Cross & Cummings, 2004). However, the data do not indicate that response fatigue occurred. Most notably, it took roughly the same amount of time (3:17 on average) to complete each of the five sets of network questions. The one exception was the innovation measure which, on average, took 26 seconds longer to complete than the other matrices. This is likely due to the fact that it was the first measure and there was a learning curve associated with understanding how to complete the survey. Further, 100% of surveys started were completed (i.e., no partial response). Taken together, this indicates respondent fatigue did not occur.

Another limitation was in bounding the network as members of the organization studied. This boundary condition is largely consistent with the hypotheses of this study and the goal of better understanding intra-organizational dynamics of collective creativity and innovation within the organization. However, actors within the organization were not the only potential relational partners for the types of relationships studied. Most notably, an individual may work with individuals from cooperating organizations. It is presumed that such interactions would involve collective creativity and innovation.

A further limitation of this study was the operationalization of innovations as a relationship between individuals, and not the measure of actual, specific innovations. This was a conscious trade-off in study design, as the survey already included over three hundred questions, and adding a two-mode network analysis of specific innovations and their relationships to individuals may have introduced greater respondent fatigue and suspect results.

A limitation inherent in the majority of network studies is the use of single-item measures to gather data about each relationship type with each individual in a respondent's network. This limitation was mitigated though asking the same single-item question multiple times, one for each individual in a person's network (Ferrin et al., 2006). It was further mitigated by surveying the components of collective creativity individually, rather than as one question. While single-item measures are regarded as a limitation generally speaking, they are accepted as a necessary tradeoff given the nature of social network research (Ferrin et al., 2006). Furthermore, methods employed in this study, such as inquiring regarding typical interaction patterns served to reduce concerns of reliability (Freeman et al., 1987).

Finally, while comparisons were made at the dyadic and network levels, ultimately the sample studied represents only one organization network. Unique elements of the non-profit

environment, and of youth-focused non-profits more specifically, may limit the generalizability of these findings to other types of organizations. On the other hand, this can be interpreted as a strength of the study given that such small non-profit organizations are often under-represented in the management literature (Bamberger & Pratt, 2010). Further, the external environment and internal culture of this organization and surrounding community may further limit the generalizability of the findings of this study.

Future Research

The findings of this study provide one of the first empirical network analyses to explore the adaptive function of complexity leadership. More work is needed to extend this nascent body of empirical understanding of complexity leadership theory and, in particular, the adaptive function.   The process of collective creativity is posited to shape future contributions while also making new sense of previous contributions (Hargadon & Bechky, 2006). This inherently time-based view of the collective process calls for future research to take a longitudinal, dynamic analysis approach of changes in network over time to better understand the causal relationship of the adaptive function, collective creativity, heterogeneity, PsyCap, and innovation. A two-mode network analysis would enable the examination of discrete innovations within the network and their relationship to individuals in the network, as opposed to innovation relationships between individuals. Future research leveraging sub-group analysis should also be explored to enable empirical understanding of group-level outcomes to the adaptive function. As the present research represents only one network in one organization, future research should examine additional organizational networks in additional contexts. Further, future research should

examine adaptive function relationships between individuals across organizational boundaries and the impact on innovation within the involved organizations.

The adaptive function was operationalized in this study as the intersection of any of the three components of collective creativity with shared leadership. This translated to four network-based measures - leadership, advice, reframing, and reinforcement – which were used to construct the adaptive function network. Future research should explore alternative ways to measure the adaptive function involving fewer network measures. This could include considering the adaptive function as a form of leadership involving the reflective reframing and reinforcing of creative ideas – which together explained the majority of variance of the adaptive function related to innovation.

Collective creativity assumes individuals are mindfully engaged in the issues at hand (Hargadon & Bechky, 2006). However, the constantly changing landscape leads to contexts where such mindful engagement can prove difficult (Osborn et al., 2002). As suggested by the data in this study surrounding specific innovations introduced, most were either incremental in nature or designed to advance a specific aspect of the organization (e.g., fundraising or seminar program approaches). Few innovations were true "game-changers" in scope and impact. While incremental innovation is much more common than radical innovation (Leifer et al., 2000), it seems more focused time for mindful engagement in the collective creativity process could lead to increased radical innovation. Future research is needed to empirically explore this paradox and articulate the contexts and processes by which mindful engagement can occur despite the constantly changing landscape.

Conclusion

For leadership and creativity research to remain relevant in this Knowledge Era, we need to augment our well-established views of individual-based leadership and creativity with views of these phenomena as a networked process that can lead to the emergence of innovation (Lichtenstein et al., 2006). Early research suggests teams that rely on this process-based approach to leadership out-perform those guided solely be a more traditional, hierarchical form of leadership (Carson, Tesluk, & Marrone, 2007). This study further contributes to this small-but-growing body of organizational leadership literature to empirically understand leadership and creativity from a process-based view.

While it was expected that there would be a strong linkage between the adaptive function of complexity leadership and innovation, this relationship was stronger than the relationship of shared leadership or collective creativity to innovation alone, with 93.5% of all innovation occurring where both shared leadership and collective creativity relationships were present. This supports the notion that shared leadership and collective creativity processes offer a combined strength beyond the individual component parts.

Lastly, this study demonstrated that individual-based positing regarding creativity have analogous collective counterparts, such as the role of heterogeneity. Taking shared responsibility in leading the bridging of the collective creativity of the academic literature will surely lead to theoretical and practical implications that can advance our disciplines further into the Knowledge Era.

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TABLES

Table 1: Descriptive Statistics and Correlations for Measured Variables (individual level)

#		Min	Max	Mean	s.d.	1	2	3
1	Degree Innovation tie (min)	0	21	3.7	4.9			
2	Degree Innovation tie (max)	2	56	24.4	12.6	0.78*		
3	Degree Adaptive Function tie (max)	3	58	25.4	13.3	0.58*	0.83*	
4	Degree Collective Creativity tie (max)	1	45	17.4	10.4	0.67*	0.81*	0.88*
5	Degree Shared Leadership tie (max)	3	58	23.3	13.3	0.59*	0.85*	0.99*
6	Degree Advice tie (max)	1	43	13.7	9.6	0.66*	0.75*	0.78*
7	Degree Reframing tie (max)	0	35	11.4	8.4	0.72*	0.75*	0.76*
8	Degree Reinforcing tie (max)	0	35	12.6	8.8	0.66*	0.82*	0.80*
9	Degree Adaptive Function tie (min)	0	19	3.1	4.5	0.84*	0.71*	0.63*
10	Degree Collective Creativity tie (min)	0	24	4.5	5.3	0.84*	0.74*	0.67*
11	Degree Shared Leadership tie (min)	0	29	5.7	6.8	0.88*	0.80*	0.73*
12	Degree Advice tie (min)	0	21	2.9	4.0	0.80*	0.66*	0.59*
13	Degree Reframing tie (min)	0	14	2.5	3.5	0.87*	0.71*	0.62*
14	Degree Reinforcing tie (min)	0	20	3.4	4.4	0.84*	0.72*	0.64*
15	Collective Psychological Capital	2.375	5	4.3	0.6	0.12	0.13	0.07
16	Tenure in organization	1	19	6.8	4.7	0.21	0.20	0.25*
17	Tenure in position	0	12	2.7	2.4	0.00	0.08	0.10
18	Previous Participation	0	1	0.8	0.4	0.28*	0.23*	0.25*
19	Gender	0	1	0.3	0.5	-0.1	-0.17	-0.20
20	Age	19	53	25.1	7.4	-0.02	-0.04	-0.06

n = 49 for all variables. Correlations with a magnitude > .20 – denoted with an asterisk (*) - are significant at p < .05. Results from both minimally symmetrized (min) and maximally symmetrized (max) adjacency matrices are reported. Degree refers to number of direct relationships for type of tie specified.

#	4	5	6	7	8	9	10	11	12	13	14
5	0.85*										
6	0.95*	0.77*									
7	0.92*	0.73*	0.91*								
8	0.92*	0.79*	0.86*	0.86*							
9	0.75*	0.64*	0.78*	0.79*	0.76*						
10	0.82*	0.66*	0.82*	0.86*	0.82*	0.94*					
11	0.76*	0.74*	0.77*	0.78*	0.74*	0.95*	0.89*				
12	0.76*	0.59*	0.79*	0.82*	0.75*	0.91*	0.96*	0.84*			
13	0.79*	0.62*	0.81*	0.86*	0.80*	0.93*	0.95*	0.88*	0.91*		
14	0.78*	0.63*	0.79*	0.84*	0.82*	0.94*	0.97*	0.88*	0.94*	0.95*	
15	-0.00	0.09	-0.03	-0.08	-0.03	0.02	0.01	0.06	-0.00	0.00	0.01
16	0.36*	0.23*	0.33*	0.44*	0.30*	0.27*	0.34*	0.24*	0.33*	0.37*	0.36*
17	0.19	0.06	0.14	0.16	0.09	0.08	0.14	0.01	0.14	0.13	0.12
18	0.26*	0.26*	0.23*	0.18	0.21	0.19	0.21	0.25*	0.18	0.23*	0.19
19	-0.10	-0.21*	-0.07	-0.06	-0.03	-0.05	-0.09	-0.11	-0.12	-0.06	-0.04
20	-0.01	-0.07	0.00	0.08	-0.03	0.04	0.06	-0.00	0.09	0.09	0.08

#	15	16	17	18	19
16	-0.29*				
17	-0.12	0.58*			
18	0.07	-0.01	0.07		
19	-0.43*	0.04	0.05	-0.07	
20	-0.09	0.62*	0.36*	-0.55*	-0.05

Table 2: Descriptive Statistics and Correlations for Measured Variables (dyad level)

#	Dyadic-level Variables	Min	Max	Mean	s.d.	1	2	3
1	Innovation tie (min)	0	1	0.06	0.24			
2	Innovation tie (max)	0	1	0.41	0.49	0.30*		
3	Adaptive Function tie (max)	0	1	0.43	0.50	0.28*	0.60*	
4	Collective Creativity tie (max)	0	1	0.30	0.26	0.36*	0.57*	0.74*
5	Shared Leadership tie (max)	0	1	0.40	0.49	0.30*	0.60*	0.93*
6	Advice tie (max)	0	1	0.23	0.42	0.38*	0.52*	0.63*
7	Reflective Reframing tie (max)	0	1	0.19	0.40	0.46*	0.46*	0.56*
8	Reinforcing tie (max)	0	1	0.21	0.41	0.40*	0.53*	0.60*
9	Formal Leadership tie (max)	0	1	0.05	0.21	0.13*	0.07*	0.08*
10	Adaptive Function tie (min)	0	1	0.05	0.22	0.59*	0.27*	0.27*
11	Collective Creativity tie (min)	0	1	0.08	0.27	0.61*	0.32*	0.33*
12	Shared Leadership tie (min)	0	1	0.10	0.30	0.53*	0.37*	0.37*
13	Advice tie (min)	0	1	0.05	0.22	0.54*	0.25*	0.26*
14	Reflective Reframing tie (min)	0	1	0.04	0.20	0.56*	0.24*	0.24*
15	Reinforcing tie (min)	0	1	0.06	0.23	0.54*	0.28*	0.28*
16	Collective Psychological Capital	5.6	25	18.40	3.72	-0.00	-0.00	0.04
17	Heterogeneity: Professional Affiliat.	0	1	0.20	0.40	-0.01	-0.01	-0.03
18	Heterogeneity: Sub-unit designation	0	1	0.21	0.41	0.16*	0.12*	0.12*
19	Heterogeneity: Tenure in organization	0	18	5.24	4.08	-0.06	-0.17*	-0.12*
20	Heterogeneity: Tenure in position	0	12	2.45	2.32	0.01	0.03	0.06
21	Heterogeneity: Previous Participation	0	1	0.70	0.46	0.13*	0.11*	0.13*
22	Heterogeneity: Education	0	5	1.70	1.33	-0.13*	-0.23*	-0.19*
23	Heterogeneity: Gender	0	1	0.43	0.50	-0.03	-0.07	-0.07
24	Heterogeneity: Race	0	1	0.93	0.25	0.00	-0.05	-0.09
25	Heterogeneity: Age	0	34	7.35	7.54	-0.11*	-0.23*	-0.23*

n = 3,540 for all dyadic-level variables. All correlations with an asterisk (*) are significant at p < .05. Given the nature of QAP correlation, there is not a consistent cutoff correlation level to denote significance. Results from both minimally symmetrized (min) and maximally symmetrized (max) adjacency matrices are reported.

#	4	5	6	7	8	9	10	11	12	13
5	0.64*									
6	0.85*	0.60*								
7	0.75*	0.52*	0.70*							
8	0.80*	0.56*	0.68*	0.68*						
9	0.07*	0.08*	0.08*	0.08*	0.07*					
10	0.36*	0.29*	0.42*	0.44*	0.43*	0.14*				
11	0.44*	0.35*	0.49*	0.53*	0.52*	0.12*	0.81*			
12	0.45*	0.40*	0.47*	0.48*	0.45*	0.15*	0.71*	0.57*		
13	0.35*	0.28*	0.41*	0.43*	0.41*	0.11*	0.71*	0.79*	0.50*	
14	0.32*	0.26*	0.37*	0.43*	0.39*	0.13*	0.66*	0.73*	0.46*	0.60*
15	0.38*	0.30*	0.42*	0.46*	0.47*	0.12*	0.70*	0.86*	0.49*	0.65*
16	0.03	0.05	0.05	0.03	0.02	0.02	0.08	0.00	0.08	0.00
17	-0.02	-0.04	-0.05*	-0.04	-0.01	-0.05*	-0.02	-0.00	-0.03	-0.03
18	0.11*	0.13*	0.11*	0.12*	0.10*	0.05*	0.14*	0.14*	0.13*	0.12*
19	-0.13*	-0.10*	-0.10*	-0.09*	-0.12*	-0.06*	-0.05	-0.09*	-0.06	-0.06
20	0.07	0.05	0.04	0.04	0.03	-0.01	0.02	0.03	0.00	0.03
21	0.13*	0.14*	0.11*	0.08	0.09*	0.03	0.07	0.09*	0.11*	0.06
22	-0.22*	-0.15*	-0.21*	-0.21*	-0.18*	-0.11*	-0.14*	-0.18*	-0.16*	-0.12*
23	-0.04	-0.07	-0.04	-0.05	-0.04	-0.03	-0.02	-0.06	-0.04	-0.04
24	-0.00	-0.09	-0.03	-0.01	0.02	0.03	-0.01	0.00	-0.06	0.00
25	-0.22*	-0.21*	-0.19*	-0.17*	-0.20*	0.07*	-0.11*	-0.13*	-0.14*	-0.09*

#	14	15	16	17	18	19	20	21	22	23	24
15	0.65*										
16	0.02	0.00									
17	0.02	-0.00	-0.00								
18	0.12*	0.16*	0.02	0.06*							
19	-0.06*	-0.08*	0.08	-0.08*	-0.12*						
20	0.01	0.02	0.02	-0.01	0.00	0.36*					
21	0.08*	0.08*	-0.01	-0.01	0.03	0.04	0.04				
22	-0.13*	-0.16*	0.05	0.06*	-0.28*	0.38*	0.06	-0.05			
23	-0.04	-0.03	0.01	-0.02	0.03	0.03	-0.01	-0.01	-0.01		
24	0.00	0.01	-0.10	-0.02	-0.04	0.03	0.09	-0.06	0.05	0.06	
25	-0.10*	-0.12*	0.03	0.01	-0.12*	0.40*	0.13	-0.40*	0.28*	-0.03	0.03

Table 3: Data for Measured Variables (network level)

Network Type	Degree Centralization	Betweeness Centralization	Eigenvector Centralization	Clustering Coefficient
Innovation	0.2982	0.1017	0.1324	0.616
Adaptive Function	0.5625	0.1036	0.1682	0.744
Collective Creativity	0.4757	0.1089	0.1755	0.61
Shared Leadership	0.5975	0.1232	0.1644	0.744
Advice	0.5053	0.1284	0.1705	0.605
Reflective Reframing	0.4062	0.1108	0.1747	0.556
Reinforcing	0.3855	0.1404	0.1788	0.563
Formal Leadership	0.6026	0.7737	0.8283	0.698

n = 1 for all network-level variables. As such, actual values are reported and summary statistics and correlations are not available.

Table 4: Summary of Hypotheses and Findings

Hypothesis		Findings
1: If actors have a collective creativity tie, they will be more likely to also have an innovation tie compared to actors without a collective creativity tie.		Supported
2a: Centralization will be higher within advice and reframing networks as compared to the reinforcing network.		Partially Supported
2b: Sub-group cohesion will be higher within reinforcing network as compared to the advice and reframing networks.		Not Supported
3: If actors have an adaptive function tie, then they will be more likely to also have an innovation tie when compared to actors without an adaptive function tie.		Supported
4: Heterogeneity in the experience and abilities of pairs of actors moderates the relationship of the adaptive function to innovation such that greater heterogeneity and greater levels of the adaptive function are related to higher levels of innovation compared to pairs of actors with lower levels of the adaptive function and lower heterogeneity.	Professional Affiliation	Not Supported
	Sub-unit designation	Supported
	Previous Participation	Supported
	Org Tenure	Not Supported
	Position Tenure	Not Supported
	Education	Opposite Direction
5: Collective psychological capital moderates the relationship of the adaptive function to innovation at the dyadic level, such that higher levels of collective psychological capital and greater levels of the adaptive function are related to higher levels of innovation compared to pairs of actors with lower levels of collective psychological capital and lower levels of the adaptive function.		Not Supported

Table 5: QAP Regression Results for Professional Affiliation (Hypothesis 4)

	Adaptive Function Only	Adaptive Function & Professional Affiliation	Adaptive Function, Professional Affiliation, & interaction
Adaptive Function	0.288**	0.288**	0.287**
Professional Affiliation		-0.002	-0.004
Adaptive Function x Professional Affiliation			-0.003
R²	0.083**	0.083**	0.083**
Adjusted R²	0.083**	0.083**	0.083**

* p < 0.05; ** p < 0.01

Table 6: QAP Regression Results for Sub-unit Designation (Hypothesis 4)

	Adaptive Function Only	Adaptive Function & Sub-unit Designation	Adaptive Function, Sub-unit Designation, & interaction
Adaptive Function	0.288**	0.272**	0.208**
Sub-unit Designation		0.134**	-0.008
Adaptive Function x Sub-unit Designation			0.209**
R²	0.083**	0.101**	0.118**
Adjusted R²	0.083**	0.101**	0.117**

$* \ p < 0.05; \ ** \ p < 0.01$

Table 7: QAP Regression Results for Previous Participation (Hypothesis 4)

	Adaptive Function Only	Adaptive Function & Previous Participation	Adaptive Function, Previous Participation, & interaction
Adaptive Function	0.288**	0.276**	0.150**
Previous Participation		0.096*	0.018
Adaptive Function x Previous Participation			0.186**
R²	0.083**	0.092**	0.103**
Adjusted R²	0.083**	0.092**	0.102**

* $p < 0.05$; ** $p < 0.01$

Table 8: QAP Regression Results for Tenure in Organization (Hypothesis 4)

	Adaptive Function Only	Adaptive Function & Tenure in Org	Adaptive Function, Tenure in Org, & interaction
Adaptive Function	0.288**	0.285**	0.293**
Tenure in Org		-0.032	-0.026
Adaptive Function x Tenure in Org			-0.013
R²	0.083**	0.084**	0.084**
Adjusted R²	0.083**	0.084**	0.084**

* $p < 0.05$; ** $p < 0.01$

Table 9: QAP Regression Results for Tenure in Position (Hypothesis 4)

	Adaptive Function Only	Adaptive Function & Tenure in Position	Adaptive Function, Tenure in Position, & interaction
Adaptive Function	0.288**	0.288**	0.272**
Tenure in Position		-0.001	-0.020
Adaptive Function x Tenure in Position			0.033
R²	0.083**	0.083**	0.084**
Adjusted R²	0.083**	0.083**	0.083**

$* p < 0.05; ** p < 0.01$

Table 10: QAP Regression Results for Educational Background (Hypothesis 4)

	Adaptive Function Only	Adaptive Function & Educational Background	Adaptive Function, Educational Background, & interaction
Adaptive Function	0.288**	0.274**	0.341**
Educational Background		-0.084**	-0.033
Adaptive Function x Educational Background			-0.102*
R²	0.083**	0.090**	0.094**
Adjusted R²	0.083**	0.090**	0.094**

* $p < 0.05$; ** $p < 0.01$

Table 11: QAP Regression Results for Gender

	Adaptive Function Only	Adaptive Function & Gender	Adaptive Function, Gender, & interaction
Adaptive Function	0.288**	0.287**	0.305**
Gender		-0.018	0.001
Adaptive Function x Gender			-0.033
R^2	0.083**	0.084**	0.084**
Adjusted R^2	0.083**	0.083**	0.083**

* $p < 0.05$; ** $p < 0.01$

Table 12: QAP Regression Results for Race

	Adaptive Function Only	Adaptive Function & Race	Adaptive Function, Race, & interaction
Adaptive Function	0.288**	0.292**	0.206**
Race		0.327	0.004
Adaptive Function x Race			0.093
R^2	0.083**	0.084**	0.085**
Adjusted R^2	0.083**	0.084**	0.085**

* $p < 0.05$; ** $p < 0.01$

Table 13: QAP Regression Results for Age

	Adaptive Function Only	Adaptive Function & Age	Adaptive Function, Age, & interaction
Adaptive Function	0.288**	0.277**	0.324**
Age		-0.054	-0.023
Adaptive Function x Age			-0.075*
R²	0.083**	0.086**	0.089**
Adjusted R²	0.083**	0.086**	0.089**

* $p < 0.05$; ** $p < 0.01$

Table 14: QAP Regression Results for Collective PsyCap (Hypothesis 5)

	Adaptive Function Only	Adaptive Function & Collective PsyCap	Adaptive Function, Collective PsyCap, & interaction
Adaptive Function	0.288**	0.289**	0.261**
Collective PsyCap		-0.011	-0.018
Adaptive Function x Collective PsyCap			0.036
R^2	0.083**	0.083**	0.084**
Adjusted R^2	0.083**	0.083**	0.083**

* $p < 0.05$; ** $p < 0.01$

FIGURES

Figure 1: Theoretical Model
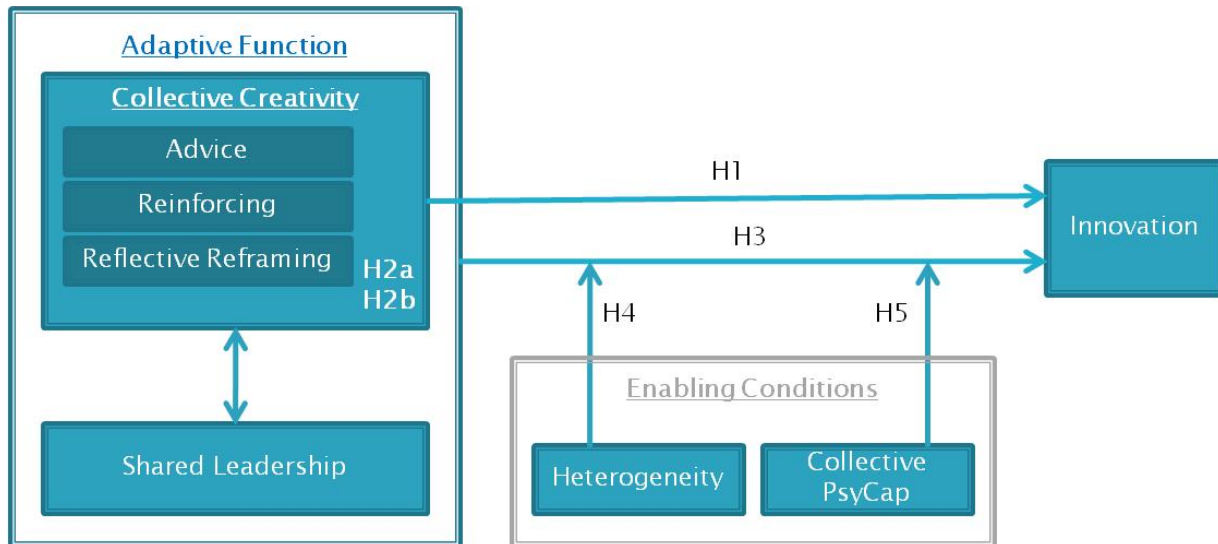
Figure 2: Sociogram of Collective Creativity Network Degree Centrality
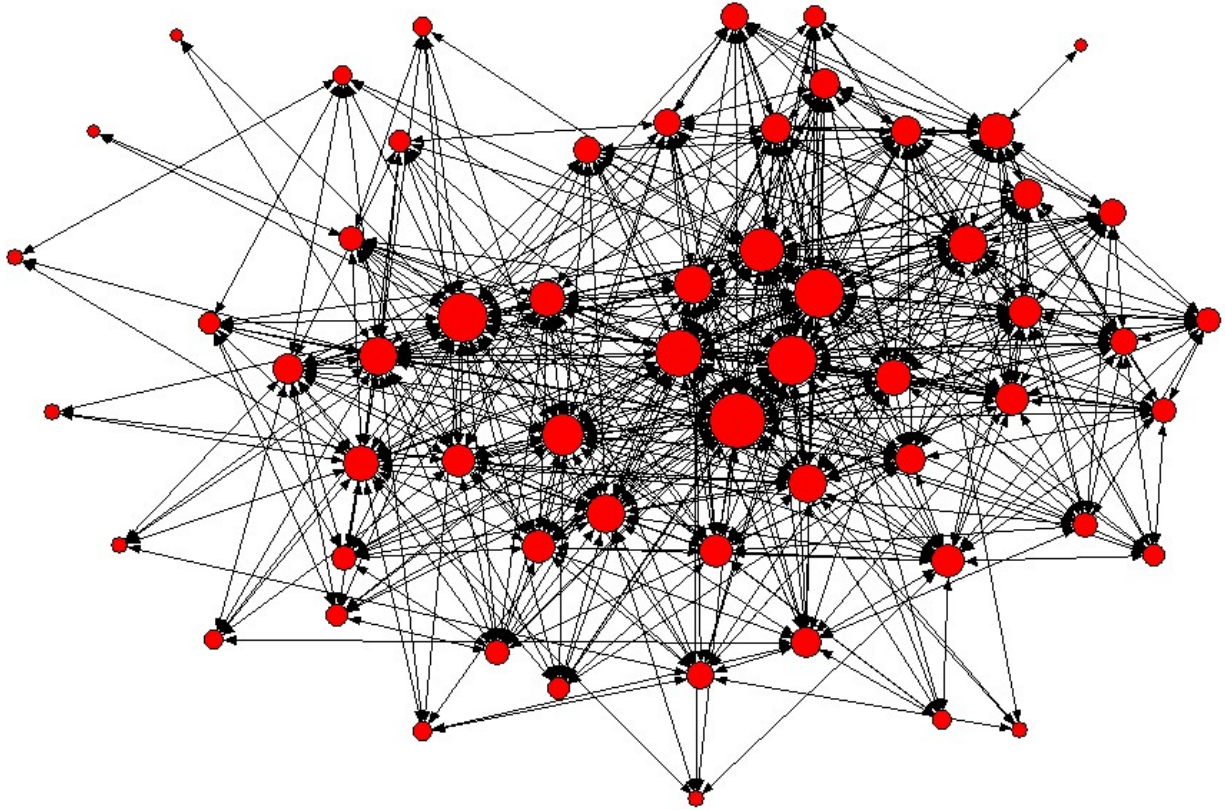
(nodes arranged by geodesic distance and sized by degree centrality)

Figure 3: Sociogram of Collective Creativity Network Betweeness Centrality
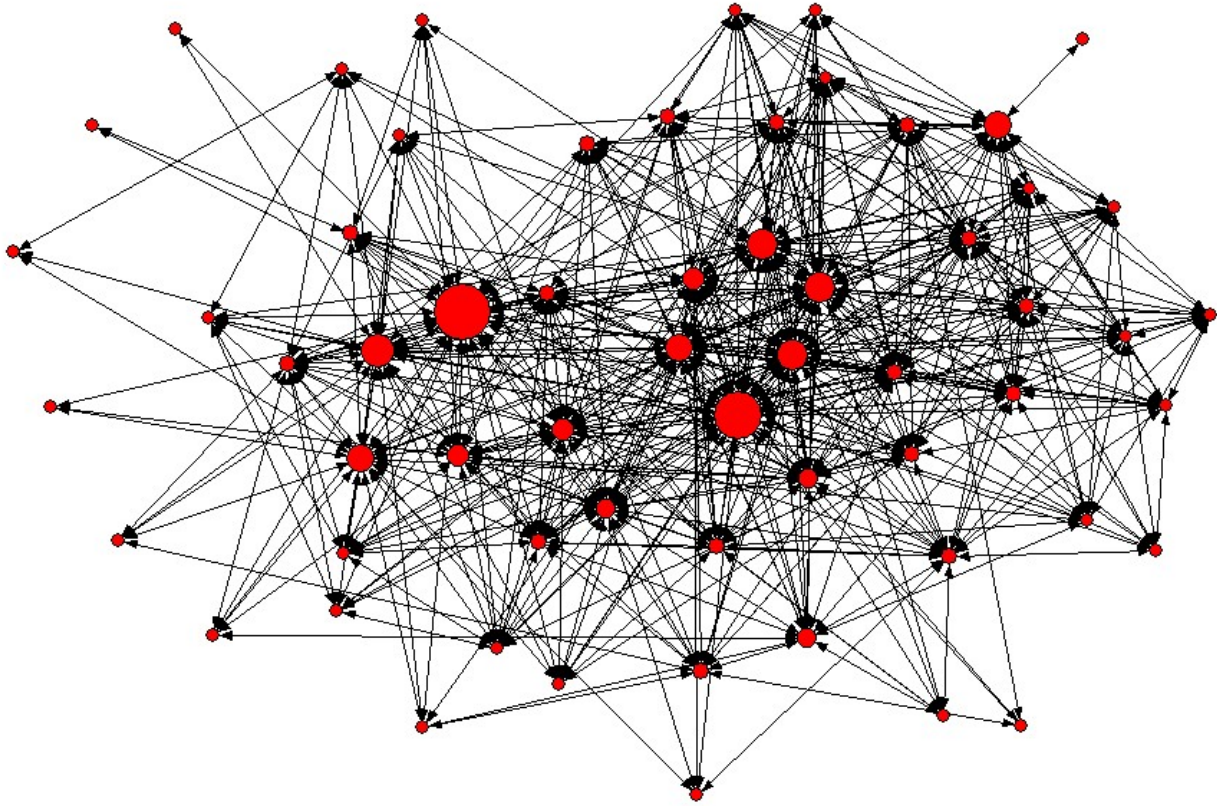
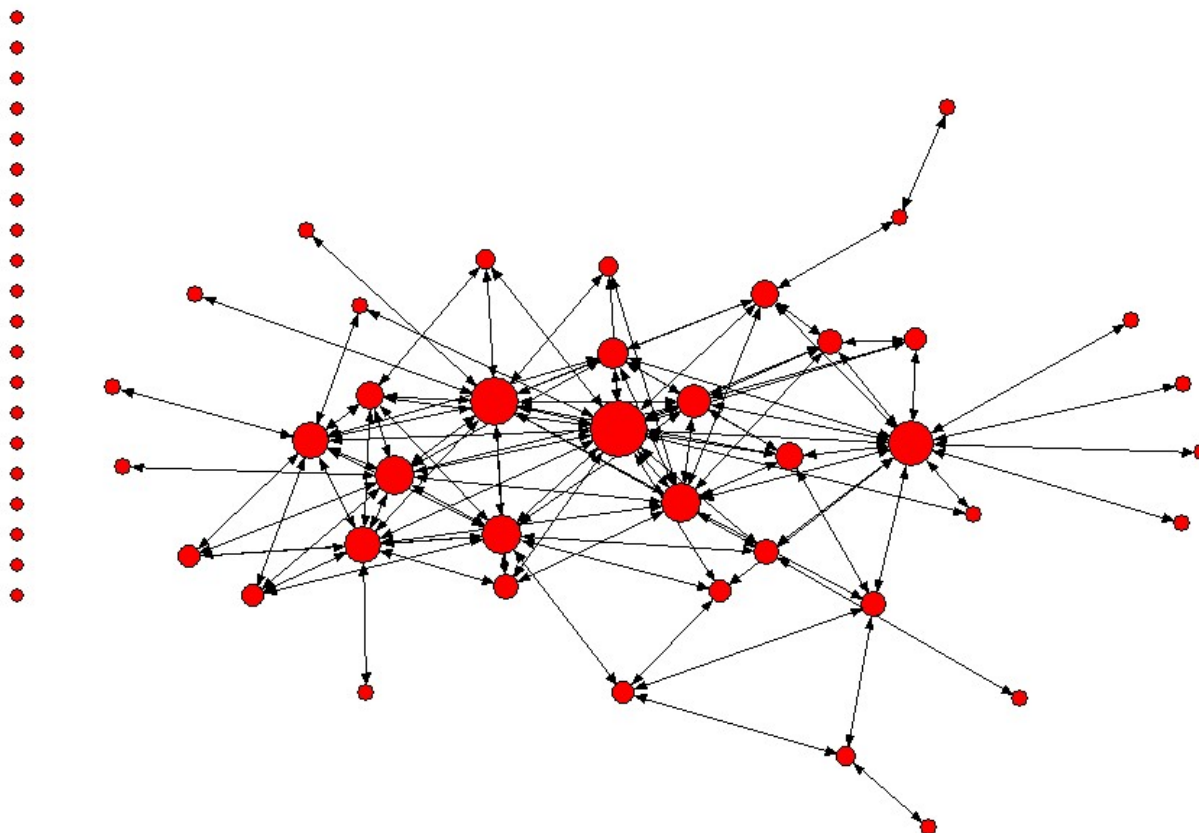**(nodes arranged by geodesic distance and sized by betweeness centrality)**

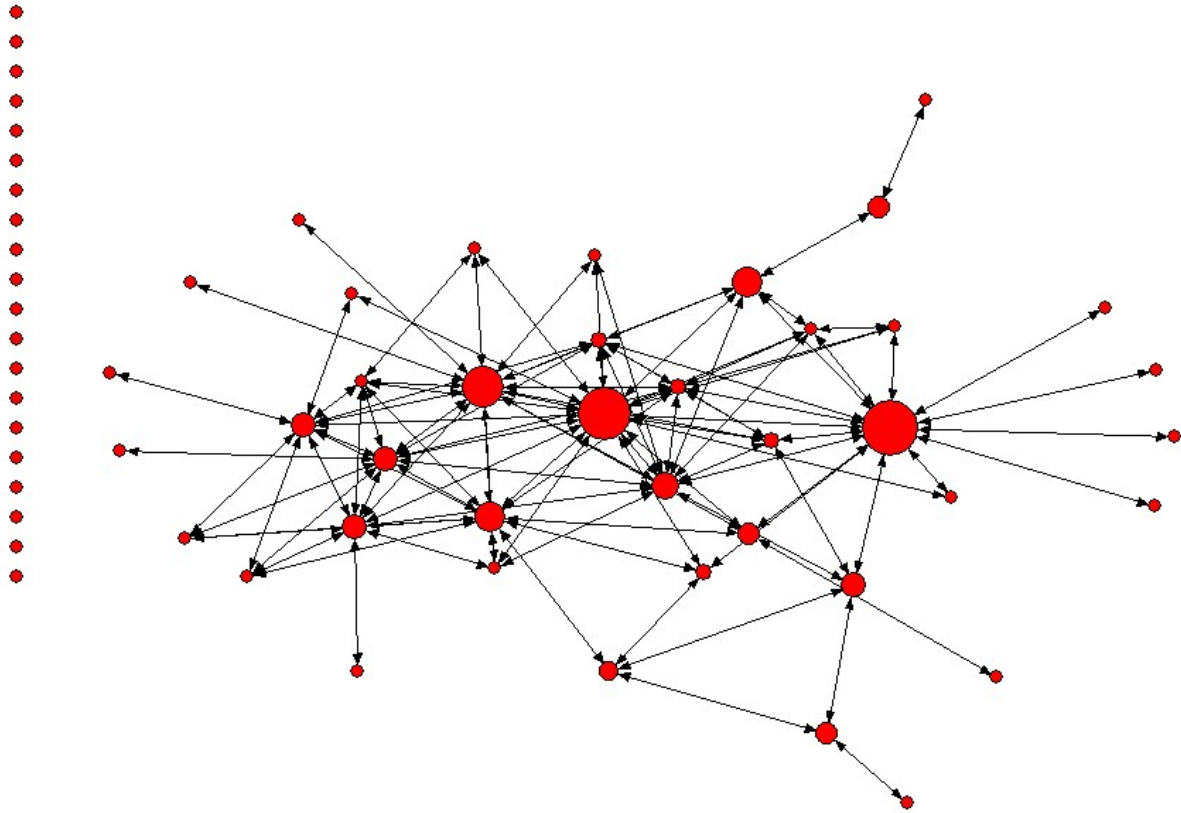**Figure 4: Sociogram of Collective Creativity Network Eigenvector Centrality**
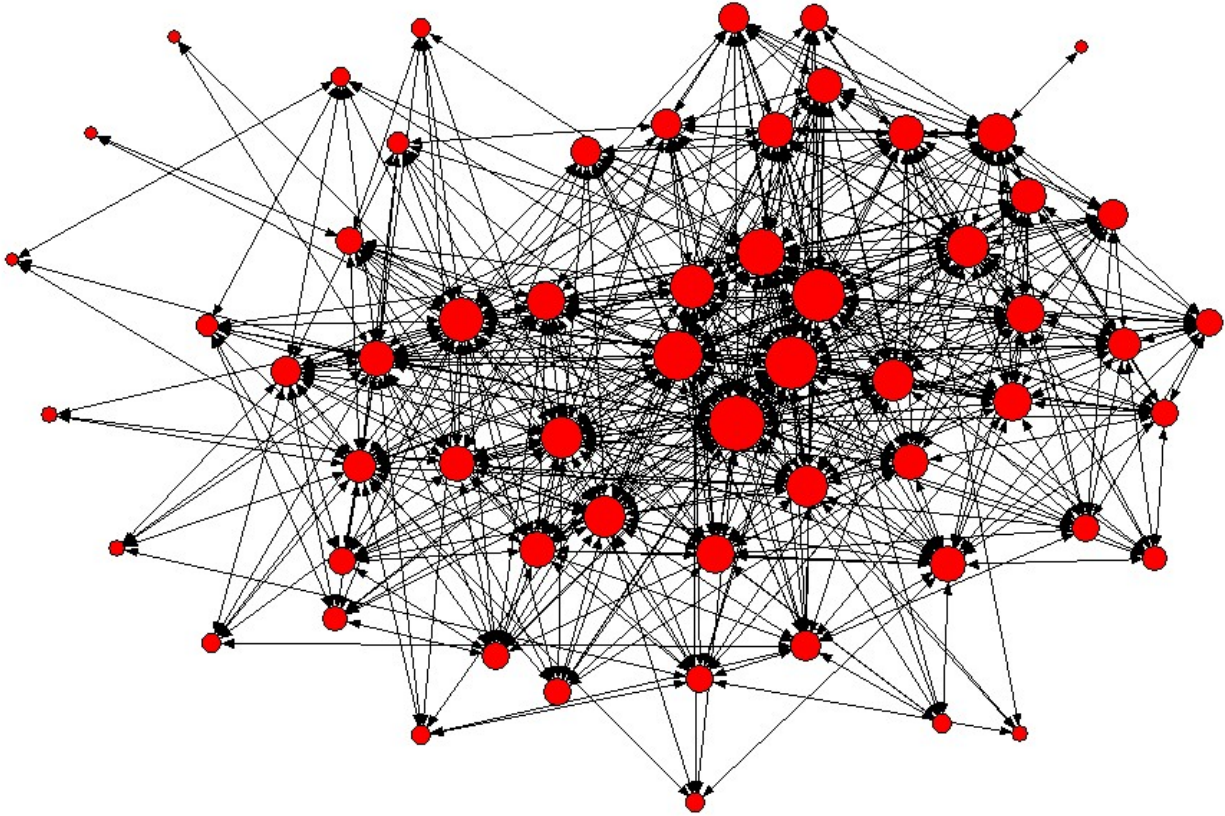
(nodes arranged by geodesic distance and sized by eigenvector centrality)

**Figure 5: Sociogram of Leadership Network Degree Centrality**
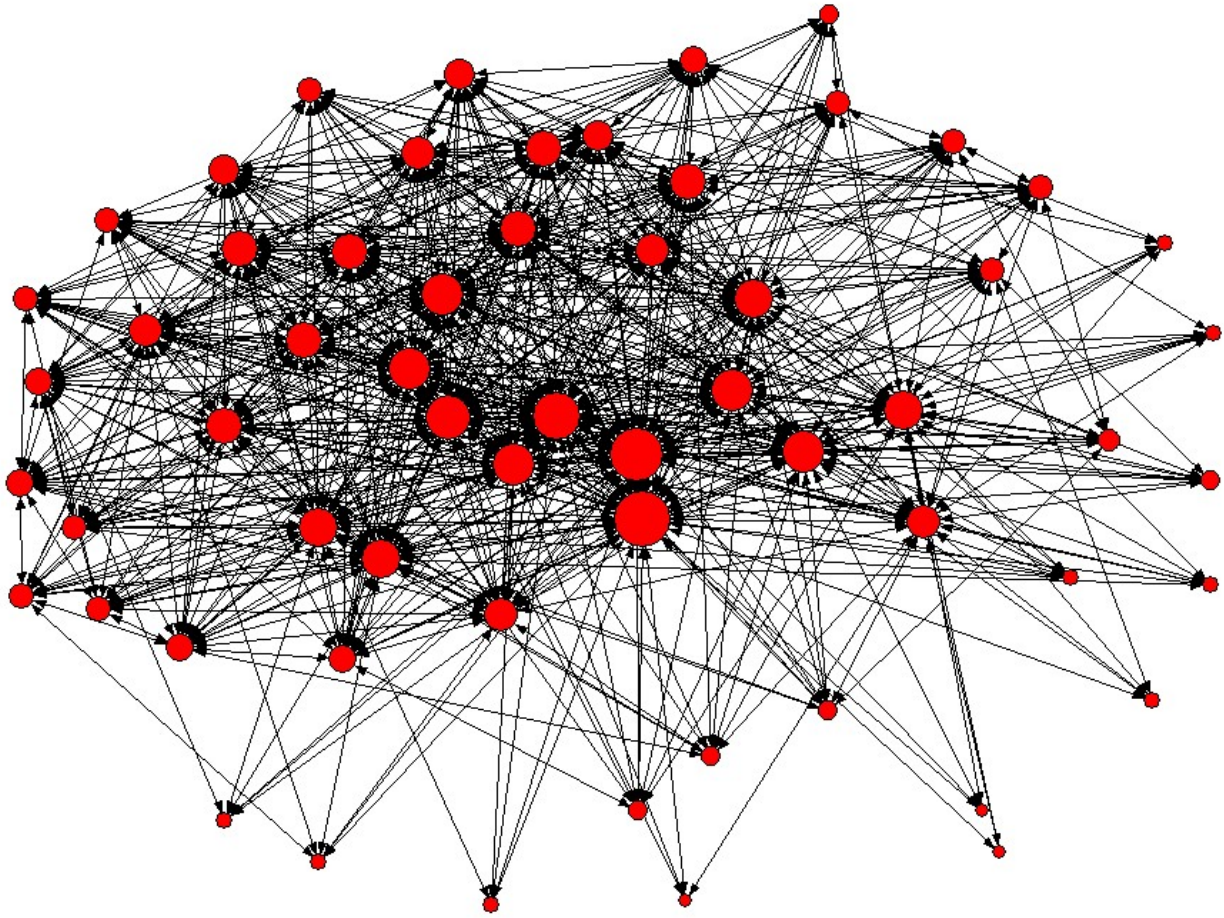
(nodes arranged by geodesic distance and sized by degree centrality)

Figure 6: Sociogram of Leadership Network Betweeness Centrality
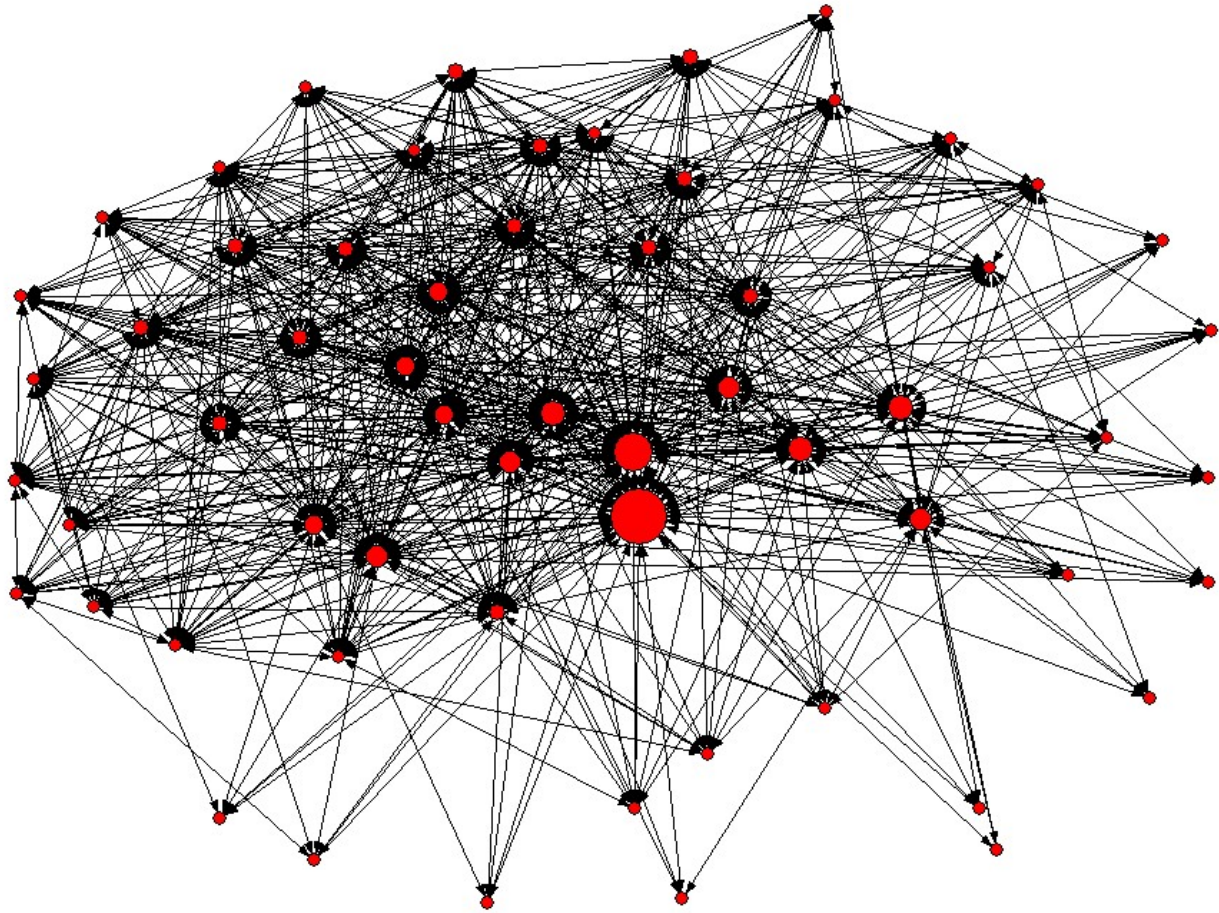
**(nodes arranged by geodesic distance and sized by betweeness centrality)**

Figure 7: Sociogram of Leadership Network Eigenvector Centrality
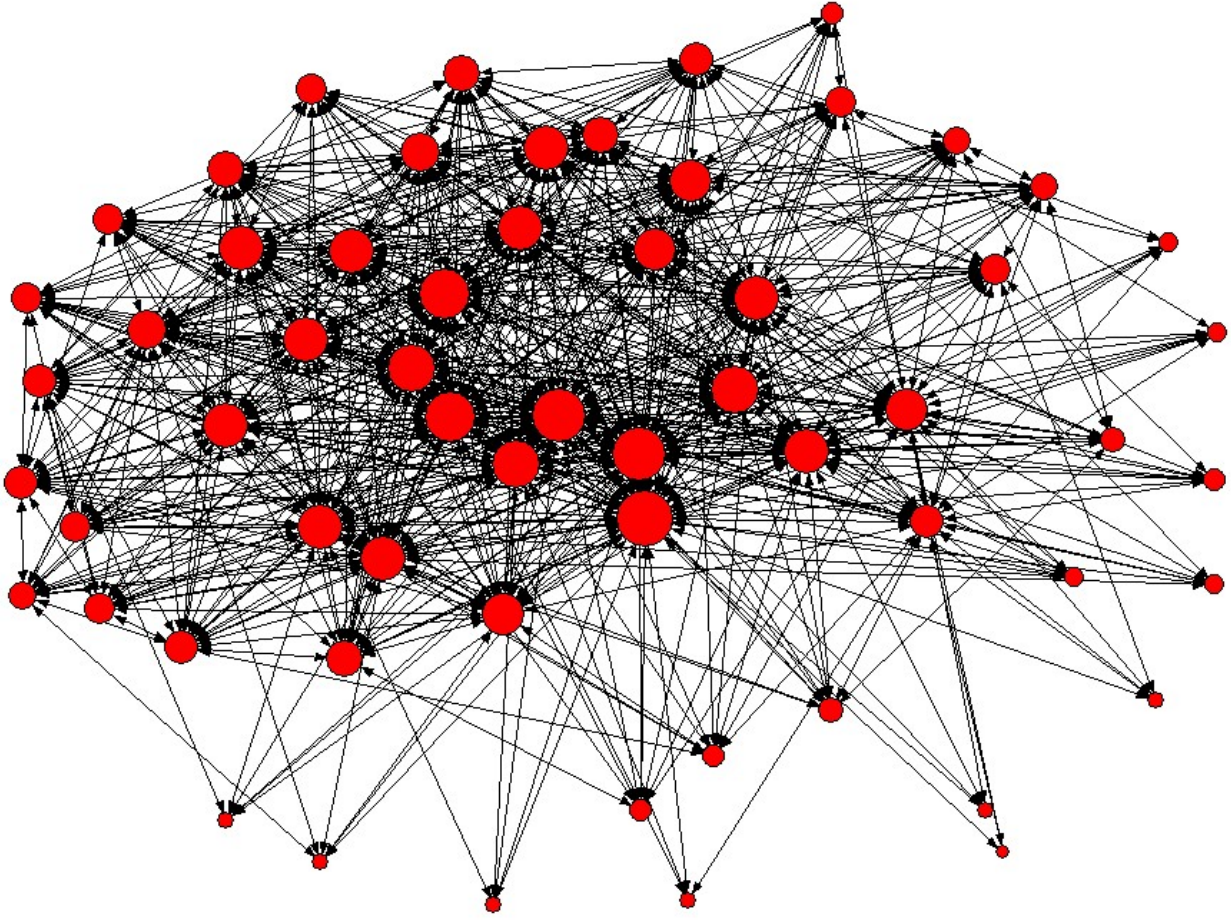
(nodes arranged by geodesic distance and sized by eigenvector centrality)

Figure 8: Sociogram of Adaptive Function Network Degree Centrality
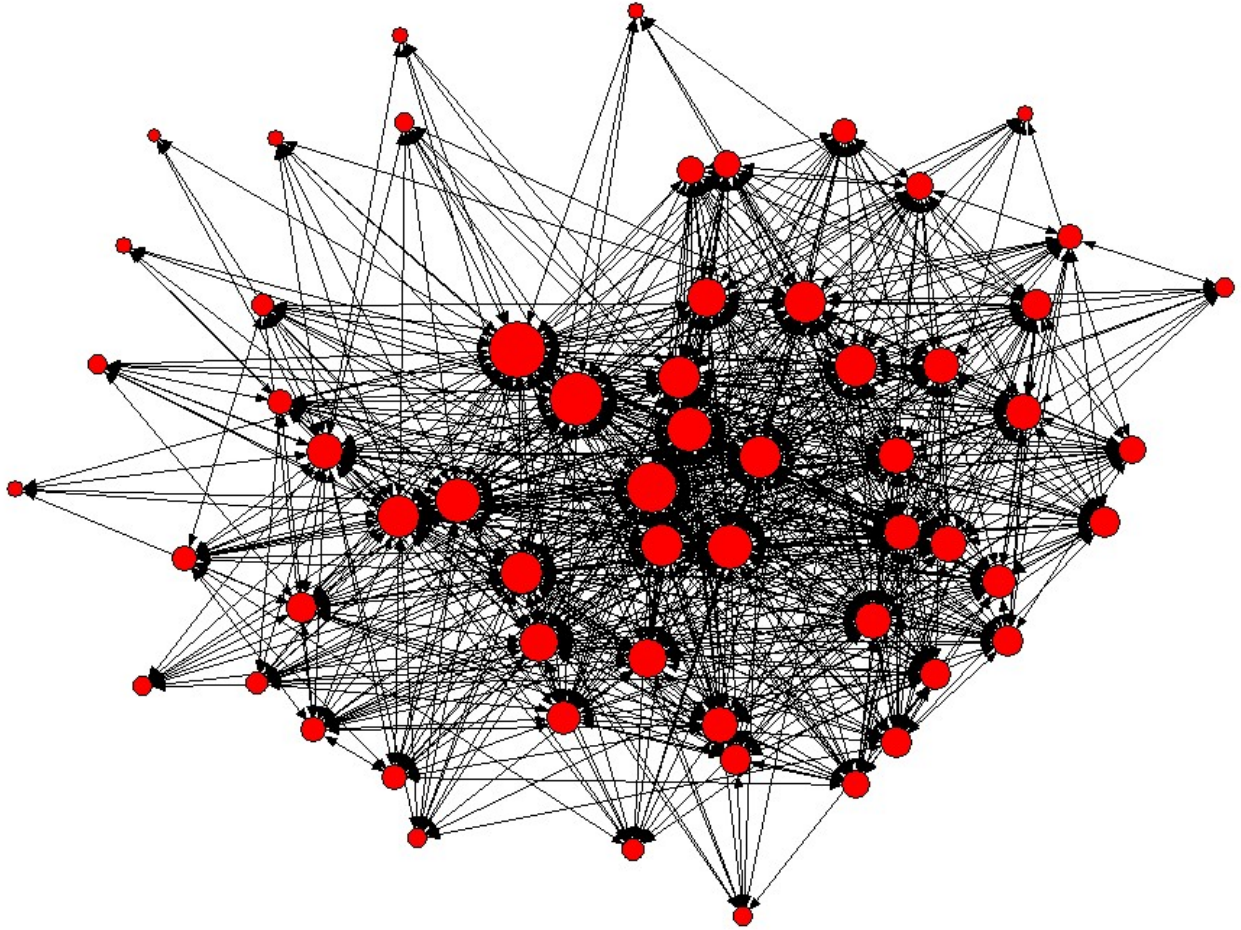
(nodes arranged by geodesic distance and sized by degree centrality)

Figure 9: Sociogram of Adaptive Function Network Betweeness Centrality
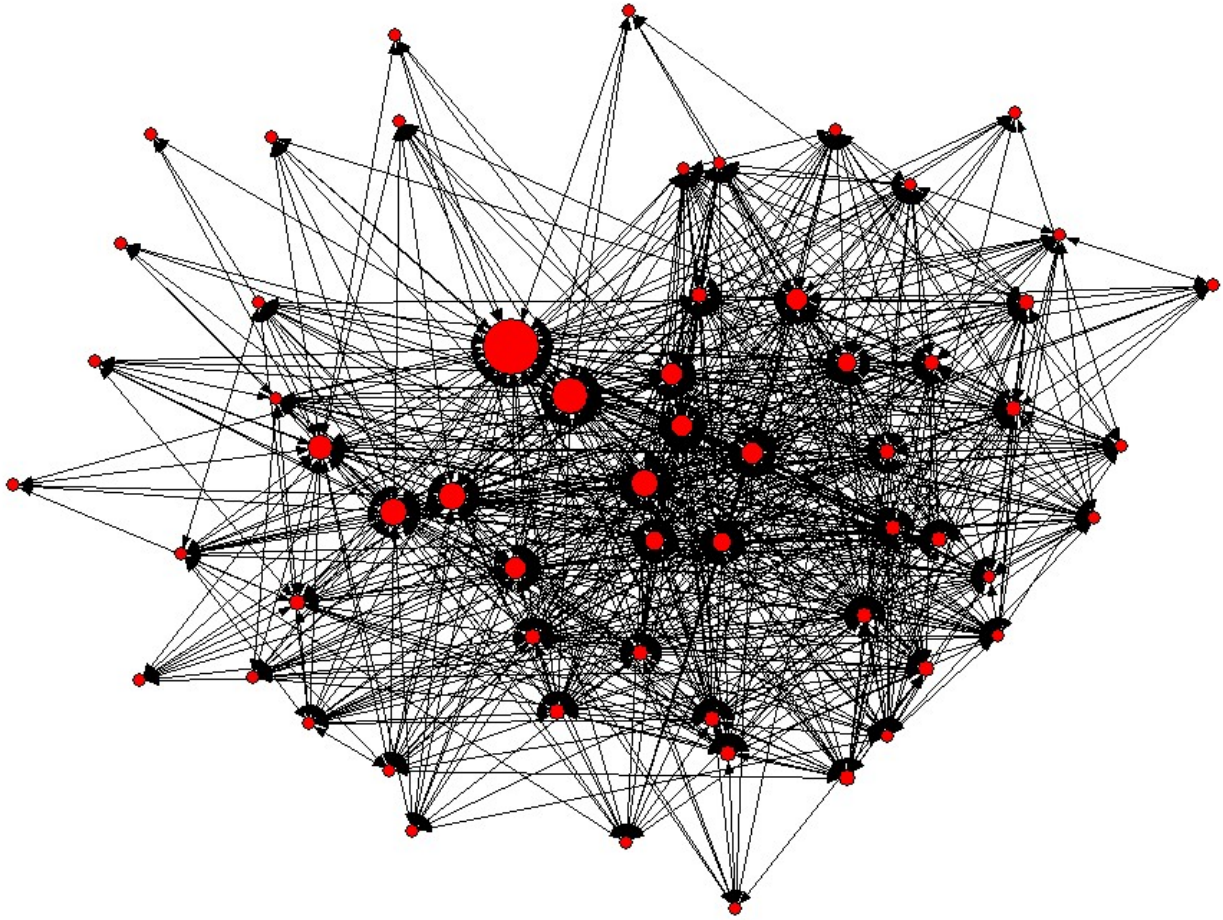
(nodes arranged by geodesic distance and sized by betweeness centrality)

Figure 10: Sociogram of Adaptive Function Network Eigenvector Centrality
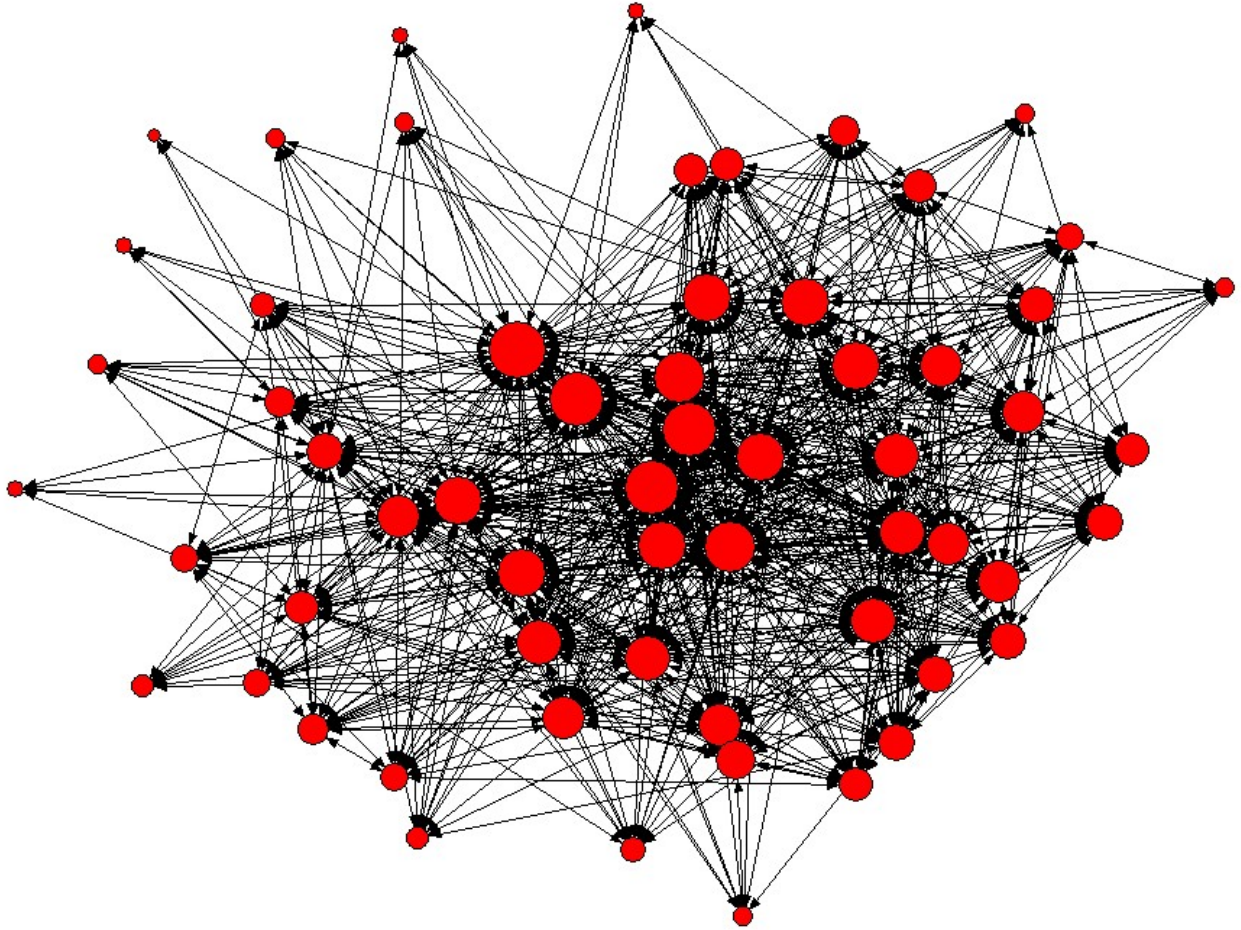
(nodes arranged by geodesic distance and sized by eigenvector centrality)

Figure 11: Sociogram of Innovation Network Degree Centrality

(nodes arranged by geodesic distance and sized by degree centrality; non-connected nodes on the side are isolates)

Figure 12: Sociogram of Innovation Network Betweeness Centrality

(nodes arranged by geodesic distance and sized by betweeness centrality; non-connected nodes on the side are isolates)

Figure 13: Sociogram of Innovation Network Eigenvector Centrality
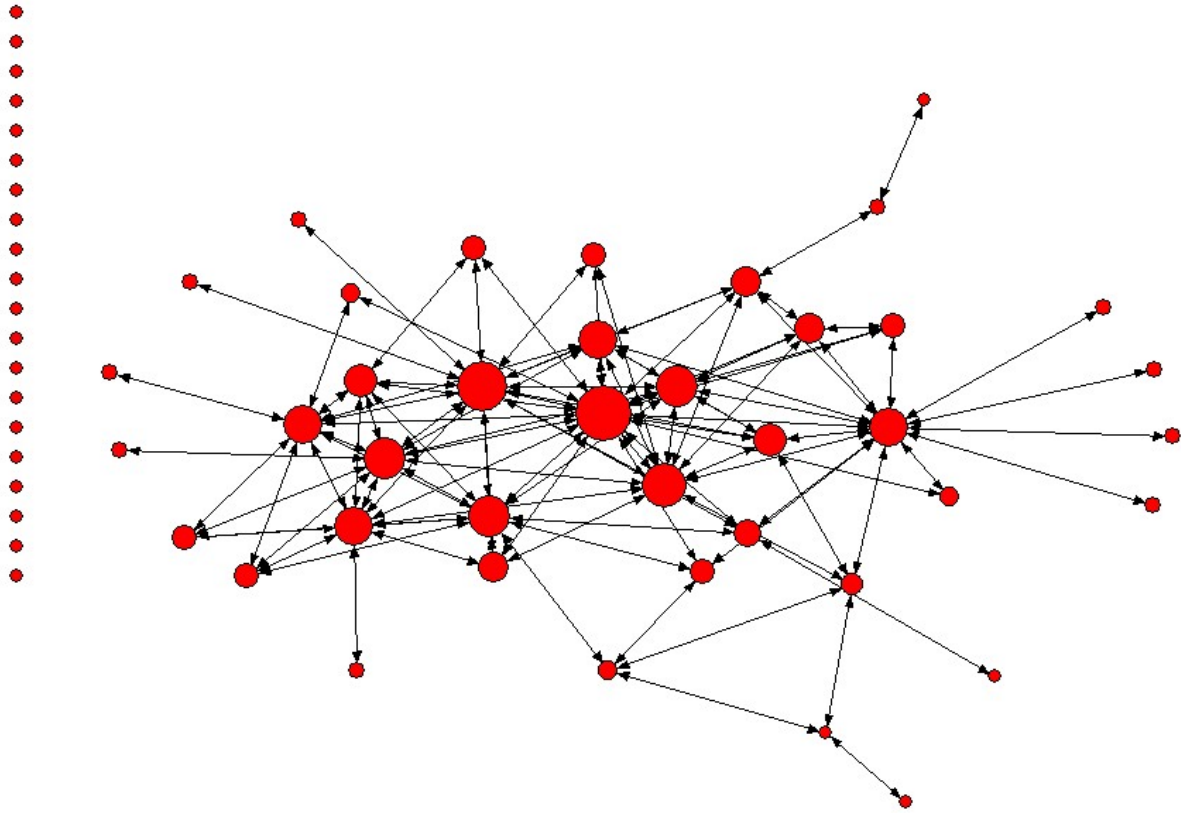
(nodes arranged by geodesic distance and sized by eigenvector centrality; non-connected nodes on the side are isolates)

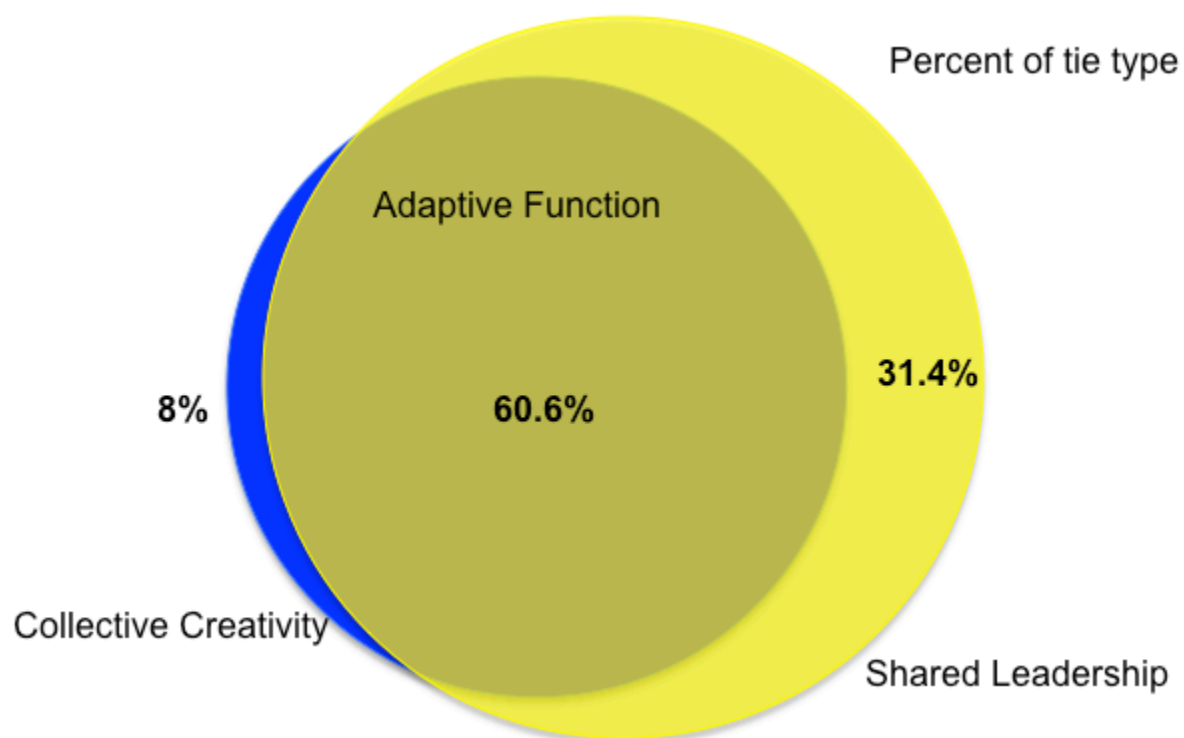**Figure 14: Venn Diagram of Collective Creativity Components and Percent of Innovation**
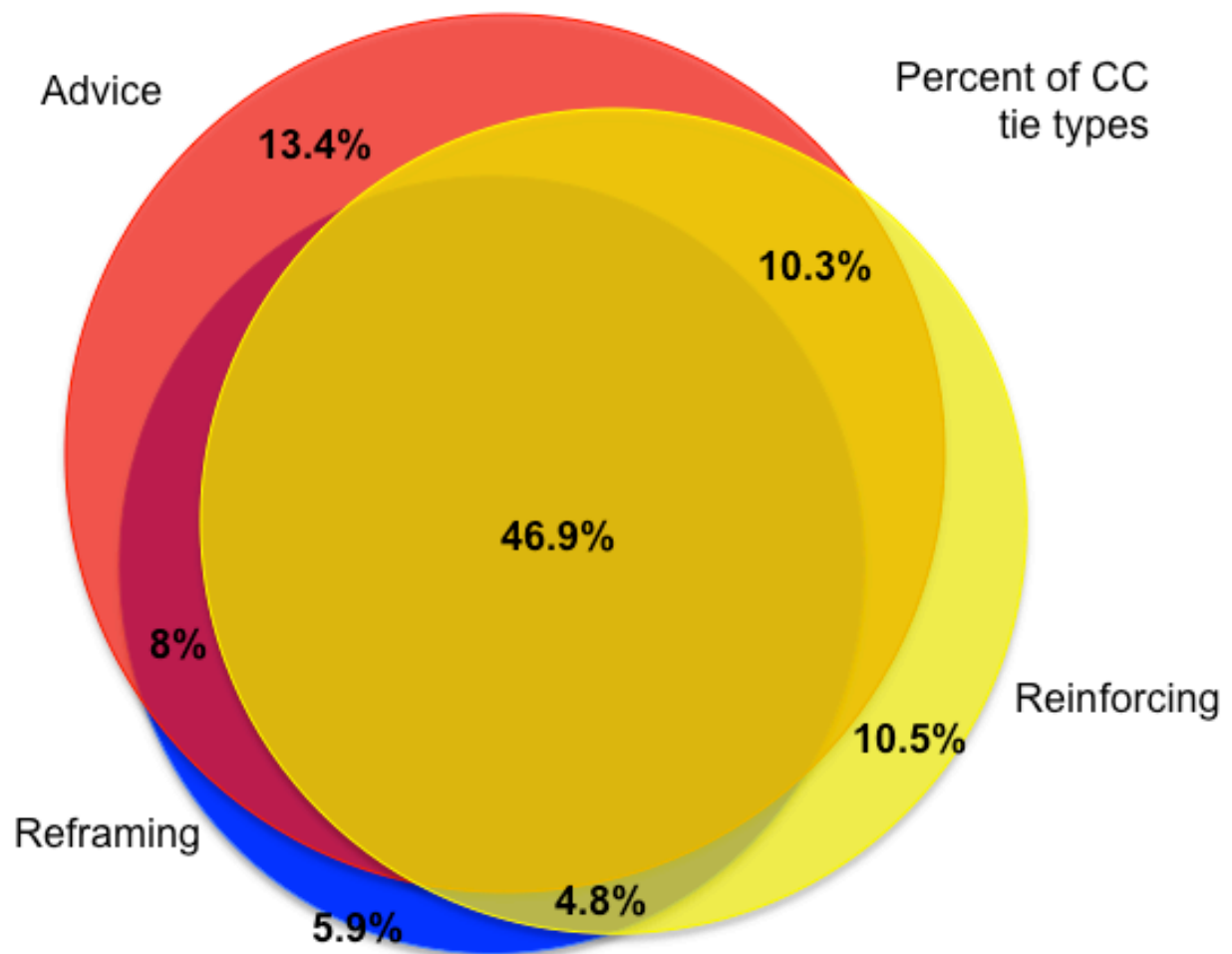
Figure 15: Venn Diagram of Collective Creativity Components
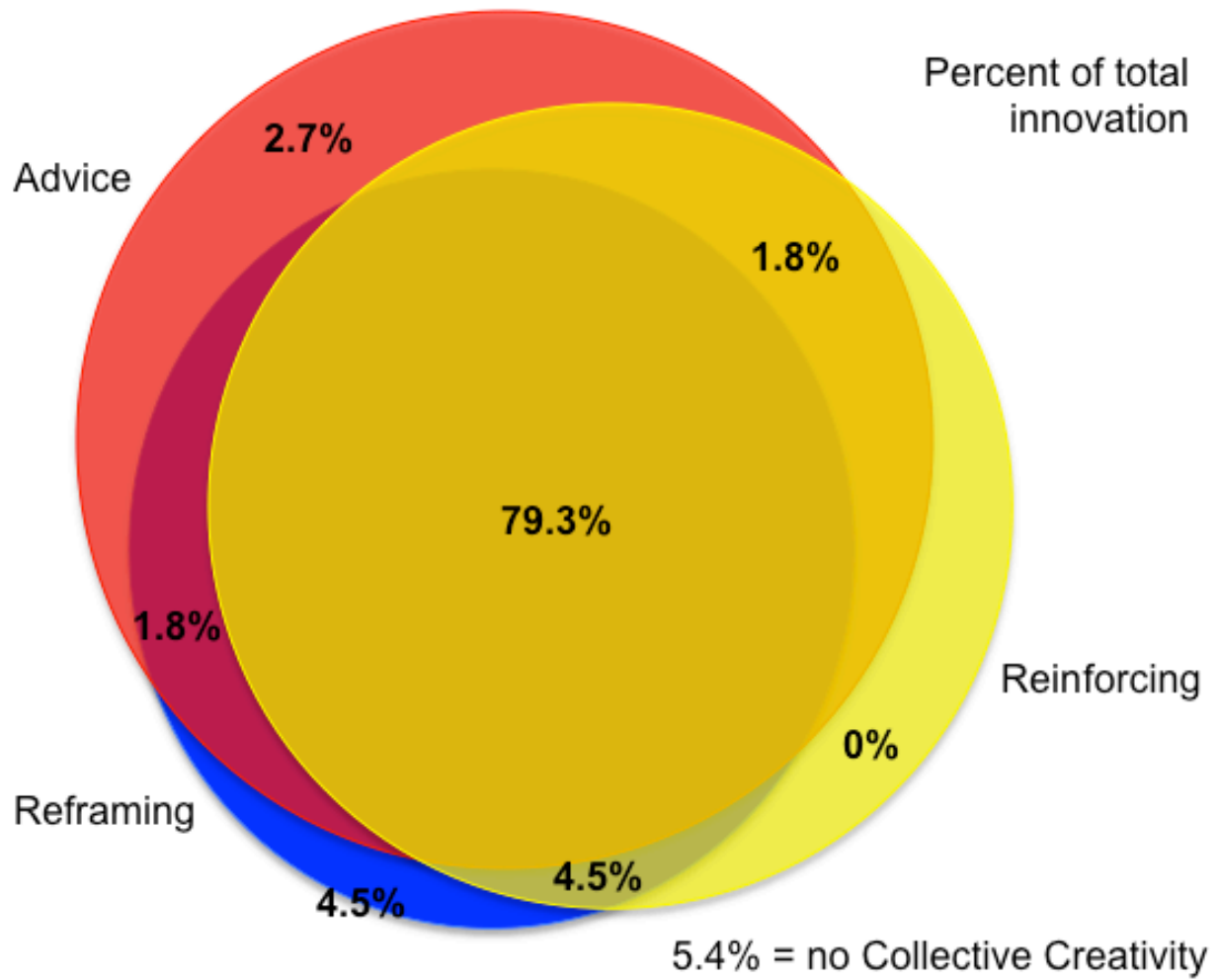
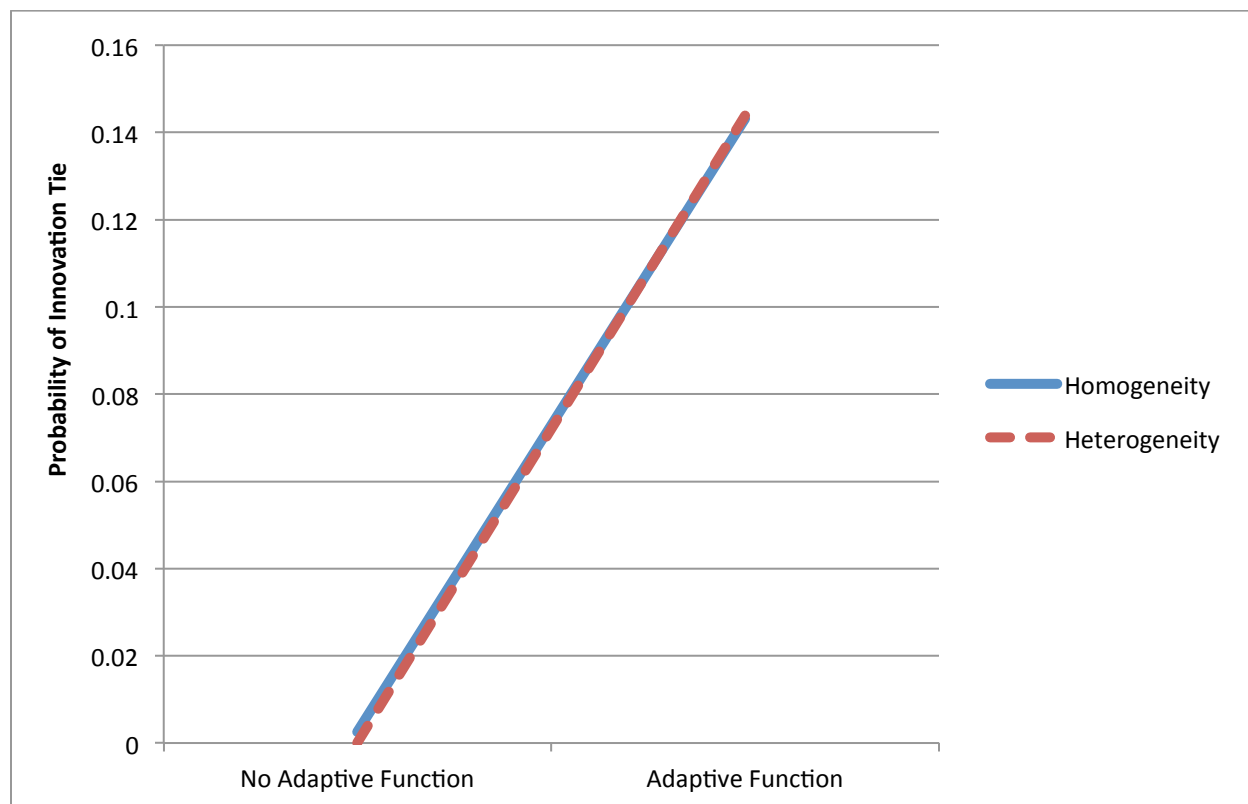**Figure 16: Venn Diagram of Shared Leadership, Collective Creativity, and Percent of Innovation**
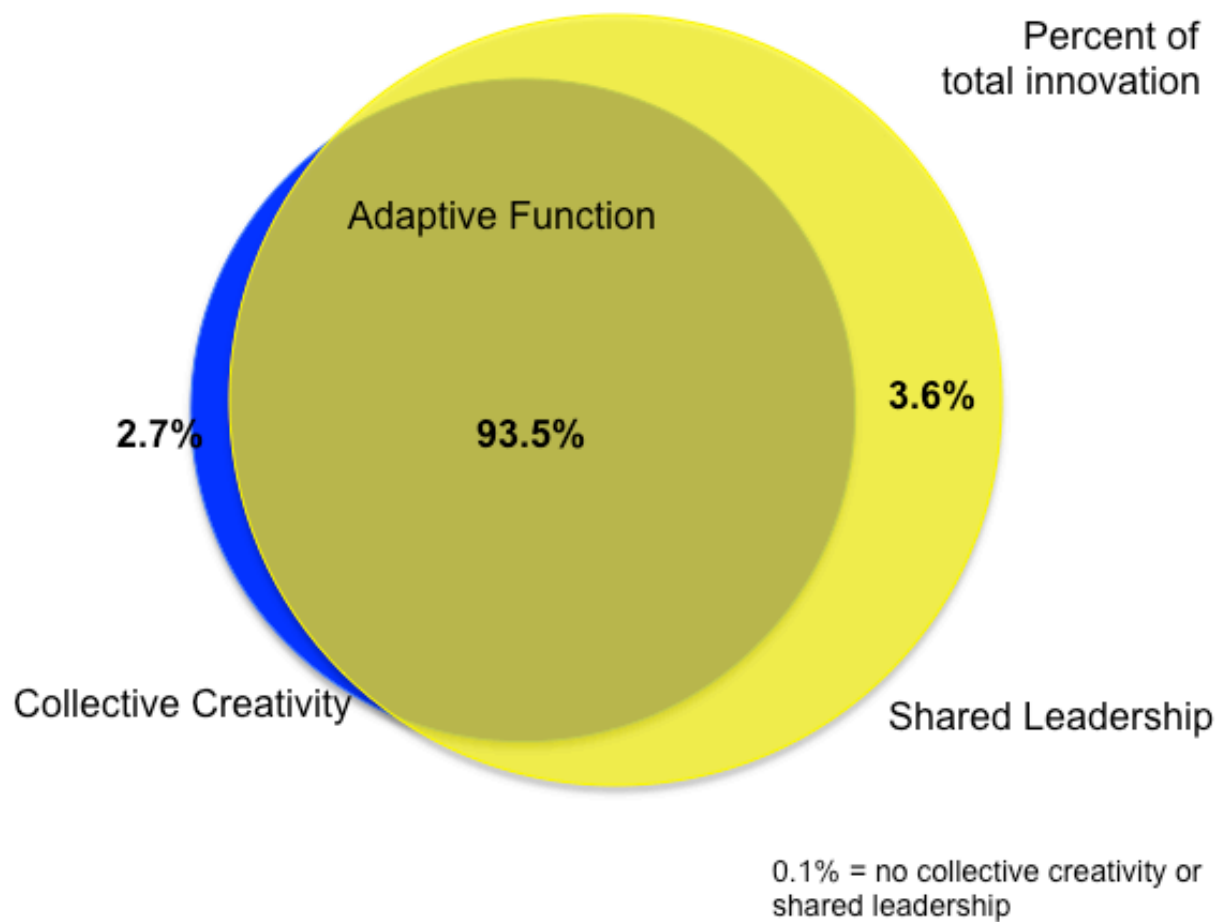
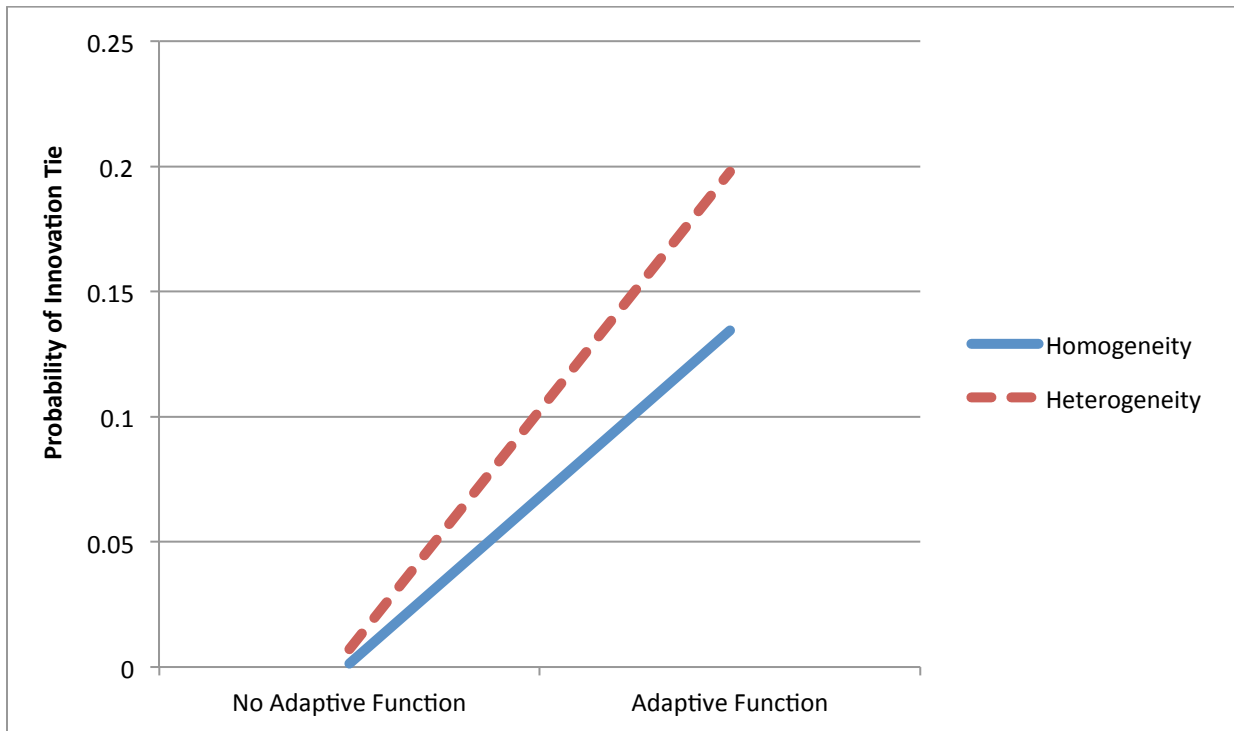**Figure 17: Venn Diagram of Shared Leadership and Collective Creativity**
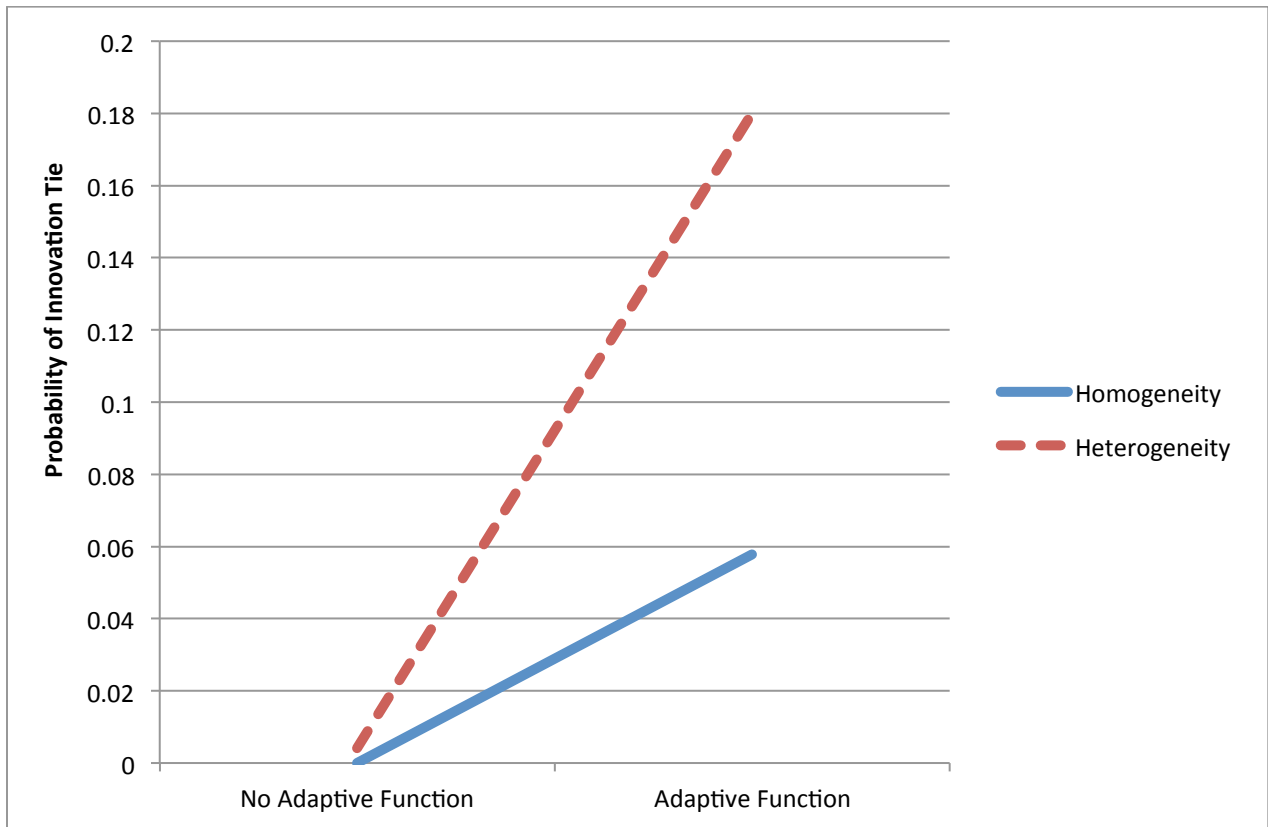
Figure 18: Interaction Effect of the Adaptive Function with Professional Affiliation (hypothesis 4)
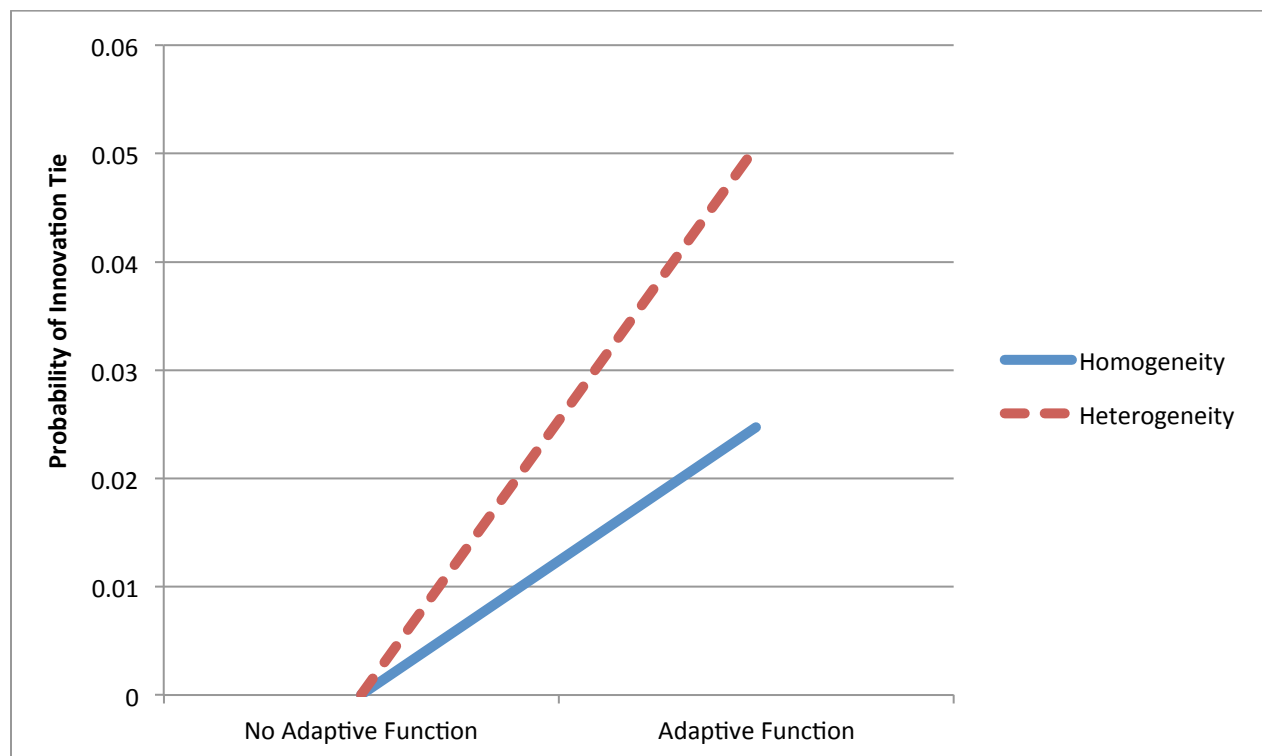
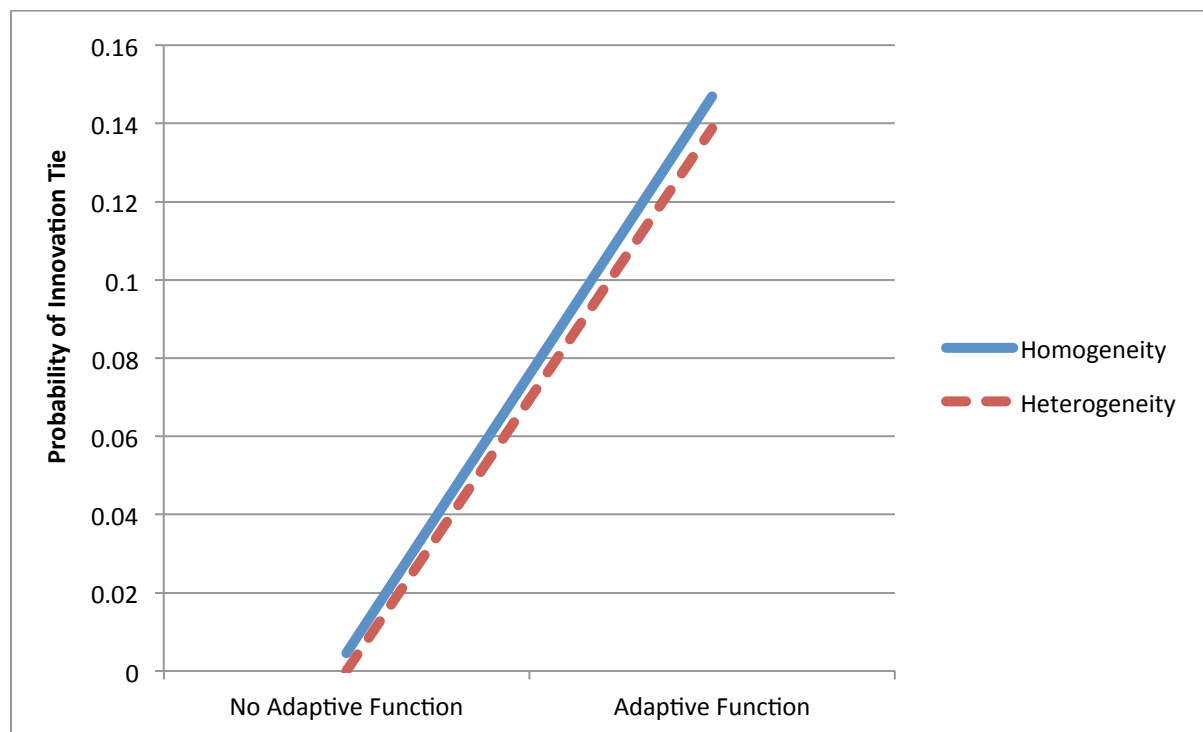**Figure 19: Interaction Effect of the Adaptive Function with Sub-unit Designation (hypothesis 4)**

Figure 20: Interaction Effect of the Adaptive Function with Previous Participation (hypothesis 4)
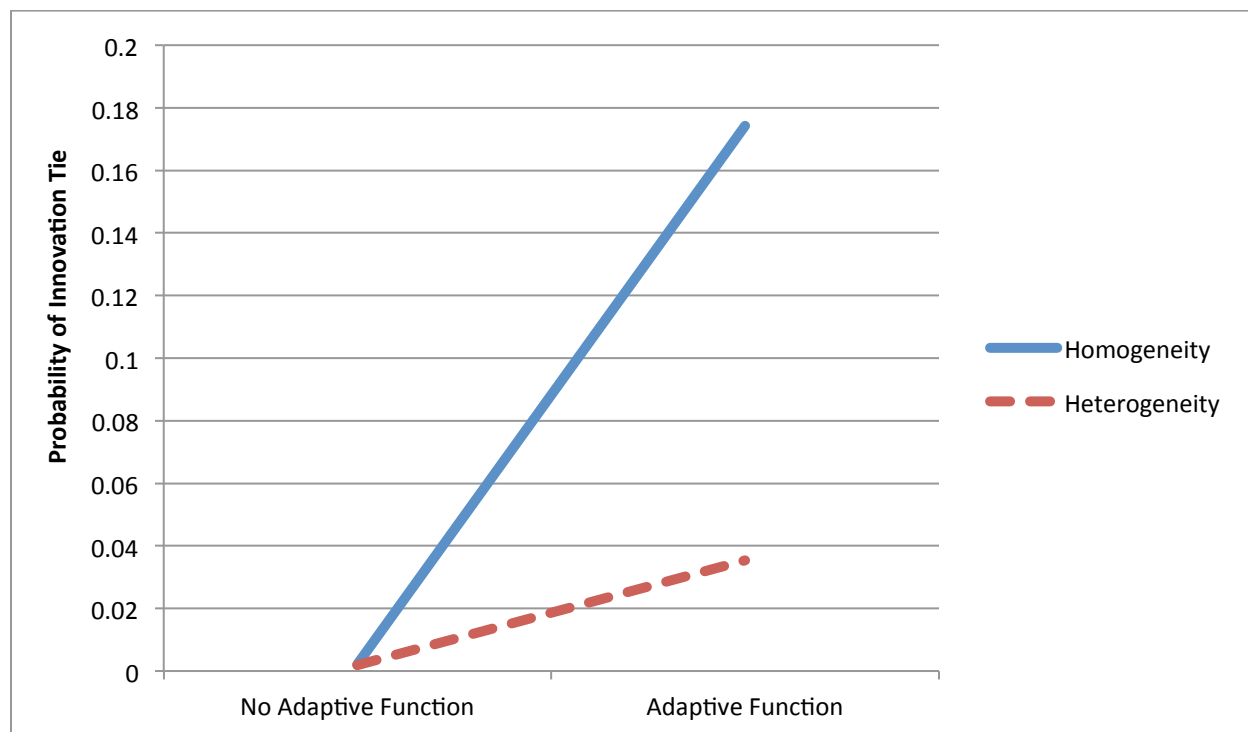
Figure 21: Interaction Effect of the Adaptive Function with Tenure in Organization (hypothesis 4)

Figure 22: Interaction Effect of the Adaptive Function with Tenure in Position (hypothesis 4)

Figure 23: Interaction Effect of the Adaptive Function with Educational Background (hypothesis 4)
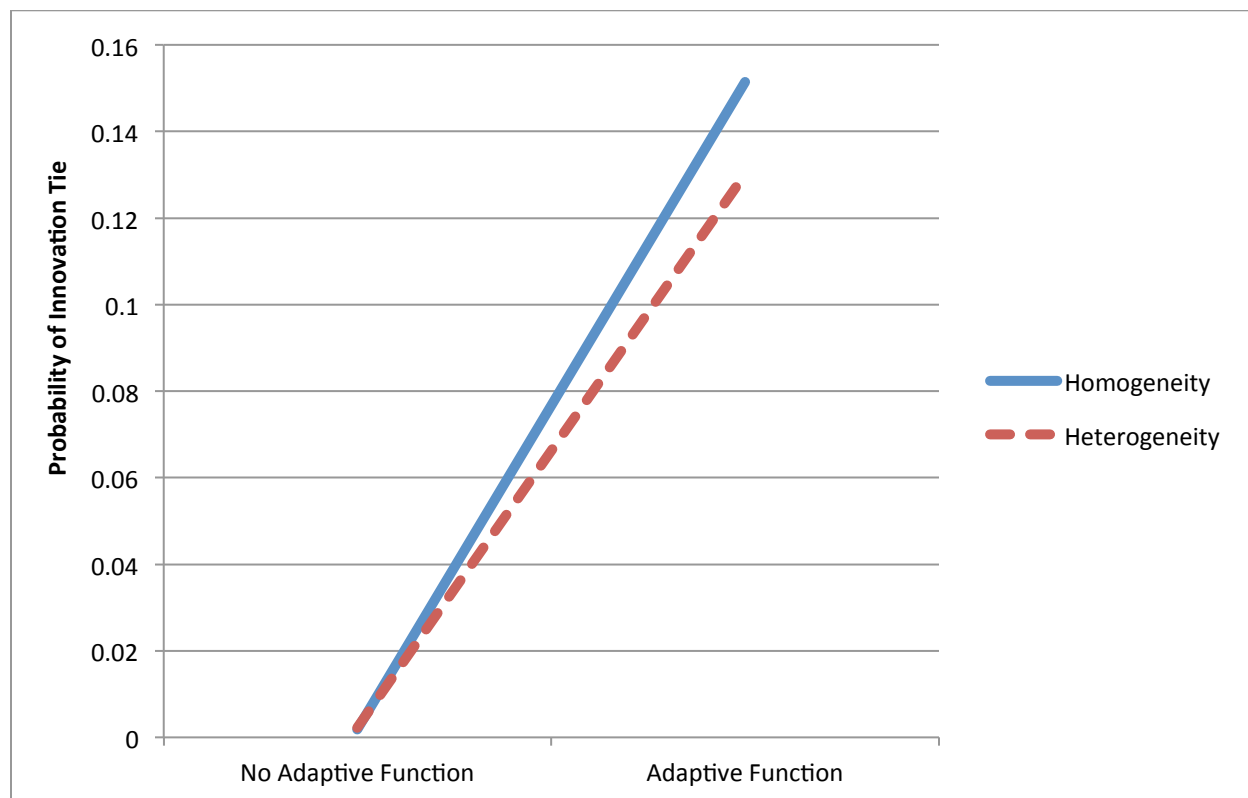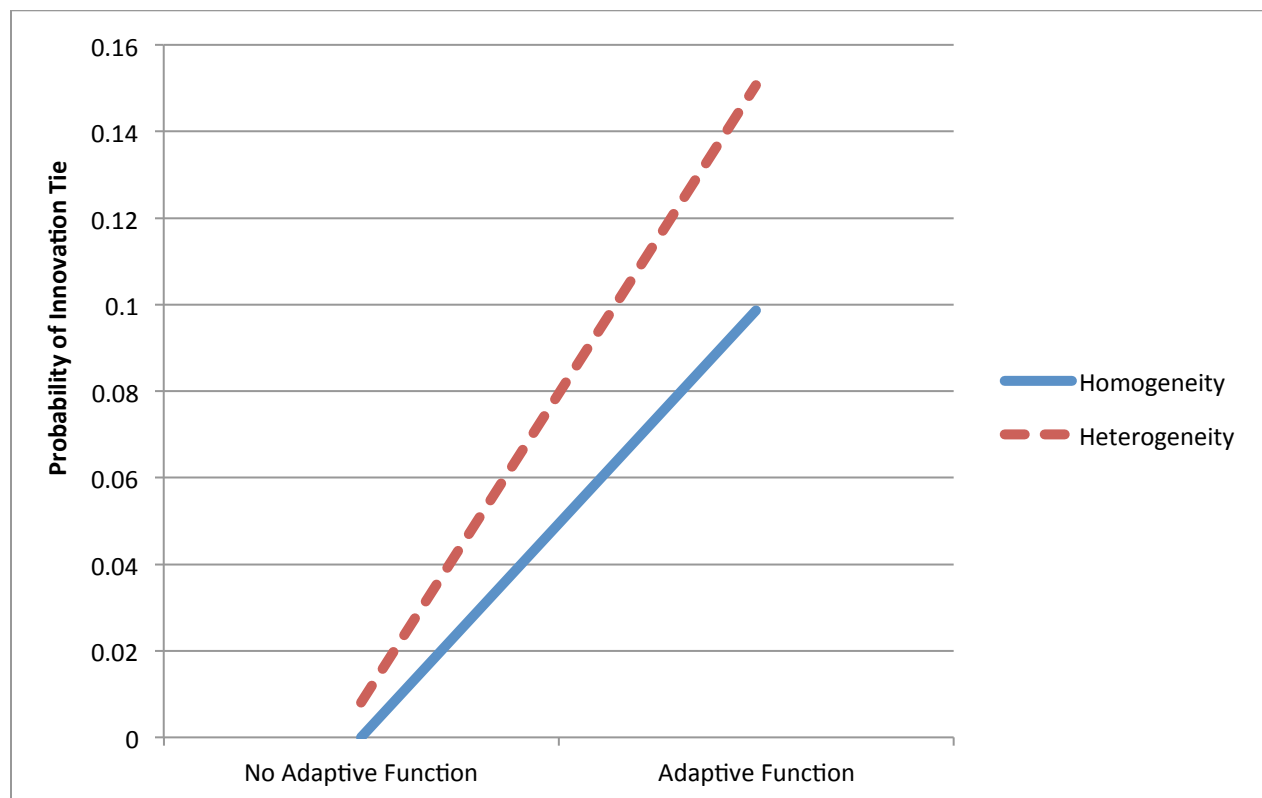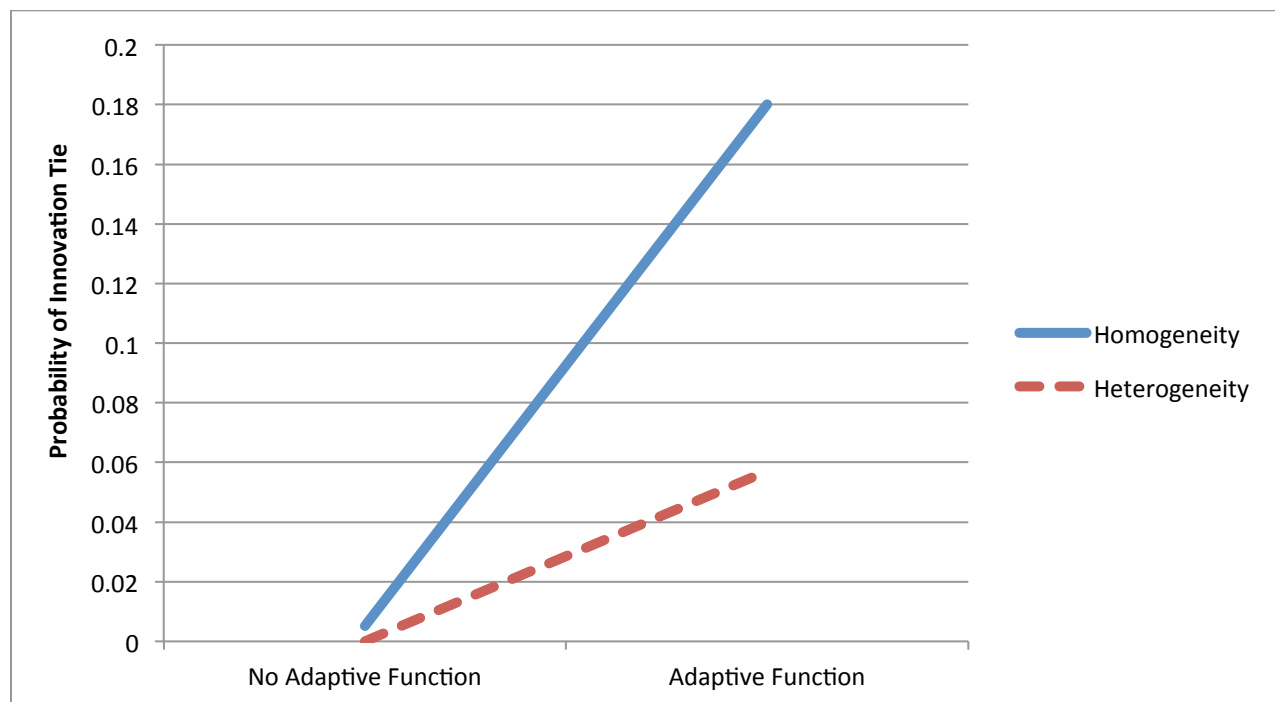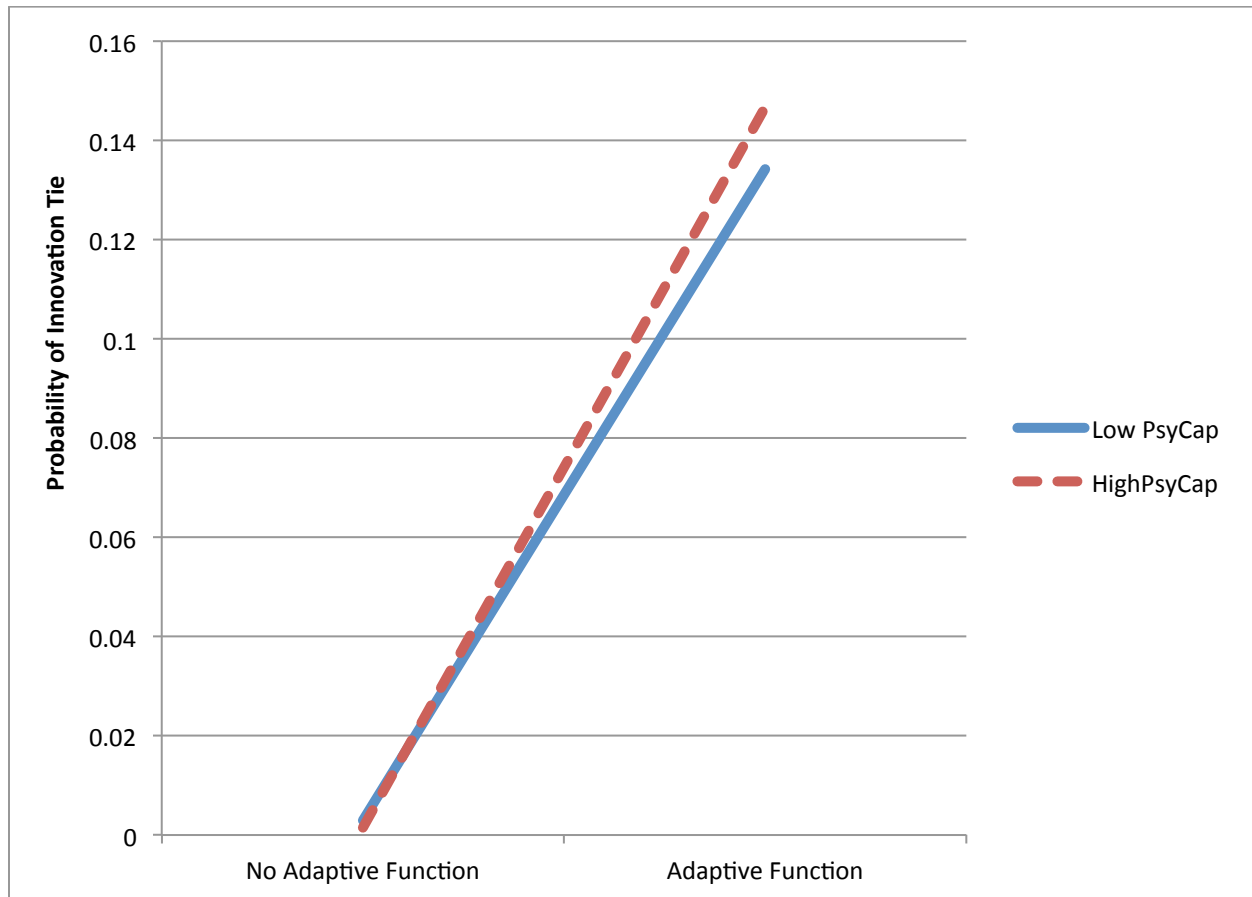
Figure 24: Interaction Effect of the Adaptive Function with Gender

Figure 25: Interaction Effect of the Adaptive Function with Race

Figure 26: Interaction Effect of the Adaptive Function with Age

Figure 27: Interaction Effect of the Adaptive Function with Psychological Capital (hypothesis 5)

APPENDICES

Appendix A: Survey

Note: to protect the anonymity of the organization, the name has been replaced with XXXXXX in all references below. Horizontal lines denote page breaks.

This survey explores innovation. By innovation, I mean new and different ideas that have been introduced and adopted by individuals within the organization. Innovations can be big, such as introducing a new service offering. Innovations can also be small, such as redoing the way certain types of tasks are routed through the organization to be more efficient. To get us thinking about innovation, please list below any innovation – big or small – that you were involved in within the organization. Please be succinct yet descriptive by listing the innovations each in a handful of words. Think back over the past couple years (ie, since the beginning of the recent economic downturn). Don't worry if you feel the items may be "little things" or if you don't have many (or any) ideas to list. Some example ideas could be introducing a new segment to the seminar program or finding a way to reach out more effectively to alumni or sophomores during the recruitment process.

(space provided for up to 8 innovations)

As explained earlier, the purpose of this study is to understand overall leadership and innovation patterns within the organization. There are many important aspects to these processes, all of which involve interacting with others.   These interactions could include interactions in person or via e-mail, phone, or other communication medium. This will be the first of five questions in this survey involving the nature of interactions you have with others in the organization. All of these questions deal with interaction patterns over the past couple years (i.e., since the beginning of the recent economic downturn). While I am asking you to identify specific people you may interact with, you can be assured that you nor any one else will be individually identified in the analysis of this data; it will be analyzed in the aggregate to understand collective interaction patterns. Your confidentiality is of utmost importance, and I hope you will complete this survey as accurately as possible. Also, please be sure to answer "not at all" if that is the answer to the question (please don't just leave it blank).

*To what extent have you **innovated with this person** to produce changes (big or small) within the organization? By innovation I mean the process by which creative ideas become recognized as valuable and implemented in the organization. For example, introducing a new segment to the seminar program or finding a way to reach out more effectively to alumni or sophomores during the recruitment process. This relates to the last question where I asked you to list innovations. Except, instead of listing innovations, you're now denoting people you may have innovated with.*

	Not at all	*Not much*	*Somewhat*	*Regularly*	*Very Often*
Name One					
Name Two					

Name Three
Name Four

(Note: actual survey would include 60 lines instead of 4, one for each member of the organization.)

---

*This next question deals with **leadership**. To what degree do you rely on this person for leadership? Here by leadership I mean a dynamic, interactive influence process to lead one another to achieve group or organizational goals.*

(Same matrix format as illustrated in the above innovation question)

Below are statements that describe how you may think about the organization RIGHT NOW. Use the following scale to indicate your agreement or disagreement with each statement …

(the questions are provided in a table with the following 6 response options)

Strongly Disagree   Disagree   Somewhat Disagree   Somewhat Agree   Agree   Strongly Agree

Our team would feel confident representing our work area in meetings with senior leaders?
Our team would feel confident presenting information to groups of colleagues?
Our team can think of many ways to reach our current work goals.
At this time, our team is meeting the work goals that we set for ourselves.
Our team usually takes stressful things at work in stride.
Our team can get through difficult times at work because we've experienced difficulty before.
Our team always looks on the bright side of things regarding our job.
Our team is optimistic about what will happen to us in the future as it pertains to work.

---

*You're now about half way done with the survey! Thank you for your thoughtful attention. Back to the relationship-type of questions. This one deals with **advice exchange**. Think of times you have been confronted with work-related problems for which you couldn't find a solution yourself. To what extent have you gone to this person for advice due to their relevant expertise?*

(Same matrix format as illustrated in the above innovation question)

---

*This question deals with **perspective**. Think of times when you have sought help in thinking through a problem and looking at it from a different perspective. To what extent have you relied on this individual to provide that help in thinking through problems?*

(Same matrix format as illustrated in the above innovation question)

You know the routine - this is the last of the relationship-based questions :-) This question deals with __reinforcement__. Think of times when you are looking for confirmation if idea is good or not. To what extent have you relied on this individual to provide that confirmation?

(Same matrix format as illustrated in the above innovation question)

Please complete the following demographic information to help me understand a little more about your personal background and your background with the organization.

What is your current role?
Q14
How long have you been with the organization (in years)?

How long have you been in your current position in the organization (in years)?

Did you participate in this organization's programs as a high school sophomore?
   * Yes
   * No

If so, what year?

Roughly how many hours per week do you commit to this organization?

What is your gender?
   * Male
   * Female

What is your race?
   * White/Caucasian
   * African American
   * Hispanic
   * Asian
   * Native American
   * Pacific Islander
   * Other

In what year were you born?

What is the highest level of education you have completed?
   * Less than High School
   * High School / GED
   * Some College

* 2-year College Degree
* 4-year College Degree
* Master's Degree
* Doctoral Degree

Are you currently a student?
* Yes.
* No.

What is your professional background?

Appendix B: Data Collection Communications

Note: to protect the anonymity of the organization, the name has been replaced with XXXXXX in all references below.

(initial e-mail from XXXXXX president)

XXXXXX,

We have the opportunity to participate in some interesting research. You will soon be receiving an e-mail from David Sweetman describing a research project with XXXXXX understand how leadership, advice exchange, and collaboration impact organizational innovation. David is conducting this research as part of the completion of his doctoral dissertation at the University of Nebraska. The XXXXXX corporate board has approved this partnership with David.

In addition to providing XXXXXX with an overall summary of findings and recommendations from this research, David is also personally making up to a $300 donation to XXXXXX as a token of his appreciation (the exact amount will depend upon how many of us respond).

What he will be asking of you is to complete a simple 15-minute survey to understand your leadership and advice exchange within XXXXXX. Your individual answers will be kept anonymous, and data will only be reported to XXXXXX in overall aggregate patterns. In order to make the results this work most meaningful, at least 80% of XXXXXX would complete the survey. You are free to choose whether or not you'd like to participate. I plan to help out, and hope you will too.

Look for more information soon from David.

XXXX XXXXX
President, XXXXXX

(initial e-mail from researcher)

I am a business researcher at the University of Nebraska. I am working on my dissertation research project to understand how leadership, advice exchange, and collaboration impact organizational innovation. Due to your involvement in XXXXXX, you are invited to consider helping with this research by completing a short survey.

The survey will only take 15 minutes. As a token of appreciation for XXXXXX' involvement in this research, I am personally making a $150 donation to XXXXXX. I will make an additional $150 donation (for a total of $300) is at least 80% of XXXXX participates. For this research to be successful, we are working toward at least 80% of XXXXXX responding; thank you for your consideration in making that possible.

Once analysis of the survey data is complete, XXXXXX will also be provided with an overall summary of findings and recommendations regarding leadership and collaboration within the organization.

You can access the survey here:

<insert website address of survey here>

Please complete the survey within the next two weeks, by <two weeks after this e-mail is sent>.

The XXXXXX corporate board has approved this study.

Again, thank you for your consideration and please let me know if you have any questions,

David Sweetman
Institute for Innovative Leadership
University of Nebraska-Lincoln
XXXXX@XXXXX.edu
(XXX) XXX-XXXX

(follow-up e-mail, to be sent by researcher one week after the e-mail above, and sent only to people who have not yet responded to the survey)

Last week, you received an invitation from me to participate in a survey on collaboration. You are receiving this e-mail because you have not yet completed the survey. Only one more week to complete the survey.

You can complete the survey here:

<insert website address of survey here>

It should only take about 15 minutes. As a token of appreciation for XXXXXX' involvement in this research, I am personally making a making a $150 donation to XXXXXX as a token of my appreciation as well as an additional $150 donation if at least an 80% response rate is achieved. To date we have achieved a <XX>% response rate. Please help us meet our goal.

Thank you for your consideration,

David Sweetman
Institute for Innovative Leadership
University of Nebraska-Lincoln
XXXXX@XXXXX.edu
(XXX) XXX-XXXX

(follow-up e-mail, to be sent by president two weeks after initial e-mail, sent only to all people in the organization)

XXXXXX,

This is a follow-up to my e-mail two weeks ago about the opportunity to participate in some research with David Sweetman at the University Nebraska. First, thank you to everyone who has participated in the survey to date. As of today, over xx% of XXXXXX has responded to the survey. In order to make the results this work most meaningful, at least 90% of XXXXXX would complete the survey.

In addition to providing XXXXXX with an overall summary of findings and recommendations from this research, David is also personally making a $150 donation to XXXXXX as a token of his appreciation as well as an additional $150 donation is at least 80% of us respond.

He will soon be calling those of you who have not yet responded in hopes that you might help him out. What he will be asking of you is to complete a simple 15-minute survey to understand your leadership and advice exchange within XXXXXX. Your individual answers will be kept anonymous, and data will only be reported to XXXXXX in overall aggregate patterns. I have already completed the survey, and hope you will too.

Look for more information soon from David.

XXXXX XXXXX
President, XXXXXX

(follow-up phone call, to be made two weeks after the initial e-mail to those who have not yet responded)

Hello, my name is David Sweetman and I'm a researcher with the University of Nebraska. You should have recently received some e-mails from me regarding a research opportunity with XXXXXX. Have you received those e-mails?

If not:

    Well, no worries, the main idea is that I'm working with XXXXXX on a research project on leadership and collaboration in XXXXXX. What I'm asking is for each member of XXXXXX to complete a brief 15-minute survey to understand patterns of interaction within XXXXXX. As a token of my appreciation for XXXXXX' participation, I'm personally making a $150 donation to XXXXX with an additional $150 if 80% of the organization participates in this survey. Additionally, once the survey is complete, I will offer an overall analysis and recommendations to XXXXXX based on the findings.

If e-mails have been received:

    Did you have any questions about the research?

If yes, answer them.

    I've noticed you have not yet completed the survey, is that something you would be interested and able to do?

If no:

    I understand. Thank you for your time, and please feel free to contact me if you have any questions either via phone (XXX) XXX-XXXX or e-mail: XXXXXX@XXX.edu. <end call here>

If yes:

    Great, the survey is web-based and I can e-mail you your personalized link to complete it, could you provide me your e-mail address? <I'll then send the link right then>. Okay, I just sent you the e-mail, could you check to see if you received it?

    As a reminder, the deadline of the survey has passed, but we can make an exception if you can complete this within the next two days, is that reasonable?

If no:

    Okay, what would be a reasonable timeframe?

If yes:

    Great – thank you so much! If you have any questions through the process, feel free to call me (XXX) XXX-XXXX or e-mail: XXXXXX@XXX.edu. <end call here>

Appendix C: Example Adjacency and Heterogeneity Matrices

Below is an example of a valued non-symmetrical adjacency matrix.

	A	B	C	D	E
A		3	3	0	1
B	4		0	0	3
C	3	3		2	0
D	0	1	1		1
E	0	0	4	0	

The rows represent individual respondents and the columns represent their perceived relationship with the other person. So, for example, the value in row B, column A signifies that person B denoted a relationship of strength 4 with person A. My dissertation dataset will be much larger, with roughly 60 rows and columns. Rows and columns will be labeled with a random number identifer as opposed to a letter, but letters are used here to make the illustrations clearer. An adjacency matrix always has the same number of rows and columns, and that is equal to the number of individuals in the network. The middle diagonal is empty (AA, BB, etc), signifying the absence of a relationship between an individual and him/herself.

As described in the methods section of my dissertation, I will be using a binary adjacency matrix (ie, yes-or-no relationships). The cut-off described in the proposal is 0-1 = no connection and 2-4 = connection. The binary version of the above matrix would therefore be:

	A	B	C	D	E
A		1	1	0	0
B	1		0	0	1
C	1	1		1	0
D	0	0	0		0

| E | 0 | 0 | 1 | 0 |

Both matrices above where non-symmetrical. For example, while person C denoted a relationship with person B, person B did not denote the same relationship with person C. A symmetrized matrix shows that a non-directional relationship exists. There are two methods for symmetrizing a binary matrix. First, the minimally symmetrized method denotes a relationship if either of the individuals signify a relationship. In the example of person B & C, the symmetrized matrix would denote a relationship between B & C. The maximally symmetrized matrix, on the other hand, requires both directions, meaning the B & C relationship would be noted as not existing. An interesting sidenote: say person B did not respond to the survey. In creating a minimally symmetrized matrix, person B would show a relationship with person C due to person C's response. Therefore, it is possible to include and analyze relationships for individuals who did not even respond to the survey. The minimally symmetrized version of the above matrix is below:

	A	B	C	D	E
A		1	1	0	0
B	1		1	0	1
C	1	1		1	1
D	0	0	1		0
E	0	1	1	0	

There will be five different adjacency matrices generated directly from survey data for this dissertation: advice, reframing, reinforcing, shared leadership, and innovation. Furthermore, two additional matrices, collective creativity and adaptive function, will be derived from those base matrices. Hypotheses 1 and 3 – the relation of collective creativity and innovation each to innovation, respectively, will be tested using QAP correlation, a method by which adjacency matrices are compared to each other to determine their degree of correlation. Hypothesis 2 analyzes adjacency matrices individually to determine centralization and density within a specific type of relationship for the entire network.

Hypothesis 4 examines the heterogeneity of actors as a moderator to the adaptive function-innovation relationship examined in hypothesis 3. For this hypothesis, QAP regression is used. Similar to QAP correlation, matrices of data are examined except, as with non-QAP regression, two or more predictor variables are involved. Heterogeneity in categorical values is represented

in a matrix as a value of "1" if heterogeneity exists and a value of "0" if there is homogeneity. For example, if the symmetrized matrix above represented heterogeneity of gender, it would signify person A & B are the same gender, A & D are different, and so on. It should be noted that heterogeneity looks at the similarity or difference between two individuals, not what the individual value of the dimension is. So, for example, we don't know if A or B are male or female, but we know they're the same gender. Alternatively, a heterogeneity matrix can also be represented in the following dyad-based form:

Dyad	Heterogeneous
AB	1
AC	1
AD	0
AE	0
BC	1
BD	0
BE	1
CD	1
CE	1
DE	0

In this representation, there is one row for each dyad. Since dyads are symmetrical, there is only one row for each dyad (eg, AB, but not BA). This heterogeneity matrix can be used to analyze at the dyad level.

Appendix D: Transforming Qualtrics Survey Responses to Network Matrices

When administering a web-based survey via Qualtrics, the output is provided in the form of an Excel spreadsheet containing one row for each respondent and one column for each question answer. This includes the five network questions, listing of innovations, collective psycap, and demographic information. The needed format for adjacency matrices is one row and one column per person.

The "conversion" of the Qualtrics Excel file to adjacency matrices for advice, reframing, reinforcing, shared leadership, and innovation will be rather straightforward. Firstly, a global search-and-replace will be conducted for each name in the survey, replacing it with a random number identifier. This will both anonymize the data both in the rows and columns. An Excel macro will be created to handle this. Seven copies of the Qualtrics Excel file will then be created, with the following purposes (1) an original file containing all data (2) a file containing only individual data (PsyCap & demographics) (3) five files, one for each network measure. These network measure files will effectively become valued and directed adjacency matrices. All row/column combinations where the person is the same will be cleared of any values that may exist in them (ie, a person cannot have a relationship with themselves). Files will be exported as tab-delimited to enable reading by UCINET. Making matrices symmetric and binary will be done using these functions within UCINET.

Matrices for the heterogeneity variables are slightly more complicated, as each individual's response will have to be compared to every other respondent. For categorical variables (work team, gender, etc) a simple binary comparison will be made and a value of 1 for similarity or a value of 0 for dissimilarity. For continuous variables (eg, years of service), the absolute value of the difference between the individuals will be calculated. These matrices will

be created using the Data → Attribute command set within UCINET. Alternatively, this matrix

can also be created programmatically. A stylized descriptive version of the programming code

to create an adjacency matrix with heterogeneity comparisons is shown below.

Write header row of each respondent ID in order (creating the columns of the matrix)

Query1 of dataset to return all respondent IDs and the variable for heterogeneity to be compared

    Write respondent ID at beginning of row

    Query 2 of data to return same as query 1

        Compare variable in query1&2, if homogenous, then value=0, else value=1.

        leave blank if respondent ID are the same (ie, don't compare an individual to self)

        if continuous variable, calculate absolute value of difference and use that

    Repeat the indented section above for all respondents in query 2 to fill all columns in row

Repeat the indented section below "Query1" for each respondent ID