COMPLEXITY LEADERSHIP IN INDUSTRIAL INNOVATION TEAMS: A FIELD STUDY OF LEADING, LEARNING AND INNOVATING IN HETEROGENEOUS TEAMS

by

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A Dissertation submitted to the
Graduate School-Newark
Rutgers, The State University of New Jersey
in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy
Graduate Program in Management
written under the direction of
Nancy DiTomaso
and approved by

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Newark, New Jersey
January, 2011
ABSTRACT OF THE DISSERTATION

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Innovation teams comprised of heterogeneous specialists are prevalent in industrial company innovation systems because these teams are perceived to possess special learning and innovative capabilities. There has been insufficient research on how leadership can help create the dynamics advantageous to learning and innovating in heterogeneous teams. Complexity Leadership Theory endeavors to address this issue (Marion & Uhl-Bien, 2001; Uhl-Bien, Marion, & McKelvey, 2007; Uhl-Bien & Marion, 2009). This study uses the insights from Complexity Leadership Theory and from research on team creativity, team innovation, small group process, group learning and team heterogeneity to develop and test a model of complexity leadership in innovation teams. Complexity leadership, which is examined with regard to the influence shared among the team leaders and the team members, is proposed to be positively linked to innovation team outcomes. The model is tested with quantitative data from a field study of 59 innovation teams from 25 industrial companies and informed as well by qualitative data on 5 teams from 3 companies. Complexity leadership was found to have a positive effect on collaborative learning, innovation enabling behaviors, and perceived performance. The analysis tested the mediation effects of collaborative learning and the existence of a heterogeneity norm on the relationship between complexity leadership and team outcomes. Collaborative learning was found to mediate this relationship and some support was found as well for a mediating effect of the existence of a heterogeneity norm. The expectation that complexity leadership would moderate the effects of job relevant
heterogeneity on innovation enabling behaviors and perceived performance received only moderate limited evidence of support.
Preface

Acknowledgements

There are many people who challenged me with new thinking and who supported me throughout the doctorate program and this research. I thank them all and want to recognize many of them.

Some were central in supporting my research progress. Nancy DiTomaso guided me into and throughout the program and through the development of my research and dissertation. Corinne Post taught me about analysis and was an important compatriot as we sought to make valuable contributions through our research to the companies of the Industrial Research Institute (IRI) and beyond. Corinne was integral to the overall project; she co-developed and co-tested the survey tool with me, led the effort to recruit and gather data for half of the teams used in my dissertation, and converted our raw data to SPSS data. George Farris was a centering force and taught me to keep things focused and to go deep in my thinking and research. For their help, I am deeply grateful.

Some were teachers who opened up new perspectives and knowledge. Ya-ru Chen introduced me to the leadership literature and helped me form the initial ideas which led to my research topic. Deborah Dougherty reframed my thinking about organizations and was instrumental in my understanding of emergence which also led to my research topic. Chao Chen showed me the value and difficulty presented by different cultures in organizations. John Cantwell taught me to see the macro view of knowledge transfer and creation. Peter Gillett taught me through his example, the discipline required for scientific endeavors. I benefited greatly from their desire to share their knowledge.

Some who helped were colleagues who furthered my work. Rob McNamee set our sights on producing creative useful work and was the master of methods. Tom Tirpak and Raju Borwankar, whom I recognize posthumously, led the project associated with my research for the IRI. Thank you.

Some were the theorists upon whose work I built my thinking. Jim Hazy of Adelphi University introduced me to the network of complexity leadership scholars. Mary Uhl-Bien is my theoretical and practical guide. She possesses and shares inspiring knowledge and feeling.

I wish to thank the Technology Management Research Center for funding and the IRI for support which helped make my research possible. Additional funding was provided from the Rutgers-Lehigh National Science Foundation grant under award # SES-085267 which supported the data collection effort. Also, I am grateful to Terri Kurtzberg and Cindy McCauley for their participation on my committee.
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CHAPTER ONE
INTRODUCTION TO THE STUDY
Context and Purpose of the Study

Dynamic overarching trends, such as globalization, technological revolution and morphing industry and company demarcations, are compelling industrial organizations to focus on increasing learning and innovating (Eisenhardt, 1989; Jennings & Haughton, 2000; Prusak, 1996). Innovations in new products and in new ways of doing business become imperatives for companies to survive and prosper. In this complex environment, leveraging knowledge assets becomes more critical for success than management of physical assets (Boisot, 1998). The success of an industrial company now rests on its organizational intelligence, that is, its capacity to learn new knowledge (Cohen & Levinthal, 1990) and its creative use of knowledge (McKelvey, 2001; Quinn, Anderson, & Finkelstein, 2002). Organizational arrangements, such as distributed knowledge networks (Miles, Snow, Matthews, & Miles, 1999) and innovation teams (Farris & Cordero, 2002; Mumford, 2000), which enable the leveraging of intellectual assets, have become commonplace. Within these new arrangements, both the work and the social relationships among people performing the work become more interdependent and more fluid (Zammuto, Griffith, Majchrzak, Dougherty & Faraj, 2007).

Leadership must also change to fit the knowledge work of these new arrangements. To avoid limiting knowledge flows and knowledge creation, leadership can no longer operate as the directing mind from the top, nor act as the only bridge across organizational boundaries and knowledge barriers. Historically, conceptions of leadership were necessarily tied to prevalent bureaucratic hierarchical structures, favored stability rather than adaptability, and were oriented to lead for efficiency and control, appropriate to manufacturing (Jones, 2000). A unifying paradigm for recent leadership conceptions is the leader to follower(s) dynamic which emphasizes the symbolic, motivational and inspirational actions of leaders with followers. While their means vary, different
leadership theories explain how leaders influence followers to align their efforts to accomplish something desired by the leader. Different means include, for example, a leader’s dominating personality and heightened prestige with followers (Hogg, 2001), leader task oriented and relationship oriented behaviors toward followers (Fiedler, 1964; Likert, 1961), fair exchanges between leader and followers (Hollander, 1964), development of valued relationships between leader and followers (Graen & Uhl-Bien, 1995), and leader’s inspirational behavior heightening followers’ emotional involvement and commitment (Bass, 1985).

The imbalance of influence inherent in the leader to follower paradigm becomes a stumbling block, however, in knowledge based organizations. Knowledge and ideas residing anywhere, at any level are the critical factors for survival and success and must be permitted the possibility of having influence. Influence is no longer understood to be limited to interactions involving leaders but is seen to occur anywhere at anytime in an organization (Yukl, 2009; Yukl & Falbe, 1990) through interactions involving knowledgeable members whatever their level or location.

In response to this, new leadership approaches are emerging that better enable learning and innovation to originate and to be propagated throughout the company (Achtenhagen, Melin, Mullern, & Ericson, 2003; Tichy, 2002). This new type of leadership (Ekvall & Arvonen, 1991, 1994) increases knowledge flows so that new ideas are prompted; reduces adherence to plans so that adaptive decisions can be made; and encourages greater cooperation so that organizational change can occur. Leadership is reconceived as a dynamic for adaptation.

Recently, a new theory of leadership, complexity leadership (Marion & Uhl-Bien, 2001; Uhl-Bien, Marion, & McKelvey, 2007), has been articulated to describe leadership which enables learning and innovating in complex environments. Complexity leadership shifts from only considering the dynamic of leader and followers; the dynamics of greater interest are the interactions among heterogeneous agents, groupings of agents or across
agent networks which generate learning and innovation. Leadership is inherent in such interactions. Here agents refer to insiders and outsiders of organizations who are collectively engaged. Leadership does not refer to an influential person as leader but to interchanges wherein influence is held by different people at different times and for different purposes. Complexity leadership is a form of shared leadership (Carson, Tesluk, & Marrone, 2007; Ensley, Hmieleski, & Pearce, 2006; Pearce, 2004; Pearce & Conger, 2002). In complexity leadership, any agent involved in collective action can manifest the influence dynamics which enable learning and innovation. These dynamics are orchestrations of interaction, interdependence, tension and resonance among heterogeneous agents (Lichtenstein, Uhl-Bien, Marion, Seers, Orton & Schreiber, 2006; Uhl-Bien et al., 2007).

Because complexity leadership theory (CLT) has only been recently formulated, little empirical study has been done, particularly, of complexity leadership at the operational level of companies, that is, where products are produced or services provided. This study is designed to address that gap and examines whether complexity leadership enhances organizational capacities to learn and to use knowledge creatively for innovation. In addition, because interaction in and among aggregates of heterogeneous agents is a fundamental dynamic of CLT, this study also examines how the dynamics associated with heterogeneity are influenced when complexity leadership is present.

The context for this study is an important consideration which will be dealt with in this introduction because complexity leadership can only be understood in its organizational context. Generally, leadership is tightly bound to its context (Osborn, Hunt & Jauch, 2002) and is mistakenly understood to be an exogenous factor acting on an organization. Rather leadership is bound to organization and is correctly viewed as a complementary element in an organizational system. While this idea is not new (Burns & Stalker, 1961; Katz & Kahn, 1978), CLT seeks to extend leadership theory into organizations exhibiting greater dynamism and complexity. Innovation teams in
industrial companies have been chosen as the context for this study because they mirror the organizational system context of complexity leadership, complex adaptive systems (CAS). CAS, which are basic units of analysis in complexity science, describe organizational systems which exhibit high levels of adaptability, innovativeness, complexity and dynamism and, consequently, possess better fitness to more complex and dynamic environments (Uhl-Bien et al., 2007).

CAS provide an ambidextrous organizational system paradigm (Schneider & Somers, 2006) comprised of both mechanistic elements needed for exploitation and organic elements conducive to exploration (He & Wong, 2004; March, 1991; Van den Bosch, Volberda, & de Boer, 1999). The ability of CAS to evolve depends upon their mix of dynamism and order (Kaufman, 1995). Too much dynamism and the system can tip into chaos. Chaos is a state of disturbance in which a system cannot maintain any pattern of behavior and can happen when a system continually overreacts to even small environmental changes. For example, overly organic organizations may readily create adaptive responses but lack structures that can stabilize a useful adaptation into routines and repeatable behavior patterns. Contrarily, organizations comprised of many ordered elements, interrelated within ordered patterns, are frozen so that only small system changes can occur even when confronted by large forces. Mechanistic systems are best at routinizing behaviors but lack structures to adapt routines when conditions change. The blend of dynamism and order make CAS particularly capable of successful adaptation (Kaufman, 1991). Through dynamism, a repertoire of responses is created and order provides buffering which allows for an accumulation of potentially useful adaptations available to respond to environmental pressures. Ambidexterity, that is blends of ordered and dynamic elements, is constituent of CAS.

Industrial company innovation teams exhibit the qualities of CAS and are the organizational context for this study. Industrial companies in their quest to improve their ability to innovate have adopted the use of project teams as a principle organizational
arrangement within their innovation systems (Farris & Cordero, 2002; Mumford, 2000). Hurdles inherent in the ordered organization of industrial companies require special systemic arrangements advantageous to innovation. Formal hierarchical structures tend to impede the dissemination of knowledge helpful to innovation and the sharing of innovative ideas and outcomes throughout the organization (Dougherty & Hardy, 1996). People and knowledge which need to be linked are not; criteria within different power bases are inconsistent, stopping collective innovative actions; and resources required for new development stay bound up in old routines (Dougherty & Hardy, 1996). Innovation teams possess the dynamism to expand the sources of new ideas, to facilitate communication across disciplines, functions, and organizations, and to speed the development of innovation from initiation to commercial success (Guimera, Uzzi, Spiro, & Amaral, 2005; Reagans, Zuckerman, & McEvily, 2004). Innovation teams overcome the de-contextualization of knowledge which occurs when knowledge pools are held in separate groups (Bechky, 2003) by bringing people possessing the different pools of knowledge together for mutual learning. Teams are particularly adept at learning and are the fundamental structure used for learning in organizations (Edmondson, 2002; Senge, 1994). Innovation teams provide the social contexts for interchange, learning and co-creation which expand opportunities for collective creativity (Hargadon & Bechky, 2006). Innovation teams are important vehicles for industrial companies to realize ambidexterity when the teams are constituted with members representing ordered functions and knowledge disciplines who are brought together for creative interaction.

Innovation teams have been researched extensively and the findings reveal characteristics and dynamics reflective of CAS. Heterogeneity of members is the most consistent distinguishing attribute of innovations teams (Brown & Eisenhardt, 1995) and mirrors the heterogeneity among agents in CAS. According to theory, CAS are fit to their environment only when their internal complexity equals the complexity on their environment (Schneider & Somers, 2006). Similarly, innovation teams are populated
with specialists possessing varied knowledge reflecting the complexity associated with the targeted innovation (Clark & Fujimoto, 1990; Quinn, 1985; Takeuchi & Nonaka, 1986) and with the different functional skills and competencies which must be synergized for both problem solving and implementation (Cooper, 1979; Cooper & Kleinschmidt, 1987; 1993). CAS are characterized by self organization, that is, structure and interconnections are fluid and changeable and are not simply determined by the environment but dynamically emerge from interaction of system elements. Innovation teams operate autonomously within the larger system of the company (Clark & Fujimoto, 1990; Quinn, 1985; Takeuchi & Nonaka, 1986) and invent routines that do not follow usual roles and relationships (Dougherty, 1990 & 1992; Dougherty & Corse, 1997). Interaction and interdependency among agents are central to the functioning of CAS and are productive of creativity and learning (Uhl-Bien et al., 2007). In their meta-analysis of 104 quantitative studies of team innovation, Hülsheger, Anderson and Salgado (2009) found that team innovativeness increased both when members engage in interactive communications among themselves and with outsiders and when individual member achievement is interdependent with achievement of other team members. Innovation performance improves when teams increase internal interaction (Dougherty, 1990; 1992; Dougherty & Corse, 1997) and external interaction (Ancona & Caldwell, 1990; 1992b). Because they typify CAS, innovation teams are an appropriate context to study complexity leadership.

Complexity leadership fits the new dynamic and complex organization systems of knowledge era industrial companies. CLT addresses leadership of ambidextrous organizational systems, such as CAS, by articulating three focuses of complexity leadership (Uhl-Bien et al., 2007). The first focus is on the management of ordered elements accomplished through planning, organizing and controlling (Fayol, 1949). The second focus addresses leading the dynamic elements arising from adaptive, creative, and learning interactions. The third focus attends to the enabling of the conditions which
catalyze learning, creative and adaptive interactions and to the managing of the
etanglements between the ordered and dynamic elements in the system. Complexity
leadership relates to the more subtle and less controlling type of leadership which has
been observed on innovation teams (Cooper & Kleinsemidt, 1987; Zirger & Maidique,
1990). Subtle leadership facilitates self organization which allows for members’ roles to
shift as developments occur and reconciles the freedom required for creative processes
and the alignment necessary to ensure the innovation advances organizational purposes
(Dougherty, 1992). Complexity leadership facilitates the dynamics conducive to
innovating and to learning, which in turn also aids innovation. The potential creative
value of the heterogeneity of the team is actualized in leadership facilitated interactions.

This study is designed to examine complexity leadership in its theorized optimal
context, CAS, and to test whether its theorized influences are present.

Theoretical Model

The theoretical model examined in this dissertation is presented in Figure 1. In
this model, complexity leadership manifested by the designated team leader and the
members of the team (i.e., vertical leadership and shared leadership: Pearce & Conger,
2002; Ensley et al., 2006; Carson et al., 2007) positively influences innovation team
outcomes, that is, innovation enabling behaviors and perceived performance. Complexity
leadership enables the dynamics of interaction and interdependency conducive to team
innovation and team learning (Uhl-Bien et al., 2007).

Team learning is collaborative learning, because members learn interdependently
from one another. Collaborative learning increases individual and group learning
(Johnson, Johnson, & Anderson, 1978) and involves the open sharing of the deeper
principles, assumptions, and metaphors associated with knowledge held by members
(Cronin & Weingart, 2007; Roschelle, 1992). Collaborative learning entails purposeful
attentive interactions, members teaching and learning, and divergent and convergent
thinking (Janz & Prasarnphanich, 2003). Collaborative learning mediates the relationship between complexity leadership and innovation team outcomes.

Job relevant heterogeneity, attributes such as, job role, function, educational background and tenure, is reflective of the knowledge based heterogeneity of CLT and has been shown to have a generally positive but inconsistent influence over innovation performance (Hülsheger et al., 2009) with a positive or negative relationship depending upon how attitudes and dynamics moderate the relationship (van Kippenberg, De Dreu & Homan, 2004). Complexity leadership catalyzes dynamics which engage member differences and increase likelihood that differences will have greater beneficial influence on creative and innovative performance (Uhl-Bien et al., 2007). Complexity leadership moderates the relationship between job relevant heterogeneity and innovation team outcomes.

Complexity leadership theory anticipates in CAS a heterogeneity norm which leverages differences among agents and has far reaching effects on dynamics (Marion & Uhl-Bien, 2001). In innovation teams, the heterogeneity norm is a team pattern of respecting, engaging and leveraging job relevant heterogeneity. Norms which align member interaction behavior are established early in team formation, and once the heterogeneity norm is formed, less leadership intervention is required regarding heterogeneity (Jassawalla & Sashittal, 2002; Taggar & Ellis, 2007). The heterogeneity norm mediates the relationship between complexity leadership and innovation team outcomes.

Significance of the Study

This study adds to research in leadership in several ways. Its primary contribution is toward understanding complexity leadership at the operational level of organizations,
that is the level of producing products or providing services (Uhl-Bien et al., 2007).
Because of the relative newness of complexity leadership theory, few studies have been
done to test or demonstrate that the theorized leadership is capable of influencing the
learning and innovation performance of CAS. Consequently, little field testing of the
theory has been done. This early stage of theory development provides a rich and open
field for this study to explore. Complexity leadership theorists suggest research strategies
that address the difficulties associated with capturing the complex dynamics of leadership
in CAS and that emphasize qualitative ethnographic approaches and the use of simulation
and other mathematical modeling as prime research approaches (Hazy, 2007; Marion &
Uhl-Bien, 2001; Uhl-Bien et al., 2007). This study, which is primarily quantitative field
research supported by a qualitative study, is designed to provide a bridge between the
existing research of leadership and complexity leadership. This study’s theory
development and research methods rely heavily on existing research literatures of team
creativity, innovation, small team process, team learning, team leadership, and team
diversity. This study’s goal is to increase the potential synergies between complexity
leadership and other research disciplines.

The second contribution of this study will be to our understanding of leadership in
innovation teams. A gap exists in our descriptions of innovation team leadership with
little research delineating leadership’s role in the internal team dynamics (Brown &
Eisenhardt, 1995). This observed gap is reinforced by Hülsheger et al.’s (2009) meta-
analysis of 104 quantitative studies of innovation teams. Leadership was not identified in
their review of the extensive empirical team innovation literature as one of the team level
variables influencing innovation performance. This current study will provide new
insights into leadership of innovation teams that will have value not only to researchers
but also to industrial companies, especially given the dominate role innovation teams
have in their innovation systems. When complexity leadership is shown to have the
influences on learning and innovating purported, new direction will be provided to
industrial companies for leadership training and development of innovation team leaders and members.

Additional value will be provided by this study to research on heterogeneity, which has been developed in the diversity literature. In this literature, the contradictory effects, both positive and negative, of diversity on team performance have led to the theorizing of moderating factors. Because diversity on teams, for example, job relevant heterogeneity, has been observed to have different, even opposite, effects in different studies, there is a need to separate the effects of diversity from the dynamics that may emerge from diversity. Intervening moderating variables, such as a positive or negative bias toward diversity, have been proposed to influence the relationship between diversity and performance (van Knippenberg et al., 2004). This study’s heterogeneity norm reflects a positive bias toward heterogeneity and, because positive bias is an understudied phenomenon (van Knippenberg & Schippers, 2007), this research will shed new light on potential moderating factors associated with heterogeneity.

Organization of the Dissertation

The study upon which this dissertation is based is presented according to the following outline. Chapter Two provides the literature review for the hypotheses tested in the study. The literature review uses empirical and theoretical research to support the proposed hypotheses summarized in the theoretical model shown in Figure 1. Chapter Three outlines the methods used to test the hypotheses presented in Chapter Two. The methods include the research design, field setting, participants and samples, measures used to operationalize the constructs in this study, data collection and data analysis. In Chapter Four, the results of the empirical hypothesis tests for this study are presented. A concluding discussion of the study’s findings, strengths and limitations, and directions for future research is presented in Chapter Five.
CHAPTER TWO
LITERATURE REVIEW AND HYPOTHESES

Introduction to Complexity Leadership Theory

Complexity leadership theory (CLT) asks that the paradigm that has held sway over leadership theory and research for some time be reshaped in light of new understanding of how complex systems learn, adapt and innovate to maintain fitness within complex environments. A shift of paradigm is called for because the context of leadership both inside companies and in the environments experienced by companies has greater complexity, that is, greater dynamism and greater number of disparate system elements needing to be interwoven. While traditional hierarchical views of leadership were relevant in bureaucratic organizations seeking consistency and predictability, the upheavals arising from the knowledge explosion, continual technology revolutions, globalization, and other complexity creating factors, require leadership that is primarily an enabler of change and adaptation in organizational systems. Conceptions of organizations and leadership must change simultaneously in order to grasp the organizational imperatives required now. Within CLT, organizational systems are not bounded entities but viewed as complex adaptive systems (CAS) made up of heterogeneous agents or elements which interact and mutually affect each other, and from this dynamic, novelties arise which change the system as a whole (Marion & Uhl-Bien, 2001). Previously, leadership would have been envisioned to be the force organizing and controlling these dynamics with the aim of producing organizational goals. Research in the leadership of innovation supports the need to change this view. Traditional top-down leadership providing direction and control limits flexibility and experimentation and
reduces innovativeness (Amabile, 1997, 1998). CLT theorizes leadership as an adaptive
dynamic, enabling the dynamics of system agents to interact through self organizing and
to create emergent learning, adaptation and innovation.

Complexity leadership is leadership of aggregates (Marion & Uhl-Bien, 2001).
Complexity leadership differs from recent leadership theories which focus on the
relationship between leaders and followers and relies heavily on dyadic, that is, leader
and follower, influence constructs and research techniques. The aggregates, to which
complexity leadership is attuned, are groups of interacting actors who operate with a
sense of commonality and, at a higher level, meta-aggregates of interacting groups linked
by some form of interdependence. The important feature of these aggregates and meta-
aggregates is their propensity for emergence, that is, pattern and order not predicted by
previous conditions arising from the multiplicity of interactions within the complex
system. Emergence happens in aggregates as conflicting constraints and preferences
clash and are resolved when correlation is created. One task of complexity leadership is
to enable dynamics which enhance emergence of learning and innovation in aggregates.
A second task is to enable the diffusion of the learning and innovation which has
emerged into meta-aggregates. The shift in complexity leadership from dyadic concerns
to aggregate concerns is central to the handling of complexity. As bureaucratic
management was formulated to lead predictable and controlled organizations, complexity
leadership leads complex organizations in complex environments and must not only
attend to the challenges of managing ordered organizational elements but also to
challenges of creating learning, innovation and adaptation in dynamic system elements. A
more detailed description of the functions of complexity leadership given in the next section will clarify the relationship between complexity leadership and innovation.

Complexity Leadership and Innovation Team Outcomes

A potent source of change and adaptation in contemporary companies is innovation which is purposively pursued through organized innovation systems. Innovation can relate to products and services, or processes and practices (Slappendel, 1996). Innovation is the generation of new knowledge with special attention to its usefulness and, subsequently the practical application or implementation of the knowledge (Camison-Zornoza, Lapierdra-Alcami, Segarra-Cipres & Boronat-Navarro, 2004). Innovation is creativity with an organizational purpose because innovation by definition entails the application or implementation of the results of creativity. In industrial companies, innovation is a team activity and the role of leadership in shaping team dynamics for innovation is essential (Jassawalla & Sashittal, 2002).

Within CLT, complexity leadership is a complex dynamic comprised of three functions: administrative leadership, adaptive leadership and enabling leadership (Uhl-Bien et al., 2007). Together, these three functions permit organizations to take advantage of the learning and innovation potential of CAS, such as the organizational systems of innovations teams, within the typically bureaucratic contexts of industrial companies. The following builds on the theory of complexity leadership, its functions relative to team innovation, and how existing research literature on group creativity, innovation teams, group conflict, and group leadership can be used to explain the relationships between complexity leadership with innovation and learning. Some of these cited studies
focus on leadership by examining the behaviors of specific leaders and are nonetheless relevant in exploring issues related to complexity leadership.

Administrative leadership is defined as management which functions to create order and alignment. This first function of complexity leadership is traditionally embodied in individuals with special influence derived from designated authority within the hierarchy. In this regard, CLT embraces earlier conceptions of bureaucratic management which attends to planning, organizing and controlling (Fayol, 1949) as necessary leadership activities in CAS pertaining to system elements requiring order and stability. In CLT, administrative leadership performs the normal managerial functions of structuring tasks, coordinating activities, managing crisis, and acquiring and allocating resources, with attention and consideration for organizational learning, adaptation and innovation (Uhl-Bien et al., 2007). In innovation teams, administrative leadership is generally performed by a designated team leader who provides guidance to the team by keeping focus on linkages to company processes, strategies, and competencies (Clark & Fujimoto, 1990; Quinn, 1985; Takeuchi & Nonaka, 1986). Administrative leadership on innovation teams seeks to deal effectively with routines in the organization’s innovation system, such as stage gate reviews and innovation portfolio management. The attention of the leader to the company’s routines helps create an environment in which the team can operate effectively. Conditions allow the team to balance its need to be independent enough from the larger organization for creativity but still be connected enough so that its efforts are supported and its creative outputs can be implemented.

Adaptive leadership, the second function of complexity leadership, is an influence dynamic emerging from the interaction and interdependence among heterogeneous agents
in a social system which specifically aids adaptation in that system. Adaptive leadership is defined as interactive influence events from which changes in knowledge, action preferences or behaviors occur that make an organization more capable of adapting (Lichtenstein et al., 2006). The consequences of adaptive leadership are present in the emergent group phenomena of learning and innovation. Emergence involves the “reformulation of existing elements to produce outcomes that are qualitatively different from the original elements” (Uhl-Bien et al., 2007, p. 308) and involves knowledge created by “seeing beyond original assumptions to something not bounded by those assumptions” (Uhl-Bien et al., 2007, p. 307). In innovation teams, adaptive leadership is occurring when interacting members generate innovation enabling behaviors and innovative outcomes to resolve preference asymmetries, that is, differences in knowledge, assumptions, perspectives, needs, behaviors, etc. Unlike previous conceptions of leadership, adaptive leadership interactions are not based upon authority asymmetries where leaders possess higher status and greater influence than followers. Adaptive leadership is not leaders influencing followers to achieve the leaders’ desires but rather members interacting to generate innovative outcomes (Lichtenstein et al., 2006). Authority asymmetries are more one-sided because, as psychological theories of power suggest, persons possessing influence and status engage in more “other approaching” behavior while the less powerful inhibit engagement (DiTomaso, Post, & Parks-Yancy, 2007; Keltner, Gruenfeld, & Anderson, 2003) which reduces open interaction and, consequently, their expression of differences. The tension arising from preference asymmetries opens up space for new understanding between members (Bradbury & Lichtenstein, 2000; Lichtenstein et al., 2006) and fosters struggles and
debates. Learning and innovation happen when the open space between members is filled by events of new knowledge creation. Ideas emerge from the clash of the member preferences. In innovation teams, adaptive leadership can be recognized as having successfully occurred when innovation is created that is deemed to be useful and is embraced by the larger organization for application and implementation (Uhl-Bien et al., 2007).

Enabling leadership is the third function in the CLT framework. Enabling leadership is defined as two separate but linked sub-functions: first, the fostering of conditions which stimulate the adaptive influence dynamics of adaptive leadership to occur and second, the forging of connections between the emerging changes from adaptive leadership with the ordered elements managed by administrative leadership (Uhl-Bien et al., 2007). Enabling leadership helps innovation teams, as CAS, create new dynamic elements and then manage the blending of dynamic elements with ordered elements. Innovation teams are challenged to generate dynamism not characteristic of the bureaucratic systems in which they operate and yet to maintain linkages with the bureaucracy. The dynamic elements produced represent new possibilities for adaptation beyond what can normally emerge from the bureaucracy. The linkages permit flows of resources and information which enable the team to innovate and also ultimately enable the larger organization to integrate the outcomes of the teams’ innovative production. To summarize, in CLT terms, enabling leadership is made up of two sub-functions: (1) enable conditions which catalyze adaptive leadership and (2) manage the entanglement between adaptive and administrative structures. Four conditions which catalyze adaptive
leadership have been identified: (1) interaction, (2) interdependence, (3) tension, and (4) resonance (Uhl-Bien et al., 2007).

**Interaction**

Interaction is defined as the interchanges between and among agents. Interaction is enabled when leadership instigates interchanges between members of the team and supports the unfolding of developing interchanges. Enabling leadership increases interchanges by improving existing connections among members and forging new ones. In innovation teams, leaders use interaction tactics by instigating interchanges within the team, with groups in the larger organization and with others outside the organization in order to spur intellectual stimulation, which is an important factor in achieving group creativity and innovation (Mumford, 2000). In a number of small group experimental studies, Maier and his colleagues (Maier, 1950; 1953; Maier & Hoffman, 1960; Maier & Solem, 1962) observed team leader behaviors which stimulated interaction and were helpful in developing group creativity. The leader behaviors included: encouraging members to share information; encouraging members to seek from others a variety of information relevant to the problem; and prolonging discussions to allow for more information sharing. Overall, interaction provides two important advantages to innovation: first, new information is made available to be processed and secondly, thinking is broadened to include more perspectives which can lead to unexpected association of ideas and new knowledge.

**Interdependence**

The second enabling condition is interdependence. Interdependence in complexity leadership theory builds on previous higher order definitions, for example, reciprocal
interdependence described by Thompson as, “referring to the situation in which the outputs of each become the inputs for the others” (Thompson, 1967: 69) and team interdependence (Van De Ven, Delbecq, & Koenig, 1976) where a group collaborates in order to perform jointly undertaken work. The interdependence of complexity leadership is people collaborating in order to co-learn and co-create and is built on collaboration between competing forces which transcend their heterogeneous agendas to achieve outcomes beneficial to all (Jassawalla, & Sashittal, 2006). This interdependence is achieved not only through technical task elements but also social context, socially constructed by members of a group. Socio-technical systems theory (Trist, 1981) recognized that both the task environment and the social environment can contribute to leveraging individual and group efforts through interdependence. In uncertain contexts, such as efforts to innovate, individual and team behaviors which maintain or build socially constructed interdependence relate to individual, team and organizational performance in terms of proficiency, adaptability, and pro-activity (Griffin, Neal, & Parker, 2007). Leaders foster interdependence by linking preferences among team members through social processes, such as mutual problem solving, to create mutual reliance and collaboration even where linkages may not occur naturally within the task environment (Wageman, 1995). The advantages observed from socially constructed interdependence include better use of collective knowledge and skills, higher quality social processes, extensive mutual learning, shared sense of responsibility for outcomes and positive interpersonal interactions (Wageman, 1995). Innovation teams, who achieve high levels of collaborative interdependence, exhibit greater creativity and quantum leaps of innovation; teams who only focus at integrating task dependencies, have difficulty
going beyond the existing technical relationships among functions and disciplines (Jassawalla & Sashittal, 2006).

The first two catalyzing conditions, interdependence and interaction, work together to enhance collective actions in innovation teams. Interdependence adds pressure to interact purposefully, mindful of mutually beneficial outcomes (Uhl-Bien et al., 2007). Interaction allows for the movement of information while interdependence provides the meaning and purpose to do so. Interdependence creates reciprocal feedback loops which enrich and amplify the results of interaction and increase emergence of unexpected innovative outcomes (Lichtenstein & Plowman, 2009).

**Tension**

The third catalyzing condition, tension, arises from interaction when differences in constraints, needs, preferences and knowledge exist among agents. The concept of tension in complexity leadership captures the stretching required to understand others’ knowledge and perspectives and to combine different knowledge into new knowledge. Enabling leadership in order to create an impetus for adaptive behaviors fosters and incites tension by influencing dynamics so that differences, dissent and divergent perspectives are leveraged and members accept responsibility for resolving differences and creating solutions (Heifetz & Laurie, 2001; Uhl-Bien et al., 2007).

Tension arises when leaders instigate divergent thinking and have positive attitudes toward disagreement. Both have been shown to influence group creativity when groups are solving work problems. Leaders use disagreements to frame more creative solutions when divergent thinking yields new ideas (Maier & Janzen, 1969). In small group experiments (Maier & Hoffman, 1965), positive leader attitudes increased the
likelihood that disagreements led to creative solutions. Leadership also instigates tension by bringing in external sources of different knowledge, perspectives or skills and by capitalizing on the heterogeneity of agents inside and outside the team. Knowledge heterogeneity precipitates tension in the team as personal knowledge bases or previously held perspectives are challenged by differences (Carley & Hill, 2001). Tension is associated with a felt need to adjust differing cognitive structures which are held individually and/or collectively. Resulting cognitive accommodations generate new structures, ideas and knowledge unanticipated from the sum of the information previously available (Uhl-Bien et al., 2007). Interactions under tension can have a non-linear influence on future interactions and produce innovative outcomes.

However, there are potential hazards associated with tension, which complexity leadership mitigates. The discomfort associated with tension can lead to premature convergence on sub-optimal solutions. Teams are challenged to maintain a state of active differences and, consequently, tend to quickly seek consensus or agreement. Leadership can negotiate sufficient deliberation to prevent premature closure of design decisions (Lester, Piore, & Malek, 1998). Additionally, an alternate problem arises when tension leads to unproductive conflict which prevents members from bringing their thinking together and therefore blocks creativity and innovation. Enabling leadership seeks to use conflict productively (Uhl-Bien et al., 2007).

The work of Basadur and colleagues (Basadur, Graen, & Green, 1982; Basadur, Graen, & Scandura, 1986; Basadur, Pringle, Speranzini, & Bacot, 2000) elucidates the role of innovation team leadership in avoiding the pitfalls of pre-mature convergence. Leadership enables four skills helpful to the creative process of the team (Basadur et al.,
(2000): (1) divergence, the ability to generate and consider a variety of options; (2) convergence, the ability to advance the process by evaluating and selecting options; (3) deferral of judgment, the ability to keep divergence and convergence separated and sequenced in the right order; and (4) vertical deferral of judgment, a more global ability to balance divergence and convergence which helps avoid skipping steps and/or advancing prematurely. Without these skills, insufficient problem definition, premature selection of a solution, and delivering sub-optimal solutions occur. To avoid these pitfalls, leadership influences the team to self-monitor and increase sensitivity to information related to creative team processes and outcomes. When teams reflect on and evaluate team dynamics, dysfunctional habits can be broken (Milliken, Bartel, & Kurtzberg, 2003). An additional important observation is made in the body of Basadur’s work: the cycling through divergent and convergent interaction happens throughout the innovation project from early problem definition to solution implementation.

Leadership helps alter the tendency to prematurely converge by engaging the team to sustain divergent interaction. However too much or the wrong type of divergence can lead to unproductive conflicts. When groups experience too much conflict, their ability to coordinate learning and implement innovative ideas becomes limited (Brown & Duguid, 2000). A substantial body of research has described the relationship between conflict and group performance. Theoretical and empirical studies document the negative influence conflict has on team performance (Brown, 1983; Gladstein, 1984; Saavedra, Earley, & Van Dyne, 1993; Wall & Callister, 1995) while others found that the level or intensity of conflict determined whether effects were positive or negative (Wall & Nolan, 1986). Low levels of conflict provided advantages when people directly dealt with issues
and learned from each other (Nemeth, 1986; Tjosvold, 1997). Another stream of conflict research called attention to the importance of understanding the differences between relationship and task conflict (Amason, 1996; Jehn, 1995; Simons & Peterson, 2000). Relational conflicts are interpersonal incompatibilities, such as, political preferences, which generally decrease team performance. Task conflicts are differences about work related issues, such as scheduling and distribution of work or resources, and their influence on performance is moderated by task routineness. Task conflict interferes with the performance of routine tasks but increases performance of non-routine or complex tasks, such as innovation (Amason, 1996; Simons & Peterson, 2000) because non-routine tasks do not depend on pre-established solutions and are better served when team members engage in deliberate processing of task-relevant information. In a meta-analysis of 28 research articles, De Dreu and Wiengart (2003) studied the effects of relationship and task conflict on team performance. They found that both types were equally disruptive of team performance. They also found that task routineness did not moderate task conflict’s impact. From their findings, they suggest that some task conflict may be beneficial but that “such positive effects quickly break down as conflict becomes more intense, cognitive load increases, information processing is impeded, and team performance suffers.” (De Dreu & Wiengart, 2003: 746). With its aim to support tension, enabling leadership does not seek to avoid conflict but seeks to use conflict productively. Hülsheger and colleagues (2009) found no correlation between conflict and team innovation performance, so it can be said that the presence or lack of conflict is not as important as what is done with it. Tjosvold and his colleagues have shown across a wide range of team issues and settings that when conflict is effectively led, it contributes
positively to team performance and does not devolve into unproductive conflict, that is, cognitive load is kept manageable at levels that enhance information processing (Alper, Tjosvold, & Law, 2000; Chen, Liu, & Tjosvold, 2005; Tjosvold, 1997, 1998; Tjosvold, Poon, & Yu, 2005; Tjosvold, Sun, & Wan, 2005; Tjosvold & Wong, 2004). Leadership of conflict entails being attuned to and recognizing conflict, openly identifying and discussing differences, and actively instigating collaborative problem solving.

Complexity leadership mitigates occurrences of unproductive conflict by recognizing when disagreements are reaching disruptive levels of hostile interaction and engaging members in interdependent conflict resolution and mutual problem solving. Leadership guides team interactions so that members can engage in conflict without adverse negative consequences (Schein, 1993). Conflict, when it is properly led, promotes learning and innovation when contending parties interact to mutually understand and search for resolutions comprised of differing perspectives.

The way enabling leadership deals with conflict highlights how tension works with the other catalyzing conditions of interaction and interdependence. Open interaction and mutual problem solving promoted by enabling leadership contributes to positive collaborative interdependence which provides encouragement for the perspective that incorporating other’s ideas will help individual and team performance and in turn will lead to more interaction (Tjosvold et al., 2005b). Tension uses and supports the benefits of interaction and interdependence on innovation teams.

**Resonance**

Resonance is the fourth condition of enabling leadership which catalyses adaptive leadership and emergence. Resonance is defined as correlation among agents which
supports their acting in concert and is a condition that helps self organized aggregations of agents choose to work and achieve a common outcome together (Uhl-Bien et al., 2007). Resonance relates to the forces which bind agents together who are heterogeneous in constraints, knowledge and preferences. While resonance is not specifically listed as a catalyzing condition by Uhl-Bien et al., (2007), subsequent discussions with one of the authors, Mary Uhl-Bien, highlighted resonance as an important catalyzing condition in CAS to which complexity leadership attends. Resonance helps the generation of new ideas and makes it possible for teams to take ideas through to application or implementation.

Resonance and leadership’s enabling role have been recognized in team research. Resonance is evident in team cognitive structures and dynamics supporting collective action, such as, team identity (Van der Vegt & Bunderson, 2005), team culture (Earley & Mosakowski, 2000), and shared super-ordinate goals (Milliken et al., 2003). Team identity is the socially constructed sense of “entitativity” (i.e., a thing unto itself or a sense being a distinct group) and is a feature of high performing heterogeneous teams who are capable of unified action (Earley & Mosakowski, 2000). Leaders use identity to frame how the members understand the nature of the team and their roles. In CAS, team identity brings degrees of stability and continuity which provide enough of a foundation for adaptation to be supportable (Schneider & Somers, 2006). Team culture refers to the social and cognitive environment, the shared view of reality, and the collective belief and value system reflected in a consistent pattern of behaviors among participants (Jassawalla & Sashittal, 2002). Creation of a team culture is an important achievement that helps equip individuals to innovate as a group and provides a means to integrate a multiplicity
of cultures with their existing viewpoints and knowledge. In innovation teams characterized by heterogeneity among organizational and demographic cultures, leadership is a factor in whether a productive team culture is blocked from emerging (Earley & Mosakowski, 2000). Effective leadership helps the team navigate interactions by making sense of the differences among the multiple existing subcultures within the group and of the emerging team culture with its new norms and values (Jassawalla & Sashittal, 2002). Super-ordinate goals have been shown to positively affect creativity and learning by bringing members with diverse agendas together through awareness of their mutual interests (Milliken et al., 2003). While control oriented extrinsic motivators, such as task oriented measurements, are detrimental to creativity, information based motivators, such as super-ordinate goals, are conducive to team creativity (Amabile, 1997). By giving meaning to the value team goals have to the larger organization, leaders create a unifying purpose that furthers the innovation of the group (Mumford & Licuanan, 2004). Underlying the formation of identity, culture and super-ordinate goals is the sense-making and sense-giving that leadership provides.

Enabling leadership uses sense-making and sense-giving to help the team increase correlation through the development of common or shared understanding (Gioia & Chittipeddi, 1991; Marion & Uhl-Bien, 2001). Sense-making and sense-giving are done through a number of leadership behaviors including: the repeated use of specific language (Lichtenstein, 2000), the use of symbols or rituals (Plowman, Baker, Beck, Silansky, Kulkarni, & Travis, 2007b), and the telling of stories (Boal & Schultz, 2007). These behaviors reveal, reinforce and frame the meaning of shared experiences and lead teams to form a shared understanding of unfolding events. Gaining credibility and
relevance for shared understanding are difficult challenges, especially given the dynamic nature of CAS and the heterogeneity among its members (Lichtenstein & Plowman, 2009; Weick & Roberts, 1993). When many heterogeneous agents are interacting to produce a creative outcome, leader sense-making helps bridge gaps in understanding and is an important factor influencing performance (Dunham & Freeman, 2000). Complex activities involving many interactions induce fluid structures and understanding (Kazanjian, Drazin, & Glynn, 2000). In these conditions, leaders’ sense-making and sense-giving activities aid the development of shared mental models about events and their consequences (Frankwick, Walker, & Ward, 1994) and are a significant influence on performance. Leadership sense-making and sense-giving enable resonance on innovation teams so that collective effort of members is engaged.

Resonance complements the second catalyzing condition, interdependence. With interdependence, team members rely upon each other; with resonance, members find reason and meaning to act in a concerted manner. Interdependence and resonance work together on innovation teams to transform potentially random interaction among members into purposeful interaction. Concerted efforts of members lead to the generation of new innovative ideas and the momentum for taking new ideas through the process of application and implementation.

*Manage the Entanglement Between Adaptive and Administrative Structures*

The second function of enabling leadership recognizes that differences between ordered administrative structures and the dynamism of adaptive structures must be managed and bridged. Enabling leadership seeks to influence the relationship and interchanges so that ordered and emergent system elements work complementarily and
not counter to one another (Uhl-Bien et al., 2007). Administrative and adaptive elements may by their nature be inherently antithetical but need not be inimical to each other. For example, the existence of functional routines will not preclude emergence and self-organization if the interfaces between formal functions and innovators are managed appropriately (Dougherty & Hardy, 1996). In order to manage the entanglement between adaptive and administrative structures, enabling leadership influences the reciprocal interaction between the two by recognizing and responding to the needs of both. In innovation teams, administrative and enabling leadership together mediate with formal organizational structures to garner resources, to ensure safety and autonomy for the team and to facilitate the dissemination of innovation outcomes into the larger organization. This function of enabling leadership represents the boundary spanning role of innovation leadership described in the literature (Ancona & Caldwell, 1992a; Burke, Stagl, Klein, Goodwin, Salas, & Halpin, 2006; Hirst & Mann, 2004).

Boundary spanning involves leadership activity with lateral and vertical outsiders and deals with both politically oriented communication that increases the influence of the team, and task coordination which expands the resources and information available to the team and resolves problems important to other groups (Brown & Eisenhardt, 1995). Occasions for intrusive outside political pressure and the resulting need for political communication happen frequently on innovation teams because their efforts span departmental boundaries, are dependent on resources throughout the organization, and involve continuous evaluation and regular review (Benjamin, 1993). Political processes entail both observable and covert influence (Eisenhardt & Bourgeois, 1988; Pfeffer, 1981). Administrative leadership engages in tangible observable interactions with formal
structures, such as stage reviews, with open and forthright discussion and full disclosure of information, while enabling leadership attends to impression management with symbolic and meaning shaping communication to influence attitudes, beliefs, and opinions of others (Benjamin, 1993). Both are necessary because political processes impacting innovation occur on two inter-related levels: first, formal maneuvering for resources and autonomy, and secondly, the shaping of meanings and attributions that influence the construal of the innovation’s value to the organization (Frost & Egri, 1991). Politically oriented activities have been characterized as ambassadorial (Ancona & Caldwell, 1992b) and include lobbying for support, protecting the team from outside pressure and managing the perceptions of outsiders about the team and its work. The second function of boundary spanning, task coordination, involves communicating with others to dialogue about technical and design issues and to acquire resources, including people, technology and information (Ancona & Caldwell, 1992b). Coordination with other groups enhances the likelihood of obtaining knowledge and perspectives about domain-relevant and procedural knowledge bases (Hülsheger et al., 2009) and of solving problems during development which will later facilitate adoption of the innovation by other groups. Enabling leadership maintains substantive two way information linkages with outsiders even as the innovation team strives to operate with the autonomy which permits the free flow of internal dialogue necessary for team creativity (Mumford, 2000). If autonomy becomes a disconnect from the formal organization, the team could be cut off from needed resources and subsequently, the adoption of the team’s innovation could be blocked.
By managing the entanglement between adaptive and administrative structures, enabling leadership helps make innovation happen within industrial companies. The resources, information and autonomy required to generate new knowledge and ideas are made available to the team. The team’s new ideas will be found to be useful because they are connected to the company’s goals, strategies and competencies and the likelihood that the ideas will be applied or implemented across the company is increased.

*Complexity Leadership as Shared Leadership*

One additional aspect of complexity leadership, its shared nature, must be considered before a statement of the hypothesized relationship between complexity leadership and innovation can be made. CLT describes that complex leaders encourage mutual influence among agents and networks of agents (Marion & Uhl-Bien, 2001). Adaptive leadership is fundamentally a mutual influence dynamic among members. Complexity leaders enable interaction which leads to members adapting and structuring their work rather than the leader controlling and directing. CLT asserts that the best innovations emerge, not from the limited vision of the leader but when members themselves work through issues (Marion & Uhl-Bien, 2001). This view of leadership has been corroborated by research which found leaders of innovation teams were more successful when they practiced subtle rather than controlling leadership (Cooper & Kleinscmidt, 1987, Zirger & Maidique, 1990). Subtle leadership facilitates self organization which allows for the leadership role to shift among team participants. Complexity leadership is not only the work of the leader but is work shared by the members of the team.
Shared leadership is a collaborative team process where members of the group enact leadership roles rather than where leadership is only the domain of the designated leader (Pearce & Conger, 2003). Shared leadership entails a simultaneous, ongoing, mutual influence process among members within knowledge based teams (Pearce, 2004). Shared leadership is evident when whole teams take on the responsibility of creating direction, alignment, and commitment that broadens and enriches the sources of expertise and insights compared to the limitations that arise when a single person, the leader, provides direction (O’Connor & Quinn, 2004). Shared leadership aligns with collaborative team dynamics arising from leadership enabled interaction, interdependence, tension and resonance. The CAS processes of self-organization and emergence are conceived as bottom up and are supported through bottom up leadership, wherein the members are involved in mutual influence rather than only influenced by the leader. Shared leadership supports collaboration in innovation teams and aligns with their information intensive interchanges.

Shared leadership has been empirically studied and its positive effects verified. In this literature, shared leadership exists when multiple group members exhibit leadership behavior within team interactions and can coexist with vertical leadership. Pearce and Sims (2002) studied change management teams at a large automotive manufacturing firm and found shared leadership provided additional positive influence on team effectiveness beyond the vertical leadership of designated team leaders. Shared leadership more strongly predicted team performance than vertical leadership in virtual teams engaged in social work projects (Pearce, Yoo, & Alavi, 2004). Ensley and colleagues (2006) studied top management teams (TMT) of new ventures and found that shared leadership
significantly contributed to company performance beyond the influence of vertical leadership. Shared leadership increased TMT performance and enabled the top managers to share divergent views and at the same time maintain a unified convergent purpose. Consulting teams performed better in projects requiring production of significant client deliverables when members shared leadership (Carson et al., 2007).

Research exists which supports a shift from considering only the influence of the leader to considering leadership as a collaborative process among the leader and group members. Hierarchical and concentrated leadership impedes innovation by blocking learning, while distributed or shared leadership facilitates learning and increases the speed of innovation in a group (Papadakis & Bourantas, 1998). Focusing energy only toward a charismatic or transformational leader and his/her vision distracts members’ attention from their work and restricts their autonomy to create their own vision, and may explain why in some studies, teams without transformational leaders outperform those with such a leader (Mumford, Scott, Gaddis, & Strange, 2002). Shared leadership, because of its information rich relational interactions, leads to greater shared learning and innovation by those involved and in the organization generally (Argryis & Schon, 1978; Beer, 1999). Leadership skills that foster innovation are more effective when they are shared across the team rather than concentrated in one person (O'Connor & Quinn, 2004).

Because complexity leadership is a form of shared leadership, this study when assessing the relationship between complexity leadership and team dynamics and innovation team outcomes must account for both the vertical, that is, the leader, and shared, that is, members, manifestations of complexity leadership and their influences.

Statement of Hypothesis
Innovation is the development of new knowledge which is subsequently implemented by an organization as new products or processes. Through administrative leadership, complexity leadership links the team to organizational administrative structures so that team efforts are supported and outputs can be implemented into the larger organization. Complexity leadership contains the mutual influence dynamics from which learning and innovation emerge. Complexity leadership fosters the conditions, including interaction, interdependence, tension and resonance, which catalyze dynamics productive of learning and innovation. Interaction makes tacit information available for team processing and broadens perspectives, both of which can lead to unexpected association of ideas and new knowledge. Complexity leadership furthers collaborative interdependence which leads teams to exhibit greater creativity and quantum leaps of innovation (Jassawalla & Sashittal, 2006). By enabling tension, complexity leadership helps prevent premature convergence by helping the team sustain divergent interaction and allows the team to use conflict productively. Complexity leadership uses sense making and sense giving to create resonance among heterogeneous members which supports their acting in concert and which creates common understanding and convergence. By managing the connection between the ordered administrative processes and emergent learning and innovation events, enabling leadership ensures that resources, information and autonomy required to generate new knowledge and ideas are available to the team and that the team’s new ideas will be implemented because they are useful to the company’s goals, strategies and competencies. Complexity leadership is performed by both the leader and members of innovation teams and, shared leadership increases information rich interactions, innovativeness and the speed of innovation in teams.
(Argyis & Schon, 1978; Beer, 1999; Papadakis & Bourantas, 1998). Therefore, it can be hypothesized:

**Hypothesis 1:** *Complexity leadership manifested by either team leader or team members or both is positively related to innovation team outcomes.*

**Complexity Leadership and Learning**

Learning and innovation are inextricably linked. Learning, because it entails the active interaction between concepts and practice, is a fundamental process in innovation and is comprised of trial and error cycles of ideas, actions, outcomes and responses (Van de Ven & Polley, 1992). Within CLT, CAS are organizational systems adept at learning and, specifically, learning within CAS is aggregate learning which connects CLT to the team and organizational learning literatures. Team and organizational learning have been described as the processes through which knowledge is obtained and used that provide opportunities for improvement (Edmonson, 1999; Gibson & Vermeulen, 2003). Individual learning is a component of team and organizational learning, but the knowledge learned by an individual only becomes organizational learning when this knowledge is shared and used for change in the organization (Fiol & Lyles, 1985). Learning at the aggregate level incorporates individual learning into group learning processes supported by interaction, interdependence, tension and resonance (Uhl-Bien et al., 2007) and is a prime purpose of complexity leadership. Organizations rely on their innovation teams to be particularly adept at learning for the benefit of the larger organization. Complexity leadership’s relationship to team learning is an important consideration to more fully understand its influence on innovation team outcomes.
Similar to the influence complexity leadership has on innovation team outcomes by increasing collaboration in creative interchanges, complexity leadership enables collaborative learning, a type of learning specifically related to team innovation.

Innovation depends upon a communal learning process involving the communal construction of conceptual frameworks, impressing it on reality and observing and interpreting the interaction (Brown & Duguid, 1991). Collaborative learning is people sharing and understanding knowledge together through their interaction and interdependence enabled by complexity leadership. The concept of collaborative learning is a team level phenomenon and builds upon the literature of cooperative learning (Johnson et al., 1978), which studied learning in dyads and among small groups. Collaborative, or cooperative, learning is contrasted to competitive learning and to individualistic learning and exists when individuals work together to maximize their own learning as well as each other’s learning. Collaborative learning was shown to improve performance individually and collectively (Johnson et al., 1978) more than the other types of learning.

Collaborative learning increases knowledge sharing and creation and develops when the interdependence of group members, the structure and content of interactions, and the pattern of other group processes are responded to positively (Janz & Prasarnphanich, 2003). In collaborative learning, members teach each other about their knowledge and expect other members to do so. Collaborative learning promotes more positive attitudes towards heterogeneity among peers (Johnson et al., 1978); different knowledge, perspectives and cognitions are respected, valued, and actively sought.

Complexity leadership helps build the collective behaviors of collaborative learning by
giving sense to the value that differences among members provide to team innovation performance. The resonance enabled by complexity leadership fosters team members to make mutual adjustments which provide feedback mechanisms and are effective means to coordinate knowledge in dynamic environments (Mintzberg, 1979) such as innovation teams. Complexity leadership addresses tension and conflict which can impede learning (Argyris, 1999). Cognitive and other behavioral changes associated with learning can cause unproductive or crippling tension; leadership helps equip the team to stretch without breaking by making sense of aspirations and increasing tolerance for interpersonal risk (Argyris, 1999), which are actions espoused in complexity leadership (Uhl-Bien, et al., 2007). In collaborative learning, team members express and explore their divergent views. Conflict can potentially block mutual learning which leadership helps the team avoid by distinguishing between the constructive and destructive aspects of conflict and by engaging conflicting parties in joint discussion to understand and resolve discrepancies between them (Argyris, 1999), actions promoted in complexity leadership (Uhl-Bien et al., 2007).

Collaborative learning involves a deep multi-step process of sharing, comparing, relating and testing knowledge. By observing learning interactions, Rochelle (1992) described a collaborative process of learning. Collaborative learning starts with expressions of perceptions of reality at an intermediate level of abstraction situated in the understandings held by participants. Relationships and differences emerge from the interaction of metaphors derived from members’ knowledge bases and which can link members understanding. Members engage in interactive cycles of confirming and/or repairing constructed shared understanding through situated actions, such as,
experimentation, simulations, appeals to expertise external to the interaction and other means. By applying progressively higher standards for testing evidence, convergence on shared understanding and/or construction of new knowledge occurs. In the collaborative learning process, team members work together to share tacit knowledge (i.e., what each individual knows but does not normally make available to others) and to develop new knowledge, and these sharing processes increase innovative performance through the socialization of knowledge which converts tacit knowledge into new knowledge and then into tested knowledge (Janz & Prasarnphanich, 2003). Collaborative learning enhances innovation performance of individuals and of the team (Janz & Prasarnphanich, 2003).

Learning is central to the goals of both exploitative and explorative innovation (March, 1991; Van den Bosch et al., 1999). Exploitation efficiently seeks to learn new uses for and to create innovation from knowledge existing in the organization. Exploration seeks to absorb, that is learn, new knowledge in order to expand the scope and variety in organizational knowledge which enables the creation of new knowledge and of innovation by combining different knowledge bases. Collaborative learning supports both forms of innovative activity.

To make possible the use of existing knowledge, collaborative learning solves a critical challenge for innovation teams. People from different thought-worlds will have sufficient understanding of one another’s existing knowledge to be able to create something new together (Dougherty, 1992). Cronin and Weingart (2007), through their concept of representational gap developed from information processing psychology and shared mental model research, present an exposition of the depth of the learning hurdle innovation teams can face. As defined by Cronin and Weingart (2007), a
“representational gap is a group-level phenomenon that arises as a function of the cognition of individuals working together to solve a problem” (p. 762). Gaps open because there are differences in individual cognitive representations about the specifics of the problem arising from their tacitly held knowledge.

Members construct their individual representations unconsciously from their existing schemas or mental models because they try to capitalize on what they know and value when solving problems (Dougherty, 1992; Weingart, Cronin, Houser, Cagan, & Vogel, 2005). For example, when experts from different disciplines try to solve a problem, each will use the trained principles from his or her domain; consequently, differences occur in goal preferences, perceived constraints, understanding of what can be altered, and the rules to apply. Because members can only make sense through their different perceptions, misunderstanding and conflict increase which can degrade team innovation performance. New knowledge communicated by other members is unlikely to influence other members’ representations because of the circularity and self-reinforcing use of their existing representations to evaluate and understand new knowledge. The same process interferes with the creation of shared representations or “communal conceptual frameworks” critical to innovation (Brown & Duguid, 1991). The unexamined use of existing representations is an example of the limitations associated with single loop learning described by Argyris (1999) where adaptive learning is blocked because underlying rules and assumptions are not examined and altered. The deeper collaborative leaning ensures that the work to explore members’ representations is done sufficiently to uncover problematic incompatibilities, contradictions and gaps. As Schein (1993) pointed out, normal coordination mechanisms are not up to the task. Deeper dialogue is required
that makes it possible for people to discover that they use language differently, that they operate from different mental representations, and that these structures are learned social constructions of reality and thus limited by nature and subject to change. When the time and effort for collaborative learning is taken, teams can engage in double loop learning, where open discussion, experimentation and other means can be utilized to ensure development and testing of new more innovatively productive representations (Argyris, 1999).

In addition to facilitating the use of existing knowledge, collaborative learning increases absorptive capacity, that is, the ability of the team to learn and use new knowledge which exists outside its current knowledge bases. New knowledge is brought into the team through formal and informal interactions and linkages with outsiders catalyzed by complexity leadership (Uhl-Bien et al., 2007). Described previously, the collaborative learning process contains steps that facilitate linking to this new knowledge. This is an important consideration because absorptive capacity is contingent on the relationships that are made between newly acquired knowledge and the organization’s existing knowledge. Only new knowledge which can be related to, can be absorbed (Cohen & Levinthal, 1990). Relationships are forged through lateral communication between members of a group which arises from coordination that can be explicitly designed but may emerge from a process of interaction among members (De Leeuw & Volberda 1996). While requiring time and effort, knowledge coordination positively influences absorptive capacity because it increases flexibility in making connections between different knowledge and expands the range of knowledge which can be related (Van den Bosch, Volberda & de Boer, 1999). Collaborative learning increases
likelihood that relationships can be discovered and knowledge absorbed because it entails intensive communication and development of metaphors which link knowledge bases.

The functions and the catalyzed conditions of complexity leadership foster the emergence of collaborative learning in innovation teams. Collaborative learning is people sharing and understanding knowledge together. Complexity leadership furthers collaborative learning by supporting the time and effort required for in depth knowledge sharing and exploration by structuring interactions, by encouraging interdependent thinking, through sustaining tension while different understandings are explored and by seeking to build connections among separately held knowledge. On a team, both the leader and members engage in complexity leadership. Shared leadership facilitates learning while only hierarchical and concentrated leadership impedes learning, (Papadakis & Bourantas, 1998). Collaborative learning is a process which closely relates with and leads to innovation in teams. Collaborative learning allows teams to understand and exploit the knowledge possessed by members and to absorb and use new knowledge. Teams uncover gaps in their knowledge which they must bridge through the creation of new knowledge. Learning and knowledge creation are fundamental work of innovation teams. By influencing collaborative learning in addition to other team process helpful to innovation, complexity leadership indirectly enhances innovation team outcomes. Therefore, it can be hypothesized that:

**Hypothesis 2a:** Complexity leadership manifested by either team leader or team members or both is positively related to collaborative learning.

**Hypothesis 2b:** Collaborative learning is positively related to innovation team outcomes.
**Hypothesis 2c:** Collaborative learning partially mediates the relationship between complexity leadership manifested either by the team leader or by team members, and innovation team outcomes.

Complexity Leadership and Heterogeneity

Heterogeneity among participants is a main characteristic of CAS and of innovation teams. In complexity theory, it is from the interdependent interaction of heterogeneous agents in CAS that learning and innovation emerge (Marion & Uhl-Bien, 2001). Innovation teams are purposefully populated with members heterogeneous in background, expertise, and perspective in order to bring together the task knowledge which can lead to productive new and novel combinations and to engage representatives of the varied functional expertise necessary for problem solving and implementation of the innovation (Brown & Eisenhardt, 1995).

Leadership is challenged to gain positive effects from the heterogeneity present on innovation teams because heterogeneity has been shown to have contradictory effects on group performance (Harrison & Klein, 2007; Mannix & Neale, 2005; van Knippenberg & Schippers, 2007; Williams & O’Reilly, 1998). Heterogeneity enhances groups’ ability to create and adapt but also increases conflict and reduces collaboration among members. Because these contradictory forces can cancel out any advantage from the critical factor of heterogeneity, the dynamics enabled by complexity leadership must help avoid the negatives and realize the positives of heterogeneity in innovation teams. CLT assumes heterogeneity to have beneficial effects in CAS without explaining the mechanisms that would lead to positive influence. Given the well documented contradictory effects of heterogeneity, it would advance CLT to conceptualize how
complexity leadership enables the leveraging of heterogeneity for learning and innovation and what potential self-organized elements arise from its dynamics which assure heterogeneity will be helpful to learning and innovating. Certainly, how heterogeneity is handled within innovation teams will influence their ability to innovate; the role complexity leadership plays will be discussed in following sections. Hypotheses will be proposed that examine how complexity leadership moderates the relationship of heterogeneity to innovation team outcomes and how positive team norms regarding heterogeneity arising from the dynamics enabled by complexity leadership, influence the relationship between leadership and team outcomes.

The effect of heterogeneity upon team performance, generally, and on team innovation, specifically, has been extensively studied in the diversity research. Comprehensive reviews of this literature have pointed to a bifurcation in the theories explaining the contradictory effects of group heterogeneity on performance (Harrison & Klein, 2007; Mannix & Neale, 2005; van Knippenberg, & Schippers, 2007; Williams, & O’Reilly, 1998). Two theoretical streams split into theories focused on social category diversity and the causes of negative effects and theories focused on job related diversity, which stress the causes of positive effects.

The social category diversity view of heterogeneity is based upon a social identity and social categorization perspective which holds that recognized differences and similarities among group members cue individuals to categorize self and others. Individuals will have favorable preferences towards others or groups seen as similar and negative responses toward those who are seen as different. The individual’s differences can negatively affect self perceptions and attitudes which influence behaviors. For
example, differences in age, tenure, education, sex and race reduce individual’s psychological attachment to the group (Tsui, Egan and O’Reilly, 1992). Because of differences in cognitive style, individuals inaccurately perceive their own creative performance and have lower group satisfaction (Kurtzberg, 2005). At the team level, social identity and social categorization theories also suggest members will identify less with the larger more diverse group and more with similar subgroups (Rico, Molleman, Sánchez-Manzanares, & Van der Vegt, 2007). Consequently, subgroup polarization increases which leads to more conflict, less collaboration, less cohesion and, ultimately, to lower quality decisions (Lau & Murnighan, 1998; Li & Hambrick, 2005). In the social category diversity view, heterogeneity presents impediments to team performance, particularly in complex tasks such as innovation.

The job related diversity view uses information processing/decision making perspective which holds that the differences among group members bring together non-redundant knowledge, skills and abilities. These unique contributions are task relevant, and even as these differences cause task oriented conflict, the interactions lead to more alternatives, new solutions and better decisions (Ancona & Caldwell, 1992a; De Dreu & West, 2001). Members from different thought worlds with different information networks articulate different ideas, concerns, beliefs and information. Through collaboration, the exchange of information and perspectives positively impacts individual and group level processing when implications are integrated (van Knippenberg et al, 2004; Jehn, Northcraft, & Neale, 1999). Further, the positive relationship between heterogeneity and performance increases as the task of the group is more complex and non-routine (van Knippenberg et al., 2004). The job related diversity view sees task relevant heterogeneity
as a positive force and a necessary team ingredient which leads to more productive innovation.

While the contradiction of heterogeneity and inconsistency in findings remain unresolved, researchers have suggested ways to untangle the knot. Van Knippenberg and colleagues (2004) propose integrating the social categorization and information processing theories into a unified model. In their theoretical model, CEM for Categorization-Elaboration Model, they expand consideration and clarify the role of elements in social categorization. It is not social categorization itself that directly influences performance but the affective evaluative responses to heterogeneity based on perceived threat or benefit from it that moderates group information processing and subsequently performance. This view opens the possibility of positive attitudes towards heterogeneity and challenges the social categorization perspective to address the need observed by van Knippenberg and his colleagues (van Knippenberg & Haslam 2003; van Knippenberg & Schippers, 2007) for the social categorization perspective to incorporate positive relationships of heterogeneity with group interaction. Additionally, van Knippenberg et al. (2004) posit that the elaboration of task-relevant information, that is the sharing, interchange and combining of ideas, knowledge and perceptions, is the information processing process and the chief means by which heterogeneity influences team creative and innovative performance. This study will follow the framework of van Knippenberg and colleagues. In its theory development, moderators and mediators will be examined by considering their social categorization effects and their information processing effects.
This study deals with heterogeneity as it is conceived by complexity leadership which focuses on differences in knowledge and knowledge networks and the skills, competencies and perspectives related to the knowledge. Other forms of diversity which have been extensively examined in the literature, such as categorical diversity, are not considered in this study because of its focus on complexity leadership theory.

Complexity Leadership and Job Relevant Heterogeneity

Complexity leadership is theorized in this study to enable dynamics which leverage heterogeneity in CAS for learning and innovation. As suggested by CLT, leveraging heterogeneity would involve enabling a collective impetus among heterogeneous agents to interact in ways that produce new patterns of thinking or new modes of operating (Uhl-Bien et al., 2007). Through leveraging heterogeneity, diversification in behaviors, strategies and responses is increased which enhances the organizational system’s capacity for innovation and adaptation to environmental problems or internal demands (McKelvey, 2007). In CLT, heterogeneity refers to differences among agents in relevant attributes, such as skills, knowledge, preferences, and outlooks (Uhl-Bien et al., 2007). Job relevant heterogeneity has been studied extensively and, similar to other types of heterogeneity, has been found to have inconsistent relationship to team outcomes. In their meta-analysis, Hülsheger and colleagues (2009) found that while generally a positive relationship between job relevant heterogeneity and team innovation was evident, the variance among studies prevented generalizing this finding. They concluded that unidentified factors which varied among studies play intervening roles in the relationship. Research has demonstrated that leadership is one potential intervening factor with positive moderation effects found for
transformational leadership (Kearney & Gebert, 2009) and with moderation effects varying for different leadership styles (Somech, 2006). Likewise, complexity leadership potentially moderates the relationship. It is proposed that through the enabling aspect of complexity leadership, dynamics are catalyzed in innovation teams which increase job relevant heterogeneity’s information processing benefits and decrease its social identity impediments.

Job relevant heterogeneity relates to the differences among members in attributes which tie closely to the task at hand, such as, function, education, professional role, and types of tenure (Millikin & Martins, 1996; Pelled, Eisenhardt, & Xin, 1999). Heterogeneity in these attributes has been theorized to be related to team innovation because they represent differences in knowledge, skills and expertise which can help the team create solutions for new products and processes (Woodman, Sawyer, & Griffin, 1993). Individual and collective creative processes are stimulated by the interaction of people with divergent job related backgrounds, such as, differing functional and/or industry experience, and with varied educational backgrounds who contribute different thinking approaches and perspectives (Perry-Smith, 2006). Additionally, team members with divergent backgrounds not only bring the knowledge they possess but also bring different information networks which broadens the sources of information and perspectives available to the team (Perry-Smith & Shalley, 2003; West, 2002). For teams where the need for cognition was high, educational diversity improved team leader assessments of team performance, presumably because high cognitive demands promote the benefits from educational differences to information processing (Kearney, Gerbert, & Voelpel, 2009). In a study of 88 cross-functional teams (Yeh & Chou, 2005), function
and job position diversity had positive influence on team learning behaviors which this study has argued, are important contributors to team innovation outcomes. However, two recent studies (Somech, 2006; Van der Vegt, Van de Vliert, & Huang, 2005) found no direct influence by function diversity on team outcomes including team reflection, team innovation and team performance. These studies reinforce the inconsistency of effects across studies noted by Hülsheger and colleagues (2009) and the need to identify intervening factors. The benefits of job relevant heterogeneity can be realized if dynamics are present on innovation teams that increase information processing capacity and avoid the effects of negative biases toward heterogeneity.

The four conditions enabled by complexity leadership: interaction, interdependence, tension and resonance, create dynamics contribute to leveraging job relevant heterogeneity in innovation teams. Complexity leadership increases interaction among agents in CAS. Interaction is a primary condition required to gain benefit from job relevant heterogeneity. Heterogeneity which is not engaged through interaction will have little influence on innovative outcomes. In their study of 224 R&D teams, Reagans and Zuckerman (2001) found that team heterogeneity by itself did not predict team productivity but heterogeneity combined with level of interaction was linked to productivity. They broke interaction into two elements: "network density" which is how much team members communicate with one another and "network heterogeneity," the percent of team communication among members with different backgrounds. They conclude that relevant heterogeneity must be engaged through social interaction for it to have value to team performance. Through enabling interaction among members,
complexity leadership increases both “network density” and “network heterogeneity” and the information processing on innovation teams.

Complexity leadership enables collaborative interdependence among team members. Pertaining to social categorization, collaborative interdependence among team members focuses members on common tasks and goals and reduces salience of subgroup categorization. Further, collaborative interdependence increases and facilitates intra-team exchange and interaction which enhances team information processing. From both the social categorization and information processing perspectives, collaborative interdependence would be associated with more positive effects of heterogeneity on team processes and outcomes. Interdependence and collaboration have been shown to moderate the relationship between group heterogeneity and group outcomes. In a number of studies, Chatman and colleagues (Chatman & Flynn, 2001; Chatman, Polzner, Barsade, & Neale, 1998; Chatman & Spataro, 2005) found that in groups with cooperative norms which favor interdependent work efforts, group heterogeneity was more positively related to group performance outcomes. Cooperative group cultures were associated with more positive relation between heterogeneity and performance (Jehn & Berzrukova, 2004). Several studies examined task interdependence, where members must work together to perform a task, and/or outcome interdependence, where outcomes can only come about from the combined efforts of members (Wageman, 1995). Heterogeneity was only positively related to innovative behavior when both task interdependence and outcome interdependence were high (Van der Vegt & Janseen, 2003). Heterogeneity was positively rated to team reflexivity, that is, the ability to self-examine team information processing, and team performance when outcome
interdependence was high (Schippers, Den Hartog, Koopman, & Wienk. 2003). While studying demographic heterogeneity, Jehn et al. (1999) found that when task interdependence was high, heterogeneity was more positively related to satisfaction and commitment.

Complexity leadership injects tension by enabling dynamics wherein differences, dissent, and divergent perspectives are encouraged and members accept responsibility for resolving differences and creating solutions (Heifetz & Laurie, 2001; Uhl-Bien et al., 2007). These tension filled dynamics have positive influence on both information processing and social categorization aspects of heterogeneity. As discussed above, heterogeneity can only provide value if it is engaged through interaction (Reagans & Zuckerman, 2001) and has greater effect through increased interaction among heterogeneous group members (i.e., “network heterogeneity”). When interaction between task related differences is encouraged by complexity leadership, the likelihood of increased “network heterogeneity” will occur which in turn increases the likelihood that the heterogeneous information available to the team will be processed. When complexity leadership makes differences salient, social categorization may act to stimulate information processing. When groups possessing heterogeneous information contain a person who is recognized as different, they tend to more effectively use their information heterogeneity which suggests that the recognized heterogeneity alerts the group to the potential existence of different information (Phillips, 2003; Phillips & Lewin-Loyd, 2006; Phillips, Northcraft, & Neale, 2006). One consequence of tension can be conflict, and conflict has also been related to heterogeneity. A basic tenant of social categorization theory supported by research is that homogeneous groups will experience less incidents
of conflict while heterogeneous groups will experience more conflict among members (Harrison & Klein, 2007; Mannix & Neale, 2005; van Knippenberg & Schippers, 2007; Williams & O’Reilly, 1998). However, inconsistent results have been found in the relationship between heterogeneity and group performance. In some studies, conflict positively affects heterogeneity’s relation to performance (De Dreu & Weingart, 2003; Lovelace, Shapiro, & Weingart, 2001); while in others the effects are negative (Cox, Lobel, & McLeod, 1991; Jehn et al., 1999; Li & Hambrick, 2005). These different results have been explained alternately by information processing theory which asserts that conflict increases the consideration of divergent information and leads to better decisions and more creative solutions and by social categorization theory’s view that conflict blocks communication and consideration of heterogeneous information. This dilemma can be used to highlight the effects of complexity leadership’s handling of conflict. While De Dreu and Weingart’s (2003) meta-analysis of the extensive conflict literature found that conflict of any type is negatively related to group performance, Hülsheger et al. (2009) found no correlation between conflict and team innovation performance. To restate the point made previously in this paper, it can be said that the presence or lack of conflict is not as important to innovation performance as what is done with conflict; the way conflict is managed determines whether performance will be helped or hindered (Simons & Peterson, 2000; Tjosvold, 1998). Complexity leadership enables open identification and discussion of differences, and actively instigates collaborative problem solving among contending parties (Uhl-Bien et al., 2007). Any conflict arising from heterogeneity is more likely to have positive effects on performance in the presence of complexity leadership.
Complexity leadership enables resonance, defined as correlation among heterogeneous agents which supports their acting in concert and is a condition that helps aggregations of heterogeneous agents choose to work and achieve some common outcome together (Uhl-Bien et al., 2007). Through leadership sense-giving and sense-making, complexity leadership fosters dynamics that enable teams to create collective structures such as team identity, team culture and team super-ordinate goals which bind heterogeneous members together. These structures focus members on what they share in common and beneficially influence team innovation (Earley & Mosakowski, 2000; Jassawalla & Sashittal, 2002; Mumford, & Licuanan, 2004). Further, they can reduce the effects of social categorization by reducing the salience of subgroup categorization. One area for common cognitions which may influence heterogeneity’s effects is members’ beliefs of how heterogeneity affects the team, referred to as “diversity mind-sets” (van Knippenberg & Schippers, 2007). Diversity mindsets, such as the “integration-and-learning perspective” of Ely and Thomas (2001) which perceives heterogeneity as a valuable resource for the group, have been shown to be associated with positive effects of heterogeneity, presumably because such attitudes are positive social categorization evaluative responses which promote information processing. Members with a more positive belief in the value of heterogeneity report a more positive relationship between heterogeneity and group identity (van Knippenberg & Haslam, 2003). Groups with gender heterogeneity are more likely to use their different information in decision making when they believe in the value of heterogeneity (Homan, Hollenbeck, Humphrey, van Knippenberg, Ilgen, & Van Kleef, 2008). Complexity leadership is associated with
positive beliefs regarding heterogeneity because it enables dynamics, such as encouraging differences, helpful to their emergence.

The four conditions enabled by complexity leadership: interaction, interdependence, tension and resonance, create dynamics on innovation teams which increase job relevant heterogeneity’s information processing benefits and decrease its social identity impediments. Interaction is a primary condition required to gain information processing benefit from job relevant heterogeneity (Reagans & Zuckerman, 2001). Collaborative interdependence focuses members on common tasks and goals reducing salience of subgroup categorization and increases and facilitates intra-team exchange which enhances team information processing. Complexity leadership injects tension by enabling dynamics wherein differences, dissent, and divergent perspectives are encouraged and these tension filled dynamics increase the likelihood that the heterogeneous information available to the team will be processed (Reagans & Zuckerman, 2001), that salient differences stimulate information processing (Phillips, 2003; Phillips & Lewin-Loyd, 2006) and that conflict based on differences is handled productively. Through sense-giving and sense-making, complexity leadership fosters correlation and focuses members on what they share in common reducing the negative effects of subgroup categorization. Because complexity leadership enables conditions in innovation teams which reduce the negative influence of social categorization, increase the positive effects of social categorization and promote information processing, it can be hypothesized that:
**Hypothesis 3:** Complexity leadership manifested either by the team leader or by team members moderates the relationship between job-relevant heterogeneity and innovation team outcomes.

**Complexity Leadership and Heterogeneity Norm**

Norms have been demonstrated to be useful structures for teams and are comprised of shared values and patterns of behavior that emerge from interactions within teams (Barker, 1993; Bettenhausen & Murnighan, 1991; Feldman, 1984; Friedkin, 2001). Team norms which regard heterogeneity positively relate to team innovativeness because these norms provide support for trust and risk taking and lead to more sharing of tacit information (Jassawalla & Sashittal, 2002). Team norms that enhance cooperation among heterogeneous members have been shown to influence effectiveness and outcomes of teams (Chatman & Flynn, 2001). In this dissertation, I propose a heterogeneity norm as an emergent structure in CAS and in innovation teams arising from the dynamics enabled by complexity leadership. A heterogeneity norm is defined as a team pattern of tolerating, respecting and engaging heterogeneity and is theorized to contribute favorably to positive social categorization evaluative responses and information processes in teams. The norm guides the teams to behaviors that gain benefit from their differences, obviating the need for intervening leadership activity.

Team norms influence team performance and are shared values, attitudes and beliefs that guide member behaviors through social pressure on members to engage in or avoid certain behaviors (Argots, 1989; Barker, 1993; Bettenhausen & Murnighan, 1985; 1991; Feldman, 1984; Friedkin, 2001). Norms about social behaviors are particularly important in groups that are highly interdependent, and their presence contributes to team
performance (Wageman, 1995). Viewed from social exchange theory, norms give rise to obligations that form the basis of each person's relationship with others and with the team as a whole (Shore & Barksdale, 1998). Social information processing theory (Salancik & Pfeiffer, 1978) showed that people form ideas and select behaviors based upon information from their immediate work environment, that is, the behavior of others. When individuals join into teams, their uncertainty regarding expected behaviors are eased as subsequent interaction within the team clarifies what is appropriate (Colman & Carron, 2001). People adopt the desire to perform a behavior when they believe that the behavior will have positive value to themselves and/or to the team (Bommer, Rubin & Baldwin, 2005). Team norms are shared cognitive structures which can guide behaviors beneficial to both individual and group outcomes.

A team heterogeneity norm relates group heterogeneity positively to team outcomes. Ely and Thomas (2001) reported that when an “integration-and-learning perspective,” which emphasizes heterogeneity as a valuable resource for the group, was present in the group, members felt more valued and respected. Intra-group relations were higher quality, and heterogeneous teams were more successful. Members shared an attitude predicated on the beliefs that a heterogeneous group of people “comes together for the express purpose of learning from one another how best to achieve the work group's mission, but that often meant tension- filled discussions in which people struggled to hear each other's points of view before resolving how to proceed,” (Ely & Thomas, 2001: 247). This view is supported by work that shows heterogeneous groups make better use of their heterogeneous information and perform better when they have value-in-heterogeneity rather than value-in-homogeneity beliefs (van Knippenberg &
Schippers, 2007). Team norms which value heterogeneity are particularly important to the performance of innovation teams because such norms support the information processing of different knowledge bases on the team. Norms which value individual differences and uniqueness tend to emerge when the success of the group is dependent on unique and specialized knowledge, skills and abilities that individual members bring to the group (Postmes, Haslam, & Swaab, 2005; Postmes, Spears, Lee, & Novak, 2005). Such norms have positive influence on trust and risk taking and lead individuals to contribute their specialized knowledge and unique perspectives (Jassawalla & Sashittal, 2002). Members who sense their difference feel safe to question assumptions and think divergently; the divergent attitude feeds their ability to construct new definitions of problems, to combine ideas with others into new solutions, and to communicate creative solutions to the team (Janssen & Huang, 2008). The heterogeneity norm shifts social categorization concerns from differences among members to a higher team level focus. Norms that appreciate value of heterogeneity and expressions of individual knowledge and expertise reinforce rather than mitigate collective goals and group attachment when heterogeneity and specialized knowledge provide value to team accomplishment (Bettencourt & Sheldon, 2001; Swann, Kwan, Polzer, & Milton, 2003). When heterogeneity is tied to the good of the team as a whole, the resulting inclusiveness supports super-ordinate identity and reduces individual and sub-group biases which could lead to conflict and deteriorated performance (Homan et al., 2008). In innovation teams, the heterogeneity norm permits members to handle contested points of view, engage in debate and realize synergies from differences (Schein, 1993)

Within CLT, a heterogeneity norm, while not explicitly theorized, is anticipated.
In CLT, individual preferences are valued because it is from the clash of heterogeneous preferences that learning and innovation emerges. Rules governing how heterogeneity is dealt with are important to the dynamics within CAS. According to most complexity theorists, agent interactions in CAS are governed by few rules which have far-reaching influence to coordinate behaviors (Lichtenstein et al., 2006; Uhl-Bien et al., 2007) and the existence of these rules leads to highly ordered but self-organized correlated actions of agents. For example, flocks of birds form intricate and quickly changing maneuvers when faced by threats simply by members of the flock observing a few simple rules governing their movement relative to other nearby members. Such rules enable network dynamics from which newness and novelty emerge and are different from bureaucratic rules which work to limit alternatives. In complex networks, interaction rules, such as a heterogeneity norm, enable open interchanges among dissimilar agents which allow ideas to emerge, to be elaborated, to conflict with one another, and to gain acceptance or die; learning and innovation are the resulting outcomes (Uhl-Bien et al., 2007). In CLT terms, the heterogeneity norm is a form of correlation, which is understood to be the emergence of areas of common understanding and/or patterns of behavior which lead to a degree of stability within CAS. Further, the heterogeneity norm is a first order correlation which means that through the correlation both the needs of individual agents and the needs of the aggregate as a whole are accommodated (Marion & Uhl-Bien, 2001).

Certain individual and team values are aligned in first order correlations. For example, with a heterogeneity norm, individuals’ needs for their unique knowledge to be valued are supported and, in so doing, the team’s need for innovative outcomes is also accommodated. In knowledge driven organizations, members are not limited to only view
their own work and immediate dependencies rather, they seek to address problems beyond their separate, specialized knowledge, and use their specialized knowledge to solve a broader range of complex and creative problems and to contribute their expertise to activities well beyond their old specialization (Zammunto et al., 2007). In so doing, they serve their organizations need for innovation. Correlation is a form of resonance in CLT (Marion & Uhl-Bien, 2001). The heterogeneity norm provides the benefits of resonance to the dynamics of innovation teams but also in a unique way, provides an additional benefit of increasing the team’s ability to handle tension arising from differences among members. When team members value different perspectives from their colleagues, they are more likely to engage in the tension filled interactions which can lead to learning and creation of innovative solutions.

CLT views the role that leadership plays in the formation of the heterogeneity norm differently from traditional leadership theory. Marion and Uhl-Bien (2001) distinguish between the traditional view of leadership as a link in cause and effect process wherein leadership influences actions of followers to attain a desired outcome. Rather, complexity leadership enables dynamics which help agents in CAS self organize, that is, structures, such as a heterogeneity norm, emerge from their interdependent interaction. The view that leadership enables conditions within teams for norm formation is supported in research about team culture formation. As previously stated, team norms are part of team culture (Earley & Mosakowski, 2000; Jassawalla & Sashittal, 2002). Leadership has been shown not to create culture but rather to facilitate a process among organizational members to create a culture which will help the group perform its tasks and achieve its goals (Earley & Mosakowski, 2000). Norms have influence because the
social expectations formed around norms are self enforced as members align their behaviors with accepted norms, decreasing deviation. This process is an example of the feedback loops which amplify processes by which emergence and self-organization occur without external intervention. Complexity leadership does not cause the norm to exist in a strict cause and effect relationship but enables dynamics by which a heterogeneity norm can emerge from the interaction within the system.

When the heterogeneity norm with its common attitudes and values is present on a team, members will tend to more readily share their uniquely held knowledge, will more confidently engage in discussions of divergent views, will expect to rely on the knowledge of other team members to resolve problems, will handle the tension associated with maintaining divergence until true learning and creativity occur, and will avoid conflict fueled by biases about heterogeneity of other members. Those behaviors represent realizations of behaviors sought by complexity leadership as it fosters the catalyzing conditions of interaction, interdependence, tension and resonance. Norms generally obviate the need for leadership intervention. Teams align member behavior by establishing norms early in team formation, and once the norm is formed, less leadership intervention is required regarding behavior (Jassawalla & Sashittal, 2002; Taggar & Ellis, 2007). Consequently, in the presence of a heterogeneity norm, less complexity leadership behaviors are required from the leader and members to influence related member behavior. It is therefore hypothesized that:

**Hypothesis 4:** A heterogeneity norm partially mediates the relationship between complexity leadership, manifested either by the team leader or by team members, and innovation team outcomes.
Chapter Summary

The picture that emerges from the discussion of complexity leadership in this paper is a leadership focused at the dynamics in aggregates of heterogeneous agents which catalyze the emergence of learning and innovating. Also, complexity leadership positively influences the relationship between the heterogeneity of agents and innovation team outcomes.

CHAPTER THREE
RESEARCH METHODS

Introduction

The methods section of this paper contains several sub-sections: the research design, the setting of the study, a description of data collection and the samples, data analysis, an enumeration of the instrumentation, and the methods of hypotheses testing.

Research Design

The research design is a field study of active or recently concluded innovation teams in industrial companies. One of the strengths of this proposal is that it is informed by the results of two studies, one qualitative and one quantitative, involving a number of innovation teams across a number of companies. The study began with interviews with participants involved in 5 innovation teams in 3 companies. This preliminary analysis clarified important functions of leadership and the ability of group members to share leadership roles, both of which make collaboration and learning possible by leveraging the heterogeneity of team members. In the quantitative phase, 59 R&D innovation teams from 25 companies participated.
Although this study is primarily a quantitative analysis, the qualitative pilot study was conducted for the purposes of understanding innovation within teams as they develop new products for the market or new operating processes for the company and of developing and validating how the factors of leadership, collaborative learning and heterogeneity affect the innovation process. The pilot study supplemented efforts of retrieving indicators used in the research literature. The findings of the qualitative pilot study were used to help build the survey instruments. The pilot study and literature search provided the basis for triangulation in developing reliable and valid indicators. By combining qualitative data extracted from the interviews with existing theoretical studies of various aspects of team leadership, learning, heterogeneity and innovation along with empirical analyses using validated scales, an item inventory was developed that was utilized in the construction of the indicators for the major variables of this study and which were included in the survey. The item inventory was then factor analyzed using respondent data so that parsimonious, reliable, and valid indicators could be identified for use in the analysis of leadership, learning and heterogeneity in the innovation process.

Field Setting

This study was conducted in conjunction with a Research on Research (ROR) committee of the Industrial Research Institute (IRI). The Industrial Research Institute is a prime professional organization for corporate research leaders, with the mission of “enhancing the effectiveness of technological innovation in industry.” Members represent over 200 major industrial R&D organizations. Within IRI, an ROR committee established as a “laboratory for innovation management” becomes the vehicle providing IRI member
companies with cutting-edge research on innovation techniques and management practices.

In order to attract and retain its membership, IRI needs to deliver groundbreaking research to its members. In addition, ROR committees have a tradition of collaborating with universities on research projects. Researchers from this university have been involved in prior research collaboration with IRI that has led to publications in top tier academic management journals. It is important to note that the member companies of IRI understand that in order to reap the benefits of their membership (e.g., cutting edge research), they need to provide access to their companies for research.

In this context, and because of membership interest in developing a better understanding of what it takes to lead heterogeneous R&D teams, the IRI ROR committee invited this researcher and colleagues in the research team to use the committee members’ influence for recruiting innovation teams from IRI member companies to participate in testing the model of innovation proposed by this study. Twenty-seven IRI companies in total participated in this project.

Data Collection and Samples

The IRB of Rutgers University approved exemption of the project under the exempt category 2 on September 5, 2007. Appropriate safeguards are provided to study participants to maintain confidentiality and to minimize risk to the companies or the participants. As required, the researchers have signed confidentiality agreements with companies when asked and received signed agreements from appropriate company representatives permitting company personnel to participate in the study.
All data have been carefully handled, made available only to those directly involved in the study on a need to know basis, and will be maintained in locations that are not accessible to those without appropriate authorization. Rutgers University, of course, maintains strict security procedures for all of its computer technologies and regularly updates security procedures to protect against unauthorized access. The researcher was assisted by research associates who had extensive prior experience in handling confidential data and maintaining confidentiality both in the data and in the research procedures by which the data are handled and reported.

Data collection required a two phase process. The first phase included the qualitative pilot study. Data were collected by interview. The second phase involved the use of self administered online survey to team members and leaders and a survey to stakeholders for which some respondents were surveyed by phone while others used a self-administered online survey. The details of data collection will be described below. Both phases of the study contain data from two separate samples: 1. stakeholders and 2. team leaders and members. In the analysis, team leader and member data are aggregated by teams. Stakeholder data are team level data and used in analyses with the aggregated team data.

**Stakeholder Sample**

A stakeholder is someone who is not on the team but cares about the outcomes of the team, that is, has a stake in the outcomes of the team. This may be an internal customer for the output of the team or someone who is responsible at a higher level to deliver the output of the team. This person must have enough interest and be sufficiently involved to knowledgeably comment about:
• the team’s performance and its current and future expected outcomes,
• the team’s innovation, and
• the environment in which the team is operating.

The stakeholder sample was chosen by submitting the above criteria to the company representatives to the study. Based upon those criteria, company representatives submitted a list of one or more stakeholders per team.

Team Leader and Member Sample

Because this is fundamentally a study of team factors, the sampling frame for this study included all members and leaders of innovation teams. The teams had to meet the following qualifications:

They had to be composed of members from multiple groups or functions because functional diversity is an important dimension in the study,

They had to be involved in innovation, whether product or process,

They had to have been operating for a minimum of two months, and

They either had to be operating at the time of the study or concluded their work within 60 days prior to the assessment.

The Pilot Qualitative Study Data Collection

In the qualitative pilot study, five teams from three companies were volunteered and interviews were conducted with participants from all five teams. A total of 24 interviews were conducted. Participants included two stakeholders, 6 team leaders, and 16 team members. All interviewees were verbally informed of their rights as participants in a scientific study of confidentiality, the right to refusal without retribution, and the right to have access to the findings of the study. Confidentiality is maintained by the
researcher by eliminating all identifiable information. Interviews were conducted predominantly in person, only four by telephone, digitally recorded and then transcribed. The digital recordings are kept in a password protected computer and backups are physically secured. Transcriptions have all identifying information removed.

This pilot study used semi-structured interviews. The format was similar for stakeholder, member, and leader interviews. The first section of the interview contained questions on general background, including tenure, training, prior experience, and career goals. Topics that were the focus of the subsequent sections of the interviews included: the types of heterogeneity that are salient in the innovation team and how they are perceived to affect the innovation process, the existence and use of leadership which facilitates or impedes innovation, and team processes that affect the team’s innovation efforts. The leader and stakeholder guides were shortened versions of the team member guide. Stakeholder interviews were the shortest, taking 45 minutes. Team leader interviews averaged 70 minutes. Team member interviews took on average two hours. Copies of the items in the member interview schedules are available upon request.

Stakeholder and leader items were selected from the member interview schedule.

The Quantitative Study Data Collection

Data were collected in the quantitative phase through two survey instruments: the leader/member survey that contains approximately 250 questions, and a much shorter stakeholder survey of about 40 questions. The leader/member and stakeholder surveys are available upon request from the author. Surveys were administered online through the use of Survey Monkey. Participation was voluntary and confidentiality was guaranteed by maintaining participation anonymity. The consent notice was included in the email
which invited the team participant to take the survey. Identifying data were deleted when extracted from Survey Monkey.

For the quantitative study, 63 teams were proposed from 25 companies of which 60 qualified. Stakeholder surveys were attempted with 94 stakeholders; 89 (95%) completed surveys. There was at least one stakeholder for each innovation team. For qualified teams, all team members and leaders were invited to participate in the survey. The population for the study was 588 team members and leaders. The response rate on the survey was high (92%) with a total of 543 usable surveys. One team was removed from the sample because it achieved only a 50% response rate which fell below the 70% qualifying threshold. The sample used in the analysis included 59 teams. Average size of the teams was 9.8 members with a standard deviation of 4.9. Four teams had 4 members, the least number, and largest team had 28. The average number of functional organizations represented on the teams was 3.8 functions. Fifty-one teams had 3 or more functions. The team with the most had 7 different functions and 2 teams had 1 function represented.

Data Analysis

Data analysis was conducted in two major phases: the first phase analyzed the interview data and the second analyzed the survey data. The survey analysis was performed in two stages: first, a preliminary analysis was conducted, in which descriptive data were computed on the reliability and validity variables. The second stage consisted of answering research questions and testing hypotheses.

The Pilot Qualitative Study Data Analysis
Using analytical techniques both from grounded theory and from more structured forms of qualitative analysis, responses across topics and teams were compared and contrasted in order to evaluate what kinds of team and leadership practices seem to be most effective and most positively related to the development of innovation and how heterogeneity is perceived within innovation teams. A coding structure was created by the researcher for encoding the responses based upon the topics contained in the semi-structured interview schedules, notes made by the researcher during the interviews, and a preliminary review of responses. The electronic coding of the transcripts was performed by an independent coder trained by the researcher. When questions arose regarding appropriate coding of responses, the coder and researcher discussed the response and jointly selected the appropriate code. During these discussions, a few new codes were created. After the coder completed all interviews, the coding was checked by the researcher. Only minimal changes were made as a result of this review and after discussion between the researcher and the coder.

The interview data were analyzed with qualitative software, Atlas.ti, which aggregated responses by the electronic codes assigned. The reports facilitated the analysis of topics and teams. Using these reports, the researcher identified recurring themes and patterns from which theory and items for scales were drawn. The findings are reported in the subsections of this chapter.

*The Quantitative Study Data Analysis*

Preliminary Analyses: Items of variables that measure the major constructs of the study were factor analyzed using principal components analysis and varimax rotation. Separate factor analyses were conducted for each construct, that is, a separate analysis
was conducted for leadership, team dynamics including learning and heterogeneity norm and innovation team outcomes. The purpose of the factor analysis was to develop parsimonious, reliable, and valid indicators of the variables in the study. The choice of varimax, an orthogonal rotation method, was made because of its simplicity of interpretation and because the results of orthogonal rotation are more replicable (Pedhazur & Schmelkin, 1991). Some consideration was given to oblique rotation because it could create a factor structure better fit to the correlations among constructs theoretically present in this study (Conway & Huffcutt, 2003). However, studies have shown that orthogonal techniques are predominantly chosen by researchers. Ford, MacCallum, and Tait (1986) found that almost 80% of articles which described their factor analyses involved orthogonal rotations, whereas only 12% either used oblique rotations or did not rotate the solution. A later similarly conducted survey of studies (Fabrigar, L. R., Wegener, D. T., MacCallum, R. C., & Strahan, E. J. 1999) found that researchers in 48.3% of articles used varimax specifically and 20.6% used oblique rotations. Varimax is used in this study because its advantage of greater generalizability of results (Pedhazur & Schmelkin, 1991) is an important benefit which offsets its limitations and because the widespread and prevalent use of varimax among researchers represents a practice standard. Interestingly, both rotation procedures can be expected to produce similar interpretations except for extremely complex factor structures (Hetzel, 1997). Conway and Huffcutt (2003) point to the advantages of using multiple analysis techniques and to observe the differences. In a later section, oblique rotation will be applied to all items in factors which are described subsequently in this section, and a discussion of similarities and differences between orthogonal and oblique results will be
provided. All variables derived from the factor analysis were then subjected to reliability checks using coefficient alpha. The scales for the factored variables for complexity leadership, team dynamics, and team reported outcomes are created by taking the averages of the ratings across the items in the scale for each individual team member. Missing data is handled by excluding the item from the average calculation. Team level aggregated variables are calculated taking the average of the team across the scale scores of its members. This approach normally requires verification that aggregation of the team members to the team level is appropriate. One widely accepted approach to test the validity of team aggregation is through the use of ICC (Interclass Correlation), however it was discovered that ICC does not handle conditions where team sizes vary substantially. In this study, team size varied from four to 28 members. Alternative but well established indices for interrater reliability and interrater agreement (LeBreton & Senter, 2008) were used and include $r_{wg}$ index and AD (average deviation). For each team, these indices are calculated for each of the six aggregated team level variables. A team is rated questionable for a variable if it fails both the $r_{wg}$ index and AD thresholds established by Dunlap, Burke, and Smith-Crowe (2003). Seven teams failed to meet these criteria for all six aggregated variables and one team failed for four of the six. While other teams failed for one or at most two variables, there was sufficient agreement in the other variables for these teams to meet standards. Excluding the seven teams from the analysis was considered but rejected. Five of questionable teams were small teams with five or fewer members which by nature lack the number of respondents needed to achieve reasonable statistics. More importantly, when using $r_{wg}$ index and AD, aggregation is evaluated on how much agreement exists among members of the group. Because this study is
examining teams with members possessing heterogeneous perceptions, teams exhibiting low levels of perceptual agreement should by design be included in the study. Table 1 shows the percent of teams which passed the \( r_{wg} \) index and AD thresholds for each of the six variables in the 59 team sample and in the 52 team sample. Regressions were run to compare the results from the original 59 team sample to those of 52 teams. The comparison showed similar results with some differences which will be reviewed in detail in the next section.

Insert Table 1 Here

Instrumentation

This study requires a number of variables. They will be discussed under their major constructs with the input variables first, mediating or intervening variables second, outcome or dependent variables third and control variables last.

Complexity Leadership

In this study, complexity leadership is conceptualized along two dimensions: behaviors and distribution. Uhl-Bien et al. (2007) developed the concept of complexity leadership and described its functions, which are incorporated into this study through behavioral descriptions constructed by the author from information gathered through the pilot study interviews and from a review of complexity leadership literature. Respondents’ perceptions of innovation team leadership were explored in the interviews and four themes of effective leadership were identified: (1) leadership assures that divergent thinking and convergent thinking occur at beneficial times; (2) leadership models collaboration and inclusion; (3) leadership manages conflict by knowing when to
take issues offline to one-on-one or smaller groups and how to resolve conflict at lowest level possible without escalation outside of the team; and (4) leadership nurtures the relationship with formal organization by anticipating needed sources of support and by controlling and designing information flows to other groups and upper management. The four themes mapped into the leadership functions described by Uhl-Bien et al. (2007) and confirmed theoretical principles of complexity leadership. Those themes were restated into behavioral statements and included into the survey section about leadership with other behaviors garnered from studies of complexity leadership (Lichtenstein et al., 2006; Lichtenstein & Plowman, 2009; Plowman et al., 2007a, b; Uhl-Bien et al., 2007).

The complexity leadership scale has eleven items each for vertical and shared complexity leadership, keyed to a seven-point Likert type response mode with higher scores indicating greater levels of leadership behaviors and included the following items:

- Fosters interaction within and outside the team by encouraging open engagement
- Instigates discussion of different types of thinking among team members
- Recognizes the difference between unhelpful conflict and helpful conflict
- Engages members of the team in mutual problem solving
- Seeks a broad range of perspectives when solving problems
- Guides team members to converge on an agreement when one is needed
- Helps the team understand new events emerging in the team's environment
- Procures resources which the team needs from other groups
- Coordinates activities with other groups
- Resolves problems raised by other groups
Releases timely information to others in the company to advance the team’s image or work

Because of overall space and time constraints for the survey and the range of topics to be covered, the number of questions related to leadership was limited. Consequently, behavioral items were constructed to yield what can be characterized as a “global” measure of complexity leadership. CLT breaks down complexity leadership into various functional and sub-functional components. These components are reflected in the measure of this study but the components are not measured separately. Some items address multiple components while others only one. For example, an item addressing interaction within and outside the team relates to the interaction condition of the sub-function, Enabling Leadership. An item which describes seeking a broad range of perspectives when solving problems relates to both the interaction and interdependence conditions of Enabling Leadership. Table 2 provides a mapping of the items to the CLT function of Administrative Leadership and the sub-function of Enabling Leadership including enabling interaction, interdependence, tension and resonance and managing the entanglement between the administrative and adaptive structure.

The second leadership dimension in this study is its distribution and conceives that leadership is not only the province of the appointed leader of the team but also emanates from members of the team. The theme of shared leadership emerged from the analysis of the pilot study interviews; leadership activity was distributed among group
members. A member of a team provides a typical statement about shared leadership;
“The team's pretty fluid in terms of who would lead at any given time…it's not a military
type organization with a hierarchy. It's got more of an egalitarian type of organization, so
in that way I think it's a pretty key norm and we share the leadership role as appropriate.”

A vertical and a shared dimension are separately conceived. Complexity leadership is
assessed both vertically in relationship to leadership from team leaders and shared in
relationship to leadership from among team members. Complexity leadership is
consequently operationalized with two scales. The technique for measuring vertical
versus shared leadership was derived from Pearce and Sims (2002). Each respondent
evaluated both leader and members on each leadership behavior. For the vertical
dimension, statements began with, "The team leader..."; for the shared dimension
statements began with, "Teammates..." In this section, the assessment of leadership
variables will be detailed.

All leadership items were keyed to a seven-point Likert-type response mode from
strongly disagree to strongly agree (1-7 respectively). The items constructed by the
author were assessed using the research sample and re-analyzed using factor analysis.
The factor analysis followed the standards set by Pearce and Sims (2002) and strove to
describe factors which were as consistent as possible between vertical and shared
dimensions in order to facilitate comparison and also reflected the theoretical basis of the
items. Separate analyses were conducted on vertical and shared items. The same items
emerged in the factors for team leader (vertical) and team member (shared) items.

Table 3 contains the factors, items and factor loadings for the two scales of
complexity leadership generated from the separate analyses of shared and vertical
complexity leadership. The rotation method used was varimax with Kaiser Normalization. These variables were used in team level analyses. The scale for vertical complexity leadership achieved a coefficient alpha of 0.92 and the shared scale an alpha of 0.89, both indicating strong internal consistency. Vertical and shared complexity leadership are input variables and are also theorized to be moderating variables of job-relevant heterogeneity.

Job Relevant Heterogeneity

Job relevant heterogeneity is conceptualized as the variety of bodies of knowledge within a team and is conceived to include the information which team members bring because of their education and work experience; information sourced from inside and outside their company from informal networks; and information made available through formal organizational contacts. Job relevant heterogeneity is operationalized by four heterogeneity variables: education, function, job role, and industry tenure. The pilot interviews reinforced the salience of job relevant heterogeneity. Leaders and members were asked to identify what type of differences among members was most salient to their team; background and skills were far and away the most often mentioned. In addition to educational and functional background, two other categories are salient; job role and work experience. Job role reflects the person’s position within the company structure and in practice determines information and networks available to the person. The pilot interviews also highlighted the relevancy of individuals’
perspectives and outside networks built from experience in other companies, both within the same industry and different industries. Expertise is recruited from the outside to gain, alternatively at times, the same or different industry related knowledge and access to outside networks for innovation efforts within the hiring company. Turn over and hiring statistics reveal relevant patterns. Turnover rates tend to be high across industries, with equal percentages of job changers moving within the same industry as moving to new industries; job changers tend to stay in the same industry when there are high returns for industry tenure (Golan, Lane, & McEntarfer, 2007), presumably because of the value of industry specific knowledge and network connections they possess. Alternatively, literature has shown the long industry tenure impedes managers’ orientation to organizational change because of their acquired preferences for industry routines and shared perspectives (Geletkanych, 1997; Hambrick, Geletkanych, & Fredrickson, 1993), which may mitigate against team innovativeness. Industry tenure heterogeneity is used in this study to capture heterogeneity in work experience and concomitant knowledge and networks. The specific questions in the survey related to job-relevant heterogeneity variables included:

For your highest degree attained, in which subject area did you earn it?
- Engineering
- Science
- Business
- Economics
- Liberal arts
- Law
- Other (please specify)

What is your current primary job responsibility? (Select the closest match)
- Accounting/Auditing
- General Management
- Computer Services
- Engineering
Finance
Human Resources
Marketing
Production/ Manufacturing/ Supply Chain
Basic and Applied Research
Information Services
Customer Service
Development
Legal
Sales
Other (please specify)

Within the structure of the company, what do you consider yourself?

A support staff associate
A technical specialist
A professional associate
A supervisor
A middle manager
An upper manager
None of these

How many years have you worked in this industry since the start of your career?

Education, function, industry tenure and job role are categorical variables which are dummy coded. The “Other” category responses for education and function were recoded when appropriate into existing categories. No new categories were identified. Industry tenure reflects amount of relative experience in the industry of the innovation team and is coded into the following experience categories: minimal (< 1 year), some (1-3 years), moderate (3-5 years), substantial (5-10 years), and maximal (> 10 years). Job relevant heterogeneity measures are calculated using the Index of Diversity (Blau, 1960; 1977) introduced into social science from biology by Peter Blau and is often referred to
as the Blau index. Selection of this index follows the guidelines established by Harrison & Klein (2007) for measuring variety diversity in groups which they define as differences based on expertise, knowledge, background, and networks and identify attributes such as educational and functional background, industry experience, and network ties. The general formula of the index is:

\[ D = 1 - \sum_{i=1}^{N} p_i^2. \]

Blau indices are normalized for the analyses. Job-relevant heterogeneity is an input variable.

**Collaborative Learning**

Collaborative learning is defined as a team processes which allows heterogeneous innovation teams to share, understand and use the tacit information held by members so that the team can work together to create new knowledge. The collaborative learning items scales are constructed from items derived from Janz and Prasamphanich (2003); and Jassawalla and Sashittal (2002). In addition, the scales originating from the literature were supplemented by items developed out of the in-depth interviews conducted by this researcher. Collaborative learning arose from the interviews as an important driver when teams have disparate knowledge which must be brought to bear for innovation. Three patterns became evident. First, people spend time and effort to fully explain their knowledge, doing the cognitive work necessary to articulate their tacit knowledge. One engineer of a team expressed this aspect: “In this case, I had to think through {my discipline} enough to explain it to {other specialists} or to somebody who was far removed, so that I could make it clear to them. So it helped me clarify my thinking and it
also allowed different team members to say what you’re proposing isn’t right for my needs. So you could fix things very quickly on the fly. So that was very powerful.”

Secondly, learning happened across all disciplines not just those with obvious dependencies and is described in the following quote: “I’d say to a fairly large extent, that we tried early on to segment it and say, ‘Well, the technical folks ought to be working on that, and they don’t need to be sitting in the meeting when we’re talking about the marketing challenges.’ But we ended up saying, ‘No, that’s really not the right approach.’ Even if it takes a little longer, technical guys need to understand the marketing style and the same vice versa, if we’re going to be successful in the long run.”

The third pattern was evidence of the use of expressions of differences as a mechanism within the learning process, reflected in the following quote: “I think the whole thing about getting used to everybody on everything, trying to express their own views. This perspective would be one that created greater flexibility and probably faster to market... And so then if I put forth an opinion, someone else will put forth an opinion based on their business experience with it. So you get a different type of conversation, a rich conversation.”

The collaborative learning scale operationalizes learning as a group phenomenon manifested in how much effort is put forth into learning the perspective of the other team members, how much teaching team members provide each other, and quantity and quality of their communication. Collaborative learning was assessed using a five item scale. The scale is designed to measure the extent to which collaborative learning takes place in a team. All variables in this scale were assessed using a seven-point Likert type response
mode from strongly disagree (1) to strongly agree (7). The scale was scored, with higher scores indicating greater collaborative learning. Items in the scale include:

*Everyone takes time to make sure the whole team learns together.*

*Our team takes time for everyone to get up to speed on difficult concepts.*

*This team takes the time to have members learn each other’s perspectives.*

*When things change, members of this team make adjustments they know will help the other members of the team.*

*This team knows when it’s time to let disagreements be aired.*

Table 4 contains the factors, items and factor loadings for the two scales of team dynamics, collaborative learning and heterogeneity norm which are theorized to be mediating variables of complexity leadership’s relation to innovation team outcomes. The indicators were subjected to reliability estimates using Cronbach's coefficient alpha. The collaborative learning factor has an alpha of 0.85.

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Insert Table 4 Here

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**Heterogeneity Norm**

The heterogeneity norm is conceived as a pattern of team attitudes and behaviors for tolerating, respecting and engaging the heterogeneity of its members. The scale for the norm is constructed from items selected from scales used by Mor Barak, Cherin, and Berkman (1998) and derived from the “integration-and-learning perspective” described by Ely and Thomas (2001). Positive attitudes and behaviors regarding heterogeneity were consistently expressed in the interviews of innovation team leaders and members. For example, a team member stated the sentiment expressed by many others: “I think what
helps the team is that we all have very unique backgrounds that are very different.” The value of heterogeneity was tied to the outputs of the team, “We’ve been able to develop some different products… I would say the different backgrounds as far as where we’re coming from a research standpoint, that brings forward a lot of discussions.”

The heterogeneity norm scale operationalizes the norm as a group phenomenon manifested in attitudes and beliefs about heterogeneity and behaviors tied to those beliefs. The norm was assessed using a five item scale. The scale is designed to measure the extent to which the heterogeneity norm operates on the team. The scale was scored with higher scores indicating a stronger norm. Items in the scale include:

- **This team believes different viewpoints add value.**
- **The differences on this team help us achieve the team’s goals.**
- **Reversed: The differences on this team seem to keep us from performing at our maximum effectiveness.**
- **Reversed: People on this team sometimes reject others for being different.**
- **Team members actively share their special knowledge and expertise with one another.**

Items were assessed using a same seven-point Likert type response mode as other variables and were subjected to the same factor analysis techniques with results shown in Table 4. The scale received reliability estimates of a 0.75 alpha.

**Innovation team outcomes**

Innovation team outcomes comprise the outcome variables in the study. In this study, innovation team outcomes include first, a set of team behaviors which have been shown to enable innovativeness and secondly, the primary performance output of the
team. Two variables, therefore, assess the innovation team outcomes: innovation enabling behaviors and perceived performance. Assessments came from two sources: stakeholders, who provided an external, more objective source of data, and team members, including the designated leaders, who provided internal sources. A strength of this study is the dual sourcing for ratings of innovation team outcomes. This approach follows the strong suggestion of Hülsheger et al. (2009) and provides their desired advantage for this researcher to assess the perspectives of the different data sources. Hülsheger and colleagues found that by far most studies, of the 104 they examined, relied on single source self-reported data only.

Table 5 contains the team member assessed innovation team outcomes factors. Table 6 contains stakeholder innovation factors. In summary, four variables relate to innovation team outcomes: stakeholder-innovation enabling behaviors, stakeholder-perceived performance, team-innovation enabling behaviors and team-perceived performance.

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Insert Tables 5 and 6 Here
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Innovation enabling behaviors. Innovation enabling behaviors was assessed using the Innovative Work Behavior (IWB) scale (Janssen, 2000), a nine item scale that asks respondents to describe their innovative behavior using a five-point Likert-type response mode in which "1" is "never," and "5" is "always." Participants are asked, "With what frequency do you engage in the behaviors listed below?" Typical items include, “Searching out new work methods, techniques or instruments," and "Generating original
solutions for problems." The IWB is scored using the summed scale technique in which the theoretical range is between 9 and 45, with higher scores indicating greater levels of engagement in innovation enabling behaviors.

The IWB was tested for internal consistency reliability using coefficient alpha, which was .94 in a study of work behaviors (Ramamoorthy, Flood, Slattery, & Sardessai, 2005). Janssen (2000), the developer of the scale, reported that it was positively related to worker education level, job control, and job demands, suggesting that the scale measured the behavior of persons in highly creative and demanding jobs that allow high degrees of worker autonomy. This is evidence of construct validity, and corresponds to the theoretical expectations. Janssen reported a coefficient alpha a .90 in a sample of 392 Dutch workers in the food industry.

From the innovative behavior scale was developed a researcher-constructed innovation enabling behaviors scale. The innovation enabling behaviors scale is used to assess perceptions of team members including team leaders and stakeholders on the extent to which the team engages in innovative actions. For both samples, the scales contain four items keyed to a seven-point Likert type response mode with higher scores indicating greater levels of innovative actions and included the following items:

- This team creates new ideas which are transformed into useful applications.
- This team mobilizes support to gain approval for its innovative ideas from others outside the team.
- This team searches out new technologies, processes, techniques, and/or product ideas.
- Please rate your satisfaction with team innovativeness.
Coefficient alpha for the member/leader survey was 0.82 and, for stakeholders, 0.84.

*Perceived performance.* Performance of a team has been assessed with comparisons to expectations (Edmonson, 1999), and satisfaction with performance (Cordero, DiTomaso, & Farris, 1996). During interviews, stakeholders also related estimates of performance to the willingness to continue to provide investment in the team’s project. Stakeholders, team members and leaders were assessed on perceived performance scales with items using a seven point Likert type response mode. For question regarding satisfaction, answers ranged from very dissatisfied (1) to very satisfied (7). For question regarding expectations, answers ranged from far below expectation (1) to far exceed expectations (7). For all other items, the range was from strongly disagree (1) to strongly agree (7). Higher scores reflect higher perceived performance. Four items were included for the team leader/member version:

* Satisfaction with overall team performance
* Satisfaction with the timeliness of team work
* Team’s performance relative to the team’s own expectations
* Team’s performance relative to the expectations of the team’s stakeholders

The perceived performance scale contains the following five items in the version for stakeholders:

* Satisfaction with overall team performance
* Team’s performance compared to your expectations for the team
* Team’s performance compared to expectations formed by performance of other innovation teams in your company
This team is on track to realize the outcomes we expect from the innovation on which this team is working.

This team will continue to receive support and resources for its work.

Both scales were assessed for internal consistency; the team members’ scale achieved a coefficient alpha of 0.87 and the stakeholder items achieved a coefficient alpha of 0.86.

Control Variables

Two control variables are used in all tests of this study’s hypotheses. Organization or team size has been shown to be a factor affecting team performance in studies regarding heterogeneity, leadership and innovation (Tsui et al., 1992; Pearce & Sims, 2002; Pelled et al., 1999; Cunningham & Chelladurai, 2005). Team size was provided for each team by the source company. Additionally, team tenure has been confirmed as a team level variable influencing team innovation (Hülsheger et al., 2009) and is, therefore, also a control variable in all hypotheses regressions. The six response options for the team tenure question were ordered to measure team tenure (1 = less than 3 months; 2 = 3-6 months; 3 = 6-12 months; 4 = 1-2 years; 5 = 2-4 years; 6 = >4 years. Team tenure is calculated as the mean of all reporting team members.

Using Oblique Rotation to Compare Factors Produced by Orthogonal Rotation

As discussed previously, varimax is the rotation technique used in this study’s factor analyses. An additional factor analysis was performed using OBLIMIN, an oblique rotation in SPSS, to provide a comparison test of the factors identified through orthogonal rotation. Oblique techniques can confirm that factors are really distinct because oblique rotation is better at finding a general factor when one exists as opposed
to separations interpreted by orthogonal techniques (Fabrigar et al., 1999). All items from the five factors of the study arising from team member assessments, that is, complexity leadership, collaborative learning, heterogeneity norm, innovation enabling behaviors and perceived performance, were included. With all items, any more general factors not identified by varimax should be detected and overlaps exposed, for example, between shared complexity leadership, which is conceived of as a team process, and another closely related team process, collaborative learning.

Table 7 contains the results of the oblique analysis and shows confirmation of the five factor structure produced previously by orthogonal rotation. The same five factors are interpreted by the oblique rotation as were interpreted by the orthogonal rotation. The same items comprise the factors, with the exception of one. The item, “When things change, members of this team make adjustments they know will help the other members of the team”, was loaded as one of 5 items comprising the collaborative learning factor by varimax with a coefficient of .586. Oblique rotation produced very low coefficients for the item and close cross loadings for collaborative learning (.280), innovative behavior (.294) and the heterogeneity norm (.305). Because those results suggest that the item should be removed, an analysis was run without the item and the results showed that the five factor structure remained constant with no other changes. Consequently, a collaborative learning factor was also tested with the remaining four items after excluding the cross loaded item. The 4 item collaborative learning factor has an alpha of .82 compared to that of .85 for the 5 item factor and a correlation of .976 significant at the .01 level to the 5 item factor. In summary, no substantial change to the orthogonal factor structure would be required because of the results of the oblique rotation. These
findings reinforce the view from the literature that in most cases, both rotation procedures will produce similar interpretations (Hetzel, 1997)

**Hypothesis Testing**

Analysis techniques used to test the hypotheses of this study are presented in this section. Variables, means, standard deviations and Pearson bi-variate correlations among all referenced variables are reported. OLS multiple regressions are used to test the relationships depicted in the study’s theoretical model displayed in Figure 1 and expressed in the hypotheses. Because the output of innovation team outcomes is comprised of four variables: stakeholder-innovation enabling behaviors, stakeholder-perceived performance, team-innovation enabling behaviors and team-perceived performance, tests of hypotheses include regressions with each of the four output variables as the dependent variable. For all hypotheses, regression testing, a probability level of .05 is used for the rejection of the null hypothesis. In this study, attention is paid to adjusted R² rather than R² because the sample size of 59 teams increases the probability overstatement of estimates. Adjusted R² provides an estimate of cross validation that adjusts for smaller ratios of samples size to predictors (Dielman, 1991). Changes in adjusted R² are prime indicators to compare the effects of different input, mediator or moderator variables. Because the effects of team level phenomena, such as shared complexity leadership, job related heterogeneity, and team-innovation enabling behaviors, are the subjects of inquiry, all hypotheses are assessed with team level data using the team as the unit of measure. In the power analysis for the 59 team sample size, the power coefficient would be greater than .80; that is, there would be less that 20% probability of a Type II error (Cohen, & Cohen, 1983) with an effect size of .15 for all
regressions except the tests of moderation which have a power coefficient of .61, that is, there would be a 39% probability of a Type II error.

Hypothesis 1 Testing

The first hypothesis theorizes a positive relationship between complexity leadership manifested by either the team leader (vertical) or team members (shared) or both with innovation team outcomes. The construct of complexity leadership was measured using two variables one relating to vertical and the other shared. Correlation estimates will provide indicators of the relationship between the distributions of complexity leadership and innovation.

Multiple regressions test the hypothesis with a regression for each of the four output variables that comprise the construct of innovation team outcomes. Each multiple regression is executed in four steps. The control variables, team size and team tenure, are entered in step one and remain in all subsequent steps. In step two, vertical complexity leadership is entered. Step three removes vertical complexity entered in step two and enters shared complexity leadership. In step four, both vertical and shared complexity leadership are present. The regression analysis is designed to test the hypotheses by providing separate estimates for distributions of complexity leadership to be compared and to ultimately estimate the effects when both types of distribution are operating.

The following equation represents the final step in the multiple regression, testing the direct effects of both vertical and shared complexity leadership on innovation team outcomes:

$$\{\text{innovation team outcomes}\} = b_1 \text{ team size} + b_2 \text{ team tenure} + b_3 \text{ vertical complexity leadership} + b_4 \text{ shared complexity leadership} + e_1.$$
**Hypotheses 2a,b,c Testing**

In the second hypothesis, the relationships among complexity leadership manifested by either the team leader (vertical) or team members (shared) or both, collaborative learning and innovation team outcomes are theorized in a set of three sub-hypotheses. The test of hypothesis 2a, a positive relationship between complexity leadership and collaborative learning, involves a multiple regression in the same structure as used with hypothesis 1. Four steps are used to compare and contrast the influence of vertical and shared complexity leadership on collaborative learning. Hypothesis 2b theorizes a positive relationship between collaborative learning and innovation team outcomes. Its multiple regression is accomplished in two steps, the first, the entering of controls and the second, the entering of the predictor variable, collaborative learning.

Hypotheses 2c involves the most complex set of multiple regressions to test whether collaborative learning partially mediates the relationship between complexity leadership and innovation team outcomes. The approach reflects the test of mediation described by Baron and Kenny (1986) which compares the regression coefficient of the independent variable before and after the mediator variable is included into the regression. If the coefficient declines to zero after entering the mediator variable, full mediation is present; any decline indicates partial mediation; and increase means no mediation. In the multiple regressions, test of mediation of vertical and shared complexity leadership by collaborative learning are done separately and together in order to compare their influences. Additionally, the bootstrapping procedures described by Preacher and Hayes (2008), which is favored over the Sobel test for smaller sample sizes, is used to verify the significance of the mediation. The following equation represents the
final step in the multiple regression, testing the mediation effects of collaborative learning on both vertical and shared complexity leadership:

\[
\{\text{innovation team outcomes}\} = b_1 \text{ team size} + b_2 \text{ team tenure} + b_3 \text{ vertical complexity leadership} + b_4 \text{ shared complexity leadership} + b_5 \text{ collaborative learning} + e_1.
\]

**Hypothesis 3 Testing**

In hypothesis 3, complexity leadership is theorized to moderate the relationship between job relevant heterogeneity and innovation team outcomes. The standard regression approach to testing moderation is used that steps into the regression equation, first the controls, then the predictors, followed by the moderator and finally the predictor/moderator interaction terms. All variables other than controls involved in the moderation test are centered. Given that the construct of job relevant heterogeneity is made up of four variables, the number of variables must be considered in constructing the regressions. Because of limits associated with the sample size of fifty-nine teams, vertical and shared complexity leadership are tested in separate regressions because in the final regression step of moderation, eleven independent variables are present. Each of the two multiple regressions will have four steps in which variables will be added in the following sequence: (1) the two control variables, (2) the four heterogeneity variables, (3) the complexity leadership variable, and (4) the four interaction terms. The following equation specifies the final step of the regression sequence, all variables other than the controls are centered variables:

\[
\{\text{innovation team outcomes}\} = b_1 \text{ team size} + b_2 \text{ team tenure} + b_3 \text{ education heterogeneity} + b_4 \text{ function heterogeneity} + b_5 \text{ job role heterogeneity} + e_1.
\]
+ b_6 \text{industry tenure heterogeneity} + b_7 \text{(vertical or shared) complexity leadership} + b_8 \text{complexity leadership x education interaction} + b_9 \text{complexity leadership x function interaction} + b_{10} \text{complexity leadership x job role interaction} + b_4 \text{complexity leadership x industry tenure interaction} + e_1.

\textit{Hypothesis 4 Testing}

Hypotheses 4 theorizes that the heterogeneity norm partially mediates the relationship between complexity leadership and innovation team outcomes and is tested in the same manner as described for hypothesis 2c above. Both the Baron & Kenny (1986) and bootstrapping (Preacher and Hayes, 2008) procedures are used to confirm the mediation.

The following equation represents the final step in the multiple regression, testing the mediation effects of heterogeneity norm on both vertical and shared complexity leadership:

{\text{innovation team outcomes}} = b_1 \text{team size} + b_2 \text{team tenure} + b_3 \text{vertical complexity leadership} + b_4 \text{shared complexity leadership} + b_5 \text{heterogeneity norm} + e_1.

\textbf{CHAPTER FOUR}

\textbf{RESULTS}

Descriptive Statistics and Correlations

Variable means, standard deviations, correlations are reported in Table 8. Additionally, alpha scores for all factored variables are shown. A number of important correlations are evident regarding the outcome variables. The dual sourcing for ratings of
innovation team outcomes from team leaders and members and from stakeholders provides stronger testing of relationships (Hülsheger et al., 2009). An important consideration is the relationship between the same measures from the two sources; significant correlation would indicate likelihood that the same phenomenon is being measured. In this study, team-perceived performance and stakeholder-perceived performance are correlated (.47, p < .01). Also, correlations were expected and found between the two variables of innovation team outcomes within each source, i.e., correlation between team-innovation enabling behaviors and team-perceived performance (.51, p < .01) and correlation between stakeholder-innovation enabling behaviors and stakeholder-perceived performance (.44, p < .01). However, difficulties can arise if there is little correlation between the same measures from the two sources which in this study is true for the innovation enabling behaviors measures. The innovation enabling behaviors scales that emerged from the team and stakeholder factor analyses contain the same four items, however, low correlation exists between innovation enabling behaviors as perceived by the two sources (.22, p > .05) and across the two sources between innovation enabling behaviors and perceived performance (.20, p > .05 for stakeholder-innovation enabling behaviors and team-perceived performance; .01, p > .05 for team-innovation enabling behaviors and stakeholder-perceived performance). Further, team-innovation enabling behaviors correlated significantly with complexity leadership (.65, p < .01 for vertical; .55, p < .01 for shared), collaborative learning (.64, p < .01) and the heterogeneity norm (.63, p < .01) but stakeholder-innovation enabling behaviors did not. Stakeholders’ perceptions of innovation enabling behaviors in this study appear disconnected from the team dynamics examined. The perceptions of innovation enabling behaviors differ markedly, as will be seen in the regression test results of this study’s hypotheses. This topic will be further discussed and possible explanations presented in the next section.
Correlations exist among many of the predictor variables, with some being very high. For example, collaborative learning is highly correlated with complexity leadership (.67, p < .01 for vertical; .57, p < .01 for shared). Similarly, the heterogeneity norm is also highly correlated with complexity leadership (.66, p < .01 for vertical; .56, p < .01 for shared). While all factors were successfully tested for discriminate validity with both orthogonal and oblique rotational techniques, concern must be given to potential overlaps in concepts or in their operationalizations. Later in this section, this topic will be taken up again in a discussion of the results of tests for multicollinearity in the regression associated with the hypotheses.

Readers are alerted to correctly interpret the team tenure control variable reported in Table 8. Because of the coding structure of this categorical variable as described in the Instrumentation section, the mean score of 3.89 is interpreted to show that average team tenure is approximately one year.

The following subsections review the results of the tests of the hypotheses of this study. Figure 2 provides a summary depiction of the hypotheses.

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Insert Table 8 Here

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Hypothesis 1 Results

Positive direct effects of both complexity leadership distributions, vertical and shared, on innovation team outcomes are proposed. The regression technique followed the approach used by Pearce and Sims (2002) which examines the separate and joint effects of the distributions. Advantages of this approach include reporting of individual and joint contributions to adjusted $R^2$ and testing for multi-collinearity. Table 8 contains the results of the regressions of the four outcome variables. Differences between the results of team reported and stakeholder reported innovation team outcomes exist; generally, team reported innovation team outcomes, which represent same source
measurement of predictors and outcomes, provided stronger support for the hypotheses in terms of higher more significant beta coefficients and contributions to adjusted $R^2$ than stakeholder reported. For team reported innovation team outcomes, vertical complexity leadership alone achieved significant coefficients ($\beta = .533$, $p < .01$ and contributed .357 to adjusted $R^2$ for team-innovation enabling behaviors and $\beta = .675$, $p < .01$ with .367 $R^2$ contribution for team-perceived performance). Shared complexity leadership also had positive effects ($\beta = .640$, $p < .01$ and contributed .368 to adjusted $R^2$ for team-innovation enabling behaviors and $\beta = .598$, $p < .01$ with .319 contribution for team-perceived performance). When both are present in the regressions, the vertical complexity leadership is the more powerful predictor ($\beta = .509$, $p < .01$) for team-perceived performance and shared is more powerful for team-innovation enabling behaviors ($\beta = .509$, $p < .01$). For stakeholder-perceived performance, vertical complexity leadership has significant positive effects when alone in the regression ($\beta = .353$, $p < .01$ with contribution of .103) and when jointly present with shared complexity leadership ($\beta = .461$, $p < .05$). Stakeholder-innovation enabling behaviors was least related to complexity leadership. When alone in the regression, shared complexity leadership achieved significance, a beta of .26 with p of .058, just marginally above the study’s .05 probability threshold and .044 contribution to adjusted $R^2$. No multi-collinearity issues were found in any of the regressions; this topic will be discussed more fully across the entire analysis later in this section. In summary, the hypothesis of direct positive effects of complexity leadership on innovation team outcomes is strongly supported by team reported innovation team outcomes and finds some support with stakeholder reported innovation team outcomes.

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Insert Table 9 Here

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Hypothesis 2 Results
The second hypothesis is comprised of three sub-hypotheses which propose a positive direct effect of complexity leadership on collaborative learning; a positive influence of collaborative learning on innovation team outcomes; and a partial mediation of the direct effects of complexity leadership on innovation team outcomes by collaborative learning. These sub-hypotheses were assessed using the Baron and Kenny’s (1986) causal step approach to assessing mediation which involves three separate regression steps. The first step is designed to verify the required direct relationship between the predictor and mediator variables; the second verifies the required direct relationship between the mediator and outcome variables; and the third is the mediation analysis which regresses the outcome variable on both the predictor and mediator.

The test of hypothesis 2a, a positive relationship between complexity leadership and collaborative learning also followed the Pearce and Sims (2002) approach, first collaborative learning is regressed against vertical complexity leadership, then shared complexity leadership and followed by both vertical and shared. The standardized coefficients and contribution to adjusted $R^2$ support the hypothesis. Vertical complexity leadership alone achieved beta of .682, $p < .01$, and contributed .429 to adjusted $R^2$. Shared complexity leadership alone achieved beta of .581, $p < .01$, with a .299 contribution. When both were present in the regression, the betas were .543, $p < .01$, for vertical and .207, $p > .10$, for shared and they jointly added .441 to adjusted $R^2$. Hypothesis 2a is supported.

The assessment of hypothesis 2b, a positive influence on innovation team outcomes by collaborative learning, requires a regression against each of the four innovation team outcomes variables. The regression analysis (See Table 10) found significant relationship for team-innovation enabling behaviors ($\beta = .592, p < .01$ and .235 $R^2$ contribution), team-perceived performance ($\beta = .738, p < .01$ and .312 $R^2$ contribution) and stakeholder-perceived performance ($\beta = .327, p < .05$ and .092 $R^2$ contribution). The relationship was not significant for stakeholder-innovation enabling
behaviors ($\beta = .101$, $p > .05$ and -.007 $R^2$ contribution). Hypothesis 2b is substantially supported except for stakeholder-innovation enabling behaviors and an important requirement for mediation is satisfied.

Hypothesis 2c is tested by comparing the direct effect beta coefficients of the distributions of complexity leadership on the four innovation team outcomes variables with the post- mediation betas generated when collaborative learning in included in the regressions (Baron & Kenny, 1986) and by using bootstrapping to generate $z$ scores which indicate the significance of the mediation (Preacher & Hayes, 2008). The results, summarized in Table 11 confirm the mediating effects of collaborative learning on vertical complexity leadership for team-innovation enabling behaviors ($z = 3.101$, $p < .01$) and team-perceived performance ($z = 4.138$, $p < .01$). Also, mediation of confirmed with shared complexity leadership for team-innovation enabling behaviors ($z = 2.973$, $p < .01$), team-perceived performance ($z = 4.032$, $p < .01$), and stakeholder-perceived performance ($z = 2.235$, $p < .05$). The proposed mediating effect associated with stakeholder-innovation enabling behaviors was not confirmed. The proposed mediating influence of collaborative learning is moderately supported.

Hypothesis 3 Results

This study proposes that complexity leadership moderates the effects of job relevant heterogeneity on innovation team outcomes. Study results yield some evidence for that hypothesis. There are thirty-two potential relationships where moderation can occur in this study. Because there are 4 heterogeneity attribute variables and 4 outcome variables, sixteen relationships are present to be tested for moderation by each of the 2
complexity leadership distributions. Of the thirty-two potential opportunities for moderation, five instances were found or sixteen percent of the relationships which is above the 5% which could be expected from random effects at a .05 threshold for accepting the null hypothesis. Tables 12 and 13 show the moderation regression results for vertical and shared complexity leadership respectively.

The direct effects of the four job relevant heterogeneity variables on innovation team outcomes are shown in step two of the regressions in Table 12. No significant direct effects by any of the variables are present for stakeholder assessed innovation team outcomes but significant influence is present for team assessed innovation team outcomes. Job role heterogeneity has significant positive effects on team assessed outcomes ($\beta = .298, p < .05$ for innovation enabling behaviors and $\beta = .318, p < .05$ for perceived performance). Industry tenure heterogeneity also has positive effects on team assessed outcomes with mixed significance ($\beta = .108, p > .10$ for innovation enabling behaviors and $\beta = .285, p < .01$ for perceived performance). Function heterogeneity has negative effects and mixed significance ($\beta = -.242, p > .10$ for innovation enabling behaviors and $\beta = -.422, p < .01$ for perceived performance). Education heterogeneity has no appreciable effects on team assessed outcomes.

Vertical complexity leadership moderated the relationship between function heterogeneity and stakeholder-perceived performance ($\beta = .396, p < .05$). Shared complexity leadership moderated four relationships: between function heterogeneity and stakeholder-perceived performance ($\beta = .438, p < .01$); between education heterogeneity and stakeholder-innovation enabling behaviors ($\beta = .398, p < .05$); and between industry tenure and both stakeholder-innovation enabling behaviors ($\beta = -.313, p < .05$) and stakeholder-perceived performance ($\beta = -.381, p < .01$).
The moderation effects on function heterogeneity, graphed in Figures 3 and 4, are key findings because function heterogeneity is a main criterion used when forming innovation teams and is a major source of team heterogeneity. The mean of .65 for the normalized Blau indices of function heterogeneity indicates high levels across the teams. Function heterogeneity is correlated with education (.43, p < .01) and job role heterogeneity (.47, p < .01). Education and job role heterogeneity increase as teams are constructed to ensure functions are represented who have required expertise and whose support will be needed in the implementation of the innovation. The direct effect betas for function heterogeneity are negative for team-innovation enabling behaviors, team-perceived performance and stakeholder-perceived performance. The positive moderation of function heterogeneity by complexity leadership contributes to the performance of innovation teams; likewise the moderation of education heterogeneity grafted in Figure 5 also contributes.

Insert Figures 3, 4 & 5 Here

Negative moderation effects on industry tenure heterogeneity by shared complexity leadership are found and are surprising findings. While moderation was hypothesized in this study, positive moderation was anticipated. The moderation effects are graphed in Figures 6 and 7. These findings imply that as members with different industry tenure enact complexity leadership on teams high in industry tenure heterogeneity, their attempts to enable interaction and interdependence will interfere with innovation team outcomes as rated by the stakeholders of the team.

Insert Figures 6 & 7 Here

With 5 instances of moderation among 32 opportunities, it can be said is that some evidence was found of complexity leadership moderating job relevant
heterogeneity’s influence on innovation team outcomes. The proposed moderating relationship finds limited support. Detailed discussion of these results in the next section will explain how and why they provide important insights into the relationship between complexity leadership and job relevant heterogeneity.

Hypothesis 4 Results

The heterogeneity norm is proposed to mediate the direct effects of complexity leadership on innovation team outcomes. Results provide some support for the hypothesis. In initial steps for testing mediation, the relationships between the predictor and mediator and between the mediator and the outcome variables must be established. Relative to the predictor and mediator, complexity leadership is positively related to the heterogeneity norm: the beta for vertical complexity leadership is .682, p < .01 and .576, p < .01 for shared. Regarding mediator and outcomes, the heterogeneity norm has significant positive relationship to team-innovation enabling behaviors ($\beta = .601, p < .01$) and team-perceived performance ($\beta = .610, p < .01$) but only has near significant relation to stakeholder-perceived performance ($\beta = .239, p = .063$) and positive but not significant with stakeholder-innovation enabling behaviors ($\beta = .152, p = .240$). The assessment of the mediation hypothesis compares the direct effect beta coefficients with the post-mediation betas generated when the heterogeneity norm is included in the regressions. Additionally, bootstrapping is used to generate z scores indicating the significance of the mediation. The results, summarized in Table 14 show mediating effects of the heterogeneity norm for team reported innovation team outcomes but not for stakeholder reported. Mediating effects are confirmed for vertical complexity leadership with team-innovation enabling behaviors ($z = 2.970, p < .01$) and team-perceived performance ($z = 4.219, p < .01$). Also, mediation is confirmed for shared complexity leadership with team-innovation enabling behaviors ($z = 2.872, p < .01$) and team-perceived performance ($z = 2.950, p < .01$). The proposed mediating effects of the heterogeneity norm are
supported by team reported innovation team outcomes but not by stakeholder reported. Hypothesis 4 finds some support.

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Insert Table 13 Here

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Other Considerations

The potential for the presence of multicollinearity among the variables of this data set is a concern. A number of variables which are used as predictors simultaneously in regressions are highly correlated, for example, shared complexity leadership and collaborative learning (.57, p < .01) and consequently, the estimate of the variables’ impacts on the dependent variable will tend to be less precise than if the predictors were uncorrelated with one another. Tests for multicollinearity indicate if the correlation is problematic and were executed with every regression in this analysis. Applying standards of the tolerance statistic of no less than 0.25 and a Variance Inflation Factor (VIF) of no more than 4.0 (Fox, 1991; O'Brien, 2007), no indication of the presence of multicollinearity is found. The lowest tolerance statistic was 0.36 and the highest VIF is 2.76 across all regressions. Another recommended approach (Berry & Feldman, 1985) closely related to the tolerance statistic and VIF was also used to test multicollinearity. Each predictor variable is regressed on all other predictors. If $R^2$ values are close to 1.0 then multicollinearity is present. The results for this data set showed that all $R^2$'s are well under 1.0 with the highest being .587 when the heterogeneity norm is regressed on collaborative learning. Multicollinearity does not present a problem in any regressions in this analysis.

Because the 59 team sample was chosen over the 52 team sample, all regression tests of the hypotheses were also executed using the 52 team sample. The 52 sample
removed teams which did not meet the $r_{wg}$ index and AD thresholds for aggregation of individual data to team level variables. The results were the same, other than minor differences of beta coefficients and adjusted $R^2$ estimates, with the following exceptions. In the test of hypothesis 1, the 52 team sample showed a significant beta for shared complexity leadership in the joint regression step with vertical complexity leadership in relation to team-innovation team performance which was not present in the 59 team sample. Similarly for hypothesis 2a, the 52 team sample, unlike the 59 team sample, also showed a significant beta for shared complexity leadership in the joint regression step in relation to collaborative learning. These results from the 52 team sample would strengthen the case for accepting the proposed positive effects of shared leadership. In hypothesis 3, the 52 team sample did not yield moderation effects in two instances present in the 59 team sample. These included vertical complexity leadership moderation of functional heterogeneity with stakeholder- innovation team performance and shared complexity leadership moderation of education heterogeneity with stakeholder innovative behaviors. Those moderation differences would weaken the argument that there is some evidence to support hypothesis 4 which was made based on the 59 team sample results.

CHAPTER FIVE

DISCUSSION

Introduction

Complexity leadership focuses on leadership that enables organizational learning and innovation in complex organizational contexts (Marion & Uhl-Bien, 2001; Uhl-Bien et al., 2007). This study provides one of the first empirical tests of complexity leadership
theory and examined issues related to innovation team outcomes, collaborative learning and heterogeneity. This study used a mixed methods approach in a field study of industrial innovation teams, in so far as a quantitative study is supported by a qualitative review. The findings, summarized in Figure 8, show general support for the hypotheses, and provide evidence which supports the model of complexity leadership.

This study demonstrates that complexity leadership has positive relationship to innovation team outcomes and to collaborative learning. Collaborative learning is positively related to innovation team outcomes, and mediates complexity leadership’s influence on innovation team outcomes. Some support is found that a heterogeneity norm associated with complexity leadership mediates complexity leadership’s effects on team reported innovation team outcomes. Findings also show very limited support for a moderating effect of complexity leadership on the relationship between job relevant heterogeneity and stakeholder reported innovation team outcomes.

This study provides strong initial support for the core concepts of complexity leadership theory, a theory that shifts the paradigm of leadership research from “leader as person” effects to “leadership as process” influence. Two aspects of this shift were examined and are shown to be effectively relevant. First, shifting the focus for leadership research from the relationship between leader and followers to the relationship among heterogeneous agents acting in complex organizational systems permits a fuller examination of how leadership is a dynamic for change, learning, adaptation and innovation. Secondly, leadership is no longer viewed as the province of an individual but a dynamic process engaged in and shared by the agents participating in an organizational system. As Marion and Uhl-Bien observe (2001), this perspective does not negate or
obviate our extensive knowledge of how leadership stabilizes system elements but adds new dimensions required to understand what leadership is in dynamic complex environments.

An important contribution of this study is its operationalization of the theoretically described elements of complexity leadership (Uhl-Bien et al., 2007) into a reliable and effective eleven item scale applicable to all agents in a system whether designated leaders or members. The measure was built from data collected in the qualitative phase of the project and from leadership and related non-leadership literatures. The scale can form a base for further development of techniques for measuring complexity leadership and opens the possibility of examining the differences and synergies among complexity leadership and other conceptions of leadership for which scales are already well developed, particularly in their shared manifestations (Avolio, Sivasubramaniam, Murry, Jung, & Garger, 2003).

This study emphasizes that leadership must be examined in context; that the context for complexity leadership is that of complex adaptive systems (CAS); and that innovation teams are CAS. This study’s results reinforce the ambidextrous nature of CAS and complexity leadership’s relation to both its stable and dynamic system elements. Complexity leadership enables dynamics of self organization and emergence which lead both to stabilizing elements such as the heterogeneity norm and to dynamic interactions such as collaborative learning in which pre-existing tacitly held cognitive structures are penetrated and revealed and new knowledge created. In the presence of a team norm that respects and uses differences, agents can depend on open interactions in which to productively share their unique tacit knowledge. The shared nature of complexity
leadership means that influence is dynamic and flowing and shifts among agents as needs and conditions change.

A strength of this study is the dual sourcing of evaluations of innovation outcomes from internal team members and external stakeholders. But this strength also presents a challenge in interpreting the results. The problems of common method variance and response biases associated with single sourcing of predictors and outcomes are well established (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). However, only external reported assessments cannot be relied on for unquestionably reliable and valid ratings (Howard, 1994; Spector, 1994). This study helps address the problem that most previous studies of innovation teams have because it relies on dual sourcing of performance evaluation, rather than single source (Hülsheger et al., 2009). This study’s findings show similar results to other studies using dual sourcing, that is, self reports of team leaders and members had higher effect sizes than independent stakeholder raters (Hülsheger et al., 2009). Also, in this study, stakeholder-innovation enabling behaviors did not follow the patterns reflected in stakeholder-perceived performance, team-innovation enabling behaviors, nor team-perceived performance. This apparent disconnect may reflect one of the potential hazards of external raters, that of being too far removed to reliably evaluate. Innovation enabling behaviors describes behaviors more internal to the team, such as searching out new technologies, which may not be as observable or salient to stakeholders compared to the items in the perceived performance measure, such as decision to continue resourcing the team. Nonetheless, with two sources for outcome variables, this study has a richer set of measures available to better judge the theorized influences (Howard, 1994; Spector, 1994). Because this study relies on both
internal and external sourcing in an attempt to overcome the limitations of each individually, findings are interpreted both by identifying consistent patterns across both sources and by comparing and contrasting the estimates provided from the two sources.

The details and theoretical implications of each aspect of the proposed model and related hypotheses will be further discussed in the following sub-sections.

Complexity Leadership and Innovation Team Outcomes

This study adds to our understanding of the leadership of innovation and contributes to the literature in two ways. First, complexity leadership theory is described and successfully field tested at the operational level of organizations (Uhl-Bien et al., 2007). Second, the gap in our descriptions of innovation team leadership delineating its role in team dynamics (Brown & Eisenhardt, 1995) is addressed. In this vein, complexity leadership theory provides the framework by which this study integrates disparate research areas such as, team creativity, team innovation, team interdependence, network dynamics, team conflict, team culture, team identity and team leadership into a cohesive and comprehensive description of leading the dynamics of innovations. This study increases and broadens the potential research linkages between complexity leadership and other research disciplines.

Complexity leadership of innovation teams plays a direct role in enabling both internal dynamics and those with external linkages which foster the creation and implementation of innovation. In this study, the patterns of influence reflected across the measures of innovation team outcomes consistently show better results from the interaction, interdependence, tension and resonance of complexity leadership. Leadership which fosters open interaction, divergent discourse, identification of unproductive
conflict, mutual conflict management among contending parties, convergent decision processes, and sense making which unites member understanding, increases innovation enabling behaviors and perceived performance. Leadership which enables productive connection between the innovation team and the larger organization through formal administrative and informal network linkages, also improves innovation outcomes.

Interestingly, differences in influence on innovation outcomes are present between vertical and shared distributions of complexity leadership. Vertical complexity leadership is more related to perceived performance and shared more related to innovation enabling behaviors. For team reported outcomes, when vertical and shared are both in the regression, only one has significance; vertical significantly influences perceived performance while shared influences innovation enabling behaviors. For stakeholder-perceived performance, only vertical had significant effects and that was both when alone and when together with shared in the regression. Only shared had close to significant effects on stakeholder reported innovation enabling behaviors ($\beta = .261$, $p = .058$ and $.044$, $p < .05$ contribution to adjusted $R^2$) when alone in the regression. These findings suggest that while both may have positive relationship to innovation outcomes, the nature and manner of the influence varies. To understand implications, it is helpful to contrast the two measures of innovation team outcomes, innovation enabling behaviors and perceived performance. Perceived performance evaluates team results versus expectations and goals, and also for stakeholders, the likelihood that resources and support will continue to be provided to the team. Innovation enabling behaviors address team creativity and ability to gather, use and implement new knowledge. Vertical leadership relates to the activity of the designated team leaders who performs most of the
administrative leadership for the team, such as dealing with routines in the organization’s innovation system including stage gate reviews where decisions about whether to continue support for the project are made. The designated leader also keeps focus on linkages to company processes, strategies, and goals (Clark & Fujimoto, 1990; Quinn, 1985; Takeuchi & Nonaka, 1986). Given the special role of the designated leaders, that vertical leadership has special relationship to evaluations of perceived performance is understandable. With the other measure, innovation enabling behaviors, shared complexity leadership’s special relationship is explained by CLT. The creative and learning processes of the team are more reliant on the mutual influence dynamics of shared complexity leadership among the members than by the vertical influence of the designated leader. To summarize, positive influence on innovation team outcomes of complexity leadership manifested by the leaders and members is supported.

Complexity Leadership and Learning

The results of this study provide confirming evidence that the dynamics enabled by complexity leadership increase team learning and that complexity leadership increases collaborative learning. This study contributes understanding to the leadership of team or organizational learning literature. Collaborative learning is a key process in organizational innovation and the results of the study show collaborative learning positively relates to innovation team outcomes. In knowledge era companies, innovation teams are brought together to intensify organizational learning well beyond simply providing better linkages between separate functions or disciplines. Also as theorized, complexity leadership indirectly improves innovation team outcomes by enabling collaborative learning.
During the interview phase of this project, it became apparent to this author that a shift has occurred in innovation teams. This author led the introduction of the cross functional product team structure in a division of a fortune 100 company in the late 1980’s and had the opportunity to lead or observe many teams develop, introduce and manage new service products through the early 1990’s. The closer linkages among functions afforded by cross functional innovation teams improved speed to market, reduced development costs and produced more marketable products and services compared to past arrangements which depended on isolated functional groups contributing to development efforts sequentially from within their functional silos.

However, it seems that since that time, a shift has occurred that changed the purpose and dynamics of cross functional innovation teams and that this shift was observable in the interviews. Responses indicated that the purpose moved from the linking of functions to collaborative learning among uniquely knowledgeable members. Innovation teams are more relied on by their companies and are more capable of being loci of organizational learning. Functional people were no longer on the team to simply represent their function, but rather to actively engage in co-learning and co-creating. Characteristics were identified by interviewees that distinguish the earlier implementation of cross functional innovation teams from the newer paradigm. Early generation teams which were brought together for the purpose of linking, exhibited the following:

- Interaction occurs across the boundaries of functions to enhance coordination and mutual problem solving.

- Dialogue is enabled between dependent functions but discouraged more broadly in order to efficiently use functional resources.
• Activity is aligned across functional boundaries through the articulation of common goals managed by clearly assigned leadership.

• Functional experts are partially vested with authority to represent the interests of their function or discipline and could lead team’s decisions in their specific realms.

• Conflict resolution and decision-making rely on functional management and are frequently escalated.

Contemporary teams which are organized for learning exhibit the following:

• Interaction and collaboration are fostered across all team participants even when there are no obvious dependencies or connection between their knowledge bases.

• In-depth dialogue, whether in person or electronically, is used to educate members about each others’ knowledge and ideas.

• The comprehensive body of shared knowledge is used by members to engage in parallel development and mutual adjustments as changes occur.

• Connection is maintained with the formal structure which does not dominate or direct the team. A balance between removing boundaries and respecting them is maintained.

• The ability to influence the team is distributed among group members and is not limited to their area of expertise.

Learning oriented teams require a new type of leadership which is more fit to higher levels of collaboration and which enables more sharing and cross learning of the tacit knowledge by expert members. The leadership characteristics identified in the interviews of the qualitative study were reflected in the description of complexity leadership used in the quantitative study: sharing leadership, encouraging divergent and convergent thinking, resolving conflict by engaging members in mutual problem solving, nurturing the relationship with the formal organization, and modeling collaboration and
inclusion. The relationship between complexity leadership and team learning uncovered in the qualitative phase was reinforced by quantitative results.

The collaborative learning examined in this study relies on in depth examination and communication which engages members in uncovering the logic behind their knowledge to themselves and to others. This deeper penetration of tacit knowledge allows members to make connection among knowledge bases which a more superficial treatment or exposition would not permit. The black boxes would remain unopened and disconnected. Collaborative learning applies to the learning needs of both exploitative and explorative innovation. In exploitation, existing connections among knowledge bases must be uncovered, in a sense re-learned so that new perspectives can be applied and new implications formulated. Explorative learning builds upon exploitative learning capability but is more challenging because previously unknown relations and interdependencies between knowledge must be discovered and/or formulated (Dunne & Dougherty, 2010). The power of the shared process of collaborative learning is shown in the positive effects collaborative learning has on innovation team outcomes and collaborative learning’s mediation of complexity leadership. Collaborative learning arises from the interaction, interdependence, tension and resonance of complexity leadership. The interplay between complexity leadership and collaborative learning is a dynamic that reinforces sharing, developing, changing, testing, and creating knowledge, all of which are central to innovation.

Complexity Leadership and Heterogeneity

The results of the analyses provide some support for this study’s two hypotheses regarding heterogeneity. The heterogeneity norm does mediate complexity leadership’s
influence on innovation team outcomes as reported by teams, and some evidence was found for a moderating effect of complexity leadership on the relationship between job relevant heterogeneity and innovation team outcomes. This study contributes to theory describing how complexity leadership relates to heterogeneity. This is important because CLT presumes that heterogeneity is constitutive of, and has positive effects in, CAS, but it does not describe the mechanisms for those effects. Additionally, this study’s theory regarding heterogeneity and complexity leadership is grounded in recent theory developed in the diversity literature to explain the persistent contradictory findings regarding the effects of diversity. For example, the CEM model proposed by van Knippenberg, et al. (2004) provides theoretical elements used to formulate the heterogeneity norm and complexity leadership relationship to job relevant heterogeneity. The results of this study also contribute to the further elaboration of that stream of research.

The Heterogeneity Norm

The effects proposed by this study for a norm that values and engages the heterogeneity of the team were supported. The heterogeneity norm was proposed to arise in the context and dynamics enabled by complexity leadership. This study confirms its presence in CAS and also confirms the positive relation complexity leadership has to it. The heterogeneity norm adds to understanding of how complexity leadership interplays with heterogeneity to create beneficial team dynamics. The heterogeneity norm clarifies how complexity leadership helps channel positive effects from heterogeneity which has been shown to have both positive and negative effects on group performance.
The relationship between complexity leadership and the norm must be distinguished from the more traditional view that leadership has a direct causal relationship to norm formation, not theorized by CLT. Leadership has been shown to influence norm formation (Jassawalla & Sashittal, 2002, Taggar & Ellis, 2007). Some studies emphasized negotiation of norms among leaders and followers and how leader expectation predicts the adoption of the norm by the group (Taggar & Ellis, 2007). Others examined how the prominent role of leadership within a social context influences the behavior of followers. Meindl (1990) showed that the leader’s behavior spreads throughout a group through social contagion because followers are susceptible to the leader’s behaviors and other members who imitate the leader. The leader has a prominent role in the social context of the group and achieves effects in the group because the information upon which the leader focuses and the behaviors the leader engages in are more salient and form internalized expectations of normal behavior within followers (Bommer et al., 2004). However, within CLT, the leader’s use of special influence to top-down control outcomes can interfere with the bottom-up dynamics in the system (Marion & Uhl-Bien, 2001) and reduces the system’s ability to adapt and achieve fitness. While leadership may provide general guidance through vision and goals to help the CAS correlate to the larger organization, complexity leadership seeks to enable the conditions which create productive dynamics and then supports these dynamics to generate self-organization and emergence of productive states, such as the heterogeneity norm.

That complexity leadership enables emergent, self-organizing behavior found support in the Plowman et al. (2007b) field study of the Mission Church. Their ethnographic analysis demonstrated that leadership of the church did not direct the
changes that occurred in the church but enabled the conditions which allowed for the
emergences of non-linear productive changes. Leadership fostered creative network
dynamics among church participants by disrupting existing patterns, encouraging novelty
and making sense as the changes unfolded. Similarly, the findings of this study are
interpreted to show that complexity leadership relates to the existence of a heterogeneity
norm because the norm arises from the interdependent interaction enabled by complexity
leadership. The heterogeneity norm can be added to CLT as an emergent structure
associated with but not caused by complexity leadership.

From social categorization theory, van Knippenberg et al. (2004) describe a
sequence of social categorization which includes elements such as salient in-group and
out-group categorizations; in-group and out-group biases; and affective responses, such
as conflict and cohesion. Using that framework, this study’s proposed heterogeneity
norm assumes that on innovation teams, the relevant in-group is the team which
encompasses all members (Homan et al., 2008); the salient characteristic of that in-group
is differences among team members which contributes to the work of the teams (Ely &
Thomas, 2001); the biases are positive toward the differences because they do not
threaten, but rather contribute to, the creative work of the team (Ely & Thomas, 2001);
and the effective evaluative response is the engagement of the differences (Janssen &
Huang, 2008). This study differs from van Knippenberg and colleagues (2004); rather
than their focus on the moderating effects of social categorization process on group
information processing, this study examines the direct relationship of the heterogeneity
norm to innovation team outcomes and considers how the norm mediates complexity
leadership’s influence with the aim to answer questions relevant to complexity leadership
theory. The exploration of the heterogeneity norm in this study contributes to our understanding of how attitudes toward heterogeneity influence team performance. The findings that the heterogeneity norm is positively related to team reported innovation team outcomes and mediates complexity leadership’s influence are noteworthy. It was proposed that the heterogeneity norm would have those effects because the norm shifts social categorization concerns among members to a higher team level focus, that is, the potential positive effect of member differences on team performance.

Because the heterogeneity norm reflects a positive bias toward heterogeneity, this study helps address an area needing more study identified by van Knippenberg and Schippers (2007), and answers their challenge to incorporate positive relationships of heterogeneity with group interaction. It can be asserted from the findings that the heterogeneity norm has positive influence on information processing, described by van Knippenberg et al. (2004); that is, the elaboration of task-relevant information facilitates the sharing, interchange and combining of ideas, knowledge and perceptions.

**Moderation of Job Relevant Heterogeneity**

The proposed moderation of job relevant heterogeneity by complexity leadership found very limited support in the results of this study. The moderation was predicted because the dynamics created by complexity leadership are proposed to catalyze information processing, which would increase job relevant heterogeneity effects on innovation team outcomes. Similar to moderators, such as task motivation in the CEM model which enhance the relationship between diversity and information processing (van Knippenberg, et al., 2004), complexity leadership provides a context through which its
enabled dynamics enhance the relationship between job related heterogeneity and innovation team outcomes.

While only 5 instances of true moderation are found in the potential thirty-two relationships, a number of interesting and surprising patterns are present which provide more weight to the findings. First, two instances of positive moderation involve function heterogeneity, a key attribute of innovation teams and its effects on stakeholder-perceived performance, as shown in Figures 3 and 4. Somewhat surprisingly, the direct effect betas for function heterogeneity shown in Tables 11 and 12 are negative for team-innovation enabling behaviors ($\beta = -.242$), team-perceived performance ($\beta = -.422$) and stakeholder-perceived performance ($\beta = -.166$). Function heterogeneity has been found to have mixed effects in cross-functional product groups with negative effects including reduced internal communications, cohesion and budget performance and increased job stress but positive effects on external communication, technical quality and schedule performance (Ancona & Caldwell, 1992a; Keller, 2001). The positive moderation of function heterogeneity by complexity leadership is an important finding of this study. The negative effects of function heterogeneity are explainable through how function diversity can impede internal communication and the development of correlation among members. Functional representatives feel a tension between their allegiance to their function and to their participation on the team. Functional representatives can come with strings attached related to their career and to the political position of their function, both of which can provide motives to keep specialized information tacit and unshared. Status differences among functions can be reflected in access to key resources such as information, are imbedded in the relationships among functional representatives and can
be formidable barriers to open and shared influence. When groups in a status hierarchy are in competition for jobs, rewards, or other resources, conflict may emerge if those with more favorable positions perceive a threat to their position from those in less favorable positions (DiTomaso, Post, Smith, Farris, & Cordero, 2007). It is an important finding that complexity leadership helps overcome cognitive and political barriers between functional representatives. As proposed by CLT, the results can be interpreted to show that complexity leadership mitigates these effects and brings forth the advantages of different functional knowledge bases by enabling interaction and interdependent dynamics, by helping the team and its members deal with tension, and by increasing correlation through sense making that builds team identity and team cohesion.

A second surprising pattern in the moderation results is presented by 2 instances of negative moderation of industry tenure by shared complexity leadership with stakeholder-innovation enabling behaviors ($\beta = -.313, p < .05$) and stakeholder-perceived performance ($\beta = -.381, p < .01$). Positive moderation was anticipated. It is difficult to propose a logic to explain this pattern. One possibility explanation comes from joining fault line research (Lau & Murnighan, 1998; Li & Hambrick, 2005; Rico et al., 2007) with how industry heterogeneity was observed to be increased in the teams of the study. On one team, because the innovation would move the company into a new industry, a cadre of people was hired from the industry. In another instance, the company’s move into a new industry was accomplished through an acquisition and, subsequently, an innovation team was made up of members from the acquired company and the acquiring company. Fault lines arise when subgroups are formed around salient characteristics and are congruent with commonly held perspectives which can be
expected when people come from the same industry or company within the industry. Members identify more with their subgroups and less with the larger group (Rico et al., 2007) which increases subgroup polarization, leading to more conflict, less cohesion and poorer group decisions (Lau & Murnighan, 1998; Li & Hambrick, 2005). A second piece of the puzzle may be that both negative moderations involved shared complexity leadership. A logic to consider which could explain the negative moderation would be the following. Using fault line theory, subgroups exist on the team distinguished by common industry experience who share similar perspectives; these fault lines lead to greater conflict and less cohesion. Shared complexity leadership is based on interactive influence among members. As greater interactive influence is attempted on the team, conflict and lack of cohesion are exacerbated which leads to poorer innovation team outcomes. But a word of caution must be noted. While a plausible logic has been attempted to be proposes, it is highly speculative. It rests on assumptions built from few data points about how industry heterogeneity was increased across the teams in the study. Additional research designed to verify and explore this phenomenon would be necessary.

A third pattern of note is that all 5 instances of moderation were related to stakeholder reported innovation outcomes. Given that stakeholder effects sizes were smaller than team effect sizes in the tests of other hypotheses, this is noteworthy. When considering only stakeholder outcomes, moderation is found in thirty-one percent of the possible sixteen relationships making the findings more relevant. Relative to stakeholder outcomes, complexity leadership is a catalyst in addition to having direct effects. These results support CLT’s assertion that the dynamics enabled by complexity leadership catalyze interactive change events among heterogeneous agents. This third pattern
contrasts from that seen in team reported outcomes. Whereas with team reported outcomes, complexity leadership has significant direct effects and no evidence of catalyzing heterogeneity. In fact, examination of the moderation tests with team-innovation enabling behaviors and team-perceived performance shown in Tables 11 and 12 reveals another interesting pattern. In step two, when job relevant heterogeneity measures are added, its measures have many significant direct effects on team-innovation enabling behaviors and team-perceived performance. However, when complexity leadership is added in step 3, the betas and significance are reduced and most lose their significance. Because this pattern of results could indicate mediation, tests for mediation were conducted. No mediation of job related heterogeneity by complexity leadership was found primarily because job relevant heterogeneity measures are not predictors of complexity leadership. However, it can be said that when controlling for complexity leadership, job related heterogeneity loses its influence on team reported outcomes which suggests that complexity leadership is a better predictor of team reported outcomes than heterogeneity. Reversing the statement describes an important finding about the relationship between complexity leadership and heterogeneity. When controlling for job relevant heterogeneity, complexity leadership’s estimated effects on team reported innovation outcomes remain stable. This observation leads to questioning whether similar relationships are present for the heterogeneity norm. The norm arises from the dynamics enabled by complexity leadership and has direct positive effects on performance. Regressions show that similar to complexity leadership, when controlling for heterogeneity, the effects the heterogeneity norm has on innovation team outcomes remain stable.
One final aspect of the moderation results is that 4 of the 5 instances of moderation involved shared complexity leadership which means that fifty percent of possible relationships involving shared leadership and stakeholder outcomes exhibited moderation. Given that shared complexity leadership showed less influence on stakeholder outcomes in the test of other hypotheses than vertical, its moderation effects are noteworthy and shed additional light on the role it plays. As reported by Reagans and Zuckerman (2001), team heterogeneity by itself does not predict team performance; heterogeneity must be engaged through social interaction for it to have value to team performance. Additionally, Ensley et al. (2006) found that shared leadership enabled teams of heterogeneous managers to share divergent views. The moderation findings of this study reinforce the view that shared complexity leadership, because it entails mutual influence among heterogeneous agents, is particularly helpful in engaging heterogeneity for the benefit of team innovation.

A main research question for this study was to answer how complexity leadership operates with heterogeneity. The full picture that can be drawn from this study is multi-dimensional and is made possible because this study has findings from two sources, internal and external, for ratings of team outcomes. Here are the major elements. First, a heterogeneity norm which values and engages differences emerges from the dynamics enabled by complexity leadership and this norm increases innovation team outcomes assessed by the team. Second, complexity leadership’s positive effects on innovation team outcomes and those of the heterogeneity norm are stable when controlling for job relevant heterogeneity. Complexity leadership and the heterogeneity norm perform positively and consistently across a wide range of team heterogeneity patterns. Third,
because of its dynamic of shared and mutual influence, shared complexity leadership catalyses job related heterogeneity to have impact on innovation team outcomes.

Implications for Management

This study provides important insight into the leadership of innovation teams, which can guide management in companies to improve the performance of this important element in their innovation systems. Because the role of leadership in forming internal team dynamics productive of innovation has not been sufficiently research, limited guidance could be given. The knowledge gained by the study can help create training programs and other skill development activities for both individuals who will play the role of designated team leader and also those who will be members of innovation teams. The shared nature of complexity leadership can provide benefit when embodied by participants on innovation teams.

Because this field study observed existing phenomena, the knowledge gleaned by this study already exists in companies. Certainly, the people who were interviewed could articulate a level of understanding of the relationships. However no evidence was found that companies were formally or intentionally developing the identified skills. The knowledge embodied in this report is tacitly and not consciously held in companies. The value of this study is that existing tacit knowledge about dynamics important to innovation teams performance has been made explicit and accessible. In some instances, the knowledge gained from their experience was nonetheless questioned by interviewees because it contradicted normal routines or generally accepted wisdom. For example, a number of team members questioned their stepping up to lead team activities. This
underscores the challenges to the dissemination and implementation of the principles confirmed by this study.

Some of the more challenging changes can be identified. The relinquishment of the directing and controlling roles of designated leaders will present difficulties, especially in environments where innovation efforts are closely managed and monitored. The environment would need to be relaxed so that leaders will not feel pressure to control events so they can step back and encourage members to step forward to act in leadership ways. Members need to shift from viewing themselves only in their functional or discipline roles and to re-conceive their role more broadly as a contributor to the learning and creativity of the team and a leader of team efforts. Important skills in this regard involve how to make their tacit knowledge explicit and explainable to others and how to develop metaphors between their knowledge and that of others. Functional management would enable this shift when they embrace and value the expanded roles of their representatives on innovation teams and in so doing would help innovation teams move to higher levels of collaborative learning. Attitudes and techniques associated with conflict will undergo change. Skills should be developed to better distinguish productive from non-productive conflict and to self-manage mutual conflict resolution. Techniques for shared sense-making and sense-giving must become widespread among participants of innovation teams. The normal tendency to seek convergence on teams prematurely must give way to adequate periods of divergent thinking. The ability to move back and forth between divergence and convergence throughout the life of the team should be supported by developing skills related to guiding and sustaining divergence, recognizing when convergence is needed and building productive convergence. Schedule
expectations for innovation teams must change to accommodate the time needed for more in depth and possibly more protracted collaborative learning; management should be attuned to the benefits of simultaneous development and mutual adjustment that will accrue.

In sum, following the principles of CLT, managerial attempts to change behavior to align with the principles learned in this study will have less impact if they are only directed in a top-down manner and if training is done individually. Learning techniques which help innovation can be applied to the dissemination of the skills identified in this study. Managers should consider introducing the principles of this study in the setting of innovation teams and to make learning how to embody the principles a team challenge which will contribute to the success of their efforts. The principles represent an innovative change to innovations teams. Seen from a CLT perspective, it is an innovation best served by the self-organization and emergence made possible through the interaction and interdependency among heterogeneous team members.

Limitations

The limitations of this study principally arise from its sample of teams. Many aspects of the sample can limit the validity of its estimates and generalization of its findings. The first limitation is that it is a convenience sample rather than a random sample. Companies were asked to select teams across the spectrum of performance from low to high but in their process of selecting teams, may have been biased toward higher performing teams. The means and standard deviations for perceived performance provide some evidence supporting this possibility (mean of 4.83 and standard deviation of .66 for team-perceived performance and 5.17 mean and standard deviation of .95 for
stakeholder-perceived performance). Survivor bias may be another contributor to the selection of higher performing teams. Innovation teams are regularly reviewed and if underperforming, can be disbanded. The population of teams from which companies could choose would consequently be biased toward those performing well enough and producing innovations valuable enough to continue to be resourced.

The sample size of 59 teams is another limitation. As was noted, because of the number of teams, regressions were constrained in the number of predictor variables which were included. This limitation chiefly determined how the regressions for moderation testing were constructed; tests for moderation of the two distributions of complexity leadership were required to be done separately. Also another limitation related to the sample size is the low power ratings reported above. Those power ratings indicate relatively high possibility of Type 2 errors. It is possible that real relationships in the data are not elucidated by the analyses due to sample size and low power.

Because most of the companies which participated in this study were global enterprises, they were asked to provide teams which reflected their international operations. However, few teams in the study had members located outside of the USA and only two teams were resident in countries other than the USA. Given the limited exposure to non-USA respondents, generalizing the results of this study globally is constrained.

By design, all teams in the sample were innovation teams which are generally project oriented. Innovation teams were selected for this study because they represent CAS and the theory of this study asserts that complexity leadership must be studied in the context of CAS. Reflecting that assertion, the applicability of the findings to other
contexts is questionable. It can be asserted that this study can be applied generally to project oriented teams for which learning and innovating are key elements of their work. Further research must be done in order to study how the description of complexity leadership developed in this study would operate in other types of teams such as long standing teams tasked with ongoing operations and teams at higher levels of the organization.

A second limitation arises from the method used in this study to measure vertical and shared leadership which is taken from the shared leadership literature. Generally, a strong relationship exists between vertical leadership and shared leadership in studies of shared leadership and is reflected in their high correlations (Ensley, Hmieleski, & Pearce, 2006; Pearce & Sims, 2002). That pattern can be explained because the exact same items are measured in the constructs but in different loci--one set focused on leader and other on team members. While their correlation is high, the different foci of the two measures make them distinct constructs that should be kept separate. However, the high correlation makes problematic interpretation of betas when both measures are in the regression equation. A useful approach (Pearce & Sims, 2002) around the dilemma to understand effects is to examine the $R^2$ contribution to the outcome measures when one distribution of leadership is added to the equation already containing the other. In this study, correlation between the two distributions of leadership is high ($r = .71$, $p < .01$) and is in line with other studies of shared leadership. When examining the contributions to $R^2$ for team-innovation enabling behaviors, for example, adding vertical to shared changes the adjusted $R^2$ from .481 to .490 (+ .009); adding shared to vertical changes the adjusted $R^2$ from .469 to .490 (+ .021). For team-perceived performance, adding vertical to shared
changes the adjusted $R^2$ from .370 to .494 (+ .124); adding shared to vertical changes the adjusted $R^2$ from .417 to .497 (+ .080). However, improvement of the measures should be sought and this topic will be discussed in the next section.

A third limitation of this study is the validity and reliability of the measure for complexity leadership. Because no measure previously existed, the goal of this study required its construction. The process this study used was designed to alleviate this limitation. The preliminary qualitative study sought to uncover leadership behaviors which respondents could identify were associated with their teams’ innovation performance. Interview questions were constructed from a review of complexity leadership literature but were open ended to allow for spontaneous minimally directed responses. The analysis of the qualitative data became a main source for the items included in the quantitative survey in addition to translation of items from the few existing field studies of complexity leadership. Factor analysis was used to identify the items which adhered in the construct statistically and theoretically. The factor analysis followed techniques previously validated for constructing a scale useable for both vertical and shared dimensions (Pearce & Sims, 2002). Nonetheless, validation by a single study can only be limited. Further validation of this study’s complexity leadership measure must rely on future research.

Future Research

The study was done at an early stage of development of complexity leadership theory. Consequently, there are many possibilities for future research questions linked to this study. The first area to consider is the further development and elaboration of complexity leadership and its associated model. This study examined complexity
leadership at the operation level of organizations. The question arises if the same
description of complexity leadership formulated in this study will have similar effects at
the general management and strategic levels. The literature exploring shared leadership is
an example to be followed by future complexity leadership research. Shared leadership
studies have confirmed similar effects on teams spanning a range of levels from change
project teams to top management teams. Another extension of this study for complexity
leadership theory would be research into other examples of CAS, particularly
organizational systems which have a greater need for stability than innovation teams. The
amount of learning, adaptation and innovation required in organizational systems will
vary. Complexity leadership recognizes this and accounts for it through its three
functions of administrative, adaptive and enabling leadership. Because this study
examined a system with high learning and innovation requirements, questions arise
whether the same description would help understand the effects of the functions and how
they interact when organizational requirements vary in their need for stability and
complex dynamics. It would appear to this researcher that the model proposed by this
study would need further elaboration of administrative behaviors to do so. Finally, the
model of this study contained two separate outcome measures, innovation enabling
behaviors and perceived performance which may be linked. Argument can be made the
perceived performance in a consequence of innovation enabling behaviors. Future
research could examine this relationship and complexity leadership’s role. For example,
path analysis flowing from complexity leadership through innovation enabling behaviors
to team innovation performance would shed light of this topic.
A second area of research which this study makes possible is the relationship between complexity leadership and other theories of leadership. Here also, shared leadership research can provide a model in so far as the effects of multiple theories of leadership are tested simultaneously in shared leadership studies using previously validated scales. Research could compare and contrast the effects of different types of leadership, for example, transformational leadership with complexity leadership. In addition, how various leadership behaviors work in concert or in contradiction to one another can be examined. Contingency leadership theory would suggest that leadership should vary depending on the conditions faced. However, this line of research presents difficulties which would require the expansion of research designs. The phenomena associated with complexity leadership are by their nature complex and unfold over time in multi-determined and emergent manners. Most complexity leadership theorists propose research studies using qualitative techniques and/or computer modeling so that complex relationships, such as, amplifying feedback loops, can be appropriately examined. A danger of inappropriately reducing the complexity of the phenomena could be present in single method quantitative research studies. This current research employed a mixed method in order to ground the quantitative study in a richer, nuanced landscape revealed in the qualitative study. A mixed method approach is therefore suggested when field studying complexity leadership in concert with other forms of leadership.

A third area for additional research arises from the measure used in this study for complexity leadership. As discussed in the Instrumentation section, this study used a “global measure” which captures the functions and sub-functions of complexity leadership in one scale. Future studies could develop measures of each component. With
separate component measure, insights into how distinct the components are could be gained. Finer tuned understanding can be gotten about the relationship of the components to learning and innovation.

An important aspect of complexity leadership, its shared nature, is a fourth area for future research. In the previous section, the limitation presented by the methods for measuring vertical and shared leadership was discussed. This limitation is understood by the shared leadership research community. Research can be undertaken that will more definitely explain the consistent pattern of high correlation between vertical and shared leadership and determine measurement techniques to better reflect the true relationship between vertical and shared leadership. As this study presented in its arguments about norm formation, members take cues from and model formal leader behaviors. One line of research would be how vertical leadership behavior influences member leadership behavior and vice versa. Can members engage in complexity leadership when leaders do not? Does vertical complexity leadership affect innovation indirectly through shared? If member attitudes are strongly positive to the vertical leader, will they tend to report shared behavior that mirrors the vertical? A second line of research in this regard could examine the effect of organizational culture on leadership behavior by testing whether certain leadership behaviors are more common in some organizations than others, that is, a reflection of organizational culture. In summary, further research could pave the way to changing methods and/or changing leadership models which contain both vertical and shared leadership.

The heterogeneity norm contributes to both complexity leadership theory and diversity research. Opportunities for further research exist in both areas. In this study, the heterogeneity norm is an emergent structure arising from the dynamics enabled by complexity leadership but it must be questioned whether this is a common occurrence
with complexity leadership or limited to contexts such as innovation teams. Complexity leadership researchers perceive that a few rules govern the interaction of agents (Lichtenstein et al., 2006). The existence of the heterogeneity norm raises questions about whether some rules are the same across different types of CAS. For diversity research, the heterogeneity norm relates to the study of attitudes toward diversity and opens up additional research questions. A line of inquiry is how existing organization attitudes influence the formation of a heterogeneity norm in the organization’s teams. Also, past research has focused on determining attitudes which management can inculcate in an organization to enhance the benefits from diversity. This study’s theory of the emergence of the heterogeneity norm from interaction among members opens up the possibility of bottom-up creation of positive attitudes toward diversity in addition to top-down direction. Research into how those two processes complement each other could yield more effective approaches to lead changes in organizational attitudes toward diversity.

Because this study focuses on heterogeneity as conceived by complexity leadership which relates to knowledge diversity and its measures, other types of diversity were not considered by this study. Other types, shown to impact individual and group performance, for example, categorical diversity, can also be studied in the context of complexity leadership. A recent paper (Post, De Lia, DiTomaso, Tirpak, & Borwankar, 2009), coming from the larger project of which this study is a part, found that differences in thinking approaches, sequential thinking, i.e. following a set sequence of steps or routines, versus connective thinking, i.e., simultaneously bringing multiple factors into play and linking previously disconnected factors, enabled innovation enabling behaviors.
By studying other types of heterogeneity together with knowledge heterogeneity, team compositional issues could be examined in concert with leadership. For example, the relative effects on team outcomes could be parsed between the various types of heterogeneity and leadership to answer whether the outcomes of the team are the result of the team composition itself or chiefly arise from the leadership behaviors in the team. Research in this vein could provide insights helpful to complexity leadership theory and to diversity research.

A closely related research area to the types of heterogeneity would be to more fully examine relationships among the constructs of collaborative learning and the heterogeneity norm with complexity leadership and the types of heterogeneity. Collaborative learning can be conceptualized to be an element in information processing mechanisms (van Kippenberg, De Dreu & Homan, 2004) through which heterogeneity provides value to team outcomes; consequently, it would be beneficial to explore the indirect effect of team heterogeneity through collaborative learning to team innovation outcomes. Because norms by their nature substitute for leadership influence in guiding the behavior in teams (Jassawalla & Sashittal, 2002; Taggar & Ellis, 2007), the heterogeneity norm may have a moderating effect on the relationship between heterogeneity and innovation team outcomes. In summary, further research would add to our understanding of the moderating effect of complexity leadership on team heterogeneity which may be better explained in concert with the effects of collaborative learning and the heterogeneity norm.

Another area for research is the relationship of complexity leadership with other team processes and dynamics not considered in this paper. An important example is the team dynamic of a shared mindset among team members. Previous research (Dougherty, 1992: Mathieu, Goodwin, Heffner, Salas, & Cannon-Bowers, 2000) suggests that a
shared mindset would be helpful to perceived performance by bridging the disparate mindsets existing on cross-function/discipline teams and closing information gaps. But the issue is complicated with effects which may not be linear and would benefit from a closer examination of the relationship between a shared mindset and innovation teams outcomes. In both the discussion and measurements of this paper, dichotomies exist. For example, a generally shared pool of knowledge is created through collaborative learning when members share and explain their individual mindsets sufficiently so others can understand, account for and use the multiple views for knowledge creation. The heterogeneity is not lost in the process but something held in common is created. Common values and norms which contribute to a shared mindset are also dealt with in the discussion and measurements. In the heterogeneity norm, something is held in common but it values difference and uniqueness. The dual conditions of tension and resonance enabled by complexity leadership are discussed and measured. They together address the need for balance between and the importance of timing divergent versus convergent thinking. Questions about shared mindset arise from the discussion about when and how the divergent thinking versus convergent thinking needs to take place and how it is implemented in heterogeneous teams so as not to diminish the value derived from heterogeneity. Fundamentally, a question can be asked if a group mindset should be developed and if so, how does it contribute positively to innovation. This is vein of research would be interesting and important question for team innovation process, for complexity leadership and for diversity research. Beyond shared mindset, other processes can also be researched in relation to complexity leadership for example, psychological safety and unproductive conflict. The research would fulfill the opportunities created by
this study to better connect complexity leadership to other existing literatures.

Conclusion

This study has striven to test and elaborate the theory of complexity leadership in innovation teams, an important context for research and for industrial organizations. This study employed a mixed methods approach because complexity theory is early in its development and both the richness and specificity of qualitative and quantitative techniques were needed to explore the concepts of CLT. This study developed a measure for complexity leadership which can be used and tested in future research. Complexity leadership is shown by this study to further organizational learning and innovation in heterogeneous organizational systems as theorized by its developers. New understanding about how complexity leadership relates to heterogeneity fills a gap in CLT and a new structure, the heterogeneity norm, has been identified for further research. This study reinforces that the shift in the complexity and dynamism of organizations has been responded to with a new conception of leadership, and organizations are now challenged to experiment with complexity leadership which is shared and is a dynamic for change and adaptation.
REFERENCES


Table 1: Variables and Ratio of Teams Meeting \( r_{wg} \) Index and Average Deviation (AD)

Criteria

<table>
<thead>
<tr>
<th>Team Level Variable Created from Aggregating Member Scores</th>
<th>59 Teams</th>
<th>52 Teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative Learning</td>
<td>0.86</td>
<td>0.97</td>
</tr>
<tr>
<td>Vertical Complexity Leadership</td>
<td>0.80</td>
<td>0.92</td>
</tr>
<tr>
<td>Shared Complexity Leadership</td>
<td>0.86</td>
<td>0.97</td>
</tr>
<tr>
<td>Heterogeneity Norm</td>
<td>0.86</td>
<td>0.97</td>
</tr>
<tr>
<td>Team Innovation Enabling Behaviors</td>
<td>0.86</td>
<td>0.97</td>
</tr>
<tr>
<td>Team Perceived Performance</td>
<td>0.86</td>
<td>0.97</td>
</tr>
</tbody>
</table>
### Table 2: Mapping Items in the Complexity Leadership (CL) Scale to Components in Complexity Leadership Theory (CLT)

<table>
<thead>
<tr>
<th>Item From CL Scale</th>
<th>Component(s) in CLT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fosters interaction within and outside the team by encouraging open engagement</td>
<td>Enable Interaction</td>
</tr>
<tr>
<td>Seeks a broad range of perspectives when solving problems</td>
<td>Enable Interaction, Enable Interdependence</td>
</tr>
<tr>
<td>Engages members of the team in mutual problem solving</td>
<td>Enable Interdependence, Enable Tension</td>
</tr>
<tr>
<td>Instigates discussion of different types of thinking among team members</td>
<td>Enable Tension</td>
</tr>
<tr>
<td>Recognizes the difference between unhelpful conflict and helpful conflict</td>
<td>Enable Tension</td>
</tr>
<tr>
<td>Helps the team understand new events emerging in the team’s environment</td>
<td>Enable Resonance</td>
</tr>
<tr>
<td>Guides team members to converge on an agreement when one is needed</td>
<td>Enable Resonance</td>
</tr>
<tr>
<td>Procurws resources which the team needs from other groups</td>
<td>Administrative Leadership, Manage Entanglement</td>
</tr>
<tr>
<td>Coordinates activities with other groups</td>
<td>Administrative Leadership, Manage Entanglement</td>
</tr>
<tr>
<td>Resolves problems raised by other groups</td>
<td>Administrative Leadership, Manage Entanglement</td>
</tr>
<tr>
<td>Releases timely information to others in the company to advance the team’s image or work</td>
<td>Manage Entanglement</td>
</tr>
</tbody>
</table>
Table 3: Factor Coefficients for Complexity Leadership

<table>
<thead>
<tr>
<th>Description</th>
<th>Shared Complexity Leadership</th>
<th>Vertical Complexity Leadership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage(s) members of the team in mutual problem solving</td>
<td>.741</td>
<td>.657</td>
</tr>
<tr>
<td>Foster(s) interaction within and outside the team by encouraging open engagement.</td>
<td>.726</td>
<td>.642</td>
</tr>
<tr>
<td>Procure(s) resources which the team needs from other groups.</td>
<td>.693</td>
<td>.724</td>
</tr>
<tr>
<td>Help(s) the team understand new events emerging in the team’s environment.</td>
<td>.680</td>
<td>.630</td>
</tr>
<tr>
<td>Recognize(s) the difference between unhelpful conflict and helpful conflict.</td>
<td>.662</td>
<td>.538</td>
</tr>
<tr>
<td>Coordinate(s) activities with other groups.</td>
<td>.638</td>
<td>.709</td>
</tr>
<tr>
<td>Guide(s) team members to converge on an agreement when one is needed.</td>
<td>.634</td>
<td>.666</td>
</tr>
<tr>
<td>Resolve(s) problems raised by other groups.</td>
<td>.604</td>
<td>.687</td>
</tr>
<tr>
<td>Instigate(s) discussion of different types of thinking among team members.</td>
<td>.577</td>
<td>.565</td>
</tr>
<tr>
<td>Seek(s) a broad range of perspectives when solving problems.</td>
<td>.576</td>
<td>.583</td>
</tr>
<tr>
<td>Release(s) timely information to others in the company to advance the team’s image or work.</td>
<td>.570</td>
<td>.605</td>
</tr>
</tbody>
</table>
Table 4: Factor Coefficients for Collaborative Learning and Heterogeneity Norm

Factor ID:
**Collaborative Learning = 1**
**Heterogeneity Norm = 2**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everyone takes time to make sure the whole team learns together.</td>
<td>.863 .105</td>
</tr>
<tr>
<td>Our team takes time for everyone to get up to speed on difficult concepts.</td>
<td>.853 .131</td>
</tr>
<tr>
<td>This team takes the time to have members learn each other’s perspectives.</td>
<td>.795 .278</td>
</tr>
<tr>
<td>When things change, members of this team make adjustments they know will help the other members of the team.</td>
<td>.586 .490</td>
</tr>
<tr>
<td>This team knows when it’s time to let disagreements be aired.</td>
<td>.547 .394</td>
</tr>
<tr>
<td>Reversed: The differences on this team seem to keep us from performing at our maximum effectiveness.</td>
<td>-.074 .753</td>
</tr>
<tr>
<td>This team believes different viewpoints add value.</td>
<td>.353 .695</td>
</tr>
<tr>
<td>The differences on this team help us achieve the team’s goals.</td>
<td>.274 .679</td>
</tr>
<tr>
<td>Reversed: People on this team sometimes reject others for being different.</td>
<td>.289 .670</td>
</tr>
<tr>
<td>Team members actively share their special knowledge and expertise with one another.</td>
<td>.470 .552</td>
</tr>
</tbody>
</table>
Table 5: Factor Coefficients for Team Reported Innovation Team Outcomes

Factor ID:
Innovation Enabling Behaviors = 1
Perceived Performance = 2

<table>
<thead>
<tr>
<th>Statement</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our team creates new ideas which are transformed into useful applications.</td>
<td>.819  .186</td>
</tr>
<tr>
<td>Our team searches out new technologies, processes, techniques, and/or product ideas.</td>
<td>.806  .040</td>
</tr>
<tr>
<td>Our team mobilizes support to gain approval for our innovative ideas from others outside the team.</td>
<td>.689  .245</td>
</tr>
<tr>
<td>Please rate your satisfaction with team innovativeness.</td>
<td>.646  .401</td>
</tr>
<tr>
<td>How do you rate the team's performance relative to the team's own expectations?</td>
<td>.086  .881</td>
</tr>
<tr>
<td>How do you rate the team's performance relative to the expectations of the team's stakeholders?</td>
<td>.065  .854</td>
</tr>
<tr>
<td>Please rate your satisfaction with overall team performance.</td>
<td>.266  .841</td>
</tr>
<tr>
<td>Please rate your satisfaction with the timeliness of team work.</td>
<td>.287  .691</td>
</tr>
</tbody>
</table>
### Table 6: Factor Coefficients for Stakeholder Reported Innovation Team Outcomes

**Factor ID:**
- **Innovation Enabling Behaviors = 1**
- **Perceived Performance = 2**

<table>
<thead>
<tr>
<th></th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>This team mobilizes support to gain approval for its innovative ideas from others outside the team.</td>
<td>.831  .091</td>
</tr>
<tr>
<td>This team creates new ideas which are transformed into useful applications.</td>
<td>.822  .105</td>
</tr>
<tr>
<td>This team searches out new technologies, processes, techniques, and/or product ideas.</td>
<td>.789  .263</td>
</tr>
<tr>
<td>Please rate your satisfaction with team innovativeness.</td>
<td>.691  .325</td>
</tr>
<tr>
<td>This team will continue to receive support and resources for its work.</td>
<td>.288  .826</td>
</tr>
<tr>
<td>This team is on track to realize the outcomes we expect from the innovation on which this team is working.</td>
<td>-.126 .805</td>
</tr>
<tr>
<td>Team’s performance compared to other innovation teams in your company.</td>
<td>.479  .677</td>
</tr>
<tr>
<td>Please rate your satisfaction with overall team performance.</td>
<td>.434  .640</td>
</tr>
<tr>
<td>Team’s performance compared to your expectations for the team</td>
<td>.573  .634</td>
</tr>
</tbody>
</table>
Table 7: Factor Coefficients of Five Factor Structure Produced by Oblique Rotation

**Factor ID:**
- Collaborative Learning = 1
- Shared Complexity Leadership = 2
- Innovation Enabling Behaviors = 3
- Perceived Performance = 4
- Heterogeneity Norm = 5

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Our team takes time for everyone to get up to speed on difficult concepts.</td>
<td>.793</td>
<td>.074</td>
<td>.036</td>
<td>.061</td>
<td>.028</td>
</tr>
<tr>
<td>Everyone takes time to make sure the whole team learns together.</td>
<td>.775</td>
<td>.107</td>
<td>.091</td>
<td>.052</td>
<td>.022</td>
</tr>
<tr>
<td>This team takes the time to have members learn each other’s perspectives.</td>
<td>.602</td>
<td>.048</td>
<td>.069</td>
<td>.307</td>
<td>.099</td>
</tr>
<tr>
<td>This team knows when it’s time to let disagreements be aired.</td>
<td>.530</td>
<td>.026</td>
<td>.145</td>
<td>-.043</td>
<td>.271</td>
</tr>
<tr>
<td>Engage(s) members of the team in mutual problem solving.</td>
<td>.060</td>
<td>.754</td>
<td>-.008</td>
<td>.020</td>
<td>.019</td>
</tr>
<tr>
<td>Foster(s) interaction within and outside the team by encouraging open engagement.</td>
<td>-.024</td>
<td>.702</td>
<td>.024</td>
<td>.031</td>
<td>.152</td>
</tr>
<tr>
<td>Procure(s) resources which the team needs from other groups.</td>
<td>-.107</td>
<td>.684</td>
<td>-.005</td>
<td>.124</td>
<td>-.006</td>
</tr>
<tr>
<td>Release(s) timely information to others in the company to advance the team’s image or work.</td>
<td>-.214</td>
<td>.662</td>
<td>.136</td>
<td>.065</td>
<td>-.018</td>
</tr>
<tr>
<td>Help(s) the team understand new events emerging in the team’s environment.</td>
<td>.239</td>
<td>.653</td>
<td>-.102</td>
<td>.102</td>
<td>-.127</td>
</tr>
<tr>
<td>Instigate(s) discussion of different types of thinking among team members.</td>
<td>.181</td>
<td>.648</td>
<td>.004</td>
<td>-.067</td>
<td>-.045</td>
</tr>
<tr>
<td>Guide(s) team members to converge on an agreement when one is needed.</td>
<td>.200</td>
<td>.624</td>
<td>.089</td>
<td>-.181</td>
<td>.004</td>
</tr>
<tr>
<td>Coordinate(s) activities with other groups.</td>
<td>-.110</td>
<td>.623</td>
<td>-.061</td>
<td>.015</td>
<td>.205</td>
</tr>
<tr>
<td>Resolve(s) problems raised by other groups.</td>
<td>-.088</td>
<td>.603</td>
<td>.135</td>
<td>.139</td>
<td>-.017</td>
</tr>
<tr>
<td>Recognize(s) the difference between unhelpful conflict and helpful conflict.</td>
<td>.184</td>
<td>.593</td>
<td>.098</td>
<td>-.058</td>
<td>-.039</td>
</tr>
<tr>
<td>Seek(s) a broad range of perspectives when solving problems.</td>
<td>.164</td>
<td>.473</td>
<td>.026</td>
<td>.070</td>
<td>.185</td>
</tr>
<tr>
<td>How do you rate the team’s performance relative to the team’s own expectations?</td>
<td>-.042</td>
<td>-.050</td>
<td>.954</td>
<td>-.012</td>
<td>-.029</td>
</tr>
<tr>
<td>How do you rate the team’s performance relative to the expectations of the team’s stakeholders?</td>
<td>.023</td>
<td>-.040</td>
<td>.904</td>
<td>-.014</td>
<td>-.065</td>
</tr>
<tr>
<td>Overall team performance</td>
<td>.039</td>
<td>.096</td>
<td>.762</td>
<td>.028</td>
<td>.073</td>
</tr>
<tr>
<td>Timeliness of team work</td>
<td>.040</td>
<td>.157</td>
<td>.575</td>
<td>.012</td>
<td>.089</td>
</tr>
<tr>
<td>Our team searches out new technologies, processes, techniques, and/or product ideas.</td>
<td>-.013</td>
<td>.022</td>
<td>-.094</td>
<td>.898</td>
<td>.014</td>
</tr>
<tr>
<td>Our team creates new ideas which are transformed into useful applications.</td>
<td>.013</td>
<td>.006</td>
<td>.080</td>
<td>.865</td>
<td>.014</td>
</tr>
<tr>
<td>Team innovativeness</td>
<td>.014</td>
<td>.127</td>
<td>.295</td>
<td>.541</td>
<td>.069</td>
</tr>
<tr>
<td>Our team mobilizes support to gain approval for our innovative ideas from others outside the team.</td>
<td>.383</td>
<td>.079</td>
<td>.007</td>
<td>.506</td>
<td>.011</td>
</tr>
<tr>
<td>Reversed: The differences on this team seem to keep us from performing at our maximum effectiveness.</td>
<td>-.141</td>
<td>.001</td>
<td>-.055</td>
<td>-.046</td>
<td>.830</td>
</tr>
<tr>
<td>Reversed: People on this team sometimes reject others for being different.</td>
<td>.211</td>
<td>.089</td>
<td>-.020</td>
<td>-.044</td>
<td>.646</td>
</tr>
<tr>
<td>This team believes different viewpoints add value.</td>
<td>.155</td>
<td>-.026</td>
<td>.124</td>
<td>.186</td>
<td>.582</td>
</tr>
<tr>
<td>The differences on this team help us achieve the team’s goals.</td>
<td>.011</td>
<td>.016</td>
<td>.224</td>
<td>.150</td>
<td>.516</td>
</tr>
<tr>
<td>Team members actively share their special knowledge and expertise with one another.</td>
<td>.184</td>
<td>.134</td>
<td>.078</td>
<td>.192</td>
<td>.419</td>
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<tr>
<td>When things change, members of this team make adjustments they know will help the other members of the team.</td>
<td>.280</td>
<td>.079</td>
<td>.294</td>
<td>.114</td>
<td>.305</td>
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</table>
Table 8: Means, Standard Deviations, Correlations of Variables and Coefficient Alphas

<table>
<thead>
<tr>
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<th>Mean</th>
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<th>2.</th>
<th>3.</th>
<th>4.</th>
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<th>7.</th>
<th>8.</th>
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<th>10.</th>
<th>11.</th>
<th>12.</th>
<th>13.</th>
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</thead>
<tbody>
<tr>
<td>1. Vertical complexity leadership</td>
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<tr>
<td>2. Shared complexity leadership</td>
<td>5.33</td>
<td>0.40</td>
<td>.71**</td>
<td>.89</td>
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<tr>
<td>3. Education heterogeneity</td>
<td>0.54</td>
<td>0.25</td>
<td>-.21</td>
<td>-.02</td>
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<td>4. Function heterogeneity</td>
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<td>0.20</td>
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<td>-.15</td>
<td>.43**</td>
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<td>5. Job role heterogeneity</td>
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<td>.47**</td>
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<tr>
<td>6. Industry tenure heterogeneity</td>
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<td>0.28</td>
<td>.12</td>
<td>.13</td>
<td>.17</td>
<td>.18</td>
<td>.04</td>
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<td>7. Collaborative learning</td>
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<td>.67**</td>
<td>.57**</td>
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<td>8. Heterogeneity norm</td>
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<td>.56**</td>
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<td>-.33**.11</td>
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<td>9. T- Innovation Enabling Behaviors</td>
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<td>.59**</td>
<td>.67**</td>
<td>.01</td>
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<td>10. T-Perceived Performance</td>
<td>4.83</td>
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<td>.55**</td>
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<td>11. S-Innovation Enabling Behaviors</td>
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<td>0.94</td>
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<td>12. S-Perceived Performance</td>
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<td>.10</td>
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<td>-.16</td>
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<td>.01</td>
<td>.47**</td>
<td>.44**</td>
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<td>13. Team size</td>
<td>9.83</td>
<td>4.91</td>
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<td>-.30*</td>
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<td>.17</td>
<td>.11</td>
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<td>-.09</td>
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<td>.06</td>
<td>.04</td>
<td>.22</td>
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<tr>
<td>14. Team tenure</td>
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<td>.18</td>
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<td>-.19</td>
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<td>-.01</td>
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<td>.07</td>
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<td>.27*</td>
<td>.29*</td>
<td>.15</td>
<td>-.15</td>
</tr>
</tbody>
</table>

n = 59. Reliability coefficients (alpha) are shown boldface italics along the diagonal where appropriate.  
* Correlation is significant at the 0.05 level 2-tailed.  
** Correlation is significant at the 0.01 level 2-tailed.  
T = Team Reported  
S = Stakeholder Reported
Table 9: Results of Standardized Regression Analysis of Complexity Leadership’s Effects

<table>
<thead>
<tr>
<th>Variable</th>
<th>Team – Innovation Enabling Behaviors</th>
<th>Team - Perceived Performance</th>
<th>Stakeholder- Innovation Enabling Behaviors</th>
<th>Stakeholder - Perceived Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1: Controls</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Team size</td>
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<td>.102</td>
<td>.086</td>
<td>.246*</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.331*</td>
<td>.288*</td>
<td>.305*</td>
<td>.188</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.112*</td>
<td>.051*</td>
<td>.060*</td>
<td>.048*</td>
</tr>
<tr>
<td><strong>Step 2: Main effect - vertical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team size</td>
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<td>.253*</td>
<td>.120</td>
<td>.325*</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.246*</td>
<td>.180*</td>
<td>.281*</td>
<td>.131</td>
</tr>
<tr>
<td>Vertical complexity leadership</td>
<td>.533**</td>
<td>.675**</td>
<td>.150</td>
<td>.353**</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.469**</td>
<td>.417**</td>
<td>.064*</td>
<td>.151**</td>
</tr>
<tr>
<td>Δ in adjusted R²</td>
<td>.357**</td>
<td>.367**</td>
<td>.004*</td>
<td>.103**</td>
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<tr>
<td><strong>Step 3: Main effect - shared</strong></td>
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<tr>
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<td>.269*</td>
<td>.158</td>
<td>.290*</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.245*</td>
<td>.208*</td>
<td>.271*</td>
<td>.167</td>
</tr>
<tr>
<td>Shared complexity leadership</td>
<td>.640**</td>
<td>.598**</td>
<td>.255*</td>
<td>.157</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.481**</td>
<td>.370**</td>
<td>.104*</td>
<td>.054</td>
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<tr>
<td>Δ in adjusted R²</td>
<td>.369**</td>
<td>.319**</td>
<td>.044*</td>
<td>.006</td>
</tr>
<tr>
<td><strong>Step 4: Main effects - both</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team size</td>
<td>.047</td>
<td>.284**</td>
<td>.156</td>
<td>.304*</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.232*</td>
<td>.173*</td>
<td>.273*</td>
<td>.135</td>
</tr>
<tr>
<td>Vertical complexity leadership</td>
<td>.190</td>
<td>.509**</td>
<td>-.041</td>
<td>.461*</td>
</tr>
<tr>
<td>Shared complexity leadership</td>
<td>.509**</td>
<td>.247*</td>
<td>.283</td>
<td>-.161</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.490**</td>
<td>.494**</td>
<td>.088*</td>
<td>.149*</td>
</tr>
<tr>
<td>Δ in adjusted R²</td>
<td>.378**</td>
<td>.443**</td>
<td>.028*</td>
<td>.101*</td>
</tr>
</tbody>
</table>

n = 59. Standardized coefficients (β) are reported.

* p < 0.10 level 2-tailed; ** p < 0.05 level 2-tailed; *** p < 0.01 level 2-tailed
Table 10: Results of Standardized Regression Analysis of Collaborative Learning’s Effects

<table>
<thead>
<tr>
<th>Variable</th>
<th>Team – Innovation Enabling Behaviors</th>
<th>Team - Perceived Performance</th>
<th>Stakeholder-Innovation Enabling Behaviors</th>
<th>Stakeholder - Perceived Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: Controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team size</td>
<td>-.137</td>
<td>.102</td>
<td>.086</td>
<td>.246†</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.331*</td>
<td>.288*</td>
<td>.305*</td>
<td>.188</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.112*</td>
<td>.051†</td>
<td>.060†</td>
<td>.048†</td>
</tr>
<tr>
<td>Step 2: Main effect</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team size</td>
<td>-.018</td>
<td>.253*</td>
<td>.093</td>
<td>.267*</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.246*</td>
<td>.180†</td>
<td>.288*</td>
<td>.134</td>
</tr>
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<td>Collaborative learning</td>
<td>.592**</td>
<td>.738**</td>
<td>.101</td>
<td>.327*</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.454**</td>
<td>.586**</td>
<td>.053</td>
<td>.140*</td>
</tr>
<tr>
<td>Δ in adjusted R²</td>
<td>.235**</td>
<td>.312**</td>
<td>-.007</td>
<td>.092*</td>
</tr>
</tbody>
</table>

n = 59. Standardized coefficients (β) are reported. 
† p < 0.10 level 2-tailed; * p < 0.05 level 2-tailed; ** p < 0.01 level 2-tailed
Table 11: Collaborative Learning as Mediator of Complexity Leadership’s Influence on Innovation Team Outcomes

<table>
<thead>
<tr>
<th>IV - Distribution of Complexity Leadership</th>
<th>DV - Innovation Performance</th>
<th>Baron &amp; Kenny Mediation Test</th>
<th>Bootstrapping Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>T - Innovation Enabling Behaviors</td>
<td>IV β Direct Effects</td>
<td>IV β Post-mediation</td>
</tr>
<tr>
<td>Vertical</td>
<td>T - Perceived Performance</td>
<td>.533**</td>
<td>.229†</td>
</tr>
<tr>
<td>Vertical</td>
<td>S - Innovation Enabling Behaviors</td>
<td>.675**</td>
<td>.309*</td>
</tr>
<tr>
<td>Vertical</td>
<td>S - Perceived Performance</td>
<td>.150</td>
<td>.144</td>
</tr>
<tr>
<td>Shared</td>
<td>T - Innovation Enabling Behaviors</td>
<td>.353**</td>
<td>.232</td>
</tr>
<tr>
<td>Shared</td>
<td>T - Perceived Performance</td>
<td>.640**</td>
<td>.430**</td>
</tr>
<tr>
<td>Shared</td>
<td>S - Innovation Enabling Behaviors</td>
<td>.598**</td>
<td>.249*</td>
</tr>
<tr>
<td>Shared</td>
<td>S - Perceived Performance</td>
<td>.255†</td>
<td>.285†</td>
</tr>
<tr>
<td>Shared</td>
<td>S - Perceived Performance</td>
<td>.157</td>
<td>.048</td>
</tr>
</tbody>
</table>

n = 59. Standardized coefficients (β) are reported.

†p < 0.10 level 2-tailed; *p < 0.05 level 2-tailed; **p < 0.01 level 2-tailed

†T = Team Reported; S = Stakeholder Reported
Table 12: Results of Standardized Regression Analysis of Vertical Complexity Leadership’s Moderation of Job Relevant Heterogeneity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Team - Innovation Enabling Behaviors</th>
<th>Team - Perceived Performance</th>
<th>Stakeholder - innovation Enabling Behaviors</th>
<th>Stakeholder - Perceived Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 1: Controls</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team size</td>
<td>-.137</td>
<td>.102</td>
<td>.086</td>
<td>.246 (^1)</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.331(^*)</td>
<td>.288(^*)</td>
<td>.305(^*)</td>
<td>.188</td>
</tr>
<tr>
<td>Adjusted R(^2)</td>
<td>.112(^*)</td>
<td>.051 (^1)</td>
<td>.060 (^1)</td>
<td>.048 (^1)</td>
</tr>
<tr>
<td><strong>Step 2: Main effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team size</td>
<td>-.179</td>
<td>.048</td>
<td>.083</td>
<td>.267</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.240 (^1)</td>
<td>.159</td>
<td>.275 (^1)</td>
<td>.090</td>
</tr>
<tr>
<td>Job role heterogeneity</td>
<td>.298(^*)</td>
<td>.318(^*)</td>
<td>.091</td>
<td>.158</td>
</tr>
<tr>
<td>Industry tenure heterogeneity</td>
<td>.108</td>
<td>.285(^**)</td>
<td>.046</td>
<td>.119</td>
</tr>
<tr>
<td>Function heterogeneity</td>
<td>-.242</td>
<td>-.422(^**)</td>
<td>.127</td>
<td>-.166</td>
</tr>
<tr>
<td>Education heterogeneity</td>
<td>.082</td>
<td>.085</td>
<td>-.241</td>
<td>-.279 (^1)</td>
</tr>
<tr>
<td>Adjusted R(^2)</td>
<td>.135(^*)</td>
<td>.181(^*)</td>
<td>.048</td>
<td>.094 (^1)</td>
</tr>
<tr>
<td>(\Delta) in adjusted R(^2)</td>
<td>.023(^*)</td>
<td>.130(^*)</td>
<td>-.012</td>
<td>.046 (^1)</td>
</tr>
<tr>
<td><strong>Step 3: Moderator</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Team size</td>
<td>-.029</td>
<td>.224(^*)</td>
<td>.122</td>
<td>.346(^*)</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.268(^*)</td>
<td>.192 (^1)</td>
<td>.283 (^*)</td>
<td>.105</td>
</tr>
<tr>
<td>Job role heterogeneity</td>
<td>-.011</td>
<td>-.044</td>
<td>.011</td>
<td>-.005</td>
</tr>
<tr>
<td>Industry tenure heterogeneity</td>
<td>-.043</td>
<td>.107</td>
<td>.006</td>
<td>.039</td>
</tr>
<tr>
<td>Function heterogeneity</td>
<td>.010</td>
<td>-.126</td>
<td>.193</td>
<td>-.033</td>
</tr>
<tr>
<td>Education heterogeneity</td>
<td>.190</td>
<td>.211 (^1)</td>
<td>-.213</td>
<td>-.222</td>
</tr>
<tr>
<td>Vertical complexity leadership</td>
<td>.577(^**)</td>
<td>.677(^*)</td>
<td>.149</td>
<td>.304 (^1)</td>
</tr>
<tr>
<td>Adjusted R(^2)</td>
<td>.356(^**)</td>
<td>.491(^**)</td>
<td>.045</td>
<td>.142(^*)</td>
</tr>
<tr>
<td>(\Delta) in adjusted R(^2)</td>
<td>.244(^**)</td>
<td>.440(^**)</td>
<td>-.015</td>
<td>.096(^*)</td>
</tr>
<tr>
<td><strong>Step 4: Interactions</strong></td>
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<td></td>
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<tr>
<td>Team size</td>
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<td>.244(^*)</td>
<td>.118</td>
<td>.316(^*)</td>
</tr>
<tr>
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<td>.228 (^1)</td>
<td>.206 (^1)</td>
<td>.313 (^*)</td>
<td>.173</td>
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<td>.053</td>
<td>-.043</td>
<td>-.098</td>
<td>-.043</td>
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<tr>
<td>Industry tenure heterogeneity</td>
<td>.006</td>
<td>.119</td>
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<td>.002</td>
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<tr>
<td>Function heterogeneity</td>
<td>.101</td>
<td>-.167</td>
<td>.274</td>
<td>-.185</td>
</tr>
<tr>
<td>Education heterogeneity</td>
<td>.057</td>
<td>.202</td>
<td>-.257</td>
<td>-.065</td>
</tr>
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<td>.685(^**)</td>
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<td>.344(^*)</td>
</tr>
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<td>Job role heterogeneity X vertical complexity leadership</td>
<td>.122</td>
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<td>.162</td>
<td>-.106</td>
</tr>
<tr>
<td>Industry tenure heterogeneity X vertical complexity leadership</td>
<td>.152</td>
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<td>-.166</td>
<td>-.178</td>
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<tr>
<td>Function heterogeneity X vertical complexity leadership</td>
<td>-.259</td>
<td>.100</td>
<td>-.092</td>
<td>.396(^*)</td>
</tr>
<tr>
<td>Education heterogeneity X vertical complexity leadership</td>
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<td>.019</td>
<td>.182</td>
<td>-.047</td>
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<td>.201(^*)</td>
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<td>(\Delta) in adjusted R(^2)</td>
<td>.272(^**)</td>
<td>.416(^**)</td>
<td>-.029</td>
<td>.153(^*)</td>
</tr>
</tbody>
</table>

\(^n = 59.\) Standardized coefficients (\(\beta\)) are reported.

\(^1\) \(p < 0.10\) level 2-tailed; \(^*\) \(p < 0.05\) level 2-tailed; \(^**\) \(p < 0.01\) level 2-tailed
Table 13: Results of Standardized Regression Analysis of Shared Complexity Leadership’s Moderation of Job Relevant Heterogeneity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Team - Innovation Enabling Behaviors</th>
<th>Team - Perceived Performance</th>
<th>Stakeholder-innovation Enabling Behaviors</th>
<th>Stakeholder - Perceived Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 1: Controls</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team size</td>
<td>-.137</td>
<td>.102</td>
<td>.086</td>
<td>.246 (^1)</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.331*</td>
<td>.288*</td>
<td>.305*</td>
<td>.188</td>
</tr>
<tr>
<td>Adjusted R(^2)</td>
<td>.112(^*)</td>
<td>.051(^*)</td>
<td>.060(^*)</td>
<td>.048(^*)</td>
</tr>
<tr>
<td><strong>Step 2: Main effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team size</td>
<td>-.179</td>
<td>.048</td>
<td>.083</td>
<td>.267(^*)</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.240(^1)</td>
<td>.159</td>
<td>.275(^1)</td>
<td>.090</td>
</tr>
<tr>
<td>Job role heterogeneity</td>
<td>.298(^*)</td>
<td>.318(^*)</td>
<td>.091</td>
<td>.158</td>
</tr>
<tr>
<td>Industry tenure heterogeneity</td>
<td>.108</td>
<td>.285(^*)</td>
<td>.046</td>
<td>.119</td>
</tr>
<tr>
<td>Function heterogeneity</td>
<td>-.242</td>
<td>-.422(^**)</td>
<td>.127</td>
<td>-.166</td>
</tr>
<tr>
<td>Education heterogeneity</td>
<td>.082</td>
<td>.085</td>
<td>-.241</td>
<td>-.279(^1)</td>
</tr>
<tr>
<td>Adjusted R(^2)</td>
<td>.135(^*)</td>
<td>.181(^*)</td>
<td>.048</td>
<td>.151(^**)</td>
</tr>
<tr>
<td>(\Delta) in adjusted R(^2)</td>
<td>.023(^*)</td>
<td>.139(^*)</td>
<td>-.012</td>
<td>.103(^*)</td>
</tr>
<tr>
<td><strong>Step 3: Moderator</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team size</td>
<td>.025</td>
<td>.215(^*)</td>
<td>.172</td>
<td>.299(^*)</td>
</tr>
<tr>
<td>Team tenure</td>
<td>.229(^*)</td>
<td>.150</td>
<td>.271(^1)</td>
<td>.088</td>
</tr>
<tr>
<td>Job role heterogeneity</td>
<td>.102</td>
<td>.157</td>
<td>.006</td>
<td>.127</td>
</tr>
<tr>
<td>Industry tenure heterogeneity</td>
<td>-.038</td>
<td>.165</td>
<td>-.018</td>
<td>.096</td>
</tr>
<tr>
<td>Function heterogeneity</td>
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<td>-.288(^*)</td>
<td>.198</td>
<td>-.140</td>
</tr>
<tr>
<td>Education heterogeneity</td>
<td>.107</td>
<td>.105</td>
<td>-.230</td>
<td>-.275(^1)</td>
</tr>
<tr>
<td>Shared complexity leadership</td>
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<td>.512(^*)</td>
<td>.271(^1)</td>
<td>.098</td>
</tr>
<tr>
<td>Adjusted R(^2)</td>
<td>.463(^**)</td>
<td>.396(^*)</td>
<td>.094(^1)</td>
<td>.054</td>
</tr>
<tr>
<td>(\Delta) in adjusted R(^2)</td>
<td>.357(^**)</td>
<td>.345(^*)</td>
<td>.034(^1)</td>
<td>.006</td>
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<tr>
<td><strong>Step 4: Interactions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Team size</td>
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<td>.201(^1)</td>
<td>.138</td>
<td>.261(^*)</td>
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<td>.169</td>
<td>.249(^1)</td>
<td>.098</td>
</tr>
<tr>
<td>Job role heterogeneity</td>
<td>.090</td>
<td>.103</td>
<td>-.176</td>
<td>.078</td>
</tr>
<tr>
<td>Industry tenure heterogeneity</td>
<td>-.048</td>
<td>.171</td>
<td>-.078</td>
<td>.129</td>
</tr>
<tr>
<td>Function heterogeneity</td>
<td>-.033</td>
<td>-.298(^*)</td>
<td>.275</td>
<td>-.259</td>
</tr>
<tr>
<td>Education heterogeneity</td>
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<td>.112</td>
<td>-.265</td>
<td>-.211</td>
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<tr>
<td>Shared complexity leadership</td>
<td>.625(^**)</td>
<td>.510(^**)</td>
<td>.258(^1)</td>
<td>.118</td>
</tr>
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<td>Job role heterogeneity X shared</td>
<td>.068</td>
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<td>.040</td>
<td>-.042</td>
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<tr>
<td>complexity leadership</td>
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<td>-.087</td>
<td>-.313(^*)</td>
<td>-.381(^*)</td>
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<td>shared complexity leadership</td>
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<td>Function heterogeneity X shared</td>
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<td>-.143</td>
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<td>Education heterogeneity X</td>
<td>.006</td>
<td>.147</td>
<td>.398(^*)</td>
<td>.146</td>
</tr>
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<td>shared complexity leadership</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted R(^2)</td>
<td>.428(^**)</td>
<td>.392(^*)</td>
<td>.154(^1)</td>
<td>.149(^*)</td>
</tr>
<tr>
<td>(\Delta) in adjusted R(^2)</td>
<td>.316(^**)</td>
<td>.341(^*)</td>
<td>.094(^1)</td>
<td>.101(^*)</td>
</tr>
</tbody>
</table>

\(n = 59\). Standardized coefficients (\(\beta\)) are reported.  
1 p < 0.10 level 2-tailed; * p < 0.05 level 2-tailed; ** p < 0.01 level 2-tailed
Table 14: Heterogeneity Norm as Mediator of Complexity Leadership’s Influence on Innovation Team Outcomes

<table>
<thead>
<tr>
<th>IV - Distribution of Complexity Leadership</th>
<th>DV Innovation Performance</th>
<th>Baron &amp; Kenny Mediation Test</th>
<th>Bootstrap Test</th>
<th>Z-Score Statistic</th>
<th>p Two-tailed</th>
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</thead>
<tbody>
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<td></td>
<td></td>
<td>IV β Direct Effects</td>
<td>IV β Post-mediation</td>
<td>Mediator β Heterogeneity Norm</td>
<td></td>
</tr>
<tr>
<td>Vertical</td>
<td>T - Innovation Enabling Behaviors</td>
<td>.533**</td>
<td>.216</td>
<td>.464**</td>
<td>2.970</td>
</tr>
<tr>
<td>Vertical</td>
<td>T - Perceived Performance</td>
<td>.675**</td>
<td>.457**</td>
<td>.320*</td>
<td>4.219</td>
</tr>
<tr>
<td>Vertical</td>
<td>S - Innovation Enabling Behaviors</td>
<td>.150</td>
<td>.081</td>
<td>.101</td>
<td>.443</td>
</tr>
<tr>
<td>Vertical</td>
<td>S - Perceived Performance</td>
<td>.353**</td>
<td>.334</td>
<td>.028</td>
<td>.204</td>
</tr>
<tr>
<td>Shared</td>
<td>T - Innovation Enabling Behaviors</td>
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<td>.420**</td>
<td>.381**</td>
<td>2.872</td>
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<tr>
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<td>T - Perceived Performance</td>
<td>.598**</td>
<td>.353**</td>
<td>.425**</td>
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<tr>
<td>Shared</td>
<td>S - Innovation Enabling Behaviors</td>
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<td>.239</td>
<td>.027</td>
<td>.151</td>
</tr>
<tr>
<td>Shared</td>
<td>S - Perceived Performance</td>
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<td>.027</td>
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</table>

n = 59. Standardized coefficients (β) are reported.

\* p < 0.10 level 2-tailed; \* \* p < 0.05 level 2-tailed; \* \* \* p < 0.01 level 2-tailed

\[ T = \text{Team Reported}; S = \text{Stakeholder Reported} \]
Figure 1: Model of Complexity Leadership in Innovation Teams

Diagram showing the relationship between complexity leadership (vertical and shared), collaborative learning, heterogeneity norm, and innovation team outcomes (innovation enabling behaviors and perceived performance), with signs indicating positive (+) and negative (-) relationships.
Figure 2: Study Model and Hypotheses

Complexity Leadership
- Vertical
- Shared

H.1

Collaborative Learning

H.2a, H.2b, H.2c

Heterogeneity Norm

H.3

Innovation Team Outcomes

- Innovation Enabling Behaviors
- Perceived Performance

Job Relevant Heterogeneity
Figure 3: Moderation of the Effect of Function Heterogeneity on Stakeholder Perceived Performance by Vertical Complexity Leadership
Figure 4: Moderation of the Effect of Function Heterogeneity on Stakeholder Perceived Performance by Shared Complexity Leadership

Stakeholder - Perceived Performance

- Low Shared Complexity Leadership
- High Shared Complexity Leadership
Figure 5: Moderation of the Effect of Education Heterogeneity on Stakeholder Innovation Enabling Behaviors by Shared Complexity Leadership

Stakeholder - Innovation Enabling Behaviors

- Low Shared Complexity Leadership
- High Shared Complexity Leadership

Low Education Heterogeneity  High Education Heterogeneity
Figure 6: Moderation of the Effect of Industry Tenure Heterogeneity on Stakeholder Innovation Enabling Behaviors by Shared Complexity Leadership

Stakeholder - Innovation Enabling Behaviors

- Low Shared Complexity Leadership
- High Shared Complexity Leadership
Figure 7: Moderation of the Effect of Industry Tenure Heterogeneity on Stakeholder Perceived Performance by Shared Complexity Leadership

Stakeholder - Perceived Performance

- Low Shared Complexity Leadership
- High Shared Complexity Leadership
Figure 8: Summary of Model Findings

Complexity Leadership
- Vertical
- Shared

H.2a

H.1

Collaborative Learning

H.2b, c

Heterogeneity Norm

H.3

Innovation Team Outcomes
- Innovation Enabling Behaviors
- Perceived Performance

Legend
Support
Some Support
Very Limited Support
VITA
EMILIO DELIA

1946 Born December 26 in Newark, NJ

1964 Graduate from St. Benedict’s Prep, Newark, NJ

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