A CONTINUOUS VIEW OF LEVELS OF ANALYSIS: INTEGRATION OF TRADITIONAL LEVELS APPROACHES AND A NETWORK PERSPECTIVE

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ABSTRACT

The literature on levels of analysis has stimulated substantial scholarly interest in exploring multilevel organizational theories and methods. Despite contributions that multilevel approaches have made to organizational science, the current levels of analysis frameworks rely on a discrete view, that is, the levels of analysis are distributed on a discrete scale (i.e., either individual level, group level, or organizational level). This discrete view of levels may not be the appropriate unit of analysis in studying today's organizational phenomena which involve complex and fluid memberships, non-independent yet heterogeneous observations, informal relations, and dynamic and emergent properties of the focal entities. As such, the objective of this dissertation is to re-examine a traditional levels-of-analysis framework from a network perspective. Focusing on team and leadership research, this study proposed a continuous view of levels of analysis by incorporating social network theory and method.

This dissertation is composed of three essays. The first essay introduces the theoretical framework for a continuous view of levels of analysis, which incorporates social network theory and builds from the traditional view of levels of analysis. A set of propositions are then developed to explore the boundary conditions for the proposed continuous view of levels of analysis. The second essay develops a network-based approach to shared leadership, proposes and tests a multilevel and dynamic leadership and team decision making model. This essay illustrates how a leadership construct can be

conceptualized and operationalized at a network level of analysis. Agent-based modeling and simulation methods test the proposed model. The third essay offers a state-of-science review of levels-of-analysis issues in social network research. A content analysis of 249 conceptual and empirical social network articles is performed. The results suggest an integration of levels of analysis and social network perspectives would benefit both areas and therefore require further development in future research.

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INTRODUCTION

The literature on levels of analysis has stimulated substantial scholarly interest in exploring multilevel organizational theories and methods. Levels of analysis refer to the entities of study and are typically at 1) individual level, 2) dyad level, 3) group level, and 4) organization level depending on the conceptualization and operationalization of the constructs. The multilevel or "meso" approach was explicated to organizational behavior and leadership research several decades ago. Roberts, Hulin, and Rousseau (1978) were among the first to call for the integration of different level-specific disciplines. Following Roberts et al. (1978), Dansereau, Alutto, and Yammarino (1984) and Rousseau (1985) explicated the concept of levels of analysis and advanced the theoretical frameworks and analytic techniques for multilevel theory developing and testing. Since then, much effort has been made to develop multilevel approaches, and calls for incorporation of levels of analysis in the research of organizational science have drawn increasing attention.

Despite the contributions that multilevel approaches have made to organizational science, there are vigorous debates regarding appropriate ways to conceptualize and measure multilevel constructs (for a review, see Mathieu & Chen, 2011). The current multilevel framework is built upon an assumption that organizations have nested structures and that one must designate a unit of analysis of interest. Another assumption that underlies much prior research is that the focal levels of analysis remain stable over time (Dansereau, Yammarino, & Kohles, 1999). The specified levels of analysis are then used to formulate

level-specific theories and direct data collection and analysis (e.g., estimation of within-group agreement or inter-rater reliability and between-group variance, aggregation of lower-level data to a higher level). The current levels-of-analysis framework is based on a discrete view, that is, the levels of analysis are distributed on a discrete scale. Taking this discrete view, researchers have to make a decision on whether the focal level of analysis is individual, group, or organizational level (or even higher than organizational level). This discrete view of levels may not be the appropriate unit of analysis in studying today's organizational phenomena which involve complex and fluid memberships, non-independent yet heterogeneous observations, informal relations among actors, and dynamic and emergent properties of focal constructs.

Today's organizations are becoming increasingly fluid, flexible and team-oriented, and moreover, employees may serve on more than one team as organizations scramble to solve complex problems quickly. As organizations become more organic and flexible, the boundaries between formal units become blurred and therefore hard to discern (Hackman, 2003). An emerging and ever-changing division of labor has stimulated new forms of interdependence and collaboration among employees. These changes in the workplace create challenges for organizational research. As noted by Gronn (2002), one issue in leadership research is researchers often "prescribe", rather than "describe," a division of labor. This raises major concerns about the appropriate levels of analysis, particularly in the circumstances where divisions of labor are constantly changing. Freeman (1980) indicates:

> The choice of unit is more problematic today than before because of the rise of open-systems approaches and because of the growing interest in longitudinal

research. If we see boundaries as permeable to varying degrees, then we have more or less of a unit. And if the permeability of boundaries varies over time, we face the real possibility that a unit definition that seems useful at the beginning of a study will be inappropriate if not entirely misleading tomorrow. (p. 60)

Because of the dynamic characteristics of today's organizations, researchers risk model misspecification by only considering a discrete view of levels of analysis and designating constructs, theories and/or data for a particular level of analysis. Given the changing nature of collaboration and interdependence between organizational personnel, it is highly likely organizational units are not as neatly nested as we implicitly assumed. Thus, forcing constructs and/or theories into either individual, or dyad, or group, or organizational level of analysis may overlook important information that pertains to the structural, relational, and emergent elements of organizational dynamics and processes.

Given the deficiency in the conventional discrete view of levels of analysis, more flexible views of levels of analysis are needed. Compared with the current levels-of-analysis framework, a social network perspective is flexible in dealing with different types of actors and different kinds of relations (Contractor, Wasserman & Faust, 2006). Social network approaches view organizations as a system of objects and "fundamentally relational entities" (O'Reilly, 1991, p. 446). This literature suggests organizations can be better represented by social networks.

Some attempts have been made to integrate levels of analysis theory and social network theory. For instance, Moliterno and Mahony (2011) integrated multilevel theory within a social network perspective to advance a multilevel network theory of organization, emphasizing that networks have the potential to simultaneously represent individuals,

dyads, groups and collectives (Moliterno & Mahony, 2011). Gnyawali and Madhavan (2001) proposed a multilevel network model, in which they examined constructs at the actor level (e.g., firm network centrality), dyadic level (e.g., structural equivalence), and global level (e.g., network density). Nevertheless, a majority of social network studies either focused on a single level of analysis or examined levels of analysis discretely, which may simplify the notion that networks can be more complicated and integrated than residing at a single level of analysis.

Because organizations are more dynamic and fluid, and because discrete levels of analysis may not be able to represent the complexity in today's integrated and interdependent organizations, the primary objective of this dissertation is to re-examine a levels-of-analysis framework from a network perspective. Three essays are developed to accomplish this purpose. The first essay introduces a theoretical framework for a continuous view of levels of analysis, incorporating social network theory into the traditional view of levels of analysis. A set of propositions are then advanced to explore the boundary conditions for the proposed continuous view of levels of analysis. The second essay develops a network-based approach to shared leadership and a dynamic leadership and team decision making model. Using agent-based modeling and simulations, this essay illustrates how a leadership construct can be conceptualized and operationalized at a network level of analysis. The third essay offers a state-of-science review of levels-of-analysis issues in social network research. A content analysis of 249 conceptual and empirical social network articles is conducted to assess the levels related issues in social network research. .

This dissertation attempts to provide an alternative view of levels of analysis to

complement the conventional or traditional view of levels of analysis. It will not replace the current multilevel framework. The objective is to stimulate further discussion about how to integrate multilevel research and social network theory and benefit both areas.

ESSAY I: A RE-EXAMINATION OF LEVELS OF ANALYSIS FRAMEWORK FROM A SOCIAL NETWORK PERSPECTIVE: LEADERSHIP ILLUSTRATION

The potential multilevel applicability of a network perspective suggests that it may add insights to the levels-of-analysis framework by considering levels of analysis as better represented as a continuum, rather than as discrete levels. Therefore, the specific structure of entities being examined can be better represented and analyzed with more a more flexible and appropriate view of the operational level of analysis. The integration of levels of analysis theory and a social network perspective has key conceptual and methodological implications for research in the organizational sciences, and also contributes theoretically to advancements in social networks and the levels of analysis literatures.

A set of important research questions I attempt to address in the present study are: what is a network level of analysis? How it is distinct from other levels of analysis? When it is appropriate to use a network level and/or traditional levels of analysis? To answer these research questions, I begin with a brief review of levels of analysis research and social network research. I then explicate possible means of integrating these two approaches, and develop a continuous view of levels of analysis by incorporating a network perspective within traditional levels of analysis theory. A set of propositions are then developed to explore boundary conditions for the proposed continuous levels of analysis perspective.

The proposed framework is then illustrated using shared leadership as an example. Finally I discuss the implications and limitations of the proposal, and suggest directions for future research.

Although this proposed approach is potentially applicable to a variety of areas in organizational science, I primarily concentrate on research in the field of leadership and teams, as teams and groups research is multilevel in nature. A great number of team theories pertaining to individuals, teams, multiteam systems, organizations, and inter-firm alliances have been developed to enhance our understanding of how inputs at multiple levels of analysis can be transmitted to organizational outcomes through a variety of team processes and emergent states (Mathieu et al., 2008; Kozlowski and Klein 2000; Ilgen et al., 2005; Marks et al., 2001). Leadership is another area that has been a pioneer in propelling the development of multilevel theories and applying a multilevel approach for theory building and testing. Thus, these areas are ripe for an extension of levels of analysis with social networks.

A REVIEW OF LEVELS OF ANALYSIS RESEARCH

Starting in the 1980s, the need for a paradigm shift from purely micro- or macro-research to meso- or multilevel research was brought to the forefront of organizational research (Rousseau, 1985; Dansereau et al., 1984; House, Rousseau, & Thomas-Hunt, 1995). Since then, conceptual frameworks and analytic techniques of multilevel approaches have been substantially advanced in organizational sciences (Mathieu & Chen, 2011). It has been widely acknowledged that explicit specification of the levels of analysis in theory at which relationships or phenomena are expected to exist is of great importance and that levels of analysis in data collection and analyses, and in inference drawing should

be aligned with the levels specified in theory and hypotheses (Rousseau, 1985; Dansereau et al., 1984; Klein, Dansereau & Hall, 1994; Yammarino, Dionne, Jae Uk, & Dansereau, 2005).

A number of articles have discussed the benefits of incorporating multiple levels of analysis in organizational research (e.g., Hackman, 2003; House et al., 1995; Klein et al., 1994; Klein, Tosi, and Cannella 1999). Multilevel approaches can "(1) enrich understanding of one's focal phenomena, (2) help one discover non-obvious forces that drive those phenomena, (3) surface unanticipated interactions that shape an outcome of special" (Hackman, 2003, p 907).

Multilevel theories integrate a micro domain which focuses on individuals and groups, and a macro domain which focuses on organizations or systems (Klein et al., 1999). Multilevel investigations are concerned with relationships among concepts at multiple levels of analysis. Although some multilevel theories have made contributions to identify the individual-level characteristics and behaviors that underlie organization-level characteristics (Klein et al., 1999), a more prevailing view in management research is higher-level variables are more likely to influence lower-lever variables than the reverse. Useful frameworks of multilevel research have been advanced to guide scholars to develop rigorous theories and avoid the "fallacy of the wrong level" (e.g., Rousseau, 1985, Dansereau et al., 1984; Dansereau, Cho & Yammarino, 2006). A number of authors recommend that scholars carefully address levels issues in theory development, data collection (or measurement) and analysis, and that these three facets should be aligned (Klein et al., 1994).

Levels in theory. *Level of theory* refers to the focal level to which generalizations

are expected to apply (Rousseau, 1985). The level of analysis can be the individual level (e.g., a manager, an employee), dyad level (e.g., two interdependent individuals), group level (e.g., cross-functional teams, top management teams) or collective level (e.g., organizations) depending on the conceptualization and operationalization of the constructs (Yammarino & Dansereau, 2009). These four levels of analysis are the most widely investigated in organizational sciences, although a level could also be lower than an individual level (i.e., within-individual level) and higher than an organizational level (i.e., industries, economies).

Before further explicating the levels of analysis issues in this study, it is important to distinguish the *levels of analysis* from the *levels of management.* As often shown in an organization chart, levels of management characterize the hierarchical levels, chain of command and the distribution of power. For example, an organization's CEO is at the highest management level, and a manufacturing team is at a lower management level. However, in terms of levels of analysis, the manufacturing team can be at the team level (e.g., team size, team cohesion), whereas the CEO can be at the individual level (e.g., CEO's personality, skills), a lower level.

Management scholars are suggested to articulate what the nature and structure of the focal concept is, why the focal unit is the appropriate level to investigate the concept and why the expected effects or relationships exist at a particular level of analysis (Klein et al., 1994). Multi-level approaches often suggest researchers address two facets of levels in theory: (1) the level of the focal unit and (2) multilevel relationships (Yammarino, 1998; Mathieu & Chen, 2011).

The essential assumption of levels of analysis approach is that organizations are

multilevel in nature (Kozlowski &Klein, 2000). The nesting structure of organizations suggests individuals are nested in groups, which are nested in higher levels such as departments or organizations. The formal organizational levels are often assumed to be the entities where relationships or phenomena are expected to exist. This assumption, however, might be problematic. Mathieu and Chen (2011) note researchers often group employees depending on their groups, work units, departments, and organizations with little validation regarding whether those distinctions are meaningful.

Theory development can proceed to building multilevel relationships once the focal unit for generalizations is specified. The earlier work by Rousseau (1985), Dansereau et al. (1984), Klein et al. (1994) and House et al. (1995) examined underlying nature of multilevel relationships and advanced guidelines for multilevel theory development. Dansereau et al. (1984) develop a multilevel varient (for *vari*ables and *ent*ities) approach and an analytic technique WABA (within and between analysis). In this book, Dansereau and colleagues advance a typology of models and describe a multilevel model, in which dependent and independent variables are at different levels, and a cross-level model, in which relationships among variables can hold at two or more levels. In the present study, I adopt Dansereau et al.'s (1984) terminology and definition of multilevel and cross-level theories and models. However, it is worth noting that other researchers have used these terms differently. For instance, Rousseau (1985) and Klein et al. (1994) define cross-level models as involving variables operationalized at different levels (i.e., a multilevel model in Dansereau et al.'s (1984) term), and multilevel modes as involving relationships that can hold at multiple levels (i.e., a cross-level model in Dansereau et al.'s (1984) term).

Levels in measurement. Another facet of levels of analysis is levels in

measurement, which refers to the "entities from which the data are drawn or are attached" (Mathieu & Chen, 2011, p. 616). Levels in measurement deals with critical issues such as: what is the appropriate level of data collection; how to justify the aggregation of lower level data; and how to perform multilevel construct validation. Chen, Mathieu and Bliese (2005) propose a five-step framework for multilevel construct validation along with a typology of multilevel constructs. They propose six types of aggregate constructs: selected score, summary index, consensus, referent shift, dispersion, and aggregate, and further indicate that any data aggregation should be guided by prior research and theories.

Kozlowski and Klein (2000) note two types of aggregation principles: composition and compilation. Composition refers to "situations where descriptive statistics of lower-level data, such as means of individuals, adequately represent the processes. For instance, one might use the sum of individuals' cognitive abilities to represent group's cognitive ability. In contrast, compilation models refer to situations where the "higher-level phenomenon is not representative of descriptive statistics of lower-level data, rather a complex combination of diverse lower-level contributions" (Kozlowski & Klein, 2000, p. 17).

Essentially, levels in measurement should be aligned with levels of analysis in theories and hypotheses. Researchers need to provide justification when levels in measurement fail to match with levels in theory (Klein et al., 1999). The alignment between these two facets of levels of analysis leads to higher within-group agreement and greater between-group variance for "wholes" theories and greater within-group variance and higher between-group agreement for "parts" theories, and therefore more rigorous theories (Klein, Conn, Smith, & Sorra, 2001).

Levels in data analysis. Levels in data analysis refer to "the unit to which data are assigned for hypothesis testing and statistical analysis" (Mathieu & Chen, 2011, p. 613). The level at which data are analyzed should align with the level of theory (Rousseau, 1985). Since early 1980s, along with the theoretical development of levels of analysis, more advanced analytic techniques for examining multilevel data have been developed. Among these techniques, WABA, cross-level operator analyses (CLOP), and hierarchical linear modeling (HLM) are the most widely used in the field of management (see Kozlowski & Klein, 2000).

HLM is perhaps the most popular among a class of several multilevel random coefficient modeling (RCM) techniques (Hofmann, Griffin, & Gavin, 2000). HLM first analyzes the relationship among lower-level variables and computes the intercept and slope(s) for the lower-level model within each unit, and then analyzes the relationships between higher-level (e.g., team-level) variables and the intercepts and slopes for each team (Hofmann et al., 2000). Dansereau et al. (1984) develop within and between analysis (commonly referred to as WABA), which is used both to justify aggregation and to analyze the relationships between variables (Dansereau & Yammarino, 2000; Klein et al., 2000). Statistically, the "whole" view of levels of analysis is supported when between-group variance exceeds within-group variance, whereas a "parts" view of levels of analysis is supported when the within-group variance exceeds between-group (Dansereau et al., 1984). CLOP is designed to examine the main and/or moderating effects of higher-level variables on lower-level outcomes and/or lower-level relationships (James & Williams, 2000) using a number of analysis of variance, covariance, and regression approaches.

Each of these approaches has its advantages and disadvantages. For example,

WABA allows for testing the "parts" view but is not suitable for testing complex models (Chen, Kirkman, Kanfer, Allen, & Rosen, 2007). RCM/HLM approaches cannot test dependent variables at levels higher than the independent variables. Both HLM and CLOP needs to be used along with, rwg, eta-squared, ICC (1), ICC (2), and/or WABA to justify data aggregation within units (Klein & Kozlowski, 2000; James & Williams, 2000).

Levels in inference drawing. A comprehensive and accurate levels-based inference can only be drawn when levels of levels of analysis in theory, measurement, and data analysis are fully incorporated in study (Yammarino, et al., 2005; Dansereau & Yammarino, 1998; Dionne, et al., 2012). Misleading or erroneous conclusions can be caused by misspecification of levels in theory, faulty measures, or inappropriate data analytic methods. As pointed out in Yammarino et al. (2005), “the mixing, mismatching, or non-use of levels in any of these three realms, limits one’s ability to employ a strong inference approach that incorporates multiple levels of analysis” (p. 881).

Critiques of Multilevel Paradigm

While the multilevel paradigm has been greatly advanced over the past quarter of a century, it also attracts many criticisms. The current levels of analysis framework suffers from its inherent weaknesses and underlying assumptions (Mathieu & Chen, 2011), and may not be appropriate in some circumstances.

Simplistic conceptualization

Klein et al. (1999) note some multilevel theory work may be simplistic. They further point out one of the barriers to develop multilevel theory is the challenge of deciding the appropriate scope for the theory. Researchers often generalize a theoretical proposition at one level of analysis to another. "We know that when individuals do x, y occurs.

Therefore, when groups do x, y must also occur" (Klein et al., 1999, p. 244). This simplistic conceptualization may yield problematic theoretical inferences. Likewise, Hackman (2003) posited an issue associated with "boundaries of levels":

> In organizational research ... the micro-meso boundary is becoming harder to discern, as scholars increasingly use concepts whose proper referents are individual cognitive or affective processes to describe group and organizational dynamics (Larson & Christensen, 1993). The trend is worrisome, because to describe a collective entity such as a group as having thoughts and feelings is to increase significantly the conceptual and empirical difficulty of explicating how the states and processes of individual persons combine to shape collective structures and interactions. (p. 920)

Although the multilevel approach has been available in organizational studies for decades, and many theoretical frameworks and analytical techniques have been developed for better theory building and testing, the field falls short of carefully specifying the levels of analysis in theory, measurement and data analysis.

Challenge in identifying unit of analysis

Multilevel research is built upon the assumption that organizations have nesting structures and that one must designate a focal unit of analysis. This focal unit of analysis is also assumed to be stable over a period of time. The focal levels of analysis, mostly the formal organizational levels (e.g., work teams, departments) are then used to formulate level-specific theories and direct data collection and analysis (e.g., estimation of within-group agreement or inter-rater reliability and between-group variance, aggregation of lower-level data to a higher level).

However, as noted by a number of scholars, formal organizational levels may not necessarily be the appropriate levels of analysis for multilevel research. As organizations become more organic and flexible, the boundaries between formal units become blurred and therefore hard to specify (Hackman, 2003). Moreover, using formal organizational levels may be unsuitable in some cases. Short, Payne, and Ketchen's (2008) research findings reveal that with little or no rationale provided, researchers heavily rely on formal organizational units, or empirically clustered organizations to cluster organizations.

Today's organizations have substantially changed from what they used to be. The boundaries among formal organizational units can be ambiguous and arbitrary. Identifying appropriate levels of analysis appears to be a challenge for multilevel research.

Overreliance on cross-sectional research

A majority of multilevel theories are developed upon cross-sectional studies. Levels of analysis in these studies are therefore assumed to be stable over time, whereas multilevel theories in some fields (e.g., education, psychology) are based on longitudinal designs, in which researchers collect observations of entities at multiple time points. These longitudinal studies allow researchers to examine the temporal pattern, group trajectories and as well as evolution of levels of analysis.

A number of scholars have realized the importance of conducting longitudinal research to examine the role of temporal factor in affecting the concepts of interest, theory or model, and initial levels of analysis (Dansereau et al., 1999; Klein et al., 1999; Mathieu & Chen, 2011). For example, Dansereau et al. (1999) pointed out a problematic assumption which underlies much previous research, that is, levels of analysis remain static over time. Dansereau and colleagues emphasized that time plays an important role in multilevel

phenomena, and provided a longitudinal levels-of-analysis framework that would capture the shift of a focal level to a higher or lower level. They argue that over time, levels of analysis or entities may (1) remain stable, (2) shift toward independence at a lower level, or (3) become homogeneous or heterogeneous at a higher level.

In summary, the deficiencies and limitations existing in current multilevel paradigm call for greater attention addressing these issues in future research. Adopting the perspective of social networks is believed to be one of the promising directions for advancing levels of analysis theories (Mathieu & Chen, 2011). Social network research has proliferated during the past decades. Advancement of social network research made both in theoretical formulation and in methodological development offers unique opportunities to investigate complex multilevel phenomena. Further, social networks have the potential to serve as an alternative level-of-analysis view and complement the current levels-of-analysis framework.

A CONTINUOUS LEVELS-OF-ANALYSIS PERSPECTIVE

Social Networks: An Alternative Level-of-Analysis View

Social network research has received considerable scholarly interest during the past decades. Parkhe, Wasserman and Ralston (2006, p. 560) note "of all the phenomena that have gripped the business world in recent years, few match the impact of networks." Network research has inspired management researchers to rethink twenty-first-century organization forms as "network organizations" (Contractor et al., 2006).

A wide range of organizational topics across different levels of analysis have been investigated from a network perspective (Kilduff & Brass, 2010). For example, at organization level, a social network perspective has been used to investigate interfirm

relations (Westphal, Boivie, & Chng, 2006), joint venture and alliances (Gulati, 2007; Batjargal et al., 2012) and firm performance (Human & Provan, 1997). At team level, social networks have been used to study leadership (Mehra, Smith, Dixon, & Robertson, 2006), interunit relations and conficts (Labianca, Brass, and Gray, 1998) and team performance (Sparrow, Liden, Wayne, and Kraimer, 2001). At an individual level, social networks have been employed to study social capital (Lester, Hilman, Zardoohi & Cannella Jr, 2008), turnover (Krackhardt & Porter, 1985), and power (Brass, 1984).

With a distinctive focus, network research investigates relations among actors (e.g., individuals, groups, organizations). Brass, Galaskiewicz, Greve and Tsai (2004) define a network as a set of ties which represent some relationship, or absence of relationship between the actors. Actors, also referred to as nodes, can be individuals, work units or organizations. Ties connecting actors can be directed or undirected and can be dichotomous (present or absent) or valued (e.g., strength of relationship). The relationships represented by network ties may have particularly unique content and researchers may look at different kinds of networks, which typically function differently (Borgatti & Foster, 2003). For example, ties in a friendship network may represent whether the pairwise friendship exist between nodes, whereas ties in an advice network may represent the flow of information or influence one has on the other.

Kilduff and Brass (2010) highlight four core ideas and fundamental features that characterize social network research. First, social network research focuses on social relations between actors. This emphasis on relations is the most significant characteristic that differentiates social network research from traditional organizational research, which focuses on the isolated actors and the attributes of these actors (Brass et al., 2004). Second,

social networks investigate structural patterning that underlies the complex social relations. Network structure lies beneath the interactions of actors, and indicated by clustering, connectivity, and centralization. Structural analysis and configurational approach can be employed to identify and analyze structural signatures.

Another fundamental characteristic of social network research is embeddedness. The idea of embeddedness states that "actors are embedded within a network to the extent that they show a preference for repeat transactions with network members (Uzzi, 1997) and to the extent that social ties are forged, renewed, and even extended (cf. Gulati & Gargiulo, 1999) through the community rather than through actors outside the community" (Kilduff & Brass, 2010, p. 323). The fourth fundamental feature of social network research is the utility of network ties. Social networks are believed to provide both opportunities for, and constraint on, organizational entities, which therefore significantly affect outcomes at multiple levels of analysis. Substantial evidence of social networks serving as antecedents of organizational outcomes has been well documented in the network literature (for reviews, see Borgatti & Forster, 2003; Burt, Kilduff, & Tasselli, 2013; Brass et al., 2004).

The emphasis on embeddedness and the association with important organizational outcomes are critical to both social network and levels of analysis research. Embeddedness is one of the fundamental assumptions underlying the levels of analysis perspective. It essentially captures the nesting structure of organizations, in which individuals are embedded in working units or teams, which are embedded in organizations (House et al., 1995; Klein et al., 1994; Hitt et al., 2007). The notion of embeddedness is concerned with the specification of focal entities and the boundary of the entities. The nesting structure of focal entities can help address questions such as how the entities at one level are nested

within higher-level entities, when an entity starts and when it ends. Although multilevel research focuses primarily on formal organizational levels (i.e., individuals, work units, departments, organizations), some scholars noticed other nesting layers might exist (e.g., House et al., 1995; Mathieu & Chen, 2011). Social network may be one of the most understudied nesting layers. Similar to nesting structures within levels of analysis, social networks also have an embedded arrangement, that is, actors are embedded in social networks, which are embedded in higher-level entities (e.g., formal teams or work units, higher level networks, organizations).

These characteristics summarized by Kilduff and Brass (2010) not only establish the common ground for levels of analysis and social network research, but also differentiate social network from the traditional levels of analysis. The common features support the potential that a network could serve as a level of analysis, and may answer the question: *can a network represent a level of analysis for theory and construct development?* While the unique features differentiate a network level from team and organizational levels, it is necessary to determine *what is unique about a network level and how may it differ from a team or organizational level*?

Additionally, the feature of association with organizational outcomes emphasizes the utility of network connections. Social networks can facilitate or constrain the activities and interactions among actors, as well as the flow of information, resource, knowledge, etc. Social networks can therefore significantly affect outcomes at all levels of analysis (Brass et al., 2004). In levels of analysis research, constructs or relations at a certain level can also have impact on the variables at the same level (i.e., single-level theory), lower-level variables (i.e., multilevel theory), lower-level relations (i.e., top-down effect), higher-level

variables (i.e., multilevel theory), and higher-level relations (i.e., bottom-up effect) (Klein & Kozlowski, 2000).

While there are commonalities between social network and levels of analysis perspectives, what brings uniqueness to social network research is its structural and relational focus. Accordingly, social network and traditional levels of analysis frameworks differ in both theoretical and empirical development. Levels of analysis scholars assert organizations are multilevel in nature, while some social network scholars argue that organizations are networks in nature and that research agenda needs to evolve from studying networks in organizations to acknowledging a network *is* the organization (Contractor et al., 2006).

When employing traditional multilevel approaches to conceptualize constructs and theories, one often starts with specifying the levels of analysis of the variables being studied and the levels of analysis of the relationships among these variables. Prior levels of analysis frameworks can help determine the proper level of analysis for the focal variables and their relations. For example, Klein et al. (1994) suggest the level specification be based on homogeneity within higher-level units, interdependence from higher-level units and heterogeneity within higher-level units. Moving to the next stage, researchers test their theory and hypotheses through sample and operationalization. Measuring higher-level variables often involves aggregating lower-level data to derive a score for the higher-level unit. Depending on the nature of the focal variables, and the research question and design, different aggregation models and methods can be used (e.g., composition model, compilation model, see Kozlowski and Klein, 2000). The most common aggregation method is taking the mean score of the lower-level values as the score for the higher-level

unit (Chen, Mathieu, & Bliese, 2003).

Social network research, however, takes a distinctive approach to conceptualize constructs and theories and measure variables. With a focus on structures and relations, network research has employed a set of indicators that capture the simultaneous structural signatures and patterns at actor level, dyadic level, and network level. For example, Roberson and Wiliamson (2012) examine the relationship between network density and the procedural justice climates. They focused on two types of network ties: instrumental ties and expressive ties, which were measured by asking participants to rate each member in their teams on the degree of how often they have sought work-related help or advice from that team member (instrumental ties), and how close their relationship with that team member (expressive ties). The authors then calculated instrumental network density by adding up the responses of every team member and dividing the sum by the maximum possible score for a team's matrix using UCINET 6 (Borgatti, Everett, & Freeman, 2002). The same procedure was used to calculate expressive network density. Finally hierarchical regression was employed to analyze the relationship between network densities and procedural justice climates.

As shown in this example, social network research employs a configurational and structural approach that is inherently different from the conceptualization and operationalization of levels of analysis approach. Besides network density, other network structure constructs that have been studied include degree centrality, betweenness centrality, closeness centrality, tie strength, multiplexity, density, cohesion, small worlds, etc. (for detailed definition for each construct, see Carpenter, Li, & Jiang, 2012), which reflect the potentially variable number of simultaneous levels perspectives present in an

existing network. In sum, with its theoretical and methodological advancement, a social network approach can offer unique opportunities to refine the current levels of analysis framework.

Toward A Continuous Levels-of-analysis Framework

The traditional levels-of-analysis perspective emphasizes the importance in explicitly specifying the levels in theory, data collection and analysis, and inference drawing. The levels of interest mostly reside at individual, dyadic, group or organizational level. Statistical procedures and criteria have been developed to help make an *either-or* decision with regard to whether the focal level of analysis should be individual or team, or a higher level (Klein & Kozlowski, 2000). Although greatly enhancing our understanding of organizational phenomena, this framework takes a static and discrete perspective, and may therefore overlook the rich information that resides *between* the adjacent levels. An integration of a social network approach with the conventional levels of analysis perspective may help capture such overlooked information, and also provide a remedy for the issues and limitations existing in the current levels of analysis framework.

Research that attempts to bridge social networks with levels of analysis has been sparse in the current literature. However, three notable studies appear to be insightful and informative. Moliterno and Mahony (2011) explore the possibility of combining these two areas. They overlay canonical multilevel theory on the social network theory to develop a notion of "systems of nested networks" and a set of postulates that expand the theoretical domain of "a multilevel network theory of organization." Essentially, the notion of system of nested networks suggests that each node in a network at a focal level of analysis is a network at a lower level of analysis. Moliterno and Mahony (2011) state that the missing

link between network perspective and multilevel perspective is graph theory, which would allow scholars to investigate the effect of a network structure at one level of the system of nested networks on the network structures and effects at adjacent (higher or lower) levels of the system.

The second study is Dionne, Sayama, Hao and Bush's (2010) computational simulation, in which leadership phenomena at different levels are represented using different network structures, and play different roles in converging teams' shared mental models. Individual-level leadership is mapped with a low-density and star-shape network structure; leader-member exchange is represented by a fully connected high-density network of in-group members and several out-group members only connected to the leaders; participative leadership (viewed as group-level leadership) are represented by a fully connected high-density network structure. The authors therefore map leadership at different levels of analysis with social networks with different density and structures. Their conceptualization of leadership involves a structural aspect, which implies that social networks within teams can serve as channels for leaders to exert their influence and the power on team decision making and particularly on the convergence of shared mental models. For instance, participative leaders that model and facilitate followers developing relationships with all other team members in the leader's ego network may promote mental model convergence, and thus, can be represented by densely connected networks.

The third study is Carson, Tesluk and Marrone (2007). They define shared leadership as "an emergent team property that results from the distribution of leadership influence across multiple team members" (p. 1218). Emphasizing the structural aspect of shared leadership, they argue that individual members of a team engaging in team activities

develop a collective structure that can be considered as a leadership network which subsequently influences activities and outcomes at both individual and team levels. "A leadership network is the pattern of individuals who rely on others for leadership within a team, and density increases as this reliance on one another for leadership grows" (p. 1220). They then measure shared leadership by asking individual respondents to rate the extent their team relied on this individual for leadership and then using network density scores to assess the distribution of shared leadership in a team.

Building on these studies, I propose a continuous and structure-based levels-of-analysis framework, integrating social network approaches with the conventional levels of analysis perspective. This framework of levels of analysis is presented in Figure 1. As compared to the conventional view of levels of analysis, this structural view is continuous. Instead of forcing the entity of interest into one particular level (i.e., either individual, team, or organization level of analysis), this theoretical framework allows researchers to conceptualize the variables of interests at a network level of analysis. Individual-, team- and organization levels can be viewed as special cases on this continuum.

Network Level of Analysis: Moving from Individual to Team Level

Individual level of analysis. If a researcher specifies that the level of a construct or a theory is the independent individual, he or she speculates that individual team members within a team are independent of that team's influence (Klein et al., 1994). Scholars with a psychological orientation typically study individual-level constructs, such as dispositions, gender, age, behavior, cognition, and so on.

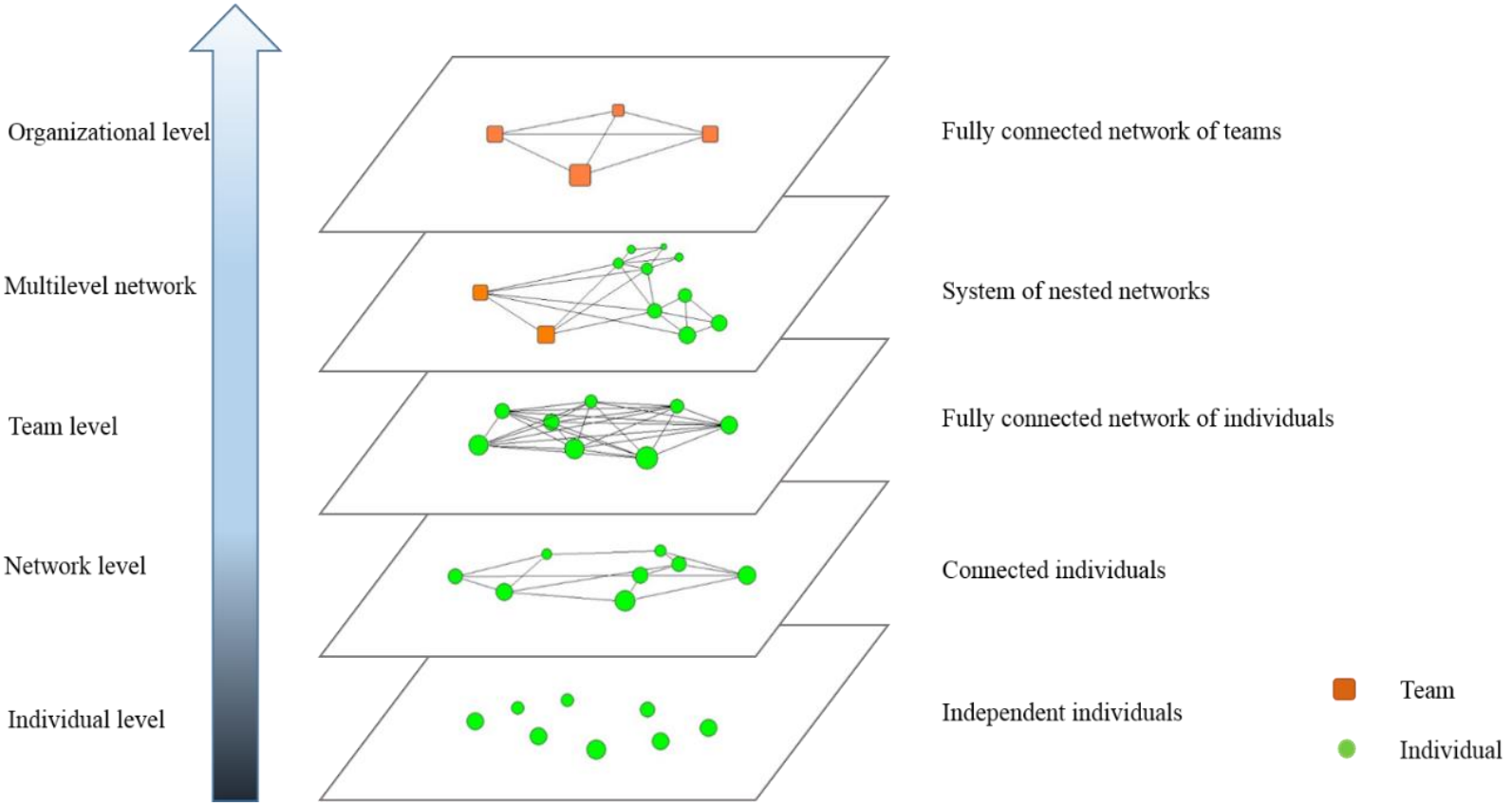


Figure 1. A Continuous View of Levels of Analysis

Team level of analysis. When team members are sufficiently similar with respect to the focal construct, the level of construct and theory may be team, and a characteristic of this team can be described by a single value. This view is also referred to as the "whole" view. Homogeneity among the team members is typically considered as a prerequisite for asserting that the construct in question resides at the team level (Dansereau et al., 1984). Examples of team-level constructs ("whole" view) include team size, cohesiveness and technology (House, et al., 1995). Relatively uncommon within the organizational research, another stream of team level research focuses on the "frog-pond" effect, that is, "individual attributes relative to the group average for this attribute" (Klein, et al., 1994, p. 201). This view is also known as within-team effects or parts effect (Dansereau et al., 1984), as within-team variance is viewed as meaningful information. Examples of constructs/theories of this type include: vertical dyadic linkage (VDL) theory, relational and behavioral patterns, demographic composition.

Over time, as individual members of a group frequently interact with one another, they may affect and be affected by other team member with respect to behavioral, cognitive, attitudinal, and emotional characteristics, and therefore no longer independent individuals. In other words, a shift of levels of analysis may occur (Dansereau et al., 1999). When the level of analysis is moving from independent individuals toward a team, I speculate the appropriate level of analysis is the network. From a network perspective, a low-density network can represent independent individuals of a team. A zero-density network represents a group of completely independent individuals. As interaction and interdependence increase, team members start to form more network ties with others, until they become a highly connected or fully connected homogeneous team. The network level

of analysis does not necessarily assume the homogeneity ("whole" view) or heterogeneity ("parts" view) among a team. Individual team members may differ in the role they play, the influence and power they possess, and the number of ties outside the team they have access to. These differences may put team member into different positions in the network within their team, with influential individuals occupying central positions, and less influential individuals occupying peripheral positions.

Multilevel Network: Moving from Team Level to Organizational Level

Organization level of analysis. Macro scholars seek to explain, understand, and predict the nature, antecedents, and consequences of organization-level constructs. While some organizational variables are collective constructs in nature, and cannot be broken down to a lower level, such as a firm's financial performance, size and degree of hierarchical stratification. Other organizational variables can be viewed as an aggregated result of individual employees' behavior, attitude, cognition, and emotion, such as commitment to organization, culture, and climate. As levels of analysis shift from individual to organization, entities involved may include individuals, teams, work units, departments and organizations. Given the complexity in the levels of analysis under this simultaneous circumstance, the conventional levels-of-analysis framework is of limited use to accurately represent the entity of the construct and the theory in question. Moliterno and Mahoney's (2011) multilevel network theory appears to be particularly suitable when multiple entities are involved. In the "system of nested networks," a node can represent individuals, teams, and/or networks, and these nodes of different types can simultaneous exist in a network.

Although a conventional multilevel approach urges researchers to examine the

effects of a higher and a lower level ("bracketing" approach), as suggested by Hackman (2003), this may be insufficient to fully capture the complexity of organizational phenomena. By employing a multilevel network approach, scholars can investigate how a network construct at one level of the system of nested networks relates to the network structures and effects at other levels of the system. In so doing, scholars may be able to reveal exploratory mechanisms that would otherwise be overlooked.

SPECIFICATION OF LEVEL(S) OF CONSTRUCTS

The current levels-of-analysis approach has advanced our understanding of complex organizational phenomena by bridging micro and macro camps and by advocating explicit specification of levels of analysis in theoretical development and appropriate procedure of data collection and analysis. It has been, and is still playing an important role in advancing our organizational thinking. Under certain situations, individual, dyad, group and organizational levels of analysis are still appropriate and accurate examining organizational constructs and/or relationships. The focus of this study is on developing an integrative approach by adding network level of analysis to the current levels-of-analysis framework. A network level is viewed as a complementary level of analysis that can be used in the circumstances when discrete levels of analysis is of limited use in depicting the nature of simultaneous constructs or relationships of interest.

I assert that network level, as an alternative level of analysis, will not replace the current levels of analysis, rather, it will stimulate a new thinking about how we theorize organizational phenomena based on more accurate and fine-grained information. An essential question is: *when* should we use network level of analysis to conceptualize and analyze the constructs and/or relationship of interest, and *when* should we use traditional

levels of analysis? In regard to answering this question, I specify a number of boundary conditions for the use of network level and traditional levels of analysis and put forth four propositions in the succeeding sections.

The Nature, Definition and Properties of the Focal Constructs

As repeatedly emphasized in prior literature of levels of analysis, it is of great importance that any study starts with explicit specification of the levels of analysis of the constructs and their relationships (Klein et al., 1994; Dionne et al., 2012; Dansereau et al., 2006; Chen et al., 2003). For instance, Rousseau (1985), indicated that "theories must be built with explicit description of the levels to which generalization is appropriate" (p, 6).

Chen et al. (2003) advance a five-step framework for theorizing and testing multilevel constructs. Specifically, the five consecutive steps include: (1) defining the focal construct at each relevant level of analysis; (2) specifying the nature and structure of the construct at higher levels of analysis; (3) testing the psychometric properties of the construct across levels of analysis; (4) estimating the construct variability between levels of analysis; and (5) testing the function across different levels of analysis. In this sequence, construct definition which determines the level of analysis, dimensionality and the nature of the focal construct serves as the most fundamental and critical step. The appropriate level(s) of analysis is determined by the nature, structure and the properties of the focal construct.

Relational. Constructs that are relational in nature may be particularly suitable for applying network level of analysis. As today's organizations are increasingly relying on teams or team-based system (e.g., multiteam systems) to make decisions, boundaries between formal organizational units are becoming blurred (Wageman, Gardner, &

Mortensen, 2012; Kims et al., 2012; Higgins, 2012; Mathieu & Chen, 2011). High level of independence and new forms of collaborations are often observed in modern organizations. Accordingly, a number of researchers advocate a relational perspective in examining organizational constructs. For example, a relational perspective has been taken in leadership research in recent years, which views leadership as a social phenomenon and a collective process (Hunt & Dodge, 2000; Murrell, 1997; Uhl-Bien, 2003, 2006). In contrast to most leadership theories that focus on identifying attributes of individuals taking leadership roles (either in the singular or in the collective form), this conceptualization of leadership emphasizes the individuals' interdependent relationships and the relation-oriented behaviors. Uhl-Bien (2006) differentiates "relational" perspective from "entity" perspective. The former focuses on "relationship" and views leadership as a process of social construction which elaborates through social interactions, whereas the latter focuses on individual entities, and identifying the attributes of the entities is at the center for this approach. Relational leadership states that leadership is fundamentally about participation and collective collaboration. Denis, Langley and Sergi (2012) notes: "The place of individuals is thus reduced: actors are present in leadership— enacting it, influencing it, and creating it—but they are not 'containers' of leadership" (p. 224).

This stream of leadership research seeks to capture the relation-oriented, interactive, dynamic and emergent facet of leadership, which is later incorporated in and extended by complexity leadership theory (Uhl-Bien, Marion, & McKelvey, 2007; Uhl-Bien & Marion, 2009). Although conceptually intriguing, it has proven difficult for empirical test using traditional linear, correlational, quantitative research design (Uhl-Bien & Marion, 2009). The traditional levels-of-analysis approach also does not fit with the

relation-focused feature in relational leadership theories. Social network approach, on the other hand, may help open the door to the empirical test of this line of research. As one of the most distinctive features of social network approach is that it focuses on the relationship between the actors rather than the characteristics of the actors themselves.

Particularly, the connectionist stream of social network literature, represented by the research of Lin (2001) and others (e.g., Snijders, 1999), focuses on the resources that flow through social ties or the interactions that occur through interpersonal connections. This view of social networks places emphasis on the relationship between actors rather than the actors themselves and therefore appears particularly suitable for studying constructs that are fundamentally relational. It is therefore reasonable to postulate that there is potentially more that network level of analysis can offer when constructs under study are relation-oriented, such as considerate behaviors (Stogdill, Goode, & Day, 1962), or leadership behavior aiming at developing trust, high quality of leader-member exchange, teamwork and taskwork, etc. (Brower et al., 2000; Graen & Scandura, 1987; Graen & Uhl-Bien, 1995).

Emergent. Multilevel research has stimulated the scholarly interest in examining both "top-down, contextual, cross level relationships" and "bottom-up", emergent phenomena (Kozlowski & Klein, 2000; Kozlowski, Chao, Grand, Braun, & Kuljanin, 2013). Much attention has been given to the research on "top-down" effects and relationships. The bottom-up phenomena, or emergence, which is derived from individual characteristics and as well as processes and interactions among individuals, however, has been studied mostly with qualitative research design, or indirectly studied documented as a by-product of construct validation and statistical justifications (Kozlowski et al., 2013).

Defined by Kozlowski and Klein (2000), emergence is a multilevel bottom-up process whereby a higher-level property of the group is generated by individual characteristics and social interaction among group members: "A phenomenon is emergent when it originates in the cognition, affect, behaviors, or other characteristics of individuals, is amplified by their interactions, and manifests as a higher-level, collective phenomenon" (p. 55). Similarly, Axelrod (1997) note that system level attributes are an "emergent consequences" of attributes and actions of "locally interacting agents" or "subsystems". Kozlowski et al. (2013) highlight that the core conceptual foci of emergence are emergent constructs that are 1) multilevel, 2) process oriented, and 3) take time to manifest at the higher level. These unique features, especially the latter two features of emergent phenomena, pose a substantial challenge for research design and measurement when empirically testing models that involve emergent constructs.

Emergence, linking lower and higher levels, unfolds over time as an ongoing process. Yet, most current research design or analytical methods have been unable to examine the effect of a lower-level entity on the higher-level construct (Heck & Thomas, 2000). A challenge of studying emergence is "in existing social units with a history, emergence has already happened for most major phenomena" (Kozlowski et al., 2013, p. 587). That is, we observe the before (lower) and after (higher) levels for emergence. This leads to one significant limitation in current emergence research, which is emergence has been mostly studied at the time the actual emergent process has already ended, rather than when it was happening.

A reason that emergent constructs and relationships have not been properly investigated is that the current levels–of-analysis framework may be incompatible with the

levels of emergent constructs. Originating from lower levels of analysis and then moving up to a higher level, the levels of analysis of emergent constructs are in between these two levels, and therefore may be well represented by the network level of analysis. In the field of team and leadership research, some preliminary effort has been made to apply a social network approach in studying emergent and dynamic team processes and leadership processes. For instance, Dionne et al. (2010) explore how different leadership styles interact with task characteristic to affect formation of shared team mental models and team performance. Team members' interaction and mutual influence are channeled through network ties. The network levels of analysis serves as the unit of analysis in their study.

I therefore propose:

Proposition 1a. Network level of analysis is more suitable than discrete levels of analysis (i.e., individual, dyad, group, organization) when constructs under study are relational in nature.

Proposition 1b. Network level of analysis is more suitable than discrete levels of analysis when constructs under study are emergent in nature.

Note that there may be overlap between these concepts. A construct can be both emergent and also relational in nature. Mathieu et al. (2008) indicate there are many constructs that are actually a blend of both processes and emergent states, such as team learning, information exchange, collaborative behavior, joint decision making, and transactive memory.

Formal vs. Informal Organizational Phenomena

Over the past decade, there has been an increasing interest in both theoretical and empirical research to explore the possibilities of new forms of leadership to understand and

explain emergent and informal, leadership. Formal organizational variables refers to the fixed set of rules, regulations, procedures, and structures for coordinating and controlling activities; whereas informal organizational variables include emergent patterns of individual behavior and interactions among individuals, and the underlying norms, values, and beliefs (Smith-Doerr & Powell, 2005).

McEvily, Soda and Tortoriello (2014) emphasize formal and informal variables capture different aspects of organizations. "Informal social structure captures the variety of inter-personal relations that emerge as actors pursue their own instrumental and socio-emotional needs. Formal organization, on the other hand, refers to the set of rules and prescriptions, including legitimate authority, designed to direct actors' behaviors toward the attainment of collective organizational goals" (p. 305).

According to the aforementioned conceptualization of informal and formal organizational variables, informal variables tend to have vague boundaries (e.g., an employee's advice network may be outside his or her work unit), whereas formal variables tend to have well-defined boundaries. Borgatti and Halgin (2011) point out one of the strengths of social network approach is its ability to study a set of actors that are not bounded by formal organizational levels. I therefore put forth:

Proposition 2. Constructs capturing the informal aspects of organizational phenomena (e.g., informal advice seeking, friendship, emergent leadership) are more likely to reside at a network level; whereas constructs pertaining to formal aspects of organizational phenomena (e.g., hieratical leadership, fixed set of rules, procedures) are more likely to reside at specific entity levels (i.e., individual-, dyad-, group-, or organizational-level).

Time Effect

The effect of time may be one of the most understudied areas in almost every single area of social science (e.g., motivation [Latham & Pinder, 2005]; teams/groups [Ilgen et al., 2005], leadership [Day, Gronn, & Salas, 2004, 2006]), although it has been quite a while since scholars first raised this issue. A majority of multilevel theories have been developed upon cross-sectional studies. Levels of analysis in these studies are therefore assumed to be stable over time. Scholars suggest more longitudinal data be collected to enhance our understanding of the temporal pattern, group trajectories and as well as evolution of levels of analysis (Dansereau et al., 1999; Klein et al., 1999; Mathieu & Chen, 2011).

For example, Dansereau et al. (1999) provided a levels-of-analysis framework for multilevel theory building from a longitudinal perspective. They argue that in addition to changing variables and relationships, multiple levels of analysis or entities can change over time. Entities may (1) remain stable, (2) shift toward independence at a lower level, or (3) become homogeneous or heterogeneous at a higher level.

A time effect also plays a pivotal role in the research of teams/groups. A number of theoretical models have been developed to investigate the dynamic nature of team cycle (Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Marks et al., 2001; Tuckman, 1965). The common theme in these models (e.g., input-process-out model, input-mediator-output-input model, etc.) is that time is significant in affecting effective team functioning. Teams go through a sequence of developmental stages and are influenced by various factors as they move into each stage (Kozlowski, Gully, Nason, & Smith, 1999).

As team members interact with one another in accomplishing the team goal, a team

proceeds through different developmental stages (Tuckman, 1965). According to Dansereau et al. (1999), a levels of analysis cycle also starts taking place when independent individuals interact with and influence one another. Combining the theories of team life cycle and the longitudinal view of levels of analysis, I assert that the evolution of levels of analysis synchronizes with team developmental stages. That is, certain levels of analysis may be most suitable for a particular developmental stage of team's life cycle. To delineate this point, I use Tuckman's (1965) model to explain how different stages in this sequence is paired with different levels of analysis.

Tuckman's model, is 'the most predominantly referred to and most widely recognized in organizational literature' (Miller 2003, p. 122). According to Tuckman (1965), team development takes time. Teams often go through a four-stage developmental sequence: forming, storming, norming, and performing. These four stages differ in both interpersonal relationship and task activities. Effective teams are those which successfully navigate each stage to achieve team goals.

In ***forming*** state, a group of people are brought together to complete a team task. Team members test and explore what interpersonal behaviors are appropriate in the group as they make an effort getting to know their colleagues. This is also a stage when team members seek to fully understand what the task the team will be performing, and what task-related behavior they are expected to display. Interdependence within team members may not start to emerge until the next stage. The level of sharedness in team members' attitudinal, behavioral and cognitive characteristics are quite likely to be low, and the individuals are still independent from each other as a result of lack of interaction and familiarity. It is highly likely that the team is merely a collection of independent individuals.

Individual level of analysis is therefore appropriate to depict the nature of the constructs.

The second stage in Tuckman's model is ***storming***, which is characterized as intragroup conflict and emotional response to task demands. Many teams fail in this stage. Polarization and disharmony around interpersonal issues are often observed in teams going through this stage. "Group members become hostile toward one another and toward a therapist or trainer as a means of expressing their individuality and resisting the formation of group structure" (Tuckman, 1965, p. 386). Additionally, group members may resist moving into unknown interpersonal relationships. In this stage, members may also encounter problems of control, and struggle to compete with their colleagues to "establish their place" in the team (Tuckman, 1965).

At this stage, interpersonal and task-related interactions start to take place, and the interdependence and collaboration between team members begin to emerge. However, this is the stage where team members struggle to reconcile differences and conflicts and attempt to ease the resistance. Thus, it is reasonable to speculate that team members are still in the preliminary stage of establishing mutual understanding, trust, group cohesion, collective potency, shared mental model and other critical team variables. Therefore, the level of interdependence among team members in *storming* stage is possibly higher than that in *forming* stage, but still too low to change the levels of analysis of focal variables. As such, level of analysis of focal variables in *storming* stage is more likely to reside on team parts level.

The third developmental stage is ***norming***, which is labeled "development of group cohesion" in Tuckman's model. In the realm of interpersonal relationship, team members resolve the differences, accept each other's idiosyncrasies and "group-generated norms" to

insure harmony and avoid conflicts. Openness is also observed in the realm of task activities. Team members in this stage display interest and openness in incorporating other team members' opinions. Roles and norms are clarified and established.

Norming is also a stage that teams develop shared mental models (Neuman & Wright, 1999), build trust, cohesion and other pivotal leadership or team process variables to achieve effective functioning. In this stage, team members develop a stronger relationship with each other, and are more comfortable seeking and providing advice and help from and to their colleagues. Team members also show stronger commitment to the team and team goal, and some teams may even have made some progress towards the completion of their team goals.

A team in this stage is no longer merely the collection of individuals, rather, a team with certain amount of interdependence and sharedness among its members. Teams in this stage may also vary in the degree to which they share homogeneous and agreement in team members' attitude, emotion, coition, and behavior. It is likely that teams under certain condition (e.g., effective leadership) may advance further in this stage approaching to the next "*performing*" stage than other teams. To capture this characteristic in the *norming* stage, I assert it is more appropriate to apply network level of analysis on the focal variables in order to develop more accurate and fine-grained team theory.

Finally, as teams mature over time, they move into the fourth stage "***performing***", which is characterize as "functional role-relatedness" and "emergence of solutions" (Tuckman 1965, p. 387). The team becomes a "problem-solving instrument" as members engage in activities that will enhance the team functioning and team performance. Team structures are now flexible and functional, and team energy is "channeled into the task".

Team members relate to one another and the whole team has become an entity focusing on constructive task-related actions. As such, team (wholes) level of analysis is most suited for focal variables in this stage. Based on the above discussion, I put forth:

Proposition 3a. In forming stage, team process and leadership constructs are more likely to reside at individual level of analysis

Proposition 3b. In storming stage, team process and leadership constructs are more likely to reside at team parts level of analysis.

Proposition 3c. In norming stage, team process and leadership constructs are more likely to reside at network level of analysis.

Proposition 3d. In performing stage, team process and leadership constructs are more likely to reside at whole team level of analysis.

Strong Context vs. Weak Context

Another factor that we should take into consideration when specifying appropriate levels of analysis for focal variables is context. House (1995) states "behavior is not context-free", and the emphasis therefore should be placed on "behavior in context" rather than either behavior or context. Prior literature has noted the significant effect of context on organizational outcomes (Cooper, 2009; Meyer, Dalal & Hermida, 2010; Salancik & Pfeffer, 1978).

Earlier I/O psychology and OB research views environmental context as a fundamental determinant of individual behavior (Dornbusch, 1955; Salancik & Pfeffer, 1978). This line of literature indicates some situations (e.g., military academies) can exert powerful influences over the people behaving in them (Dornbusch, 1955). These situations provide strong contextual cues and constraints that create similar attitudes and behaviors

in people. An example of the significant effect of context on one's behavior is Zimbardo's prison role-play experiment, which documented the behavioral regularities shown by individuals who were randomly assigned to play the role of prisoners or guards and who were kept in prisoner-of-war situations (e.g., Zimbardo, Ebbesen, & Maslach, 1977).

Salancik and Pfeffer's (1978) social information processing theory also emphasizes the effects of context (i.e., social information) in forming individual's behaviors. From a distinct perspective, Schneider's (1987) ASA model argues that it is the people who "make the place," which subsequently affects individual and organizational outcomes through an attraction-selection-attrition (ASA) cycle. Although distinct from the perspective of "situation" camp (i.e., situations make the people), Schneider's (1987) ASA model supports the idea that contextual factors such as processes and structures (e.g., daily meetings) in an organization yield particular kinds of persons. Apparently, according to ASA model, the level of analysis is not solely individual level when context serves as a strong impact on individuals.

While recognizing the effects of context, scholars also acknowledge the existence of weak situations, which grant individuals more flexibility and autonomy to express their personality traits, attitudes, and behaviors (see Meyer et al., 2010 for a review). More recently, Tett and Burnett (2003) develop a person-situation interactionist model of job performance that specifies conditions under which particular personality traits are related with performance in specific jobs. Their model indicates that employees seek out opportunities for expressing their personality traits. External context constantly offers cues to the employees for trait expression. Once the context allows employees to display trait-expressive behavior, they will feel satisfied and motivated. The strength of the context

plays a critical role in this trait activation process, in that 'weak' situations may maximize variance in trait-expressive behavior of individuals. Whereas in 'strong' situations, extrinsic rewards will largely decrease individual differences, and therefore make the individuals show similar attitudinal, cognitive, and behavioral characteristics. I therefore propose:

Proposition 4. In strong contexts, the focal constructs are more likely to reside at team level or organizational level depending on the level of contextual variable; whereas in weak context, the focal constructs are more likely to reside at network level or individual level depending on the strength of the context.

In sum, the proposed continuous framework for levels of analysis encourages researcher to consider all the possible levels of analysis for the focal constructs and theories without jumping into an either-or decision (i.e., either individual, dyad, group, or organization) too quickly. As a first attempt to begin to think about levels of analysis on a continuum, I fully recognize that the proposed framework and the boundary conditions discussed above may be debatable. Nevertheless, as a point of departure, it is my hope that this approach can stimulate further discussion on the possibilities of integrating the multilevel approach and social network theory perspective. Employing this approach, I now use leadership research to illustrate a network-level conceptualization of shared leadership.

AN ILLUSTRATION WITH SHARED LEADERSHIP

Shared leadership is a complex collective phenomenon (Pearce & Conger, 2003; Denis, et al., 2012, Uhl-Bien, 2006). This stream of research focuses on an increasing body of research that conceptualizes leadership as a group or collective property, and as a

dynamic, interactive influence process among team members through which they lead one another to achieve group goals or organizational goals (Pearce & Conger, 2003; Carson, 2007; Yammarino, Salas, Serban, Shirreffs, & Shuffler, 2012). The notion that leadership roles and responsibilities can be shared or distributed among multiple persons is not new. Early leadership scholars (e.g., Gibb, 1954) argued "leadership is probably best conceived as a group quality, as a set of functions which must be carried out by the group" (p. 884).

The concept of shared leadership contrasts with focused leadership (Gibb, 1954) or "vertical leadership" (Pearce & Sims, 2002), which narrowly emphasizes the influence of an individual manager, who is formally appointed and has formal authority over the team (Kozlowski & Bell, 2003; Hackman & Walton, 1986). The emergence of shared leadership is often driven by the complex demands of work situations, technology, the high level of expertise required to perform the task, and flatter organizational structure (Day, Gronn, & Salas, 2004; DeNisi, Hitt, & Jackson, 2003).

Both conceptual and empirical efforts have been made to identify essential antecedents, mediating and moderating mechanisms and consequences of shared leadership. In a more recent meta-analysis, Wang, Waldman and Zhang (2014) reveal an overall positive relationship between shared leadership and team performance. Specifically, shared leadership tends to be more strongly related to team attitudinal outcomes and behavioral processes and emergent team states, than with team performance. The cumulative evidence also suggests that shared leadership adds distinctive contribution to the increase in team effectiveness in addition to formal leadership.

The Levels of Analysis of Shared Leadership

Focused leadership or "vertical leadership" represents a conventional, singular

form of leadership whereby leadership is focused on a formally designated leader. Prior studies which take this conventional perspective of leadership pervasively employ an individual level of analysis, and focus on how the formally appointed leader influences the individual followers, teams, or collectives. In contrast, distributed or shared leadership focuses mostly on entire teams. As a form of "plural leadership" (Denis et al., 2012), shared leadership proposes that, influence, power, responsibilities or roles, expertise or other aspects of leadership are distributed across multiple team members, rather than centralized in the hand of one leader (Yammarino, 2012).

Despite of various definitions given by the existing studies, researchers appear to reach a consensus that shared leadership is a group property and has been therefore conceptualized and operationalized primarily at group level (Wang et al., 2014; Carson, 2007). For instance, Pearce and Sims (2002) define leadership as distributed influence within teams, and measure this team-level leadership by aggregating individual ratings on five leadership strategies: aversive, directive, transactional, transformational, and empowering. Likewise, Avolio, Jung, Murry and Sivasubramanium (1996) view shared leadership as transformational leadership displayed at the team level and aggregate individual ratings on Team Multifactor Leadership Questionnaire (TMLQ- Form 5X) as team leadership scores.

Although shared leadership has been predominantly investigated at the team level, two notable studies, Carson et al. (2007) and Mehra et al. (2006) employ network analysis to investigate the link between shared leadership and team performance, and their findings suggest a network approach provides additional insight, which is otherwise difficult to obtain using individual of group level of analysis. In their meta-analysis, Wang et al. (2014)

classify this network approach as a cumulative, or overall view of shared leadership. They argue:

> In research of this nature, the content of leadership is not specified for raters. Instead, there is a shared perception that, in general, members show leadership toward each other. In this case, members use their own implicit leadership theories to evaluate the extent to which others in the team exhibit leadership. (p. 184)

A network approach usually asks individual respondents to rate the extent their team relied on this individual for leadership and then used network density scores to assess the distribution of shared leadership in a team. This is how Carson et al. (2007) measured shared leadership.

Similarly, Mehra et al. (2006) also studied sales teams using network analysis to assess the degree of leadership distribution. Their study, however, yielded an interesting finding, which was the team-level hypothesis (shared leadership is positively related with team performance) was not significant, whereas different types of network structures were found to be predictive of team performance. This ability to look at the structural differences which reflect variance in the pattern of leadership distribution is unique within a network approach. The structural characteristics of interdependence and cooperation within teams with shared leadership that can be captured by network approach may be valuable and informative for understanding leadership effectiveness. Mehra et al.'s (2006) study also provides indirect evidence supporting the idea that it may be insufficient to study shared leadership merely at the team level of analysis, and that alternative levels of analysis may also need to be taken into consideration in order to fully understand this complex and dynamic phenomenon.

Consider two teams (in Figure 2), team 1 and team 2. They have same number of network ties connecting individuals within each team. According to the network approach to shared leadership, the two teams have same density scores and therefore have same degree of shared leadership. However, in team 1, mutual acceptance between formal leader and informal leader did not exist (no ties connecting these two nodes) and therefore the network of team 1 is referred to as distributed-segmented network. Whereas in team 2, formal leader and informal leader acknowledge the leadership role of each other and therefore formed a distributed-coordinated network, and outperformed the distributed-segmented teams (team 1).

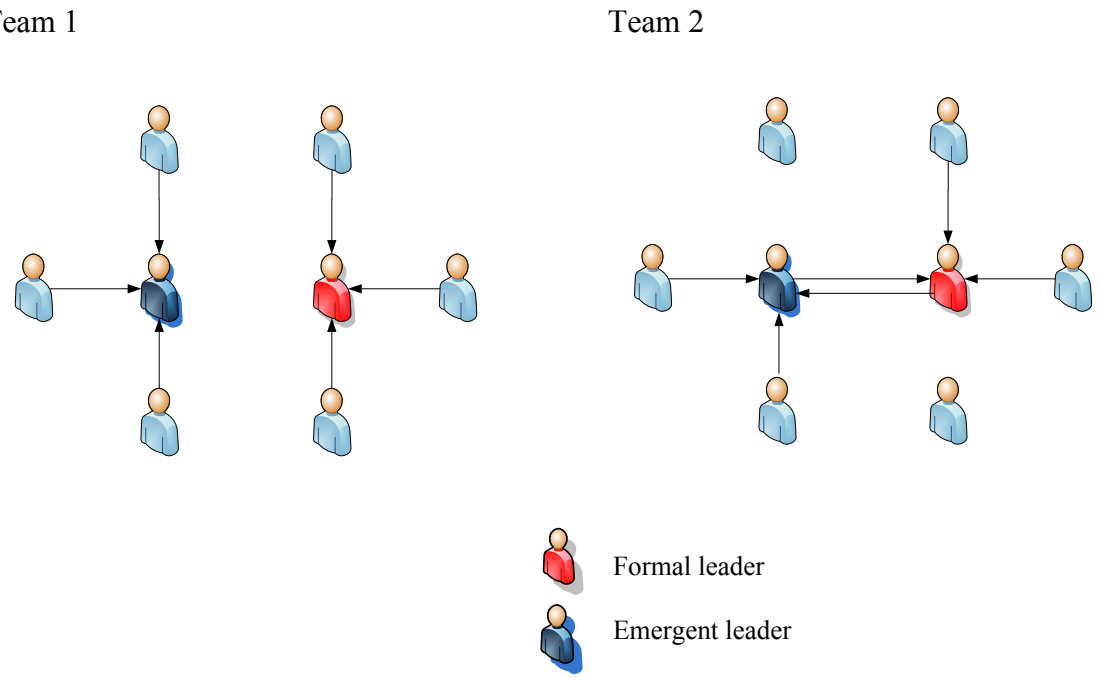


Figure 2. Comparing Structural Differences in Two Teams

In the above example, the structural difference at the network level would not be revealed if only the team-level variables were examined. Mehra et al. (2006) conclude that

it is valuable to supplement team level of analysis with a more fine-grained observation of how leadership is actually distributed within the team. If team were the only level examined in their study, the critical role of leadership structure (i.e., pattern of leadership distribution) in affecting team performance would not be revealed. The traditional level of analysis framework is based on a discrete view that classifies the focal entities into individual, teams/groups, organizations, or collectives. This discrete level of analysis may be particularly unsuited to the research of shared leadership.

The Need for an Alternative Level of Analysis for Shared Leadership Research

As demonstrated in the above example, the network level of analysis helped reveal additional findings, which would be overlooked if only individual or team level of analysis was employed. By zooming in for a closer look at the patterns of leadership perception within teams, different leadership structures were found associated with team performance. This relationship between leadership structure and team performance holds true even when the effect of shared leadership conceptualized and measured at the team level was not significantly predictive of team performance. This supports the idea that traditional view of levels of analysis may have hindered the realization of the full potential of shared leadership, which has the potential of studying a more complex shared or distributed phenomena within or across the formal organizational units (Gronn, 2002).

The conventional levels-of-analysis framework is built on a discrete scale, whereby research entities are classified into individuals, dyads, groups, or organizations. Although this levels of analysis view has substantially advanced research in the area of leadership and other fields in organizational science (Day, Fleenor, Atwater, Sturm, & McKee, 2014; Dionne, et al., 2014; Dinha, et al., 2014), for the aforementioned reasons it may no longer

be the most appropriate fit for the emerging, plural forms of leadership-- shared, distributed, collective, relational or integrated leadership (Carson, et al., 2007; Gronn, 2002; Mehra et al., 2006, Denis et al., 2012). Using the prevailing levels of analysis framework as a convenient means for directing the conceptualization of leadership, data collection and analysis might cause serious conceptual and methodological issues. As Denis et al. (2012) note:

> The conceptual and methodological traditions of this research stream, embedded as they are within a broader tradition of leadership research that emphasizes almost exclusively variance models and quantitative methods (Glynn & Raffaelli, 2009), may have limitations when it comes to examining in finer detail the nature of shared leadership in organizations and the processes associated with its emergence and development. (p.231)

Minimally, I believe that the current levels of analysis framework needs to be expanded by adding a network level of analysis to better suit the notion of shared leadership. My reasoning is based on the aforementioned distinctive nature and characteristics of shared leadership and the unique conceptual and methodological issues it has raised. However, inserting a new level (i.e., network) into the existing discrete levels of analysis may not adequately address the dynamic and emergent nature of leadership suggested by Denis et al. (2012). First, a line of research within the domain of shared leadership challenges the conventional way of understanding leadership, and submits a radical proposition that shared leadership should be conceptualized as a continuum rather than on a discrete scale. Gibb (1954) proposed the concepts of focused leadership and distributed leadership. Building on Gibb's work, Gronn (2002) argued that these two concepts be

considered endpoints on a continuum rather than rigid either-or categories. In addition, Gronn (2002) provide several examples that illustrate how leadership can be shared among limited number of leaders (two-member form, three-member form, etc.) an as well as among a constellation of leaders across units.

Shared leadership emerges from team interactions. Team members engage in activities that relate to direction, motivation and support (Yukl, 1989). Through this interactive process, team members negotiate and share leadership responsibilities (Pearce & Conger, 2003; Carson, et al., 2007). This interactive pattern captures the essential element of shared leadership, and the structure of shared leadership can be therefore represented by a leadership network (Carson et al., 2007). This definition places emphasis on multiple sources of influence and refers to generic influence within teams rather than to "specific leadership behaviors, formal positions, specific types of influence, or the effectiveness of the leadership exhibited by these sources" (Carson et al., 2007, p. 1220). Based on the number of leadership sources, Carson et al. therefore conceptualized leadership along a continuum, with the low end of the continuum referring to the state that leadership is focused on a single individual, and high end of continuum referring to the state that leadership is distributed among the entire team. This conceptualization of shared leadership seeks to capture the relational and interactive aspect of shared leadership, and has added unique contribution to the current research. However, this conceptualization of shared leadership is incompatible with the discrete level of analysis approach. Carson et al. define shared leadership based on the number of leadership sources, individual and team levels of analysis are therefore only two special cases on a continuum, and only appropriate when leadership role is taken by one individual (individual level of analysis) or the entire

team (team level of analysis).

Second, shared leadership is inherently an interactive and relational phenomenon, which focuses on mutual influence between team members as they collectively participate in the completion of team goals. Uhl-Bien (2006) suggests that this relational conception of leadership has methodological challenge, that is, it cannot be studied with the conventional methods generally used by traditional approaches to leadership, but calls for "richer methodologies." Research on this relational leadership view has mostly stayed conceptual with only a few exceptions (e.g., Vine, et al. 2008).

This line of studies conceptualizes leadership as a social phenomenon, as a collective process in which the importance of single individuals is thus reduced: "actors are present in leadership— enacting it, influencing it, and creating it—but they are not "containers" of leadership" (Denis, et al., 2014, p. 254). The relational leadership theories place emphasis on the actors' relations, rather than actors themselves. Shared leadership is viewed as a product of actors' interactions.

The conventional levels–of-analysis framework is developed primarily to classify the research objectives of interest (e.g., individuals, dyads, groups) based on the interdependence between and within entities. In other words, it is the actor that matters when applying levels of analysis approach. When a relational view of shared leadership is employed, it naturally conflict with levels of analysis approach as levels of analysis approach is not developed to investigate the relational phenomena. Social networks, on the other hand, provide an appropriate theoretical and analytical approach to studying the concept of relational leadership (Mehra et al., 2006), as it is the relations (i.e., ties) in the network that matters for a leadership network.

Third, the fluid and changing membership in the units where shared leadership is believed to exist makes the boundary between leaders and followers ambiguous and blurring (Denis et al., 2012). It is therefore more challenging to identify leaders in shared leadership research than in vertical leadership research, as a team member can be a leader at one time and a follower at a later time. Shared leadership theories propose that leadership roles and responsibilities can be distributed among some or all team members. That is, in addition to formal leaders, informal or emergent leaders can have a good deal of influence that may significantly affect team dynamics and processes, and which in turn affect team performance (Wang et al., 2014). Despite their influence over teams or organizations, informal or emergent leaders are not easy to identify (Huxham & Vangen, 2000). To date, knowledge on who is taking leadership roles, and at what level of analysis leadership should be conceptualized, may be quite limited as the result of lack of clear empirical evidence.

What is clear is that shared leadership resides at a higher level than individual level. But, what is less clear is which level of analysis should be applied for leadership variables, who are jointly taking leadership roles, dyad, triad, or multiple persons within a team, or a constellation of leaders from different organizational units. With these levels related issues unsolved, it may be problematic to use current levels of analysis approach, as the appropriate levels cannot be justified by the exiting literature. In sum, traditional levels of analysis is suitable for research on vertical or hierarchical leadership, in which the focus is on the formally appointed leader and their traits, behaviors, attitudes, and affects and the influence of the leader on the individual followers or the entire group or organizations. In other words, levels of analysis works well addressing a hierarchical, traditional leadership

scenario with the simple individual, dyad, group or organizational level, or neatly nested structure (e.g., individuals nested in groups, groups nested in organizations). Shared leadership, however, may not be a good fit for this discrete levels of analysis view, as the membership is structured in a more complex way. Therefore, it is difficult for researchers to determine the levels of analysis appropriate for theories and hypotheses.

It is important to note that I am not implying that network is the only appropriate level of analysis for the research of share leadership. What is emphasized is that a network level of analysis has great potential to help explore the distributed or shared phenomena, and address unsolved issues that plague traditional levels of analysis approach (Denis et al., 2012). Denis (2012) highlighted the possible fruitful results when incorporating social network analysis into the research of shared leadership:

> Social network analysis has the potential to describe in a fine-grained detail the structure of shared leadership roles (often measured by aggregate indicators in many existing studies) both within teams and across whole organizations. (p. 230)

IMPLICATIONS, FUTURE RESEARCH, LIMITATIONS

The primary objective of the current study was to integrate a social network perspective and multilevel approaches to advance a continuous view of levels of analysis. This integrative approach is believed to benefit future multilevel theory building and testing. Although focusing on leadership and team research, this continuous perspective and the propositions developed in the current study are applicable to other areas of organizational research. Implications for future research and limitations are discussed in this section.

The proposed model is believed to be a good fit for dynamic and longitudinal

theories and models. While developing such models, it is worth noting that some concepts are more time sensitive than others. There are constructs that are most likely to shift to another level of analysis as the teams move onto another developmental stage. On the other hand, some concepts tend to stay stable over time. It is likely the proposed time effect hypotheses are more suited with the concepts whose levels of analysis changes over time. Future research may make an effort identifying the concepts that are more suited for an evolutionary/longitudinal view of levels of analysis, and the concepts that are more suited for a static levels-of-analysis view.

Also, propositions 3a, 3b, 3c, and 3d developed in this study used Tuckman's team developmental model as a heuristic to capture temporal effect on the evolution of levels of analysis for focal constructs. However, it is important to note that in real work setting, where both external factors (e.g., task characteristics, external leaders, environmental constraints) and internal factors (e.g., changing membership, interpersonal conflicts) may come into effect and largely complicate the process of team development. As indicated in a number of studies, teams do not necessarily go through Tuckman's four phases in the exactly same order as the theoretical model suggested (Marks et al., 2008). It is also possible that teams revisit an earlier stage or skip a certain stage. In addition, there are alternative models that provide different conceptualizations of team development, such as Gersick's (1988, 1989) punctuated equilibrium models, which postulates that sudden and dramatic shifts may occur in team collaboration as teams approach task deadlines. Due to lack of empirical evidence in this line of literature, it is difficult to evaluate to what degree Tuckman's model represents the teams actual developmental cycle. Tuckman's model therefore serves as one possible point of departure for specifying the appropriate levels of

analysis for working teams in real time.

For team-related hypotheses, several other factors also need to be taken consideration to be able to appropriately apply the proposed approach. In other words, other boundary conditions may also be important, such as team type: traditional work team, stable membership, fixed structure, same tasks (Cohen & Baily, 1997). The levels of concepts may be more stable in this type of teams. Project teams on the other hand may be quite different than work teams (Cohen & Baily, 1997). There might be a higher level of dynamic and changes going on in a project team. The levels of analysis of a focal concept may be changing over time as predicted in out hypotheses.

The current study develops an integrative and structural approach for multilevel theory building. Although the analytic techniques of social network data have been greatly advanced, a majority of organizational research has been focusing on only several network theoretic constructs such as network density and centrality. Other network constructs that can be used to depict the characteristics of a network include degree centrality, betweenness centrality, network constraint, structural equivalence, strength of ties, multiplexity, small worlds, etc. Social network theory may have great potential to advance our understanding of multilevel organizational phenomena if scholars seek to take full advantages of what it offers.

The present study focuses on exploring the possibility of conceptualizing *constructs* at network level of analysis as a preliminary effort to establish a topology for multilevel theory from a continuous levels-of-analysis perspective. A comprehensive theoretical framework would call for more sophisticated thinking that includes both constructs and theory (the relationships among constructs). Other important research questions such as

how to integrate traditional levels of analysis and social network approach to build multilevel and cross-level theories need to be addressed. This integration is particular useful in examining emergent phenomena, which has yet to be studied in quantitative research (Kozlowski & Bell, 2003).

In conclusion, an integrative approach combining social network theories and methods within a multilevel framework is a promising area that will open up many possibilities both theoretically and methodologically, for the development of organizational theories. Future attention should be rendered to social network analysis and network level of analysis.

ESSAY II: A MULTILEVEL AND DYNAMIC MODEL OF NETWORK-BASED SHARED LEADERSHIP: EVIDENCE FROM AGENT-BASED SIMULATIONS

INTRODUCTION

As noted in Pearce, Manz and Sims (2009) and Day et al. (2006), leadership and team research has entered a new era — "one that required a radically different approach to influencing teams and teamwork" (Pearce et al., 2009, p. 234). Driven by the changes in workplace, the high level of knowledge, expertise, and skills required to perform the task, a collective form of leadership—shared leadership, has emerged as an effective means of enhancing team and organizational performance (Day et al., 2004; DeNisi et al., 2003; D' Innocenzo, Mathieu, & Kukenberger, 2014; Wang et al., 2014). Despite the various definitions existing in the area, the common theme of shared leadership is leadership roles, influence, functions and responsibilities can be shared or distributed among multiple persons in a team (Gibb, 1954; Carson et al., 2007; Denis, et al., 2012; Uhl-Bien, 2006; Morgeson, DeRue, & Karam, 2010; Neubert, 1999; Day et al., 2004; Yammarino et al., 2012).

Shared leadership is a complex, dynamic, interactive influence process, and therefore may be a difficult fit for the conventional research design and method as well as conventional levels of analysis. In addition, the fact that multiple persons are performing

leadership functions requires researchers to investigate the structural characteristics of shared leadership, as the structural pattern of leadership distribution can affect critical team and/or organizational outcomes (Mehra et al., 2006; Carson et al., 2007; Erez, LePine, & Elms 2002).

As established in Essay 1, a social network approach is a natural conceptual and methodological tool to study shared leadership. The network approach captures relational patterns among team members, and helps describe the fine-grained details and nuances (Denis, 2012; D' Innocenzo et al., 2014), which would be overlooked using conventional quantitative research designs and methods. As such, the primary objective of this study is to advance a network-based approach to shared leadership. The second objective is to enhance our understanding about the nature and dimensions of multiple roles and functions shared within a team. As a point of departure, the current study focuses primarily on two leadership roles, *social leaders* and *task leaders,* and the role they play separately and jointly, in affecting team process and outcomes.

In addition, prior research has long called for process-oriented theories and methods to uncover the "black box" of the team dynamic and leadership process (e.g., Kozlowski & Klein, 2000; Kozlowski et al., 2013). Responding to this call, the third objective of the current study is to develop and test a multilevel, dynamic, and longitudinal model of shared leadership and team process using agent-based modeling and simulations.

Agent-based modeling and simulations are a commonly used computational technique to study collective behavior of agents, emergent phenomena, generation of social instability, and decision making (Hiroki, 2015) and have been used previously in the field of organizational science (e.g., Tindale & Kameda, 2002; Dionne & Dionne, 2008; Dionne

et al., 2010; Serban et al., 2015; Richard et al., 2014). Capability in simulating dynamic, emergent and adaptive phenomena distinguishes computational simulation from traditional research methods (Macal & North, 2010; Fioretti, 2012). Simulation allows researchers to set state variables for agents, and these state variables change as a function of other variables. Hundreds or thousands simulation iterations can be conducted in a simulation, and values of state variables may be changed in each single simulation run. As such, agent-based modeling and simulations are particularly suitable for study of interactive, dynamic and complex phenomenon.

In a simulation, a researcher defines agents' characteristics and how agents are connected or interacted with others based on literature. This provides us with an opportunity to test a hybrid model which is concerned with both the characteristics of actors and the relations among them. In advancing computational simulation technique, a number of scholars have developed modeling procedures (e.g., Davis & Bingham, 2007, Macal & North, 2010) to guide simulation studies. Generally, these procedures include the following six steps: 1) specify the research questions, 2) specify simulation method, 3) specify simulation representation, 4) verify simulation representation, 5) report simulation results, and lastly and most importantly, 6) validate simulation results with empirical data. Therefore, as a next step for my future study, the empirical data will be collected in a laboratory or work setting and analyzed using a distinctive set of analytical techniques to validate what has been found in simulations. As such, the present study will follow this guidance to test the proposed model. However, future research that provides empirical data is required to further validate the simulation results.

SHARED LEADERSHIP

Definition

There are various definitions of shared leadership existing in the current literature. Recent effort has been made to clarify the definitional confusions (DeRue, 2011; Denis, 2012) and offer a typology of collective leadership (Contractor, DeChurch, Carson, Carter, & Keegan, 2012). In a recent meta-analysis, D' Innocenzo et al. (2014) offers an integrative definition which conceptualizes shared leadership as "an emergent and dynamic team phenomenon whereby leadership roles and influence are distributed among team members" (p. 5). Morgeson et al. (2010) propose two dimensions for identifying the source of shared leadership in teams: the locus of leadership and the formality of leadership. The former dimension deals with whether the leadership originates from the outside (i.e., external) or inside (i.e., internal) the team. The latter dimension reflects whether the leader is formalized in the organization (i.e., formally designated) o whether the leader emerges as a result of team process and interaction and takes no direct responsibility for team performance (i.e., informal).

Although some shared leadership may be formally designated (for examples, see Gronn, 2012), the primary focus of shared leadership research is the informal and internal leadership (e.g., Gupta, Huang, Yayla, 2011; Carson et al., 2007; Mehra et al., 2006). In consistent with prior research, the current study concentrate on the informal and internal leadership as the source of shared leadership within a team. It is worth noting that, however, a team cannot be independent from the influence of formal leadership (Carson et al., 2007; Luciano, Mathieu, & Ruddy, 2014). As such, external leadership is also taken into consideration as an important variable affecting the leadership and team process in the proposed model (which will be introduced later).

Leadership Functions and Roles

Recently, leadership scholars have been urged to closely examine the nature and dimensions of shared leadership, which would inform the current research of what exactly is shared within a team (Wang et al., 2012; D' Innocenzo et al., 2014). One essential aspect of shared leadership is the multiple functions or roles distributed among team members. Several typologies of roles and functions required to perform tasks have been developed (e.g., Morgeson et al., 2010; Contractor et al., 2012). Earlier work on team leadership proposed two types of leadership in teams: task and relational leadership (Bales, 1950). Experts tend to occupy the "task leader" role (Homans, 1961), and are more likely to engage in instrumental behaviors to assist the team in completing its objectives (Bales & Slater, 1955). The most liked member, on the other hand, tends to occupy the "social leader" role, whose behaviors are relationship-oriented, and focused on the social and emotional needs of team members (Bales, 1950; Bales & Slater, 1955).

Some recent work has shown consistent results with these early studies, indicating task coordination behaviors and members' support and development behaviors are associated with leadership emergence (Kellett, Humphrey, & Sleeth, 2002). As such, I focus on these two established types of leadership roles – task leaders and social leaders, and examine how task-focused and relationship-focused leadership are developed during team members' interaction, and how they affect the subsequent team process and outcomes.

A Network Approach to Shared Leadership

As established in Essay 1, shared leadership is inherently a multilevel, dynamic, interactive, and relational process, which is particularly suitable for a social network approach. In two recent meta-analysis, Wang et al. (2012) and D' Innocenzo et al. (2014)

both highlighted a network-based conceptualization and research design for shared leadership. The majority of prior shared leadership studies have adopted an aggregating-based approach, which uses a referent-shift conception and takes an average of all team members scores as an index for the team-level shared leadership (D' Innocenzo et al., 2014). In contrast, a network-based approach uses network density (e.g., Carson et al., 2007) and centralization (e.g., Mehra et al., 2006) to capture the structure and distribution leadership influence and relationship patterns, which is a pivotal and fundamental property for shared leadership. D' Innocenzo et al. (2014) predict studies using a network-based approach can obtain bigger effect sizes. Their research findings confirmed this prediction, and supported the advantages of using a network-based conception and research design in shared leadership research. Based on this, the current study applies a network-based approach to model shared leadership and team dynamics. Specifically, two types of shared leadership— task-focused and relationship-focused leadership are examined in this study, each of which is represented by a leadership network, whose density serves as an index of shared leadership.

A MULTILEVEL AND DYNAMIC MODEL OF SHARED LEADERSHIP AND TEAM PROCESSES

Team Development and Processes

Prior literature has well documented leadership and team processes are dynamic in nature (Mathieu et al., 2008, Kozlowski and Klein 2000, Ilgen et al., 2005; Marks et al., 2001). Team members experience cyclical and iterative team processes, formal and/or informal interaction (e.g., information exchange, communication, and networking) and perform routine or non-routine tasks (e.g., a manufacturing team vs. a crisis response team).

As a result, many dynamic leadership and team process models have been developed, such as Steiner (1972), McGrath (1984), and Hackman's (1987) I-P-O (i.e., input-process-output) model, Ilgen et al. 's (2005) IMOI (i.e., input, mediator, output, input) model, Marks et al.'s (2000) cyclical temporal team process model, Lichtenstein and Plowman's (2009) meso model of leadership emergence. Building on prior knowledge of team/group research (e.g., Ilgen et al., 2005; Kozlowski & Klein, 2000; Marks et al., 2001), Mathieu et al. (2008) propose an integrative model, in which inputs variables lead to mediators (i.e., mediating states or team processes) which then lead to outputs. In addition, the model features three feedback loops: inputs--mediators--inputs loop, mediators--outputs—inputs loop, and inputs--mediators--outputs--inputs. The feedback loops capture the cyclical and dynamic team processes, as the inputs, mediators and outputs can consistently change over time.

A Model of Leadership and Team Mental Model Convergence

One of the important tasks or functions of today's teams is decision making (Kerr & Tindale, 2004). Research has shown convergence of team mental models play an important role in determining decision quality (Mathieu et al., 2000; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005; Webber, Chen, Payne, Marsh, & Zaccaro, 2000). Convergence describes a cognitive process where team members develop shared and similar information processing and understanding of taskwork and teamwork (Mathieu et al., 2005). Prior research has supported the positive relationship between converged mental models and team functioning and performance (Edwards, Day, Arthur, & Bell, 2006; Mathieu et al., 2000). As such, team mental model convergence is included in the current model as an output variable.

Building on Mathieu et al.'s (2008) model and prior leadership and team research,

I propose a multilevel and dynamic model for shared leadership and team mental model convergence that captures a cyclical team development and performance process. The model is presented in Figure 3. Essentially, team members' individual characteristics (i.e., personality, expertise, cognitive ability, self-efficacy), and team's internal and external environments serve as input variables that jointly influence the emergence of shared task-focused and relationship-focused leadership. The emerging leadership in a team then serves as an input that affects and changes team member's attitude, perception and behavior, which lead to the subsequent changes in the previous leadership network (i.e., input-leadership-input loop). The emergent leadership networks also serve as input variables for the convergence of team mental model in the leadership-output-input-leadership loop.

General Research Focus

The proposed model describes a development process of shared leadership and a mediating role shared leadership plays in shaping a team's shared mental model. I expect both individual-level variable-- expertise and team-level variables-- internal and external environment positively relate to shared leadership. Expertise is a key individual characteristic, which refers to the ability of an expert to represent and understand problems that appear in that particular domain (Salas, Guthrie Jr, Wlison-Donnelly, & Heather, 2005). Research has established links between expertise and effective decision making (Bottger & Yetton, 1988; Littlepage & Silbiger, 1992). As one's task-related skills and expertise are related to the emergence of task leaders (Bales, 1950; Hollander, 1961), I predict a positive relationship between expertise and the emergence of task-focused leadership.

At team level, a team's internal environment plays an essential role in developing its shared leadership. Carson et al. (2007) highlighted three aspects of internal

environment: shared understanding of a team's primary goals (Liden, Wayne, & Sparrowe, 2000); emotional and psychological support (Marks et al., 2001); and participation in communication and decision making (Van Dyne & LePine, 1998). These three aspects are complementary and mutually reinforcing, and therefore represent a higher-order construct—internal team environment, which can facilitate the development of shared leadership within a team. I therefore expect internal environment positively affect shared leadership emergence in the proposed model.

In addition, external team leaders, who are not members of the team and do not participate in team's day-to-day activities (Morgeson et al., 2010; Luciano et al., 2014) provide guidance and coaching to the team, which in turn supports and reinforces a team's shared leadership (Morgeson, 2005; Wageman, 2001). Carson et al. (2007) highlighted three explanatory mechanisms. First, coaching behavior of external leaders may encourage, reinforce and reward leadership behaviors demonstrated by team members. Second, external coaching can help team members build a shared commitment to the team and team goal. Third, by advising team members on adopting appropriate task strategies and on managing teamwork and team process, team members tend to be more willing to influence each other. As such, I predict external leadership positively influences the development of shared leadership.

Finally, prior research has found formal leadership plays a critical role in shaping and developing the convergence of team's mental model (e.g., Dionne et al., 2010). As team members can collectively perform leadership functions, I predict shared leadership can also help develop the team mental model convergence.

METHODS

In the preceding sections, theories and key underlying properties for developing a dynamic leadership and team process model were introduced. I next implement a series of agent-based simulations to model this process using Matlab. The proposed theoretical model depicts two phases of team development and performance: the transition phase (emergence of shared leadership) and the action phase (convergence of shared mental model and problem solving). I therefore simulated these two phases in two models. Details of two models are described below. A review of relevant literature was conducted to help set up the values of model parameters and guide the agents' interactions. The means and ranges of parameters are presented in Table 1.

Prior literature has identified a great number of factors that affect team process and performance. Salas et al. (2005) propose a heuristic to guide researchers to determine the critical factors to include in team performance models. Following Salas et al.'s (2005) guidance, Dionne and Dionne (2008), Dionne et al. (2010), and Serban et al. (2015) have developed several dynamic team process and leadership models using agent-based simulations. The selection of the variables in this simulation is therefore guided by these prior studies.

The current simulation study includes a set of individual, team, task and environment characteristics that are significantly associated with leadership perceptions and emergence. At the individual level, individual difference literature and leadership literature has found support for the linkage between leadership emergence and cognitive ability (Lord et al., 1986; Taggar, Hackew, & Saha, 1999), extraversion (Bono & Judge, 2014), conscientiousness (Taggar et al., 1999), expertise (Dionne & Dionne, 2008) as well as self-efficacy (Gershenoff, 2003).

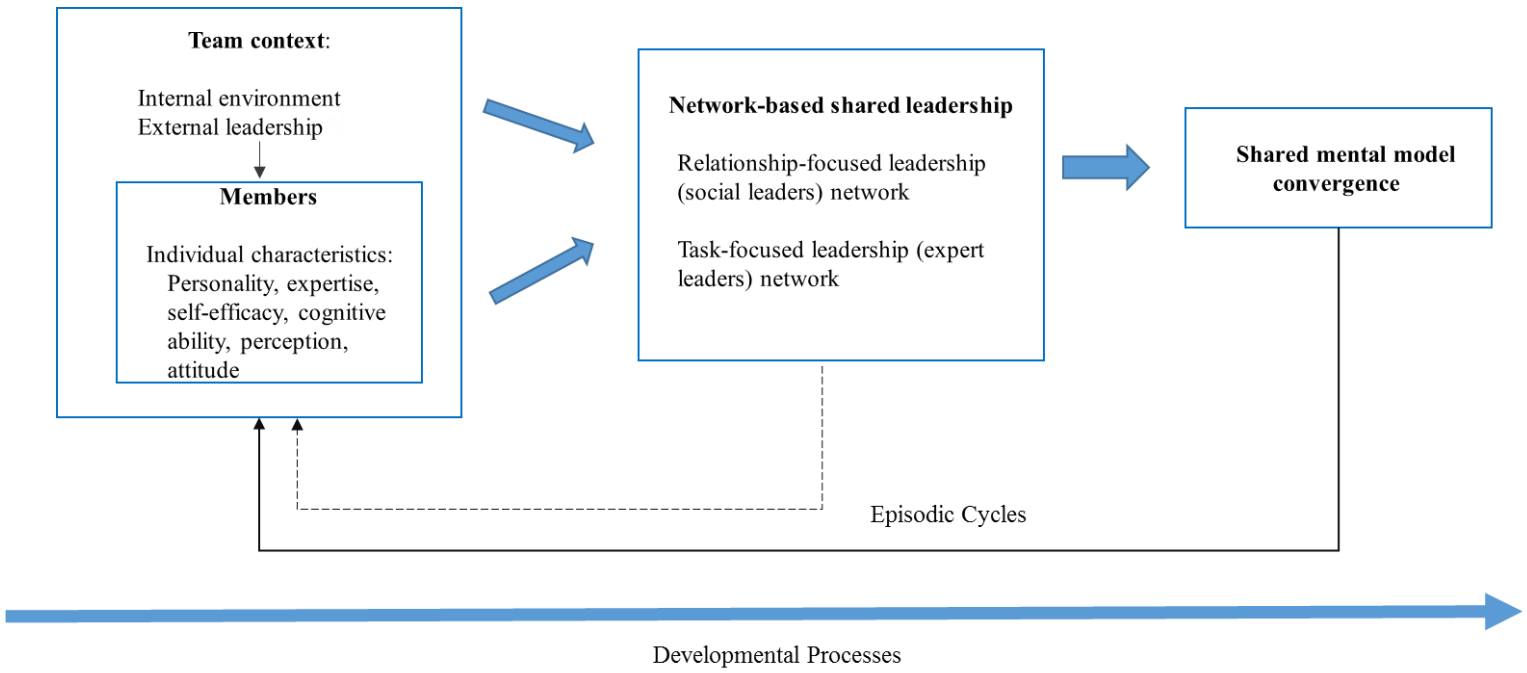


Figure 3. A Multilevel and Dynamic Model of Shared Leadership and Decision Making

At the team level, team type (Horwitz & Horwitz, 2007), structure (Mehra et al., 2007; Balkundi, Kilduff, & Harrison, 2011), and internal environment (Carson et al., 2007) have been related to key team process and outcome variables. Finally, Dionne and Dionne (2008) and Serban et al. (2015) also consider several task and external environment variables, which were viewed as critical components to their team development and performance models.

In sum, the current study includes these key individual, team, and task and environment variables to simulate a dynamic, recurring, and developmental team process and performance model. Note that although other variables may also affect leadership perception and emergence, the selected variables are viewed to be particularly important for self-managing teams, the type of teams simulated in the current study, when performing a decision making task, which involve a great deal of application of knowledge, expertise, and decision making (Cohen & Bailey, 1997), and therefore are included in the current study.

Individual Characteristics

Cognitive ability. Defined as a tendency to successfully perform information-procession tasks, cognitive ability is a stable and reliable predictor of job performance (Pearlman, Schmidt, & Hunter, 1980) and leadership emergence (Lord et al., 1986). Team members with high cognitive ability are more likely to emerge as leaders (Serban et al., 2015). In this simulation, individual cognitive ability is generated by Matlab program, following a normal distribution with a mean of 21.75 and a standard deviation of 7.6. These values were derived from the Wonderlic reports in Taggar et al. (1999) and also used in Serban et al.'s (2015) agent-based simulation.

Extraversion and Conscientiousness. Individuals high on extraversion tend to be "assertive, active, talkative, upbeat, energetic, and optimistic" (Costa & McCrae, 1992 cited in Bono & Judge, 2004, p. 902), and are more likely to exhibit leader behaviors (Barry & Stewart, 1997). Conscientiousness, another personality dimension, is the tendency to maintain ethical principles and obligations, display high aspirations and hardworking behavior as well as the ability to successfully accomplish goals and tasks (Neuman & Wright, 1999). Research has shown evidence of the association between conscientiousness and leadership emergence (Taggar et al., 1999; Neubert & Taggar, 2004). Both extraversion and conscientiousness are randomly simulated by Matlab program ranging from 0 to 1, with 0 representing low extraversion/conscientiousness and 1 representing high extraversion/conscientiousness.

Self-efficacy. Self-efficacy refers to a comprehensive judgment about oneself and one's capability to successfully perform a certain task (Bandura, 1986) and have been indicated to be a significant predictor of task performance and leadership emergence (Gershenoff, 2003). This variable is also random generated by the program with a range from 0 to 1, with 0 representing low self-efficacy and 1 representing high self-efficacy.

Expertise. In this simulation, individual expertise is first randomly generated with a range of 0 to 1. This expertise level also determines the accuracy of an individual team member's problem function in the action phase (model 2), which will be introduced later.

Team Characteristics

Team type. Self-managing teams appear to particularly suit the purpose of this study, which is to study the development of shared leadership in teams without an internal formal leader. Self-managing teams are becoming increasingly common in organizations

(Manz & Sims, 1987; Cohen, Chang, Ledford, 1997; Morgeson, 2005), whose members are interdependent and self-manage performance of tasks that often involve high autonomy, and have considerable decision making authority.

Table 1. Model Components

Shared Leadership model		Component mean values	Component ranges around mean values
Individual characteristics			
Cognitive ability	Wonderlic	21.75	± 7.6 (14.15-29.35)
Personality	Extraversion	.5	(0-1)
	Conscientiousness	.5	(0-1)
Self-efficacy	Belief in one's capacity to successfully perform a certain task	.5	(0-1)
Expertise	Accuracy of a team member's IPF	.5	(0-1)
Team characteristics			
Team type	Self-managing team		
Team size	8	Assigned	No variability
Internal environment	Shared purpose, social support, voice	4.08	± 2 x .41 (3.26-4.9)
Shared leadership	Density of relation-focused leadership	.2, .5, .8	(0-1)
	Density of task-focused leadership	Depending on team processes and developmental stage	(0-1)
Task and environment characteristics			
Task type	Decision task	.5	(0-1)
Time pressure	Time-step iterations	1000	No variability
External leadership	Coaching	3.76	± 2 x .64 (2.48-5.04)
Noise	Random noise	Deviation from TPF at each location on a problem domain	(0-1)

Team size. Previous literature revealed that larger teams often face greater coordination challenges and are more prone to motivation and coordination losses (LePine et al., 2008). Teams of more than 10 members often divide into sub-teams (Likert, 1977). Small teams appear to be the primary focus in the team/group research. For example, in Horwitz and Horwitz's (2007) meta-analysis study, of 27 articles included, none of them examined teams with more than ten members. Team size in this study is therefore established as eight-person team. Eight-person teams have been used previously in leadership and team dynamic research (e.g., Dionne & Dionne, 2008; Black et al., 2006).

Internal environment. In the current study, the internal environment value for each team is generated by Matlab program, following a normal distribution with a mean of 4.08 and a standard deviation of .41. These values were derived from the Carson et al. (2007). The internal environment values generated in this study range from 3.26 to 4.9 (mean ± 2 x standard deviation).

Shared leadership. Team members' interactions depend on the network structures of shared leadership. In this study, I simulated two types of networks which represent task-focused leadership and relation-focused leadership respectively. Networks provide both opportunities and constraints for team members' interaction, information exchange, and convergence of shared mental model (Borgatti & Forster, 2003; Brass et al., 2004; Dionne et al., 2010). A network-based approach to shared leadership (i.e., using network density to conceptualize and assess shared leadership) has been more predictive of team outcome than aggregating individual team member's leadership ratings (D'Innocenzo et al., 2014).

In this study, the densities of social- and task-leadership networks both range from 0 to 1. The social leadership network (i.e., relationship-focused leadership) is assigned at

different levels in the initialization stage of the simulation. In other words, the process of the emergence of social leadership is not simulated in current study. The density of social network is operationalized at low (density = .2), medium (density = .5), and high level (density = .8), to represent the pre-existing social structure. Social network serves as channel through which resource, information as well as team members' perception, affect and attitude transfers within a team (Brass et al., 2004), thereby affecting the team members' leadership perception (Balkundi et al, 2011; Mehra et al., 2006). As such, social network is established as an important predictor of the development of shared task-focused leadership.

Task and Environment Characteristics

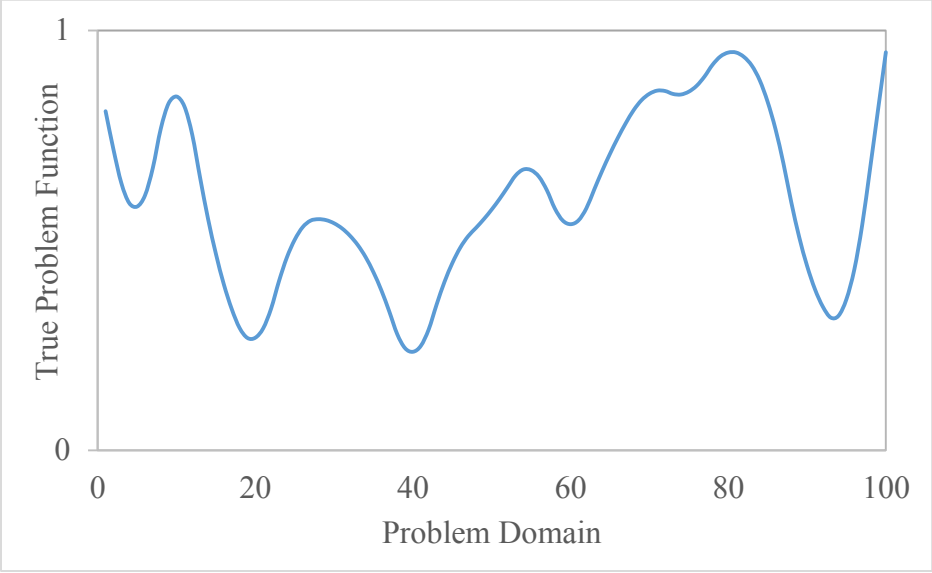


Figure 4. Example of a True Problem Function (TPF)

Task type. As established earlier, the teams simulated in this study are self-managing work teams, whose members are granted considerable authority and autonomy to make decisions. As such, the task assigned to the teams in the second model (action

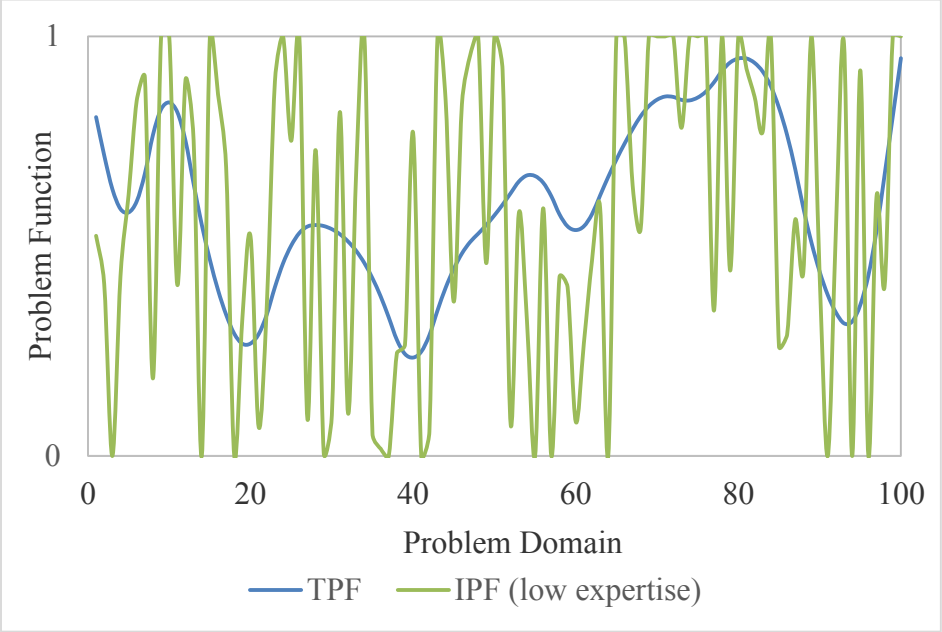
phase) is a decision-making task. Specifically, this model represents a process of a team working on a problem representation task. A true problem function (TPF) is simulated by assigning random numbers from 0 to 1 in the one-dimensional continuous problem domain between 0 and 100 (example shown in Figure 4). The value of the TPF at each point in the problem domain represents the best choice for that particular aspect of the problem. The team goal is to estimate the TPF as accurately as possible. Individual team members have individual problem functions (IPF) which is generated by adding random noise (discussed later) to TPF (see Figure 5).

Time pressure. Consistent with prior simulations studies (i.e., Dionne & Dionne, 2008; Dionne et al., 2010; Serban et al., 2015), time is represented by model iterations with a higher iterations representing longer period of time.

External leadership. Values of external leadership for each team are generated by program, following a normal distribution with a mean of 3.76 and a standard deviation of .64. These values were derived from the Carson et al. (2007). The internal environment values generated in this study range from 2.48 to 5.04 (mean ± 2 x standard deviation).

Noise. Because individuals cannot perfectly predict the true problem function, random noise, a random number between 0 and 1 is added to TPF to generate individual problem functions for each individual team members depending on the level of expertise of the member. For example, IPF of a member with high expertise shows low level of deviation (noise) from the TPF (Figure 5b), whereas IPF of a member with low expertise shows high level of deviation from the TPF (Figure 5a).

a) Individual Problem Function of a Team Member with Low Expertise



b) Individual Problem Function of a Team Member with High Expertise

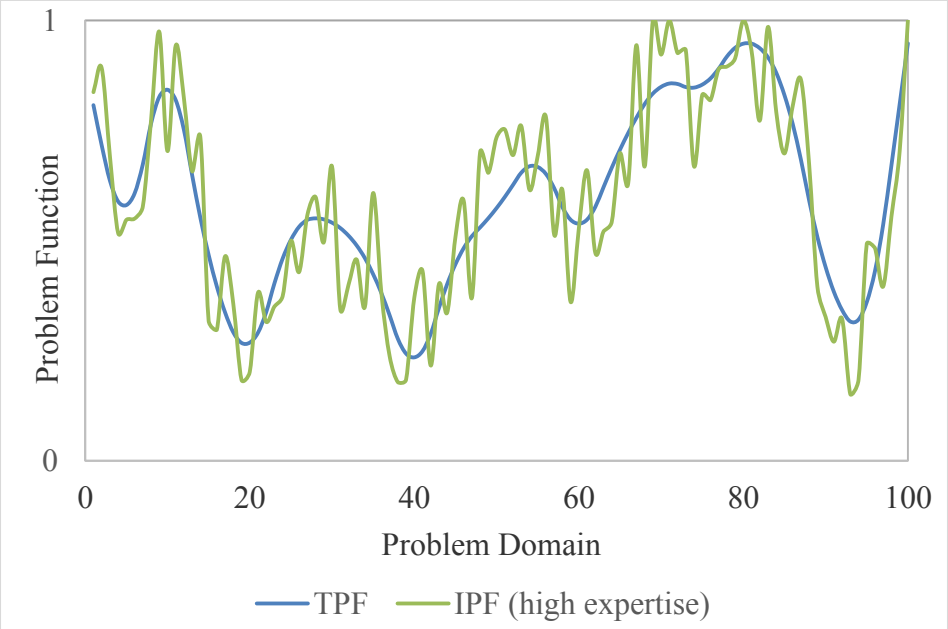


Figure 5. Examples of Team Members' Individual Problem Functions (IPF)

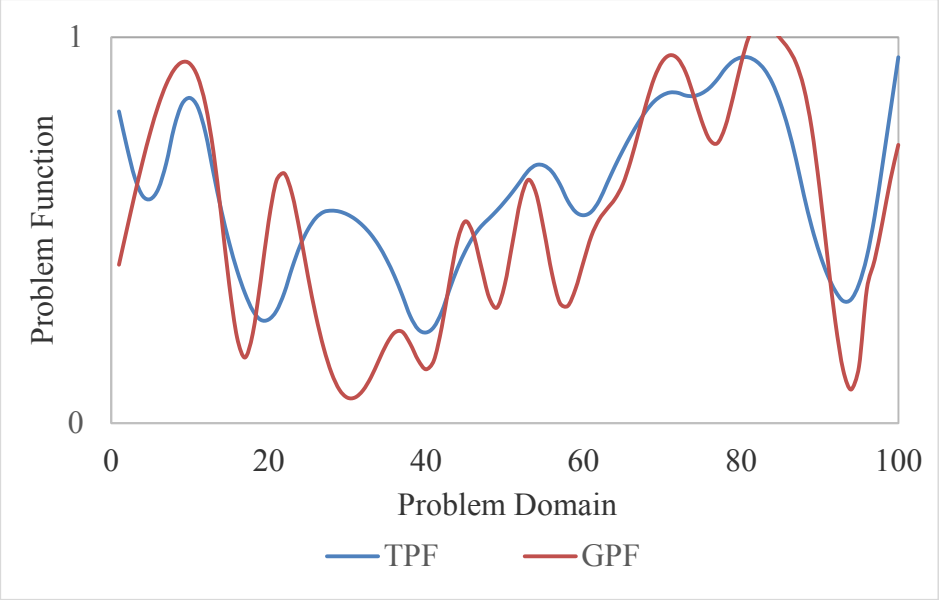


Figure 6. Example of a Group Problem Function.

Note: The red line represents the group problem function calculated as a weighted average of team members' IPFs using their confidence values as weights.

Transition Phase: Emergence of Network-based Shared Leadership

The first model aims to simulate the transition phase of team processes where shared leadership emerges as a result of team members' interaction. According to Morgeson et al. (2010), teams in this phase do not perform activities that directly contribute to goal accomplishment, rather, teams engage in activities that help evaluate the task, establish team norms and develop relationships among team members. The distribution of knowledge and expertise within the team also becomes clear to the team members in this phase. I speculate this is the stage where teams identify task leaders and develop task-focused leadership within teams. As established in the theoretical model, the emergence of shared leadership is a result of cyclical process of team members' interaction based on their individual, team, and task variables.

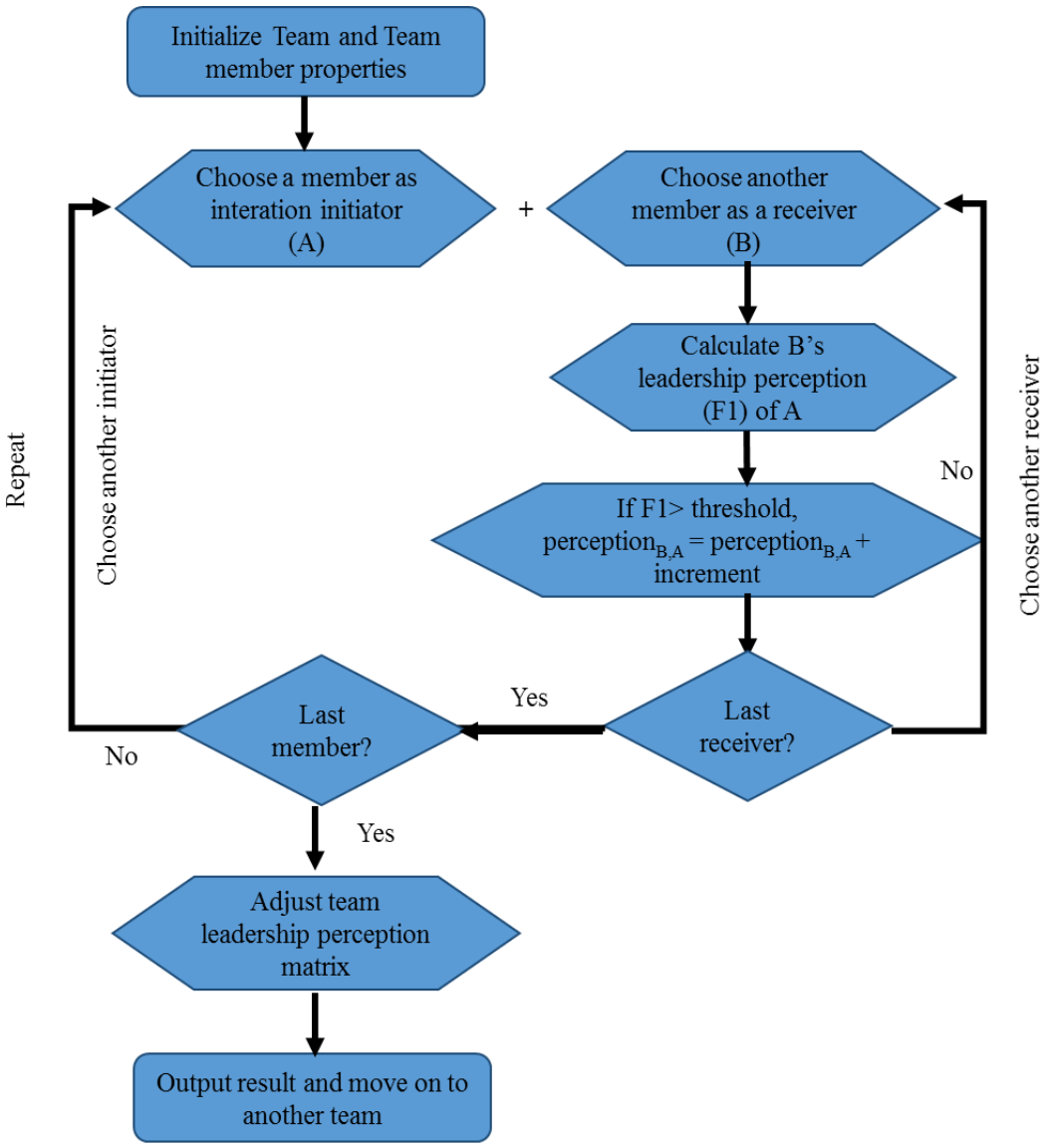


Figure 7. Flow Chart of an Emergent Model of Network-Based Shared Leadership

The simulation algorithm for the transition phase is depicted in a flow chart shown in Figure 7. First, I initialize simulation parameters by assigning individual team member's characteristics, team characteristics and task characteristics to members and the team

following the distributions and setting-up rules of each variables introduced earlier. In addition, each member has N (N = 8 in this study) separate leadership perceptions (0< perception < 1), one of which represents perception of his/her own, while the other N – 1 represent perceptions for other team members. The values of all the perceptions are initialized to 0 and may be changed during the team development. The perceptions of all team members constitutes task-focused shared leadership network.

A team member (A) is randomly selected (denote as interaction initiator) out of eight members to initiate an interaction with other team members. Another team member (B) is randomly selected out of the rest seven members as an interaction receiver.

The interaction between A and B occurs with a probability (P) which is calculated as a function of internal environment (IE), external coaching (EC), and the presence of the social tie between A and B. If A and B are connected by a social tie, P equals to 1. If A and B are not connected in the social network, P = $\sqrt{IE * EC}$ (both IE and EC are rescaled with the peak individual maximum being normalized to 1). The probability function models the effect of social network, external coaching and internal environment on team members' interaction. That is, the team members are more likely to engage in interactions if the team has dense social network, supportive internal environment and effective external coaching.

If A-B interaction occurs, member B's perception of A (denote as perception $_{B,A}$) increases by a small increment (0.001) when A's leadership score evaluated by B exceeds a threshold (0.5). This leadership score is calculated as a function (denote as F1, 1>F1>0) of A's cognitive ability, self-efficacy, personality, A's relative expertise compared to B's (expertise $_A$ – expertise $_B$) and the density of social network. This function reflects the prior research findings on the predictors of leadership emergence, and is consistent with the

simulation algorithm of prior agent-based modeling studies (i.e., Dionne & Dionne, 2008; Dionne et al., 2010; Serban et al., 2015). Essentially, the higher level of expertise, cognitive ability, extraversion and conscientiousness a member possesses, the more likely he/she is perceived as a task leader. After B modifies perception $_{B, A}$, interaction between A and B in this iteration ends, and another receiver will be selected and go through the same evaluation process and modify his/her perception of A. When all the team members have been selected and generated a new set of perceptions of A, the evaluation process of A ends, and another team member will be selected as an iteration initiator, and be evaluated by other team members and then receive a new set of perceptions. When all of the team members have been evaluated by other members, each member adjusts his/her perceptions of others based on another experimental parameter, "adjustment weight" ($0< AdjW <1$). Adjustment weight is calculated as a function of internal environment. $AdjW = 0$ means one's perception of others are solely based on one's own judgment, while $AdjW = 1$ means one's perception of others are based on average responses of the members who are connected with him/her. This adjustment reflects the notion that connected individuals in a social network tend to form similar behavior, attitude, and affect (Erickson, 1988; Umphress, Labianca, Brass, Kass, & Scholten, 2003).

The team completes one iteration when all team members have gone through the evaluation and adjustment process. Preliminary tests of the simulations indicated teams reached a stable leadership network within 500 iterations, I therefore used 500 iterations to produce the simulation results for each experimental condition. With an attempt to investigate the factors that affect the development of shared leadership, the simulation was conducted under different conditions (by changing the values of parameters): (a) high (0.8),

medium (0.5) and low (0.2) density; (b) high expertise (0.5-1), low expertise (0-0.5) and heterogeneous expertise (0-1); (c) high coaching (2.48-3.12) and low coaching (4.4-5.04); (d) high-support internal environment (4.49-4.9) and low-support internal environment (3.26-3.67). In addition, the interaction between social network density and external coaching, and the interaction between social network density and internal environment are examined.

Performance Phase: Team Decision Making and Convergence of Shared Mental Model

The second model aims to simulate the action phase of a team working on a decision-making optimization task. Informed by Dionne et al. (2010), the current study adopts their method to simulate teams' mental models and the information elaboration process. However, this study differs from their study in two significant ways. Dionne et al. (2010) focuses on the effects of leadership at different level (represented by social networks with different densities and structures) on the convergence of shared mental model. The leadership densities and structures are preset as initial conditions in their simulations, whereas in the current study, leadership networks are developed based on team members' interaction in the previous transition phase, and serve as a mediating variable that affects the subsequent performance phase. In addition, Dionne et al. (2010) investigate the effect of social network, whereas the current study investigate both social network (i.e., relation-focused leadership) and task leadership network to help understand how the multiple functions and roles of leadership affect the convergence of shared mental model.

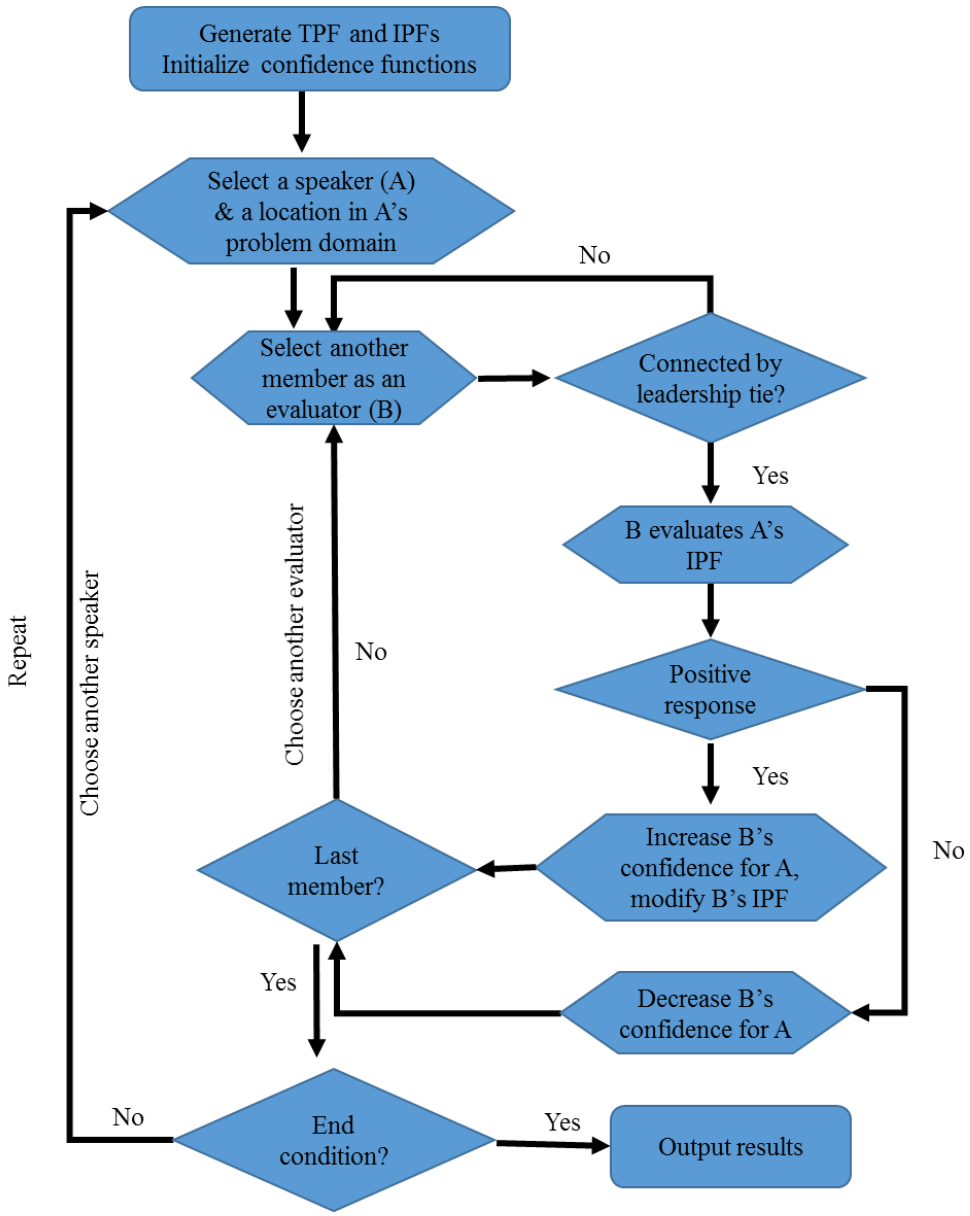


Figure 8. Flow Chart of a Model of Shared Mental Model Convergence

The simulation algorithm for model 2 is shown in Figure 8. The team's objective is to collectively estimate the true problem function (TPF) as accurately as possible. As discussed earlier, each individual team member has an individual problem function (IFP)

which reflects their view of the problem representation and their expertise level. In addition, each member has N separate confidence functions, one of which is the confidence for oneself, while the other N−1 represent confidence for other members. In Dionne et al. (2010), confidence functions were used to represent the knowledge about "who knows what" within the team, which reflect each member's view of team's mental model. The current study adopts their method to simulate team's mental model. Specifically, the sum of all team members' confidence is always conserved to 1 at any time and location in the problem domain. The group-level problem function is a weighted average of the IPFs of all team members, using the average of confidence values given to each member at a specific point in the problem domain as a weight (see Figure 6). As team members interact, and exchange information with each other, these confidence functions will change over time throughout the information elaboration process.

Information elaboration is at the center of a team's decision making process (Dionne, et al., 2010). Based on McComb's (2007) three-phase model of shared mental convergence, the process of information elaboration is modeled as orientation, differentiation and integration. Specifically, orientation is the phase where a speaker shares an opinion (see Step 2, below), differentiation is the phase where a listener evaluates the speaker's opinion, (see Step 3, below) and finally, integration represents the subsequent modification of the listener's own opinion (see Step 4, below). More detailed information will be described below.

1. Initialization. A team is assigned with a TPF. Each member is assigned with an IPF, and a set of confidence functions.

2. Orientation. A speaker (A) is selected as a speaker. Team members' self-

confidence is used as the probabilities of selection. This reflects the notion that confident individuals are more often to speak in a team. A then expresses his/her opinion (the value of A's IPF) on a selected topic (i.e., a randomly selected location from his/her entire problem domain).

3. Differentiation. A's opinion is evaluated and responded to by team members (evaluators) who perceive A as a task leader (i.e., members connected with A in task leadership network) based on the difference between A's IPF and B's IPF on the selected location in the problem domain (d, $0<d<1$). If d is less than 0.5, the response is positive.

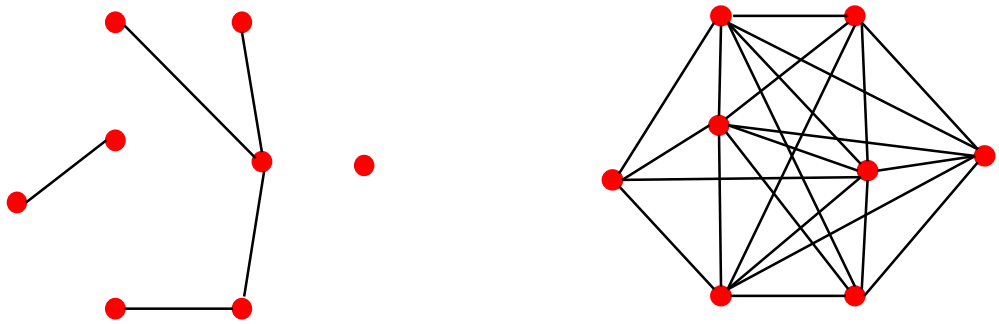
4. Integration. If the evaluator's response is positive (or negative), the confidence function for A is increased (or decreased) by an increment at the selected location in the problem domain. The confidence values for all team members are normalized so their sum is 1.

The ***convergence of mental models*** is assessed by the total disagreement of confidence functions existing among team members. This disagreement is obtained by (1) calculating the standard deviation of the confidence value each member received, and (2) summing up N standard deviations. As such, a low (or high) disagreement of confidence functions represent a high (or low) convergence of team mental model.

5. The above steps 2 to 4 are repeated for 500 iterations for one team.

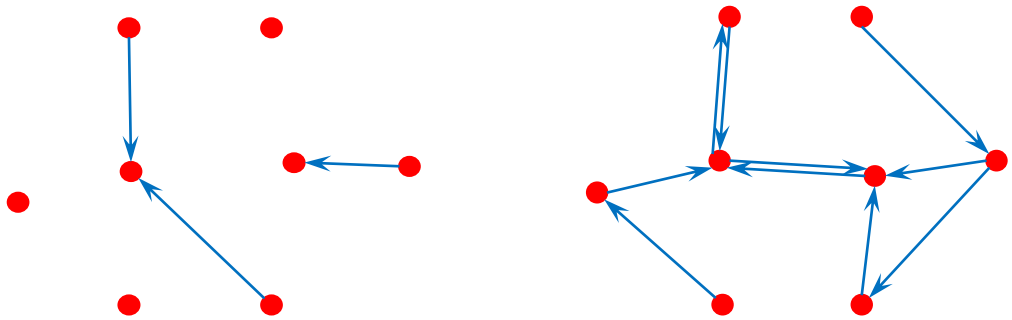
I used 500 teams to simulate the convergence of mental model under each condition. In this simulation, four conditions are examined: (1) high relationship-focused leadership density (RLD) and high task-focused leadership density (TLD), (2) high RLD and low TLD, (3) low RLD and high TLD, and (4) low RLD and low TLD. The total number of iterations is therefore 500*500*4. Examples of high and low RLD and TLD are shown in

Figure 9 and 10.



a) Low density b) High density

Figure 9. Examples of Low- and High-density Relation-focused Leadership



a) Low density b) High density

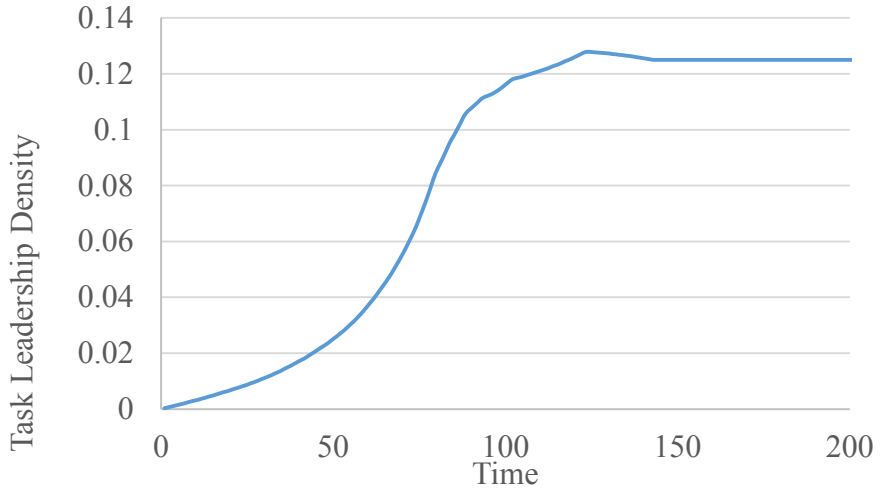
Figure 10. Examples of Low- and High-density Task-focused Leadership

RESULTS

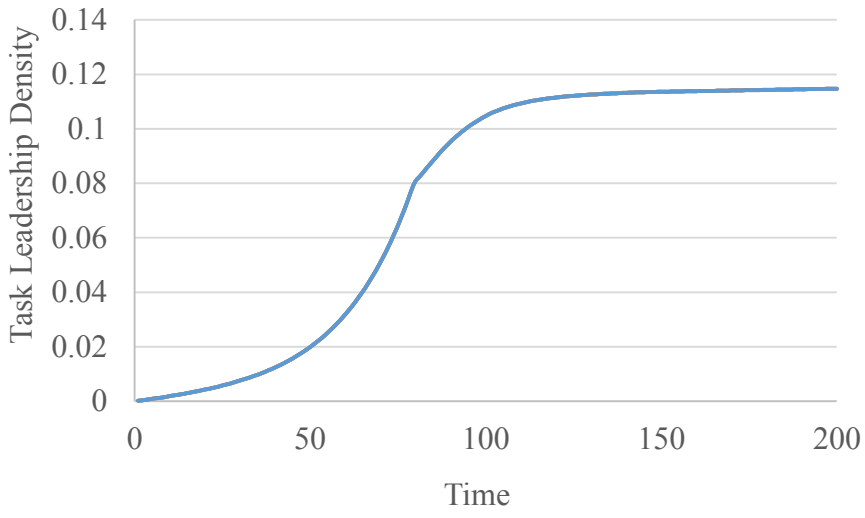
Development of Shared Task-focused Leadership

As shown in Figure 11a, a team's development of shared leadership is a dynamic and longitudinal process. During the first 50 iterations (i.e., time steps), the density of leadership network increased slowly, with only one or two leadership ties developed (number of ties equals to density times the number of all the possible ties). During the second 50 iterations, the density curve becomes steeper than the initial stage. The team

developed four or five leadership ties during this period of time. The third 50 iterations showed a nearly static leadership development. Only one or no leadership ties were developed during this period of time, indicating the team reached a stable state in terms of the perception of team's task leaders. When examining the averaged results of shared leadership development of 500 teams, a similar pattern is observed in Figure 11b.



a). Development of Shared Task-focused Leadership over Time (One Team)



b). Development of Task-focused Leadership over Time (500 teams)

Figure 11. Development of Shared Leadership

Note: Figure 11a shows a developmental process of the task-focused leadership for a randomly selected team, while Figure 11b shows an averaged result of the task-focused leadership development over 500 teams. The values of the key parameters are as follows: social network density = 0.5; time step: 500 (only the first 200 are shown as the leadership network density remains stable after the first time steps); number of teams: 500; expertise: 0 – 1; external coaching: 2.48~5.04 (mean: 3.76, SD: 0.64); internal environment: 3.26~4.9 (mean: 4.08, SD: 0.41)

The social network density also affected the time it takes for a team to reach a stable leadership network, where team members' perception of others remain the same and no new leadership ties will be developed. Low density teams (red line in Figure 12) reached this stable state faster than high density teams (green line in Figure 12). It appears that the dense social network within a team prompted team members to take time to interact, communicate and exchange their opinion with others, which in turn, allowed the team to better identify the experts (i.e., task leaders).

In addition, expertise was speculated to be an important predictor for the development of task-focused leadership. The results confirmed this prediction. Three different expertise conditions were examined, high expertise (0.5-1), low expertise (0-0.5) and heterogeneous expertise (0-1). Members in a low-expertise team were assigned an expertise on a scale from 0 to 0.5, where members in a high-expertise team were assigned an expertise on a scale from 0.5 to 1. Members in a heterogeneous-expertise team had most variability in their expertise, ranging from 0 to 1. The results showed no significant effect of the distribution of the expertise. However, the averaged expertise of all the team members seemed to positively relate to the development of shared task leadership. As shown in the Figure 13, the high-expertise condition produced the most leadership ties (i.e., highest density), followed by the heterogeneous-expertise condition. The low-expertise condition yielded the least leadership ties.

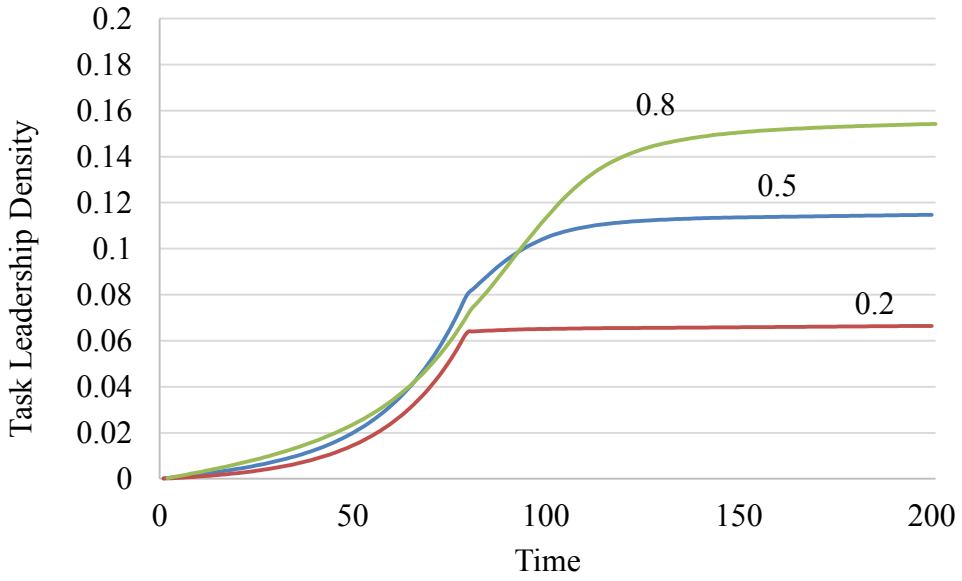


Figure 12. Development of Task-focused Leadership by Social Network Density.

Note: The values of the key parameters are as follows: social network density = 0.2, 0.5, 0.8; time step: 500 (only the first 200 are shown here); number of teams: 500; expertise: 0 – 1; external coaching: 2.48~5.04 (mean: 3.76, SD: 0.64); internal environment: 3.26~4.9 (mean: 4.08, SD: 0.41)

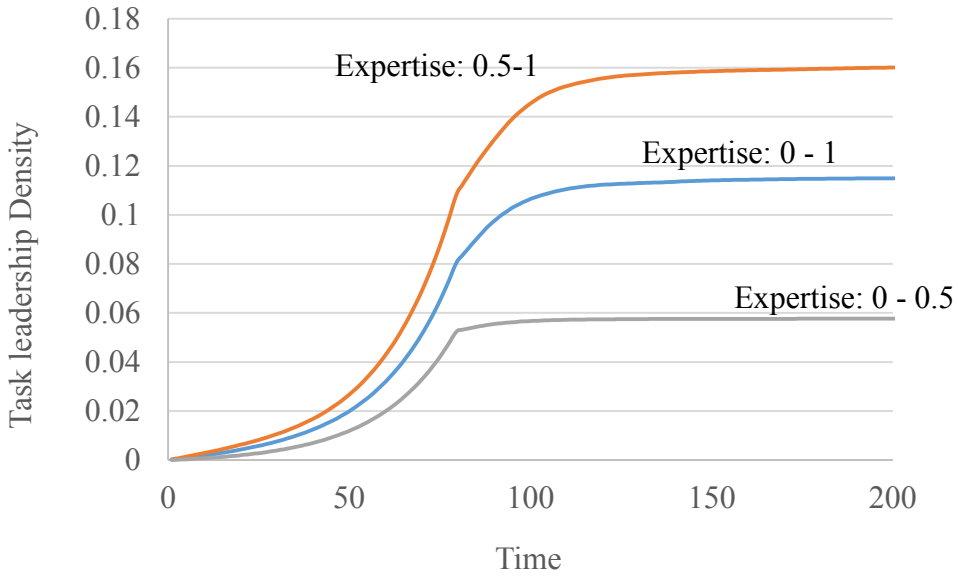


Figure 13. Development of Task-focused Leadership by Expertise.

Note: The values of the key parameters are as follows: expertise: 0.5-1 (high expertise condition), 0-1 (heterogeneous expertise condition), 0-0.5 (low expertise condition); social network density = 0.5; time step: 500 (only the first 200 are shown); number of teams: 500; external coaching: 2.48~5.04 (mean: 3.76, SD: 0.64); internal environment: 3.26~4.9 (mean: 4.08, SD: 0.41)

External coaching related to the development of shared task-focused leadership

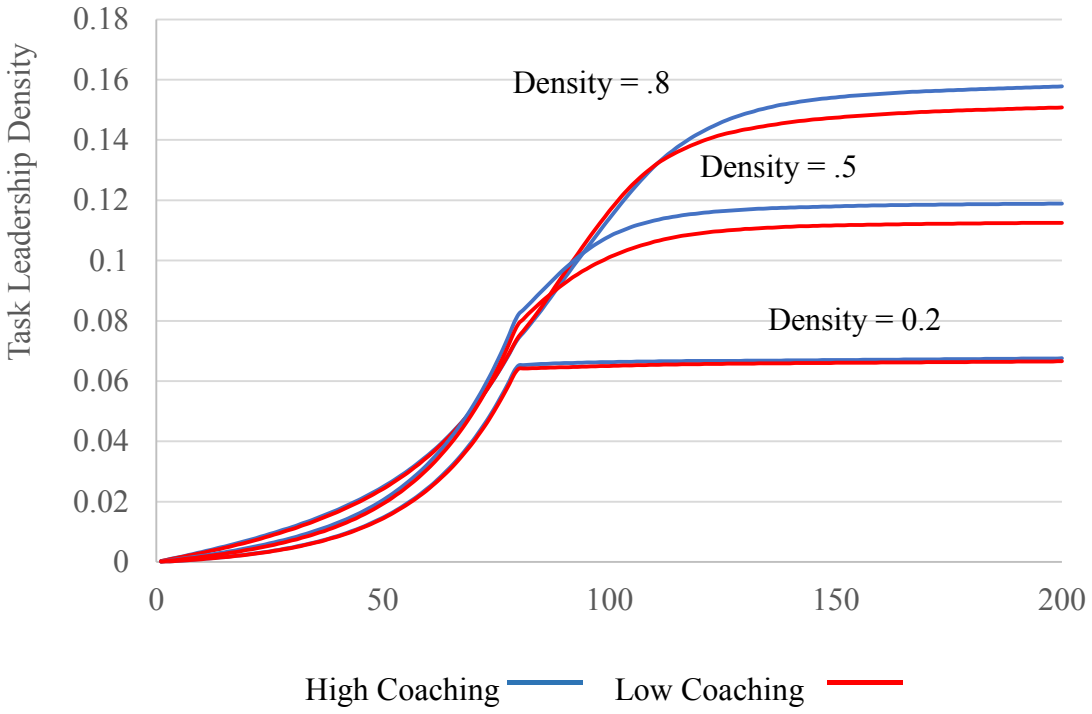


Figure 14. Development of Task-focused Leadership by Density and External Coaching.

Note: The values of the key parameters are as follows: external coaching: 2.48~3.12 (high), 4.4~5.04 (low); social network density = 0.2, 0.5, 0.8; time step: 500 (only the first 200 are shown); number of teams: 500; internal environment: 3.26~4.9 (mean: 4.08, SD: 0.41); expertise (0-1)

As shown in Figure 14, external coaching also displayed influence on the development of teams' shared leadership. When social network density is 0.5 (the two lines in the middle), teams with a high-level external coaching (represented by the blue line) developed more task-focused leadership ties than the low-coaching teams (represented by

the red line). The same patterns are also observed when social network density is 0.8 (the top two lines). However, there was no significant difference between high-coaching and low-coaching conditions when the social network density is low (the bottom two lines).

Internal Environment Related to the Development of Shared Task-focused Leadership

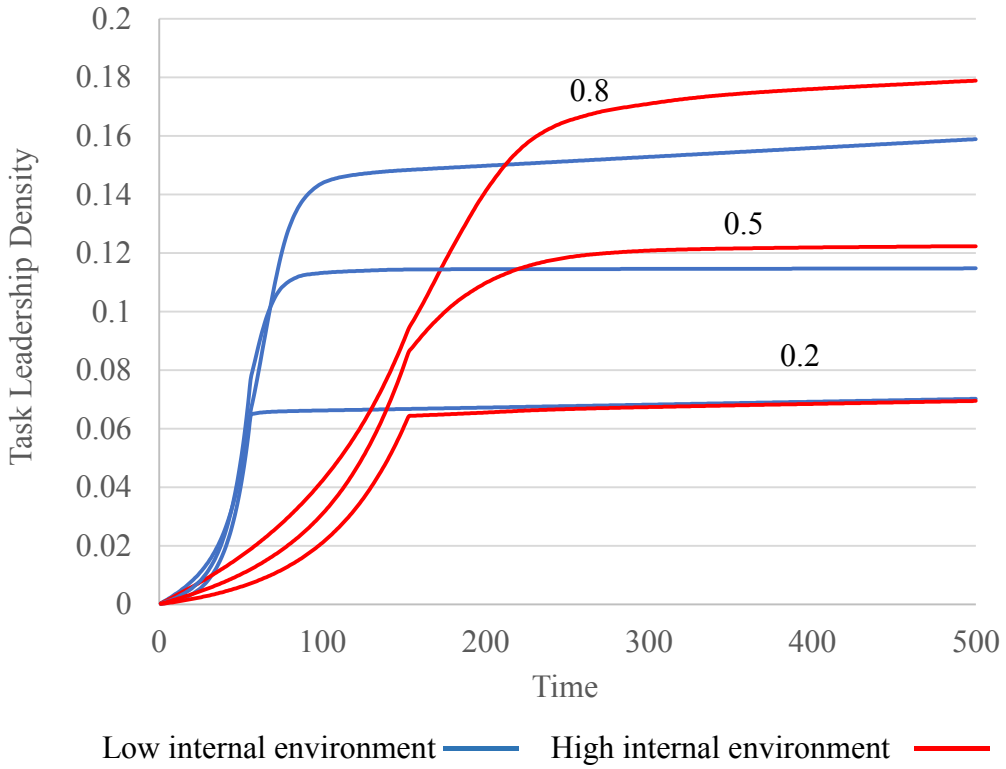


Figure 15. Development of Task-focused Leadership by Density and Internal Environment

Note: The values of the key parameters are as follows: social network density = 0.2, 0.5, 0.8; internal environment: 4.49 – 4.90 (high), 3.26 – 3.67 (low); time step: 500 (only the first 200 are shown here); number of teams: 500; expertise: 0 – 1; external coaching: 2.48~5.04 (mean: 3.76, SD: 0.64)

As shown in Figure 15, internal environment also affected the development of teams' task-focused leadership. In general, the team tended to develop more task-focused

leadership ties when team's internal environment was more supportive. The high internal environment condition (represented by the red lines) produced more leadership ties than low internal environment condition (represented by the blue lines) at all three social network density levels. In addition, the internal environment appeared to affect the time it takes for a team to reach the stable leadership network. The three blue lines representing the low internal environment condition reached saturation faster than the three red lines representing the high internal environment condition.

Furthermore, there is an interaction effect between social network density and the internal environment. That is, the difference between high and low internal environment conditions increases as the social network density increases. As shown in Figure 15, the largest difference between red and blue lines occurred when social network density is 0.8; a modest difference occurred when network density is 0.5; whereas no difference was shown when network density is 0.2.

Effects of Shared leadership on the Convergence of Team Mental Model

Two aspects of shared leadership were examined in the current study, relation-focused leadership (represented by social network) and task-focused leadership (represented by task leadership network). Both types of shared leadership were expected to relate to the development of team mental model. The effect of shared task-focused leadership is supported by the simulation results. As shown in Figure 16, teams in the high task-leadership condition (represented by the red and black lines), as compared with those in the low task-leadership condition (represented by the green and blue lines), developed less disagreement in their confidence functions, which indicates a higher level of mental model convergence. Therefore, consistent with my prediction, shared task-focused

leadership is positively related to the development of team mental model.

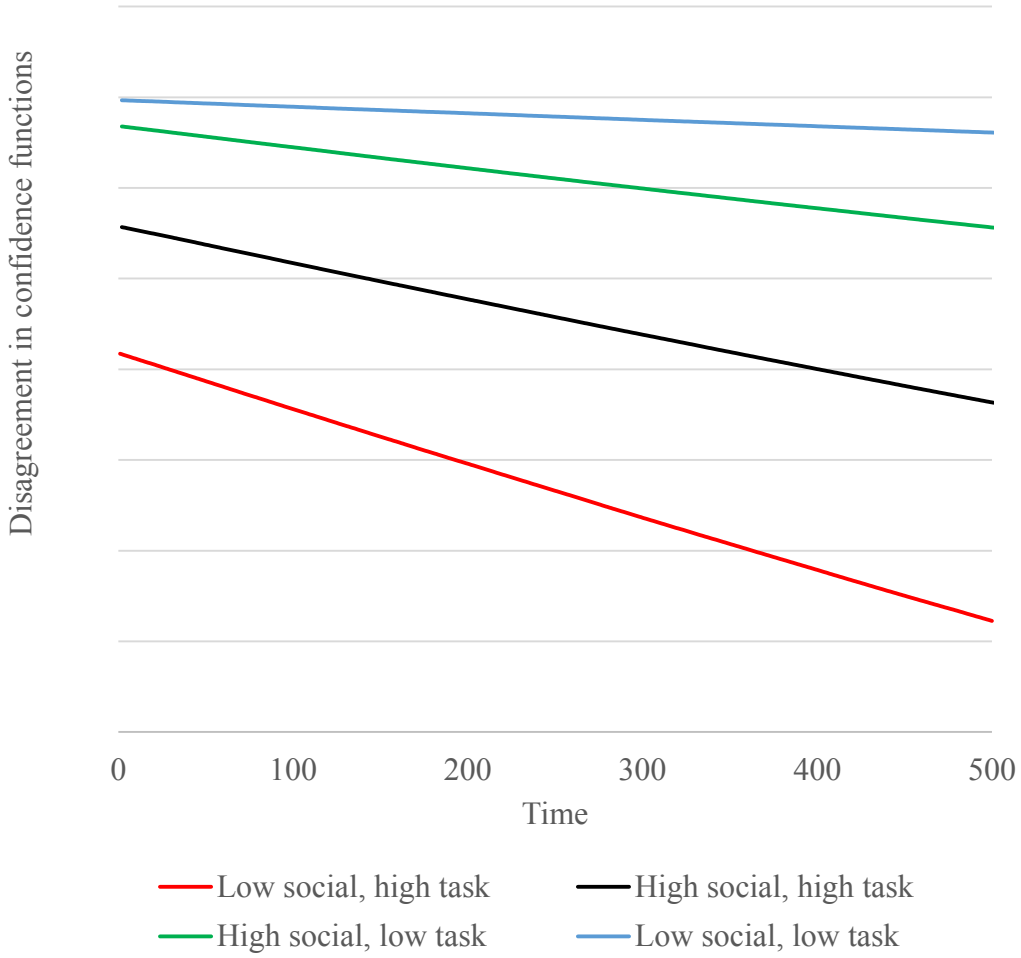


Figure 16. Convergence of Team Mental Model by Leadership Conditions.

Note: the density of task-focused leadership: 0.15 (high), 0.05 (low); the density of relation-focused leadership: 0.2 (low), 0.8 (high). Each line represents the averaged results of 500 teams.

The shared relation-focused leadership was also expected to positively associate with the convergence of team mental models. This prediction, however, was only partially supported in that when the task-leadership was low, there was a higher level of convergence (i.e., less disagreement) in teams with high relation-focused leadership (green line in Figure 16) than in those with low relation-focused leadership (blue line in Figure 16). When the

task-focused leadership was high, teams with a low social network density (red line) tended to outperform those with a high social network density (black line) in terms of the development of team mental model.

DISCUSSION

Building on Mathieu et al.'s (2008) team process and performance model and McComb's (2007) information elaboration model, a leadership and team process model was developed, and tested using agent-based modeling and simulations. Using an agent-based modeling method, the current study was able to capture the trajectory of the leadership development process in teams. Gully (2000, p. 35) stated that "to fully understand work teams, researchers must investigate how team dynamics develop and change over time." The simulation results showed the emergence of shared leadership in a team takes time. The teams first went through an initial stage, where team members' interaction was limited, and few leadership ties were developed due to the unfamiliarity with other members and the team task. The team then entered a stage where team members interacted actively, leadership ties (i.e., task leadership) developed quickly in this stage. In the final stage, the leadership network in teams reached saturation and remained stable after that point. This finding is consistent with a developmental perspective of team and leadership process (Kozlowski et al., 1999), and can also be mapped into Tuckman's (1965) stages model.

Regarding how fast a team reached a stable leadership network, two variables, the density of relational leadership (represented by social networks) and the internal environment, appeared to be significant predictors. Results indicated teams with a more supportive internal environment form a stable leadership pattern faster than teams with a

non-supportive internal environment. Supportive internal environment emphasizes an understanding of team objectives and offering other team members social support. Teams with a supportive environment are therefore more likely to engage in leadership behavior and more willing to rely on others as leaders. In addition, results showed that teams with a sparse social network reached saturation level faster than those with a dense social network. This result may suggest there are more interactions, dynamics and information exchanges existing in a team rich in social ties. The team members constantly influence, and are influenced by, other team members, and cognitive, behavioral, attitudinal characteristics also change as a result of team development. Therefore, leadership emergence is a more time-consuming process in highly connected teams.

Regarding how much task-focused leadership was shared in a team, the proposed theoretical model speculated the expertise, internal environment and external coaching are all predictors and positively related to the density of task-focused leadership. Results derived from simulations confirmed these predictions. Teams with high level expertise, supportive internal environment and high level of external coaching tended to develop more leadership ties over time.

Intriguingly, the density of relation-focused leadership (i.e., social network) plays an important role in directly affecting task leadership as well as moderating effects of other variables on task leadership. By itself, the density of social network is positively associated with the density of shared task leadership, that is, the more social ties a team had, the more task-focused leadership ties the team developed. This finding is consistent with prior literature which emphasizes the important role social network plays in leadership process and outcomes (e.g., Balkundi et al., 2011; Serban et al., 2015). Balkundi et al. (2011)

conducted a longitudinal study, and found the structure of social network affects leadership attribution, in that one's centrality is an antecedent of leadership attribution to the leader by team members. Although Balkundi et al. (2011) focused on formal leaders, the notion that occupying a structurally favorable position increases the probability for one to be perceived as a leader is applicable in the scenario of shared leadership. At the team level, a dense social network offers team member more communication channels for them to interact and share information. Members with more task-related skills, expertise and competence may be more likely to be recognized as task leaders.

Social network also moderated the effects of both internal environment and external coaching on task-focused leadership. When social network density was medium and high, the effects on task leadership were as predicted. However, these effects disappeared when the social network density was low. This finding suggests social networks may represent a relational and structural characteristic that underlies a team's day-to-day interactions and activities. A modest level of social relations may be required for any team process and formal interventions to take effect.

Regarding the convergence of team mental model, the effect of task-focused leadership is consistent with my prediction. More task leadership ties were associated with higher level of convergence (represented by lower level of disagreement in team members' confident functions). In contrast, the effect of relationship-focused leadership was not as straightforward. The effect of social network was found dependent on the density of task-focused leadership. When taking a closer look at the joint effect of these two types of shared leadership, results indicated social network density has a positive relationship with team mental model convergence when task leadership density is low, and a negative relationship

with team mental model convergence when task leadership density is high. In other words, when fewer experts were identified by team members, a dense social network is desirable for the team to develop a converged mental model; whereas, when a number of members emerge as task leaders, a highly connected structure can decrease the team's performance in terms of the convergence of a team mental model. The reason that social network may negatively affect team mental model convergence is still unclear. One explanation may be that when the team has well established a task leadership network, ideally, team member would rely on task leader's expertise to solve problems and complete the team goals. However, members connected by social ties may influence each other during the process of information elaboration. Such influence, based on interpersonal relationships and not necessarily task-related issues, can be a detrimental source of confounding information, and therefore hinder an individual's judgment.

Theoretical and Methodological Implications

This study contributes to the current leadership and team research with several theoretical and methodological implications. First, the study added to the network-based shared leadership literature by exploring the antecedents and consequence of shared leadership. Although advocated by scholars, a network-based shared leadership framework remains understudied. The current study constructed shared leadership at a network level of analysis, which focused on the structural characteristics of leadership in teams, and used network density as an index to assess shared leadership. Such an approach brings both theoretical and methodological benefits to the leadership research. A network-level conceptualization of shared leadership make no assumptions of within-group consensus and agreement, rather, it allows the existence of discontinuity, complexity, asymmetry, and

nonlinearity in the construct, and offers unique opportunity to study the structural signatures, relational patterns, and distributions of multiple aspects of leadership.

This study also made an effort in looking into the "multiplexity of shared leadership" (Contractor et al., 2012)—multiple roles or functions collectively taken by team members. Two types of roles are of primary interest: task leaders and social leaders. Prior research indicates the two roles can result from different antecedents and can be taken by different individuals. Task-related skills and expertise is critical in the emergence of task leaders, whereas interpersonal skills are important in the emergence of social leaders. The current findings support the important role of expertise in the development of task-focused leadership. Further, the current study also investigated the relationship between these two types of shared leadership. Relationship-focused leadership can affect task-focused leadership emergence, and together, the two types of shared leadership affect the convergence of team mental model.

In addition, the current study makes a methodological contribution by using agent-based modeling and simulations to model a dynamic and complex leadership and team process. Computational modeling methods are often used in the field of complex systems. Lichtenstein and Plowman (2009) noted that leadership research can be greatly informed by the research of complex systems, which studies the agents that are constantly interacting and exchanging information with, and learning from, other agents, and adapting their behavior in their local system.

Every contact, every exchange of information presents an opportunity for influence, which reflects one important type of leadership. While these everyday contacts may seem routine, they can be significant because each conversation builds on the last

and is infused with the new information provided by the one before. In addition, some interactions can be perceived as more "meaningful" to agents, depending on the content, the norms, and their interaction. (Lichtenstein & Plowman, 2009, p. 618)

Although applying theories and modeling methods of complex systems seems highly promising, only a few of studies have made an effort in exploring the utility of computational modeling and simulation in the field of organizational science. Recently, Kozlowski et al. (2013), Li (2013) and Borgatti and Halgin (2011) have explicitly advocated for the use of modeling methods in studying complex, emergent, and network-related organizational phenomena. The present study therefore contributed to the current literature by employing a modeling method in studying team dynamics and leadership process.

Limitation and Future Directions

There are several limitations of this study. First, as Kerr and Tindale (2004) indicate, team studies tend to oversimplify team processes. The current study may potentially suffer from this issue. For example, the emergence of leadership is a complex phenomenon potentially related to many factors at multiple levels of analysis. While the current study focuses only on several key individual level and team level variables, other input variables at other levels of analysis may also have a significant effect on leadership emergence. Including these variables may change the simulation results. For example, team members' inter-unit ties, organizational culture, and/or task interdependence may also affect shared leadership. Future research may want to identify and investigate other critical variables that can affect shared leadership in teams.

Second, the current study focuses on only two types of leadership roles. Although I believe these two types of shared leadership capture the most fundamental leadership functions required for a team to successfully perform tasks, other leadership roles or functions also need to be investigated in future research (Morgeson et al., 2010; Hiller et al., 2006). For instance, Hiller et al. (2006) offer a typology for leadership functions, including planning and organizing, problem-solving, support and consideration, and developing and mentoring. What are the antecedents and consequences of these functions? How may different functions or roles affect one other, and further, how may they interact to affect team outcomes? Future research may want to develop a more comprehensive view of shared leadership by embracing multiple dimensions of shared leadership.

Third, there are some disadvantages concerning use of simulation methods. One key shortcoming is simulation results may have limited contribution to theory development. The preset parameters and interaction rules may limit its generalizability. In addition, as in traditional research design, validity test is critical in simulation. However, there is no consensus on how a simulation should be validated. Davis and Bingham (2007) recommend several strategies to examine validity of a simulation, including 1) test simple theories with the basic model and 2) validate simulation study with empirical data. In sum, a simulation itself is unable to provide sufficient evidence for a proposed theory. Additionally, simulations often require researchers to make arbitrary decisions. When no relevant literature is available, making decisions about parameter values or interaction rules may be a biased result of researchers' knowledge or preference. This can potentially yield biased model estimates.

Future research may want to employ a hybrid research design, in which, multiple

research methods including modeling and simulations, field studies, and/or laboratory studies are used to test a theoretical model. Serban et al. (2015) offers an example for using a hybrid method to test a team leadership and performance model using three different research methods. While computational modeling methods may have shortcomings and may be challenging to apply, it is a potentially promising research method that well suits examining the increasing complexity and dynamics in today's organizations.

ESSAY III: LEVELS OF ANALYSIS IN SOCIAL NETWORK RESEARCH: A STATE-OF-THE-SCIENCE REVIEW

INTRODUCTION

In the early 1980s, the need for a paradigm shift from a purely micro- or macro-research to meso- or multilevel research was brought to the forefront of organizational research (Rousseau, 1985; Dansereau, Alutto, & Yammarino, 1984; House, Rousseau, & Thomas-Hunt, 1995). Since then, calls for the incorporation of levels of analysis in theory building and testing have increased over the last 25 years (Dionne et al., 2014). Many conceptual frameworks and analytic techniques of multilevel approaches have been developed to address levels-of-analysis issues (Mathieu & Chen, 2011). Research findings have asserted that both theoretical and empirical research in the field of organizational science could greatly benefit from the appropriate incorporation of levels-of-analysis perspective into conceptual development, measurement, data analytic techniques and inference drawing (Dansereau et al., 1999; Dansereau et al., 1984; Klein et al., 1994; Dionne et al., 2014; Hitt, Beamish, Jackson, & Mathieu, 2007).

The levels-of-analysis paradigm has permeated and significantly influenced every sub-discipline of organizational science since its introduction into organizational research (Mathieu & Chen, 2011; Kozlowski, Chao, Grand, Braun, & Kuljanin, 2013). In particular, in the field of social networks, one of the fastest growing areas of research during the past decades, levels-of-analysis issues are also becoming increasingly important (Brass, 2000;

Moliterno & Mahony, 2011). A wide range of organizational topics across different levels of analysis have been investigated from a network perspective (Brass, Galaskiewicz, Greve, & Tsai, 2004; Kilduff & Brass, 2010; Borgatti, Mehra, Brass, & Labianca, 2009). Kilduff and Brass (2010) posit that one of the major contributions the network approach brings to management science is a distinctive lens to examine a variety of organizational phenomena at different levels.

Although a social network approach has the potential to investigate complex organizational phenomena that involve concepts and relationships at multiple levels of analysis, many levels-of-analysis issues in social network research have remained unsolved (Moliterno & Mahony, 2011; Contractor et al., 2006). Borgatti and Brass (2003) indicate that levels of analysis in network research are confusing and unclear, because:

> In traditional research, we typically define levels of analysis in terms of the scope and complexity of the entities being studied ... However, in network research, the situation is subtly and deceptively different, because the obvious levels of analysis (dyadic, actor and network) do not necessarily correspond in a simple way to the type of entities being studied. (p. 1001)

Likewise, Brass (2000) notes the research of social network does not fit into the traditional notions of levels of analysis because the unit of analysis is the relationship among the actors rather than the actors themselves.

Despite the challenges, some effort has been made to overlay levels-of-analysis perspective onto the research of social networks. Brass et al. (2004) review the antecedents and consequences of networks at the interpersonal, interunit, and interorganizational levels of analysis. Likewise, Carpenter et al. (2012) incorporate a levels of analysis perspective

to organize prior research in social networks and recommend an appropriate research design according to the levels of analysis of the focal network (e.g., network composed of individuals, network composed of groups, network composed of organizations) and levels of analysis of the focal constructs. In addition, the scholarly interest in developing a framework of multilevel social networks is increasing. For instance, Contractor et al. (2006) advance a multilevel network framework that encompasses dyads, triads, and global networks of individuals, units, and organizations. Moliterno and Mahony (2011) also explore the possibilities of integrating levels-of-analysis perspective and social network research.

Given the burgeoning popularity of the social network research, and the need for understanding levels-of-analysis issues in this field, I assert it is imperative to assess *where the research of social network has been* and *where it is going* in terms of levels of analysis. Moving on to more complex and comprehensive multilevel frameworks requires a clear understanding of the current state of social network research. As no prior review has provided an in-depth investigation of levels-related issues in social network research, it is my attempt to fill this gap by assessing the levels-of-analysis issues in the social network literature.

The current study reviewed and content-coded 249 social network articles published in top-tier journals in the field of management and applied psychology. Variables coded in our study included (1) *levels-related variables* such as levels of network actors, levels-of-analysis of theory and hypotheses, incorporation of levels in conceptual development, measurement and inference drawing, and (2) *general variables* such as type of network, research streams, year published, etc.

Terminology

Social network. With a distinctive focus, network research investigates relations among actors. According to Borgatti & Halgin (2011, p. 1169), a network "consists of a set of actors or nodes along with a set of ties of a specified type (such as friendship) that link them". *Actors*, also referred to as *nodes*, can be individuals, work units (e.g., groups, divisions, business units), organizations, etc. *Ties* connecting actors represent some relationship, or absence of relationship between the actors. Ties can be directed or undirected and can be dichotomous (present or absent) or valued (e.g., strength of relationship).

Levels of analysis. *Levels* refer to the focal unit the study aims to examine. According to the operationalization of the constructs, the level of analysis can be the individual level (e.g., a manager, an employee), dyadic level (e.g., two interdependent individuals), group level (e.g., cross-functional teams, top management teams*)* and organization level (Yammarino & Dansereau, 2009). In social network research, the commonly studied levels also include triadic level, collective level (e.g., nations), and network level (e.g., co-authorship network). With the purpose to provide a comprehensive review of levels-of-analysis issues in social network research, I examine all the aforementioned levels of analysis.

Levels of analysis of theory and hypotheses. Prior research of levels of analysis provides several frameworks that classify levels of analysis of theory and hypotheses (for details, see Dansereau et al., 1984; Klein et al., 1994; Rousseau, 1985; Mathieu & Chen, 2011). Essentially, levels of analysis of theory and hypotheses are jointly determined by the levels of analysis of all the focal variables in the theory/hypotheses. Theory and

hypotheses can be at a single level of analysis (e.g., individual, group, organization, network, etc.). For instance, the level of analysis of theory/hypotheses is individual level when dependent and independent variables are both at the individual level (e.g., one's cognitive ability predicts one's performance). There are also multilevel theory/hypotheses, which depict relationship between independent and dependent variables that operate at different levels of analyses (e.g., individual dependent variable and group independent variable). Finally, there are cross-level models where patterns of relationships exist across multiple levels of analysis (Dansereau et al., 1984). It should be noted that I did not differentiate mixed effect models and mixed determinants models from general multilevel models for the purpose of simplicity.

Levels of actors. When referring to "level of analysis" in a social network article, the authors often mean "levels of actors" or "levels of network" (e.g., Brass et al., 2004; Carpenter, et al., 2012). It is therefore necessary to clarify the linguistic confusion caused by the different use of the term "levels of analysis" in the social network research. I employ the term "*levels of actors*" to capture whether the focal network is composed of individuals (individual peoples as actors) or groups (groups as actors), or organizations (firms as actors), etc.

Incorporation of levels of analysis. Following the guidance of Yammarino, Dionne and Chun (2002) and Yammarino et al. (2005), I review three elements of a levels-of-analysis-based framework: *levels of analysis in theory formulation* (levels of analysis of the theory and hypotheses is explicitly specified), *levels of analysis in measurement* (measure variables at the same level at which they are conceptualized), and *levels of analysis in inference drawing or theory-data alignment* (empirical assessment is aligned

with theoretical development). Although Yammarino et al. (2002, 2005) also evaluated the appropriateness of the methodology employed analyzing multilevel data, I do not include that element in the current review. As an initial investigation, I am more interested in the framework surrounding network-based theory and hypotheses development and measurement, and as such include only the theoretical assessment, measurement assessment and alignment between theory and measurement in the current review.

General Research Questions

As in other fields of organizational research, there are critical levels-related issues remaining unsolved in social network research. For instance, a micro-macro divide exists in organizational network research, as it does in other areas of organizational sciences. The typical macro topics include interfirm relations (Westphal, Boivie, & Chng, 2006), alliances (Gulati, 2007), interlocking directorates (Mizruchi, 1996), etc.; whereas micro network research traditionally focuses on leadership (Pastor et al., 2002), teams (Reagans, Zuckerman, & McEvily, 2004), social influence (Sparrowe & Liden, 2005), etc.

In recent years, scholarly interest in building and testing multilevel and cross-level theory has inspired numerous studies in social network research that attempt to link macro with micro (Gnyawali & Madhavan, 2001; Ibarra, Kilduff, & Tsai, 2005). As research moves from single-level to multilevel, the level of complexity in measurement, data analysis, and theory-data alignment dramatically increases. Explicitly specifying levels of analysis of the focal constructs and the hypotheses also becomes more critical in multilevel studies than in single-level studies.

The purpose of the current study is to present a state-of-the-science review of levels-of-analysis issues in social network research. In so doing, our research findings can

inform researchers of what has been done, what has not been done, and where we are going, in terms of levels of analysis. Specifically, our general research questions are as follows:

Research Question #1: Are a majority of the published social network articles single-level studies?

Research Question #2: Do a majority of the published social network articles focus on individual-level actors (i.e., network of individuals)?

Research Question #3: Do a majority of the published conceptual social network articles explicitly represent the level of analysis in theory and hypothesis formulation?

Research Question #3a: Do a majority of the published empirical social network articles explicitly represent the level of analysis in theory and hypothesis formulation?

Research Question #4: Do a majority of the published empirical social network articles appropriately represent the level of analysis in measurement?

Research Question #5: Do a majority of the published empirical social network articles appropriately align theory and data when levels of analysis are considered?

METHODS

The current coding scheme builds on the levels-based research of Yammarino et al. (2002, 2005), and Dionne et al. (2012, 2014). However, the focus here is not on leadership research, but on conceptual and empirical articles on social networks. Other key differences between our review and prior levels-of-analysis state-of-the field reviews reside in the range of publication dates and the publication outlets, which are exclusively journal articles.

The articles included in this study were limited to 13 top-tier management and applied psychology journals for two reasons: 1) networks represent a fairly complex and recent research phenomena from a levels-of-analysis perspective and I assert top-tier

journals tend to publish more rigorous theoretical and methodological studies, and 2) the search yielded hundreds of high quality articles which represent a strong sample for an initial investigation. I searched six computerized databases (i.e., ABI/Inform, Business source complete, PsycInfo, Psycharticle, Elsevier Science Direct, and Saga Journal) that include most business and management journals, using key words: "managerial ties", "social ties", " social network", "social relationship (s)", "social capital", "embeddedness", "network organization", "knowledge management", "social cognition", "joint ventures", "joint alliances", and " board interlocks". Thus, all articles with at least one of the aforementioned key words in their title, abstract, or subject terms were collected.

Table 2. Frequency and Percent of Coded Articles in Journals

Journal	**Frequency**	**Percent**
Academy of Management Journal	66	26.5
Academy of Management Review	18	7.2
Administrative Science Quarterly	44	17.7
Group and Organization Management	8	3.2
Journal of Applied Psychology	9	3.6
Journal of Management Studies	30	12.0
Journal of Organizational Behavior	14	5.6
Journal of Management	14	5.6
Leadership Quarterly	5	2.0
Organizational Behavior and Human Decision Processes	5	2.0
Organization Science	35	14.1
Research in Organizational Behavior	1	.4
Total	**249**	**100**

My search started from the year of 1995, because key influential articles advocating multilevel or meso frameworks were published around that time (e.g., House et al., 1995; Klein et al., 1994; a two-part special issue on levels-of-analysis issues in *Leadership*

Quarterly, guest edited by Dansereau, 1995). As such, these articles seemingly triggered increased scholarly interest in levels-of-analysis issues in many areas of organizational science, including research regarding levels-based issues in social networks.

The journals included in the study are listed in Table 2. This preselection resulted in more than 800 articles. I evaluated abstracts from all articles and excluded any articles that did not include social network concepts (e.g., ones simply citing social capital theory in general without using any social network concepts in theory or methods sections). I also excluded general reviews which focused on a broad range of concepts and theories, as these articles did not aim to propose or establish a specific theory or model. Additionally, I focused only on articles that had a strong management base, and that examined the commonly studied subjects in the field of organizational behavior. I therefore excluded studies that studied community network, family or personal network, teenager friendship network, disease diffusion network, etc. The combined result of these searches resulted in 355 publications. I randomly selected 70% (249) from these articles as the sample of the current review. Random selection of a subsample from a larger sample has been used in prior research as a strategy to manage the work load of a content-coding study (e.g., Li, 2013). Of those 249 articles included in this review, 210 were empirical and 39 were conceptual. Publication dates ranged from 1995 through 2013.

Coding Process

Network components. For preliminary classification, all articles were coded as either "conceptual" (containing only theory and no data), or "empirical" (containing data). Meta-analyses and instrument development research also was coded as empirical. Next, according to data type, empirical articles were coded as qualitative, quantitative or both.

When data contained numbers associated with qualitative data, we coded articles as qualitative. Once articles were categorized as conceptual or empirical, we classified the network literature into eight streams (social capital, embeddedness, network organizations, board interlocks, joint ventures/alliances, knowledge management, social cognition and group processes) for organizational purposes and based on the review of Borgatti and Foster (2003).

Brass et al. (2004) note the relationships represented by the ties may have particular content and researchers may look at different kinds of networks, and networks of different kinds typically function differently (Borgatti & Foster, 2003). For example, ties in a friendship network may represent whether the pairwise friendship exist between nodes, whereas ties in an advice network may represent the flow of information or influence one has on the other. We therefore coded type of network being evaluated in each study. Based on prior literature (McPherson, Smith-Lovin, & Cook, 2001), we included seven types of network which represent the most commonly studied types of social network in organizational research: (1) friendship, (2) coworker and workflow, (3) advice and communication, (4) similarity, (5) cognitive network (who knows what, e.g., mental models, transactive memory) and knowledge network, (6) affective (e.g., likes or dislikes) and (7) transaction (e.g., making a sale).

Levels of analysis. We identified level of analysis of network actors and the level of analysis of theory and hypotheses in each study. The classification of levels of actors produced eight categories: indeterminable, individual, dyad, triad, group, organization, collective and network. For levels of theory and hypotheses, we had two additional categories aside from the eight mentioned above: multilevel and cross-level.

Additionally, we assessed whether publications addressed levels of analysis issues in theoretical formulation, empirical specifications (i.e., measurement) and inference drawing. We evaluated all conceptual and empirical publications for explicitly or implicitly incorporating levels of analysis in conceptual development, and we noted when the level of analysis was indeterminable. For all empirical publications, we also assessed whether levels of analysis were represented appropriately in measurement (i.e., concepts and measures were at the same level or aggregated appropriately; measures were not aggregated appropriately; concepts and measures were at different levels; or the level of measure was indeterminable).

Finally, as in prior levels-of-analysis reviews, all empirical publications were evaluated for alignment between conceptual (theory) and empirical (data) specifications. Inference drawing was assessed based on whether alignment was at the appropriate level; theory and data were at different levels of analysis; or the level of theory and data represented was indeterminable with regard to levels of analysis.

Coding Agreement

Coding of all journal articles was conducted by four trained coders (PhD students), who worked in two coding dyads and were unaware of the research questions. For practice purposes, 10 articles were first selected and assigned to each coder. Coders coded each article independently and compared ratings between all four, achieving an initial agreement rate of 71%. Areas of disagreement were discussed and recoded by all coders, to yield a post-discussion agreement rate of 100%. An additional practice steps involved 10 additional articles which coders first compared as dyads and then across dyads. For the remaining articles, the publications sample was split into two and each dyad coded half of

the articles. The initial agreement rate for one of the dyads was 79% and for the other 82%. After discussion, both coding teams reached agreement rates of more than 95%, and when coders within dyads could not agree, I acted as a tie-breaker.

As in prior reviews of levels-of-analysis, I note that the assessment of levels-of-analysis issues in theory, measurement and inference drawing was done in a liberal/generous way. Coders gave authors the "benefit of the doubt," trying to interpret/infer levels, even when these were less than explicit.

RESULTS

Results were analyzed based on the ratings from the two coding teams, each of which coded half of the articles included in the present review. Among these 249 articles coded, 15.66% were conceptual, and 84.34% were empirical. For the empirical studies, 8.1% of the empirical studies used qualitative data, 69.7% of the empirical studies used quantitative data, and 18.9% used both qualitative and quantitative data.

I first present results classified via one of the eight key research streams (Borgatti & Foster, 2003), in terms of levels of actors , levels of analysis of theory and hypotheses, levels represented in theoretical formulation, measurement, and theory-data alignment (for a summary, see Table 3, 4 and 5). The appropriate incorporation of levels of analysis was assessed by the number of articles achieving the highest standard of levels specification in theory formulation, appropriate measures of variables and appropriate theory-data alignment (i.e., explicitly stated the level where theory was formulated; concept(s) and measures were at the same level, and alignment between theory and data was at the appropriate level of analysis). For conceptual articles, levels in measurement and theory-data alignment were not applicable as there was no data collected and analyzed in these

studies. What follows is the summarized results across all eight key research categories in terms of the distribution of journals, levels of actors, types of network, levels of theory and hypotheses, and levels of analysis represented in theory formulation, measurement and theory-data alignment.

Social Capital

This line of research focuses on the value of social ties, and investigates the relationship between a person's social ties or network position to significant outcomes such as performance, power, leadership, mobility, employment, creativity and so on (Bartkus & Davis, 2009). Some example topics in this category include social support (James, 2000), social resource (Lin, 1988) and structural holes (Granovetter, 1973). Consistent with the findings in prior reviews (e.g., Borgatti & Foster, 2003), results showed social capital is the most popular and the most studied area. Out of 249 articles, 92 (36.9%) were classified into Social Capital.

Conceptual. Of the articles coded in this category, 15.2% (14/92) were conceptual. Among these conceptual articles, a majority (64.3%, 9/14) of the articles studied individuals as actors of the focal network and 28.6% studied organizations as network actors. Furthermore, 85.7% were multilevel studies, meaning the concepts of interest in these articles were at multiple levels of analysis (e.g., individual social ties as independent variable, organizational performance as dependent variable) rather than at a single level of analysis (e.g., individual social ties as independent variable, individual performance as dependent variable), although only 35.7% (5/14) explicitly specified the levels of analysis in theoretical formulation.

Table 3. Incorporation of Levels of Analysis in Conceptual and Empirical Articles by Research Stream

Research stream	Conceptual articles	Empirical articles			Empirical and conceptual articles combined
	Levels in theoretical formulation *(explicit)*	**Levels in theoretical formulation** **(***explicit)*	**Levels in measurement** *(same level of aggregated appropriately)*	**Levels in inference drawing** *(aligned)*	**Levels in theoretical formulation** *(explicit)*
Social capital	5/14 (35.7%)	21/78 (26.9%)	57/78 (73.1%)	67/78 (85.9%)	26/92 (28.3%)
Embeddedness	2/4 (50%)	7/19 (36.8%)	16/19 (84.2%)	16/19 (84.2%)	9/23 (39.1%)
Network organizations	5/7 (71.4%)	7/20 (35%)	15/20 (75%)	16/20 (80%)	12/27 (44.4%)
Board interlocks	0/1 (0%)	1/10 (10%)	7/10 (70%)	10/10 (100%)	1/11 (9.1%)
Joint ventures	0/2 (0%)	9/23 (39.1%)	15/23 (65.2%)	18/23 (78.3%)	9/25 (36%)
Knowledge management	0/2 (0%)	3/12 (25%)	9/12 (75%)	12/12 (100%)	3/14 (21.4%)
Social cognition	2/4 (50%)	3/11 (27.3%)	6/11 (54.5%)	10/11 (91%)	5/15 (33.3%)
Group processes	1/5 (20%)	13/37 (35.1%)	22/37 (59.5%)	31/37 (83.8%)	14/42(33.3%)
All approaches	15/39 (38.5%)	64/210 (30.5%)	147/210 (70%)	180/210 (85.7%)	79/249 (31.7%)

Table 4. Levels of Actors by Research Stream

Categories	0	1	2	3	4	5	6	7	Total
Social capital	3	64	1		5	16		1	90
Embeddedness	2	7	2		1	9	1		22
Network organizations	1	8	2		1	15			27
Board interlocks	3				8				11
Joint ventures	1	4			1	17	1	1	25
Knowledge management	9				1	4			14
Social cognition	1	12				1		1	15
Group processes	34	2			5	1			42
	54	97	5	0	22	63	2	3	246

Note: 0 = Indeterminable; 1 = Individual; 2 = Dyad; 3 = Triad; 4 = Group; 5 = Organization; 6 = Collective; 7 = Network.
Levels of actors in three articles coded in the current review were indeterminable.

Table 5. Levels of Analysis of Theory and Hypotheses by Research Stream

Categories	0	1	2	3	4	5	6	7	8	9	Total
Social capital	4	24	2		6	7			49		92
Embeddedness						2		3	22		27
Network organizations	2	2	2	1		2	2	2	10		23
Board interlocks						2			9		11
Joint ventures	1		2			3	1	3	15		25
Knowledge management					1	1		1	11		14
Social cognition	1	1					1	2	10		15
Group processes	1	6	3		7				23	2	42
											249

Note: 0 = Indeterminable; 1 = Individual; 2 = Dyad; 3 = Triad; 4 = Group; 5 = Organization; 6 = Collective; 7 = Network; 8 = Multilevel; 9 = Cross-level

Empirical. In this category, 84.8% (78/92) of the articles coded were empirical. Individuals (70.5%) and organizations (15.4%) were also the primary levels of network actors. In terms of levels of analysis of the theory and hypotheses, 47.4% were multilevel

studies, and 30.8% were individual-level studies. Only 26.9% explicitly specified the levels of analysis in theory. Levels reflected in measurement and alignment of theory and data were both high (73.1% and 85.9%, respectively).

Embeddedness

Embeddedness is often defined as the nesting of firms or market behavior in a social context. "Embeddedness was basically the notion that all economic behavior is necessarily embedded in a larger social context" (Borgatti & Foster, 2003: 994). Embeddedness literature usually explores how embedded ties affect the choice of joint venture partners, consumer purchasing decisions, the continuity of client relations, and the performance of firms. Of all the articles we coded, 9.2% (23/249) were categorized into Embeddedness.

Conceptual. In this category, 17.4% (4/23) of the articles were conceptual, 50% of which focused on organizations as network actors, and the levels of theory and hypotheses were equally distributed on indeterminable, dyad level, organization level, and multilevel (all 25%). Two of the four conceptual articles in this category explicitly stated the levels of analysis in theory.

Empirical. For empirical articles, a majority of the articles had a focus on either individuals (36.8%) or organizations (36.8%) as network actors, whereas multilevel was the predominant levels of analysis for theories and hypotheses (47.4%). Of these articles, 36.8% explicitly specified the levels of analysis in theory. Levels reflected in measurement and alignment of theory and data were both high (84.2% for both).

Network Organizations

This stream of research takes a structural perspective, and argues "every form of organization is a network" (Podolny & Page, 1998: 59). Network organizations are viewed

as organizational forms characterized by "repetitive exchanges among semi-autonomous organizations that rely on trust and embedded social relationships to protect transactions and reduce their costs" (Borgatti & Foster, 2003: 996). Of all the articles coded in the current review, 27 were categorized into Network Organizations.

Conceptual. In this category, 25.9% (7/27) of the articles were conceptual. Of these conceptual articles, 71.4% (5/7) studied organizations as actors of the focal network, as this line of research has a macro-level focus in nature. Additionally, 85.7% were multilevel studies, and 71.4% explicitly specified the levels of analysis in theory.

Empirical. The majority of the articles in this category were empirical (74.1%, 20/27). For empirical articles, half of the articles coded focused on organizations (10/20) as network actors and 30% focused on individuals. In terms of levels of analysis of the theory and hypotheses, multilevel was the predominant levels of analysis (80%), although only 35% explicitly specified the levels of analysis in theory. Levels reflected in measurement and theory-data alignment were both high (75% and 80%).

Board Interlocks

An interlocking directorate occurs when a person of one organization sits on the board of directors of another organization (for a review, see Mizruchi, 1996). This line of literature has examined causes and consequences of interlock ties, diffusion of poison pills or diffusion of innovation, corporate acquisition behavior, the adoption of organizational structures, joint venture formation, and the use of imitation strategies, etc. Of all the articles included in this review, 11 articles were coded as Board Interlocks.

Conceptual. There was only one conceptual article in this category, which studied individual-level actor and theory, and implicitly specified the levels of analysis in theory.

Empirical. The remainder of the articles in this category were empirical (90.9%, 10/11). Organization level (80%) was the primary level of network actors. In terms of levels of analysis of the theory and hypotheses, 80% were multilevel studies. Only 10% explicitly specified the levels of analysis in theory, although levels reflected in measurement and theory-data alignment were both high (70% and 100%).

Joint Ventures and Alliances

This line of literature has focused on explaining and understanding why organizations form joint ventures and alliances and how they choose their partners (Gulati, 2007). Specifically, this line of literature has examined the effect of inter-firm alliances, innovation and learning, information sharing, firm performance, etc. The coders identified 25 article as Joint Ventures and Alliances.

Conceptual. There were only two conceptual articles in this category with one being a network-level study and other being a multilevel study. Both articles implicitly specified the level of analysis in theory.

Empirical. In this category, 92% (23/25) of the articles were empirical. More than half of the articles focused on organizations (16/23) as network actors. In terms of levels of analysis of the theory and hypotheses, multilevel was the most prevalent level of analysis (60.9%), followed by organization level of analysis (13.0%). However, only 39.1% explicitly stated the levels of analysis in theory. Levels reflected in measurement and alignment of theory and data were 65.2% and 78.3%.

Knowledge Management

This line of research primarily focuses on how knowledge is created, utilized, and transferred (Brown & Duguid, 2000). The coders identified 14 articles as Knowledge

Management studies.

Conceptual. There were only two conceptual articles in this category, both of which were multilevel studies, focused on individual-level actors, and implicitly specified the levels of analysis in theory.

Empirical. The remainder of the articles were empirical (85.7%, 12/14). For these articles, the primary level for network actors was individual level (58.3%, 7/12), followed by organization level (33.3%). In terms of levels of analysis of the theory and hypotheses, 75% were multilevel studies, although only 25% explicitly specified the levels of analysis in theory. Levels reflected in measurement and inference drawing were both high (75% and 100%).

Social Cognition

This research stream concerns the perception of networks (Krackhardt, 1990). It focuses on the methodological implications of respondents' inability to report their interactions accurately and as well as the respondents' theoretical model of the entire network. The coders categorized 15 articles into Social Cognition.

Conceptual. There were four conceptual articles in this category. For these articles, the primary levels for actors and for theory and hypotheses are individual level (50%) and multilevel (50%) respectively. Half (2/4) explicitly specified the levels of analysis in theory.

Empirical. Nearly three-quarters (73.3%, 11/15) of the articles coded in this category were empirical, among which, individual level was the predominant levels for network actors (90.9%, 10/11). In terms of levels of analysis of the theory and hypotheses, 72.7% (8/11) were multilevel studies, although only 27.3% explicitly specified the levels

of analysis in theory. Levels reflected in measurement and alignment of theory and data were both high (54.5% and 90.9%).

Group Processes

This line of literature is concerned with how physical proximity, similarity of beliefs and attitudes, amount of interaction, and affective ties are interrelated. This research stream has investigated topics such as conflict, social referent choices, interaction between personality and network position, evolution of group structure, group stability, growth of friendship networks, trust networks and so on (Borgatti & Foster, 2003). The coders identified 42 articles into Group Processes.

Conceptual. In this category, five articles were conceptual. Most (80%, 4/5) of these conceptual articles studied individuals as actors of the focal network, and 80% were at multilevel of analysis for levels in theory and hypotheses. However, only 20% explicitly silicified the levels of analysis in theory.

Empirical. Of the articles coded in this category, 88.1% (37/42) were empirical. Individual level was the primary level of network actors (81.1%, 30/37), followed by group level (10.8%, 4/37). In terms of levels of analysis of the theory and hypotheses, 51.4% were multilevel studies, 16.2% were group-level studies and 16.2% were individual-level studies. For levels of analysis in theory, 35.1% were explicit. Levels reflected in measurement and alignment of theory and data were 59.5% and 83.8%, respectively.

Summary across Research Categories

Sources. The following journals produced the majority of articles included in the sample: *Academy of Management Journal* (66/249, 26.5%), *Administrative Science Quarterly* (44/249, 17.7%), *Organization Science* (35/249, 14.1%), *Journal of*

Management Studies (22/249, 8.8%) *and Academy of Management Review* (18/249, 7.2%), *Journal of Organizational Behavior* (14/249, 5.6%) and *Journal of Management* (14/249, 5.6%).

Levels of theory and hypotheses. A majority of articles coded were theorized at multiple levels of analysis (59.8%). Among the single-level studies, individual level was the most common level of analysis (13.3%), followed by organization level (6.8%) and group level (5.6%). In response to Research Question #1 *(Are a majority of the published social network articles single-level studies?)*, the overall data reflected that the great majority of studies were multilevel; single-research only accounts for less than 40%.

Levels of actors in the focal network. More than half of the articles (56.6%) coded in this review focused on individual actors (see Table 6). This may be related to the large number of studies in the area of social capital, which typically studied individual-level concepts. The results supported my Research Question #2 *(Do a majority of the published social network articles focus on individual-level actors?).* The second most studied level for network actors was organization level (28.5%), as research streams such as embeddedness, network organizations and joint venture and alliances typically have a macro-level emphasis. Network actors at other levels (e.g., dyad, triad, and group) received significantly less attention than individual and organization levels (14.5% altogether).

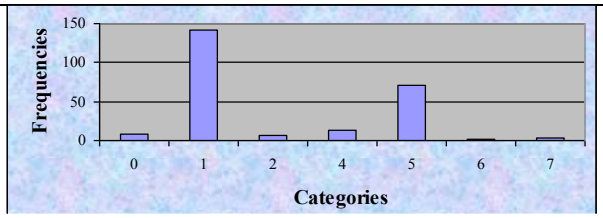
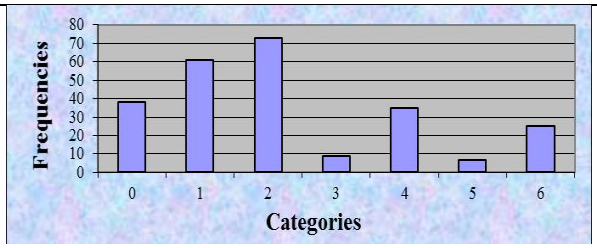
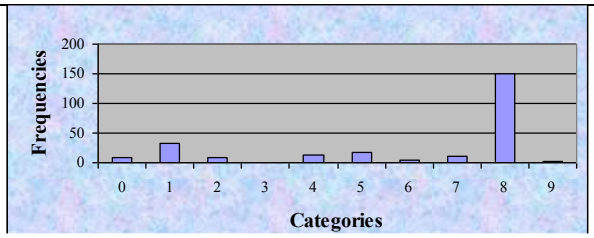
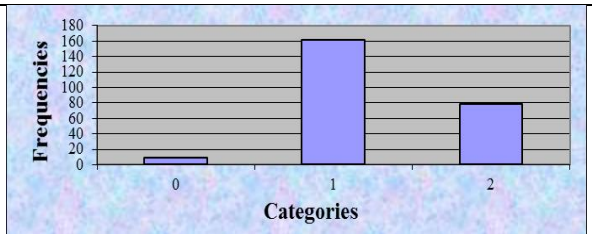
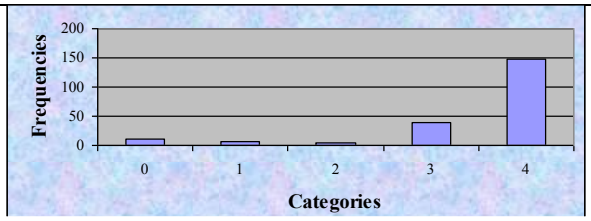
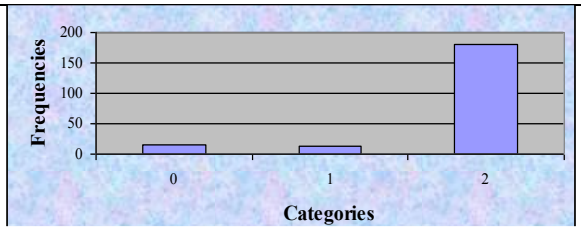
Type of network. According to the results, the most studied types of networks published in top-tier journals were advice and communication networks (29.3%), co-worker and workflow networks (24.5%), friendship networks (15.3%) and cognitive and knowledge networks (14.1%). Similarity networks and affective networks received far less

scholarly interest as compared with the other types of networks (3.6% and 2.8%, respectively).

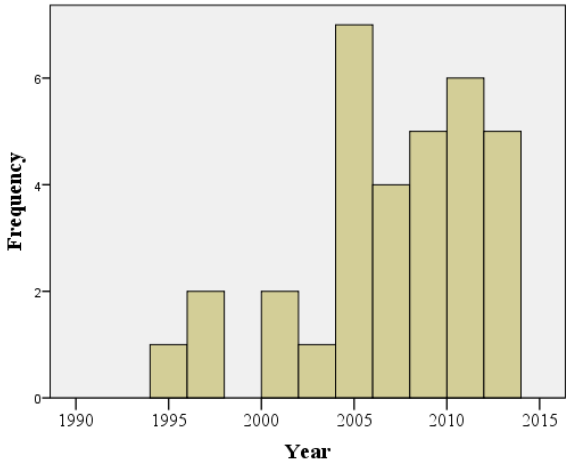
Appropriate incorporation of levels of analysis. Despite the popularity of multilevel theories and models in the research of social networks, only 31.7% of all the articles (38.5% for conceptual articles and 30.5% for empirical articles) coded in this review explicitly stated the levels of analysis in their theory formulation. Therefore, in response to Research Question #3 *(Do a majority of the published conceptual social network articles explicitly represent the level of analysis in theory and hypothesis formulation?)* and #3a (*Do a majority of the published empirical social network articles explicitly represent the level of analysis in theory and hypothesis formulation?*), few articles explicitly specified the level of analysis in conceptual development for both conceptual and empirical social network articles. In contrast, levels represented in measurement and theory-data alignment were high (59% and 72.3%, respectively). Therefore, for Research Questions #4 and 5 *(Do a majority of the published empirical social network articles appropriately represent the level of analysis in measurement and reference drawing?)*, results showed that a majority of articles appropriately measured variables and aligned theory and measurement in regard to levels of analysis.

Research trend over time. Over time, the numbers of both individual- and multilevel-studies are increasing (see Figure 17). Studies at other levels had too few cases to show any significant pattern. I also examined the trajectory of levels-of-analysis incorporation (as shown in Figure 18). According to the results, there is a generally positive increase in the explicit incorporation of levels of analysis into theory development, measurement, and theory-data alignment for research of social network.

Table 6. All Categories Summary: Overall Descriptive Statistics

Levels of actors *Indeterminable = 0; Individual = 1; Dyad = 2; Triad = 3; Group = 4; Organization = 5; Collective = 6; Network = 7*	
Type of network *Friendship = 0; Coworker & Workflow = 1; Advice & communication = 2; Similarity = 3; Cognitive network & knowledge network = 4; Affective = 5; Transaction = 6*	
Levels of theory and hypotheses *Indeterminable = 0; Individual = 1; Dyad = 2; Triad = 3; Group = 4; Organization = 5; Collective = 6; Network = 7; Multilevel = 8; Cross-level = 9.*	
Levels in theoretical formulation *Indeterminable = 0; Implicit = 1; Explicit = 2*	
Levels in measurement *Indeterminable = 0; Concepts and measure(s) at different levels = 1; Measure(s) not aggregated appropriately to level of concept = 2; Measure(s) at one level, but aggregated appropriately to level of concept(s) = 3; Concepts and measure(s) at same level = 4*	
Levels alignment *Indeterminable = 0; Theory at some level other than data level = 1; Yes, at appropriate level = 2*	

a) Individual Level Theory and Hypotheses



b) Multilevel Theory and Hypotheses

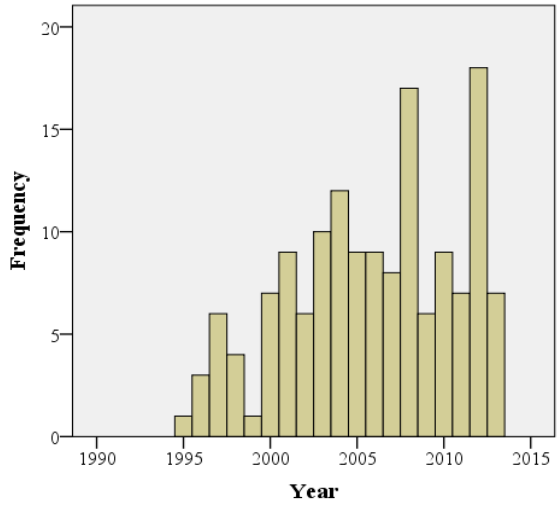
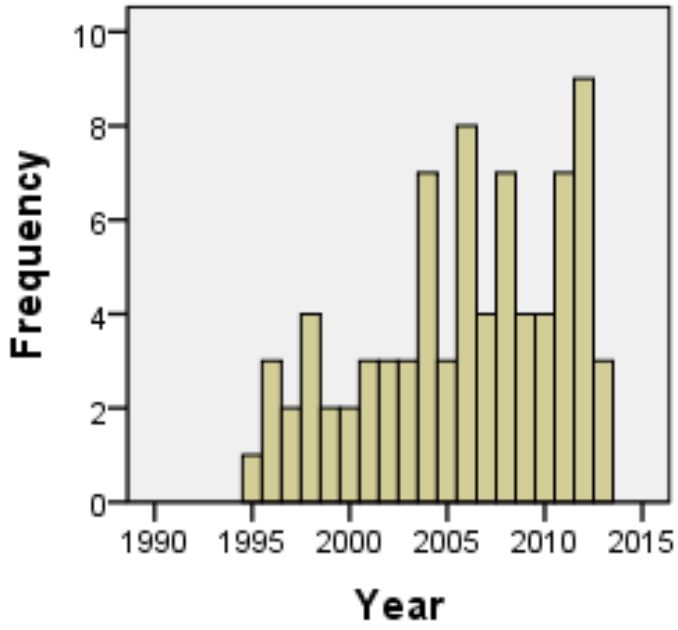


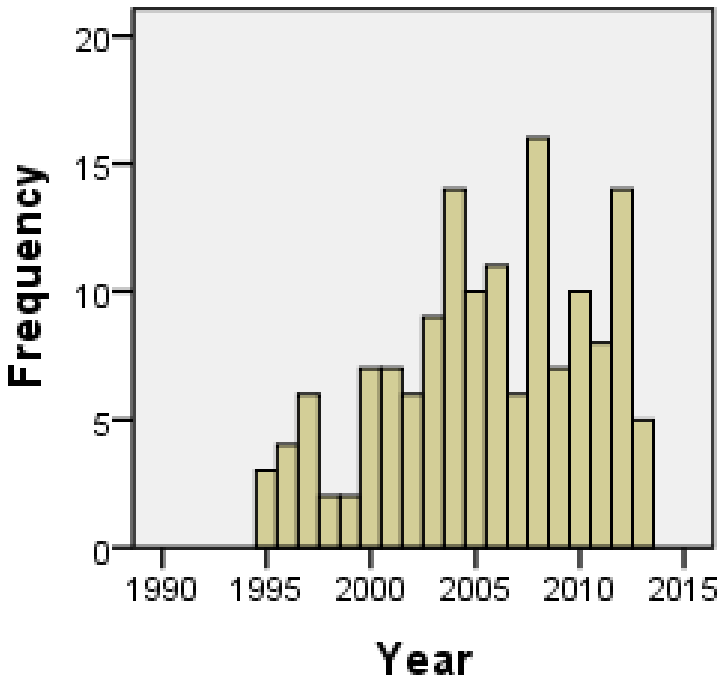
Figure 17. Levels of Analysis in Theoretical Formulation over Time.

Note: Horizontal axes in a) and b) indicated the number of articles that developed individual-level theory and hypotheses (Figure 17a) and multilevel theory and hypotheses (Figure 17b).

a) Levels of Analysis in Theory Formulation



b) Levels of Analysis in Measurement



c) Levels of Analysis in Theory-data Alignment

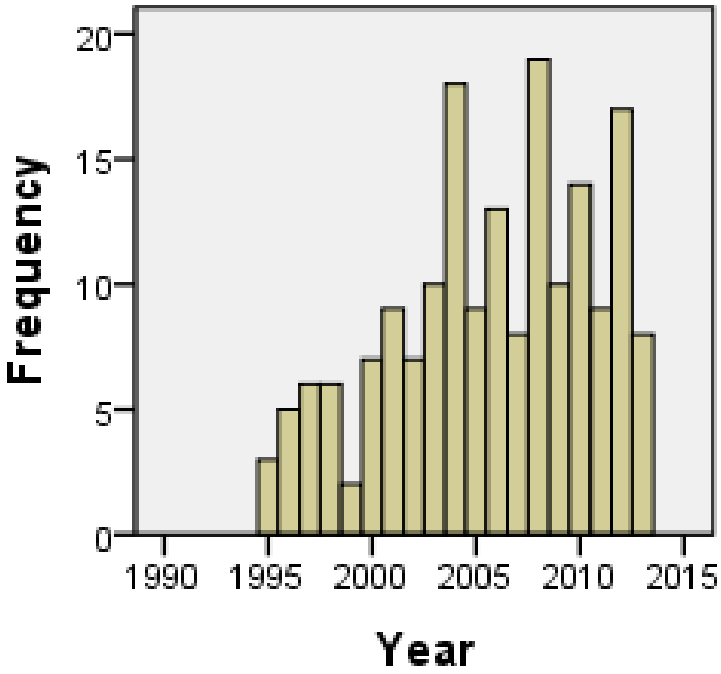


Figure 18. Appropriate Incorporation of Levels of Analysis over Time.

Note: Horizontal axes in a), b) and c) showed the number of articles that achieved the highest standard of the incorporation of levels of analysis in theory formulation, measurement and theory-data alignment.

DISCUSSION

The last decade has witnessed rapid growth and significant developments of social network research (Burt, Kilduff, & Tasselli, 2013). There are many general and specialist introductions that provide overviews for well-established theories in every research stream of social network literature (e.g., Borgatti & Foster, 2003; Brass et al., 2004; Hansen, Shneiderman, & Smith, 2011; Wasserman & Faust 1994; Newman 2010). In my review, I focus specifically on levels-of-analysis issues in social network research. The purpose of this study is to inform researchers in the areas of both social network and levels of analysis

of *where we have been* and *where we are going*, in terms of incorporation of levels-of-analysis perspective in conceptual development, empirical assessment and inference drawing.

In general, the results showed multilevel theories and models are of great popularity in all the research streams of social networks, even in the fields where the literature traditionally has a micro focus (e.g., social capital). Nearly 60% of all the articles coded in this review were multilevel studies. Although noted in prior research that there have been "few bridges linking [the micro-macro gap], and no joint agenda" (Ibarra et al., 2005, p. 359), our findings showed substantial effort has been made to understand and explain complex organizational phenomena that involve variables residing at multiple levels of analysis. This may suggest that social networks, as a research field, where plentiful well-established theories and a set of advanced analytic techniques have been developed, provide researchers with great opportunities to investigate multilevel relationships and dynamics.

Despite the prevalence of multilevel studies, the assessment of appropriate incorporation of levels of analysis in theoretical formulation showed there is still significant room for improvement. Less than one third of all the articles included in this review explicitly specified the levels of analysis in theory/hypotheses. The rest of articles either implicitly implied the levels or left the levels of their theory and hypotheses unclear. Compared with the low rating of levels of analysis in theory formulation, levels of analysis in measurement and inference drawing were both high (59% and 72.3%, respectively), indicating the majority of articles measured the focal variables and drew inference at appropriate levels of analysis.

However, this finding was insufficient to conclude the network research has appropriately dealt with levels-of-analysis issues. First, nearly one-third of articles coded were single-level studies, in which the degree of complexity and difficulty in the process of data collection tended to be lower than that in multilevel studies. Second, the articles included in this review were published in the most prestigious journals, which typically represent the highest standards of rigorousness and robustness in both theoretical formulation and empirical assessment. It is therefore highly likely that the ratings of levels in measurement and theory-data alignment were overestimated.

In addition to the levels-related issues, this review also provided insights concerning the research trends in social network literature. Generally, the focus on interpersonal networks (individuals as actors) and interorganizational networks (organizations as actors) were predominant. Nearly 90% articles examined either interpersonal or interorganizational networks. Social networks as a useful lens that provides a structural perspective to view individuals, groups, organizations, and collectives may greatly benefit current research if researchers can take full advantages of what it offers. Future research may want to place more emphasis on other levels of actors (e.g., dyads, triads, groups, etc.)

Also, the most studied types of networks were co-worker and workflow networks, advice and communication networks, and friendship networks. The least studied networks were cognitive networks and affective networks. While cognitive and affective networks are important, their dynamism and within-person changes are somewhat more difficult and invasive to assess and/or measure. Moreover, considering that individual-level dynamic models are complicated, adding a network structure to include several individuals'

dynamic cognitions and affective components increases the complexity significantly. However, as the field of networks science evolves, it is likely that advances in research techniques will increase the frequency with which these types of studies occur.

Implications and Future Directions

Given the above findings, implications and future directions for the field of social network can be derived. First and foremost, as more attempts are made to bridge micro-macro gap by encompassing multiple levels of analysis in theories and models, it is important to clarify levels of analysis in theoretical formulation, measure variables at appropriate levels, and assure the alignment of theory and data. As emphasized in Dionne et al. (2014),

> Researchers need to understand that levels of analysis are a complete theoretical and methodological framework, not merely a data analytic tool. Levels of analysis investigations begin with sound theoretical development of constructs. Researchers should answer questions as to why we expect variables to be relevant at certain levels of analysis, and also why we would expect those same variables not to be relevant at other levels of analysis. (p, 1023)

As social network research tends to shift from single level of analysis to multilevel of analysis, levels of analysis in theory development, measurement, data analysis and theory-data alignment may become more problematic. I therefore call for a more deliberate and comprehensive consideration of levels-of-analysis issues when building and testing multilevel theories in social network research.

Second, some preliminary effort has been made to integrate levels-of-analysis perspective and social network approach (Moliterno & Mahoney, 2011). One possible

integration is to establish multilevel-network frameworks as suggested in Moliterno and Mahoney (2011), Contractor et al. (2011), and Contractor et al. (2006), in which social network is viewed as multilevel systems of nested networks. Essentially, the notion of system of nested networks suggests that each node in a network at a focal level of analysis is a network at a lower level of analysis, and a closer examination of the characteristics of lower level network is critical as they can have a significant effect on the higher-level network.

Another possible way of integrating these two areas of research may be to view social network as a unit of analysis, which is not limited by the formal organizational levels and can be employed to study flexible and informal entities. Mathieu and Chen (2011) point out several critical limitations exiting in the current levels-of-analysis paradigm (e.g., nesting assumption, unit problem, etc.), and suggest the use of social network may help address these issues. By adding network level of analysis to the current levels-of-analysis framework, the traditional and discrete perspective of levels of analysis (i.e., individual, dyad, group, collective, etc.) may be transformed to a continuous perspective. Also briefly mentioned in Dionne et al. (2014), a discrete view of levels of analysis may have limited use in examining organizational phenomena which involve complex and fluid memberships. I therefore suggest future research explore the possibility of complementing the current levels-of-analysis framework with social network perspective to better represent and analyze the structure of focal entities and build theories with more accuracy and rigor.

Limitations

As is the case with any study, there are several limitations associated with the current research that are worth being acknowledged. First, the coding scheme employed is based on subjective judgments of social network theory categorization. While I have built on prior research to develop the social network categories, there were a few studies that did not seem to perfectly fit any of these categories. The great majority of these were placed under "Group Processes" (e.g., Dobrow, Chandler, Murphy & Kram, 2012).

Second, some articles could have been included in two or three of our categories. For example, Gopalakrishnan, Scillitore & Santoro (2008) could have been included both in joint ventures and in social capital research. Literature reviews on social networks could also be placed under multiple categories. Additionally, because of the nature of theory, some categories present a certain level of overlap (e.g., knowledge management and social cognition).

I strived to mitigate the effects of categorization judgments by using a detailed coding of the variables within each article and by having a team of coders and a tie-breaker assessing and ultimately deciding on the placement of articles within categories. However, I do acknowledge the fact that a different set of coders could subjectively place certain articles under other categorization schemes.

Last, for the purpose of this research I have focused only on three of the four aspects previously assessed by prior literature on levels of analysis reviews (e.g., Yammarino et al., 2005): theory formulation, measurement and inference drawing. Future work could go into more depth in terms of methodological issues and review data analysis issues as well

for empirical work, to complement our findings and provide a more comprehensive assessment of levels of analysis incorporation in the current social network research.

Conclusion

Social network research has huge potential to investigate complex organizational phenomena that involve concepts and relationships at multiple levels of analysis. Researchers in this field need to be prepared to employ multilevel approaches in their studies. Conceptualizing and testing of multilevel theories call for an appropriate incorporation of a levels-of-analysis perspective. This review hopes to provide a comprehensive state-of-the-science picture of levels-related issues for social network research. Our ultimate goal is to help build more rigorous multilevel social network theories.

SUMMARY

Research in the field of management had a long history of being fractionated and divided into macro and micro domains. There was little communication between the two camps and limited effort attempting to integrate macro and micro research. About three decades ago, a group of scholars foresaw the benefits of bridging the two areas and envisioned the field of management as a multilevel and interdisciplinary science of organizations. Since then, many multilevel frameworks, typologies and techniques have been developed and have stimulated substantial research focusing on multilevel organizational phenomena.

I assert multilevel approaches will continue to play an important role in helping researchers reveal the richness of social behavior. Furthermore, I believe an incorporation of social network theory and methods into the traditional multilevel framework will offer great potential for advancement of organizational science. Social networks can be viewed as a structure- and relationship-based level of analysis, and offer a distinctive lens to study organizational dynamics. By integrating social network and levels of analysis approaches, this dissertation aims to develop a continuous view of levels of analysis that will help multilevel research accommodate the increasing complexity, flexibility and dynamics in today's organizations. Three essays are developed to accomplish this goal. Essay 1 advances a theoretical framework for an integration of social network theory with the traditional levels of analysis perspective, and proposes a set of boundary conditions for the

use of this integrative framework. Drawing on the results derived from agent-based modeling and simulations, Essay 2 provides empirical support for a network-based approach to studying leadership and team processes. Essay 3 adopts a content analysis method and examines the levels of analysis related issues in the current social network research, seeking to lay the groundwork for future development of the proposed integrative approach.

Recent research anticipates a fundamental shift in the current multilevel paradigm may take place soon. This dissertation hopes to contribute to this paradigm shift, and serve as preliminary evidence for an integration of social network theory and levels of analysis research as a promising area for further theoretical and methodological developments.

APPENDIX

References for Coded Articles in Essay 3

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