2018

Knowledge Asset Value and Network Safeguards: Impacts and Outcomes

Karen R. Nicholas

Knowledge Asset Value and Network Safeguards: Impacts and Outcomes

Karen R. Nicholas

Dissertation submitted
to the College of Business and Economics
at West Virginia University

in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in
Business Administration, Concentration in Management

Curt B. Moore, Ph.D., Chair
Olga Bruyaka, Ph.D.
Jennifer Sexton, Ph.D.
Miles A. Zachary, Ph.D.
G. Tyge Payne, Ph.D.

Department of Management

Morgantown, West Virginia
2018

Keywords: Management, Knowledge, Networks

ABSTRACT

Knowledge Asset Value and Network Safeguards: Impacts and Outcomes

Karen R. Nicholas

Knowledge is a key resource for firms, capable of providing a firm-level competitive advantage. Interfirm networks are a valuable source of knowledge for firms, as both breadth and depth of knowledge can be developed via interfirm relationships. However, for firms that have acquired and developed valuable knowledge assets, they may view their interfirm network as providing an opportunity for knowledge loss via knowledge spillovers. Knowledge spillovers allow the recipient to gain knowledge without compensation to the knowledge-originating firm. Spillovers lead to a loss of present and future value to the knowledge-originating firm. Indeed, firms with valuable knowledge asset may implement network safeguards to limit potential knowledge spillovers via their network size, intensity, structure, and position within the network. While extant research has examined the effect of networks on knowledge outcomes, limited attention has been paid to how firms may adapt their networks to safeguard their knowledge once they have created significant value in their knowledge assets. Furthermore, as networks are a key knowledge resource, it is unknown if these network safeguards will harm the future value of the firm’s knowledge asset due to the restriction of available knowledge. This dissertation seeks to explore these issues by examining how firms with knowledge assets of high value may safeguard their knowledge via their network size, intensity, structure, and position, and ultimately how these efforts may impact the value of their future knowledge assets.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I: INTRODUCTION

A number of theoretical perspectives, including the knowledge-based view of the firm (Grant, 1996a, 1996b: Spender, 1996), social capital (Burt, 1992, 2000; Coleman, 1988; Lin, 1999, 2002), organization learning (Levitt and March, 1988; March, 1991), and absorptive capacity (Cohen & Levinthal, 1989, 1990) perspectives, suggest knowledge acquired within interfirm networks is often shared among network members (Appleyard, 1996; Dyer & Nobeoka, 2000; Lipparini, Lorenzoni & Ferriani, 2014; Owen-Smith & Powell, 2004). Indeed, firms that have already accumulated substantial value in their knowledge assets may view the risk of knowledge spillovers (i.e., unintentionally spilling valuable knowledge to partners) to be greater than the benefits gained by acquiring new knowledge. Network safeguards, such as restricting network size, intensity, structure, and position, may, therefore, support firm goals of reducing the potential for knowledge spillovers. However, these safeguards may, over time, hamper the ability of firms to gather new knowledge, depending on the magnitude in which they are implemented. Thus, network safeguards at one point in time may negatively affect the future value of the firm's knowledge assets. These potential outcomes indicate that research examining these issues over the long-run can clarify our understanding of how network safeguards, designed to protect the value of firms' knowledge assets at one point in time, may ultimately have a negative impact on the future value of knowledge assets.

The knowledge-based view (KBV) of the firm (Grant, 1996a, 1996b; Spender, 1996), in particular, conceptualizes the firm's principal function as ensuring that accumulated knowledge generates a return equal to the value of the knowledge, thereby recouping, or appropriating, all possible returns from the knowledge asset (Coff, 1999). In addition to knowledge accumulated via internal research and development activities, external sources of knowledge are also viewed as fundamental in developing value in a firm's knowledge asset, leading to new opportunities (Levitt & March, 1988; March, 1991). However, when knowledge is exchanged between parties without compensation to the knowledge originator, this is considered a knowledge spillover (Agarwal, Audretsch, & Sarkar, 2010), potentially reducing both present and future value of a firm's knowledge assets. Gaining access to knowledge is a prime motivator for firms to enter in interorganizational relationships (Kogut, 2000), regardless of whether all parties involved in the relationship desired the knowledge to be transferred (Martinez-Noya, Garcia-Canal & Guillen, 2013). While interfirm relationships can be formed with the primary goal of knowledge transfer or creation, whereby the relationship includes compensation to the knowledge-originating firm, interfirm relationships afford the potential for all parties to accumulate knowledge from each other (Shu, Liu, Gao, & Shanley, 2014). Thus, while KBV is focused on gathering knowledge from all sources to increase the value of a firm's knowledge assets and thereby its competitive advantage, firms already in possession of valuable knowledge assets may be seeking safeguards from knowledge spillovers in order to protect the value of their knowledge assets.

As interorganizational relationships can reap knowledge rewards, networks of firms have the ability to extend knowledge opportunities via the transference of knowledge across extended interorganizational ties. The volume and variety of ties found in an interorganizational network affects the breadth of available knowledge, expanding the potential benefits (Love, Roper, & Vahter, 2014). Network ties allow knowledge to transfer throughout the network, resulting in firms gaining knowledge from indirect links, not necessitating a direct linkage to the knowledge originator (Wagner, Hoisl, & Thoma, 2014). Furthermore, the ability to gain knowledge from relationships is found in all relationships, including those between knowledge originating firms and their suppliers and customers (Alcacer & Oxley, 2014). Indeed, firm networks can be viewed as an origin for value-creating resources as well as a valuable resource in and of itself (Gulati, Nohria, & Zaheer, 2000), with both direct and indirect linkages contributing to the network's value.

Nonetheless, a firm's knowledge can also be unintentionally dispersed via firm networks. Networks have been identified as a valuable source of knowledge, enabling firms engaged in networks to increase their knowledge (Dyer & Nobeoka, 2000; Fjeldstad & Sasson, 2010). However, the opportunity of accumulating knowledge from interfirm relationships, whether intended or otherwise, is also afforded to partnering firms (Giarratana & Mariani, 2014; Hernandez et al., 2015). Knowledge spillovers, whereby knowledge accrues to other firms without compensation to the creating firm (Mayer, 2006; Uzzi & Gillespie, 2002), are prevalent in networks. Knowledge spillovers are considered a positive by many researchers; for example, entrepreneurial opportunities can be generated via spillovers (i.e., Agarwal, Audretsch, & Sarkar, 2007; Agarwal et al., 2010; Shu et al., 2014), industry productivity can be increased (Motohashi & Yuan, 2010), and firm innovation output can be enhanced (Operti & Carnabuci, 2014) as firms opportunistically generate value from knowledge spillovers. However, even though firm networks are viewed as an opportunity to accumulate knowledge (Phelps, Heidl, & Wadhwa, 2012), some firms may view the risk of their network accumulating their valuable knowledge without consent as an avoidable risk and thus alter their network characteristics in order to safeguard their knowledge asset value.

Indeed, while benefits to the recipients of knowledge spillovers are not questioned (Agarwal et al., 2010), research examining the negative outcomes of knowledge spillovers on the knowledge originating firm is limited. The awareness of the issue is long-standing; in the 1960s, Arrow (1962) recognized that firms may restrict knowledge development efforts if they cannot recoup their costs or appropriate full value. Recent research has focused on whether firms can manage their relationships to reduce spillovers (Mayer, 2006; Oxley & Sampson, 2004) indicating an assumption that spillovers cannot be avoided, yet can be restricted. Other research has focused on firms' responses to knowledge spillovers, including the subsequent formation of alliances (Phene & Tallman, 2014) and increases in competitive pressures (Pacheco-de-Almeida & Zemsky, 2012). Furthermore, firms may select or avoid network partners based on their connections to avoid potential spillovers to rivals (Hernandez, Sanders, & Tuschke, 2015). However, while this research indicates that spillovers are prevalent and that above-noted mechanisms are available to reduce the impact of spillovers, a gap still exists in our knowledge of whether there is a relationship between firm knowledge asset value and network characteristics such as their network size, structure, and firm position within the network. If this relationship exists, it may be indicative of firms implementing network safeguards in order to limit potential knowledge spillovers.

Gaps in Knowledge and Network Outcomes Research

With knowledge being considered a significant resource that contributes to a firm's competitive advantage (Grant, 1996a, 1996b; Spender, 1996) and firm networks providing a key avenue for gathering knowledge (Lipparini, Lorenzoni, & Ferriani, 2014; Mahmood, Zhu, & Zajac, 2011; Wagner et al., 2014), it is proposed that firms in possession of valuable knowledge assets may attempt to safeguard their knowledge. Via interfirm networks, firms seeking knowledge protection may have dissimilar network characteristics, such as network size, structure, and firm position within the network, as compared to firms with limited knowledge asset value. Empirical research into this area has received scant attention, indicating a gap in our knowledge and understanding of this phenomenon.

In contrast, the research examining the relationship from interfirm networks to knowledge accumulation and development has accumulated a significant body of extant research[1], while a gap exists in our understanding of the next phase in the process; specifically, the impact of knowledge asset value on network characteristics such as size, intensity, structure, and firm position within the network due to spillover concerns. Research proximal to this area has been concerned with how firms respond to spillover threats. For example, attempts by firms to safeguard knowledge within networks may be inadvertently signaling that the knowledge is valuable, and therefore the knowledge may be pursued with greater vigor by networked firms (Shu et al., 2014). Further research has examined how relationships may be terminated or initiated depending on indirect connections to rivals (Hernandez et al., 2015), indicating firm awareness of potential spillovers' negative outcomes. More proximal to the current research goals, a study was conducted that indicated that firms may choose to avoid external relationships when concerned with knowledge spillovers (Giarratana & Mariani, 2014; Mayer, 2006). However, the predominance of research (including the above-noted research) has been conducted at the dyadic level, limiting our understanding on how potential knowledge spillovers may induce firms to guard their knowledge via their network. While specific research examining the threat of knowledge spillovers on networks is still a gap in our knowledge, the recent forays into firm responses to spillovers indicates that knowledge protection efforts are of interest to strategy researchers. Thus, a detailed examination of how the value of knowledge assets may impact network characteristics is warranted.

[1] See the literature review by Phelps et al., 2012, and examples of empirical research Dyer and Nobeoka, 2000; Kogut, 2000; Laursen and Salter, 2006 as well as Chapter II)

A second gap exists in our understanding of how industry and environmental factors may affect firms' knowledge protection practices. First, regarding industry factors, the essential element in this argument is that the value or duration of the value of knowledge may not be constant across industries (Brown & Eisenhardt, 1997), thereby increasing (or decreasing) the need for network safeguards. Recent research indicates that knowledge's value may be reduced in dynamic industries (Wang & Chen, 2010), suggesting that environmental effects may provide a valuable source of explanatory power regarding knowledge protection efforts. High-technology contexts are frequently chosen for research both in networks (i.e., Burt, 2000; Stuart, 1998; Stuart & Podolny, 1996) and knowledge (i.e., Ciborra, 1996; Liu, Wright, Filatotchev, Dai, & Lu, 2010; Mayer, 2006; Zhang, Soh, & Wong, 2010) due to the value of knowledge in this industry, yet this focus reduces our understanding of how a firm's industry may impact the value of knowledge, and thereby impact the implementation of network safeguards. Secondly, while extant research has examined geographical effects on knowledge accumulation and the potential for spillovers (i.e., Coombs, Deeds, & Ireland, 2009; Frost, 2001; Funk, 2014; Phene & Tallman, 2014), our understanding of environmental effects has been neglected in theoretical arguments, yet frequently employed as statistical controls and thus acknowledged as potential influences. Environmental factors such as dynamism and munificence may impact choices available to firms, broadening or restricting options (Boyd & Gove, 2006). Industry dynamism indicates the instability or unpredictability in the environment (Dess & Beard, 1984), and may lead to increased knowledge protection as firms seek to guard any current or future competitive advantage in an uncertain environment. Munificence indicates an abundance of resources (Dess & Beard, 1984) and may lead to decreased knowledge protection as firms will not need to protect resources, including knowledge. However, to date, no research has been conducted including industry or environmental factors and how they may impact knowledge protection efforts and ultimately firm networks.

Finally, a gap exists in our understanding of what the performance outcomes are for firms that strategically manage their network size, intensity, structure, and position in order to protect their knowledge asset value. While positive relationships have been found between knowledge networks, and outcomes[2], it is unknown how firms' attempts to restrict knowledge spillovers from their network will eventually impact long-term performance. The rational goal of network safeguards is to preserve the value of knowledge in order to maximally appropriate value. However, if knowledge protection efforts lead to a reduction or restriction of a firm's network, this may impact the volume of the knowledge asset over time as opportunities for knowledge generation and accumulation decrease (Levitt & March, 1991; Wagner et al., 2014), eventually having a negative effect. For example, firms' networks provide opportunities for learning via intermediaries from resources not directly tied to the firm (Wagner et al., 2014), though these intermediaries also provide a pathway to disseminate knowledge, increasing prospects for spillovers (Hernandez et al., 2015). Accordingly, while the goal of network safeguards is to protect the value of the knowledge asset, as network size, intensity, structure, and position are increasingly restricted, the result may ultimately be a negative relationship with future knowledge asset value. This potential outcome indicates that this research has the potential to clarify our understanding of how the degree of network safeguards may impact knowledge value over the short- and long-term.

---

[2] Positive relationships have been found 1) for knowledge and firm performance – both financial outcomes (Decarolis and Deeds, 1999; Uotila, Maula, Keil, and Zahra, 2009) and knowledge outcomes (Aces and Audretsch, 1988; Ahuja and Katila, 2001; Gay and Dousset, 2005) and 2) for networks and firm performance – both financial outcomes (Hite and Hesterly, 2001; Goerzen, 2007; Riccaboni and Pammolli, 2002; Shipilov and Li, 2008) and knowledge outcomes (Lipparini et al., 2014; Mahmood et al., 2011; Wagner et al., 2014).

Research Questions

The first research question asks what are the effects of knowledge asset value on subsequent firm network characteristics. An initial proposition is that firms may reduce their overall network size to reduce the potential for knowledge spillovers. Protection of knowledge assets may be necessary to maintain and recoup its value, as once knowledge is revealed via interfirm networks, other firms can readily imitate (Kogut & Zander, 1992). Thus, as the value of the knowledge asset increases, the perceived need to protect knowledge may intensify in order to maintain a competitive advantage for as long as possible (Barney, 1991).

It is proposed that there are four main methods for firms to safeguard their knowledge assets from their network partners; reducing network size, increasing the intensity of the relationships, changing the structure of the network, and modifying the firm's position within their network. When a firm changes its objective from gaining knowledge via its network to an objective of safeguarding knowledge from its network, what was once considered a positive aspect of networks will now be viewed as a risk that arises from knowledge spillovers. First, a firm may reduce their network size to reduce the absolute number of opportunities for knowledge spillovers, both direct and indirect. By reducing the absolute number of direct relationships, two avenues for reducing knowledge spillovers are presented[3]. The number of direct network partners that could gain from spillovers is restricted as the firm becomes more isolated (Lavie, 2006). Additionally, with fewer relationships, the management of these relationships can

[3] While Transaction Cost Economics (Williamson, 1979, 1981) could be argued to be an alternative theoretical explanation for this hypothesis, it must be noted that the question asked here is not whether the firm selects internal or external resources, but rather whether the size of the network is reduced. In the situation proposed here, the volume of work assigned to external resources may be the same but structured in such a way as to reduce the number of interfirm relationships.

increase, creating trust relationships whereby the opportunities for knowledge spillovers are reduced and positive knowledge transfer may be increased (Ireland, Hitt, & Vaidyanath, 2002). These trust relationships may furthermore result in reducing indirect spillovers (from the direct network partner to their partners), thereby impacting both direct and indirect knowledge spillovers.

Secondly, firms may choose to guard against knowledge spillovers by not only reducing the size of the network but also by changing the intensity of their relationships and their network structure. A firm's network may be comprised of both strong ties, indicated by long-lasting, repeated relationships (Coleman, 1988; Granovetter, 1973) and weak ties, which are less time-intensive. Strong ties are associated with relatively closed networks; that is, where most, if not all firms, have strong tie relationships with each other. The development of a closed network "facilitates the emergence of effective norms and maintains the trustworthiness of others, thereby strengthening social capital" (Adler & Kwon, 2002, p. 24). As bonding forms of social capital are developed within the network (Adler & Kwon, 2002), norms and trust operate as governance mechanisms (Moore, Payne, Autry, & Griffis, 2016; Uzzi, 1996). Conversely, weak ties tend to create bridges from one network to another, opening up new avenues for information that increases the range of knowledge (Burt, 1992; Granovetter, 1973) yet not creating the same environment of trust as found between strong ties. While the attractiveness of new knowledge may promote firms to seek weak ties to increase their knowledge asset value, the countervailing force of a reduced or nonexistent expectation of trustworthiness may drive firms to safeguard their knowledge asset value by maintaining a network comprised of strong ties (Ireland et al., 2002).

Finally, high knowledge asset value may lead a firm to occupy a less central position in order to reduce the volume of indirect relationships. Centrality, in general, is viewed as the prominence or importance of a firm (Borgatti & Everett, 2006). A firm will have a higher centrality score to the extent it is connected to many firms who themselves are highly connected, termed beta centrality (Bonacich, 1987). This indicates that not only does is a central firm associated with multiple other firms, but that their direct partners are also associated with multiple other firms, and so on, creating a broad network. Indeed, a highly central position has been considered a sign of status and provides both tangible and intangible benefits (Devers, Dewett, Mishina, & Belsito, 2009; Podolny & Phillips, 1996).

For firms with valuable knowledge asset, centrality can indicate that the firm is widely connected, directly and indirectly, to other firms in their network (Borgatti, 2005) increasing the potential for knowledge spillovers. While central firms are viewed as having higher levels of influence (Borgatti, Everett, & Johnson, 2013), this influence may not extend to their partners' partners and beyond. As the volume of indirect relationships increases due to their central partners, the ability for the knowledge-generating firm to manage these indirect relationships weakens. Thus, while a highly central firm may have increased access to network knowledge, the firm is also placing their knowledge at risk of spillovers due to their central position and subsequent high visibility. Consequently, when knowledge asset value is high, firms may strategically adopt a less central position in their network by connecting to less central firms and thus reduce knowledge spillover opportunities and their visibility. However, current research has yet to examine how knowledge asset value may impact firm network characteristics such as network size, intensity, structure, and firm position, and thus, the first research questions asks:

RQ1: How does the value of a firm's knowledge assets relate to their subsequent network size, intensity, structure, and position?

The second research question focuses on whether industry and environmental characteristics affect the perceived value of a firm's knowledge asset, thereby altering how firms respond to knowledge spillover threats. For example, high-technology industries frequently view knowledge as a key resource leading to competitive advantages (Alnuaimi & George, 2016; Appleyard, 1996; Mayer, 2006), indicating that this industry may place a higher emphasis on knowledge asset value, and thereby network safeguards. While knowledge is not conceptualized as being without value in low-technology industries (e.g. Koka & Prescott, 2008), high-technology industries are viewed as placing a higher value on their knowledge assets (Mayer, 2006). This may be due to the rapid technological changes found in the high-technology industries, whereby high-technology firms are under constant pressure to invest in and develop new knowledge (Soh, 2010; Vanhaverbeke, Duysters, & Noorderhaven, 2002). Thus, in industries where rapid technological changes are present, knowledge assets may be viewed as more worthy of protection (Cruz-Gonzalez, Lopez-Saez, Navas-Lopez, & Delgado-Verde, 2015; Tatarynowicz, Sytch, & Gulati, 2016). The ability to compare network safeguards in different industries can increase our understanding and awareness of how firms in various industries value and guard their knowledge assets via their networks.

In regards to environmental characteristics, levels of industry dynamism and munificence can modify how firms view the value of their knowledge assets and thus influence whether firm networks are altered in order to protect knowledge asset value. Dynamism refers to the unpredictability found in a firm's external environment while munificence indicates the availability of resources (Aldrich, 1979; Boyd & Gove, 2006; Dess & Beard, 1984). These two factors may affect how firms seek to safeguard their knowledge asset value. For example, in highly dynamic environments, uncertainty is high (Boyd & Gove, 2006) and the rate of change may be increased, driving firms to maintain or increase their knowledge-based competitive advantage (Fang, 2011). Thus, firms may seek to protect their knowledge asset value in order to hedge against an unpredictable future. Conversely, in highly munificent environments, firms may feel a reduced need to implement network safeguards, as resources are freely abundant. In munificent environments, firms may not feel the need to appropriate all possible value from their knowledge asset, as the level of competition is reduced (Decarolis & Deeds, 1999), diminishing the need to safeguard knowledge asset value. However, research has yet to examine how specific industry and environmental characteristics affect firm knowledge protection in regards to their network size, intensity, structure, and position. Thus, the second research question asks:

RQ2: How do industry and environmental characteristics affect the relationship between a firm's knowledge asset value and subsequent network size, intensity, structure, and position?

While the first two research questions explore the relationship between knowledge asset value and firm network characteristics, the final research question seeks to extend the previous research questions by including future knowledge asset value. As noted earlier in this chapter, positive relationships between networks and knowledge outcomes have been supported in extant research (Lipparini et al., 2014; Mahmood et al., 2011; Wagner et al., 2014), indicating the presence of a direct relationship between knowledge asset value and multiple performance measures. Thus, research has indicated that firms with valuable knowledge assets will perform strongly. Furthermore, extant research has also found positive relationships between networks and firm outcomes (e.g. Hite & Hesterly, 2001; Goerzen, 2007; Riccaboni & Pammolli, 2002; Shipilov & Li, 2008). However, this research has been predominantly conducted using cross-sectional data (for exceptions, see Ahuja & Katila, 2001 and Lipparini et al., 2014). Indeed, qualitative research and case studies indicate that extensive time may be required to ascertain the effect of networks on firm outcomes (Figueiredo, 2011; Pacheco-de-Almeida & Zemsky, 2012; Yang et al., 2010). Specifically, two studies have examined how interfirm relationships impact knowledge accumulation and knowledge value over a ten-year period, indicating that extensive time periods may be necessary to include in research to determine outcomes (Figueiredo, 2011; Yang, Phelps, & Steensma, 2010). Even though these studies indicate the long-term effects of relationships on knowledge, specific network characteristics were not examined in this research, indicating a gap in our understanding of the time effects of network characteristics on knowledge asset value.

Thus, this dissertation intends to examine longitudinal relationships and seeks to increase our understanding of how network safeguards focused on size, intensity, structure, and position may ultimately affect firm knowledge asset value. In this regard, this research is not intending to include firm network characteristics as mediators, but rather continue along the path taken by research question one, which proposes that firms with high knowledge asset value may alter their network characteristics in order to protect their knowledge. If firms with high knowledge asset value implement network safeguards, how will this ultimately affect future knowledge asset value? Indeed, while both knowledge and network factors have been shown to lead to positive outcomes in the same or highly proximal time periods, it is unknown what outcomes will be seen by a network modified to reduce knowledge spillovers over a longer time period. Though firms alter their networks with the goal of maintaining or extending the value of their knowledge asset and thereby appropriating maximum rents (Coff, 1999), the ‘unintended consequences’ may be in the opposite direction due to the restriction of flow of new knowledge required to develop future valuable knowledge assets (Merton, 1936). Stated more formally, the third research question is as follows:

RQ3: How do network safeguards impact subsequent knowledge asset value?

Organization of Dissertation

This dissertation is comprised of six (6) chapters. This introduction, which describes the gaps of our current understanding of knowledge asset value and network safeguards and the specific research questions, serves as Chapter I. As previously noted, the overall goal of this research is to answer the following question; “How do firms adjust their network characteristics based on their knowledge asset value?” A literature review follows in Chapter II. The literature review provides an examination of the core perspectives employed in this research, the Knowledge-Based View (KBV) of the firm (Grant, 1996a, 1996b, Spender, 1996), as well as reviewing the current state of knowledge and network research. The purpose of the literature review is to provide a review of research that not only includes the theoretical perspective of interest, but also an assessment of the research utilizing the constructs of interest.

Chapter III draws on KBV and network perspectives to derive a set of hypotheses specific to the three research questions presented in this chapter. The proposed methods for this research study follows in Chapter IV of this dissertation, including the research design, sample, sources of data, specific variables and their operationalization, and the data analysis techniques used to test the hypotheses. Chapter IV contains the analysis results. Chapter V contains the discussion of the results of this dissertation and acknowledges and explores other possible explanations for the findings. Limitations, contributions, and the conclusion are also incorporated in Chapter V.

CHAPTER II: LITERATURE REVIEW

The goal of this chapter is to review the literature that focuses on knowledge and networks in order to evaluate existing research and identify research gaps that represent potential for future study. Thus, a literature review was conducted on extant literature discussing knowledge and networks. The structure of this review is as follows; first, the sampling criteria will be described, with results and descriptives provided. Secondly, a brief section containing definitions for key terms used in the literature review will be presented. Subsequently, the research collected for this review will be examined based on the four core theories used in this literature; the knowledge-based view (KBV) of the firm (Grant, 1996a, 1996b; Spender, 1996), organizational learning (OL) (Levitt & March, 1988; March, 1991), absorptive capacity (AC) (Cohen & Levinthal, 1989, 1990), and social capital perspectives (e.g., Adler & Kwon, 2002; Burt, 1992, 2000, 2001; Coleman, 1988). Within each theory, an overview of the literature will be provided, examining how each theory's literature views knowledge and networks, and the key findings. As the knowledge-based view of the theory most closely aligns with this dissertation's research objectives, a more in-depth view of KBV will be provided as a foundation for this dissertation's research questions and hypotheses.

Review on Knowledge and Networks Research in Mainstream Management Literature

To uncover existing gaps and identify possible opportunities for future research, the empirical literature including the constructs of firm knowledge and networks was examined. No time restriction was imposed on this search, thereby including the full breadth of the research in the areas of interest. The major management journals, as well as key entrepreneurship journals, were searched in an attempt to be inclusive. These journals include: the *Academy of Management Journal*, *Administrative Science Quarterly*, *Entrepreneurship Theory and Practice*, the *Journal of Management*, the *Journal of Management Studies*, *Organization Science*, the *Strategic Entrepreneurship Journal*, and the *Strategic Management Journal*. Multiple searches were conducted in order to gather all extant research. The first search using the 'Web of Science Core Collection' included the terms "knowledge", "network", and "strateg*", returning 166 articles[4]. A second search was focused on knowledge spillovers, and used the search terms "knowledge spill*" and "strateg*" and returned 34 articles. While research on knowledge spillovers frequently examines external relationships, the use of the word 'network' is not always included, and when added to the search criteria, resulted in only seven articles being found; therefore, the search was left broad in order to include all relevant literature. As the concept of knowledge spillovers is central to this dissertation, this extra step to gather relevant research was deemed necessary[5]. The returned articles were carefully examined to ensure the topic was focused on interfirm networks and knowledge, with the final result being 56 articles (Table 2.1). These articles ranged in time from 1993 to 2016, though the predominance of research occurred within the last ten years (41 of 56 articles).

Insert Table 2.1 around here

Each article was coded in regards to the theoretical perspectives employed, how knowledge and networks were conceptualized and operationalized, whether knowledge and

---

[4] 490 articles were returned without the "strateg*" keyword

[5] An additional search was conducted using the term 'knowledge protection'. Two articles were returned within the focal journals, but neither was focused on organizational knowledge or networks.

networks were included as antecedents or outcomes, if industry or environmental characteristics were included, the presence of mediating and moderating variables, the level of analysis, and what specific outcomes were of interest to the researchers. While other items were also categorized, the above elements were considered particularly relevant for this literature review. Based on this categorization, a distinction was noted in that the majority of the research focused on four core theories; the knowledge-based view (KBV) of the firm (Grant, 1996), the social capital perspective (Burt, 1992, 2000, 2001; Coleman, 1988; Granovetter, 1973), organizational learning (OL) ((Levitt & March, 1988; March, 1991), and absorptive capacity (AC) (Cohen & Levinthal, 1989, 1990). Furthermore, each of these theoretical perspectives views knowledge from a unique perspective, and the role of networks or interfirm relationships is also distinctive. Thus, this review will compare and contrast these four theoretical perspectives and the literature found within each perspective. It should be noted that a large volume of research involving both knowledge and networks is not aimed at providing a theoretical contribution, but rather focuses on examining a particular phenomenon. While this form of research contributes to our understanding of these phenomena and provides a basis for future research focused on theoretical developments, the phenomenological research will not be a prime focus of this literature review.

Definitions for Key Terms

Before examining the literature in regards to knowledge and networks, this section will provide key terms and their definitions that are included in this literature review as well as in subsequent chapters. Table 2.2 displays the terms included in this section, along with key definitions and their citations.

Insert Table 2.2 around here

Knowledge Asset

The first term to be explained is *knowledge asset*, defined as knowledge resident within a firm that creates value due to its characteristics of transferability, capacity for aggregation, and appropriability (Grant, 1996a). For knowledge to be considered a valuable asset, it must be easily transferred within an organization yet difficult to imitate by other firms (Kogut & Zander, 1992). As knowledge is aggregated within a firm, organizational capabilities are developed, "creating value through effecting the transformation of inputs into outputs" (Grant, 1996b, p. 377). Finally, appropriability refers to the ability of the firm to recoup returns equal to the value of the knowledge (Grant, 1996a). Knowledge assets provide a firm with competitive advantage and superior performance, and may include "information, know-how, and technologies that help a firm improve its product effectiveness and process efficiency" (He & Wang, 2009, p. 920). Knowledge assets are argued to be the focus for firm existence, with the 'essence of the firm … its ability to create, transfer, assemble, integrate, and exploit knowledge assets" (Teece, 1998, p. 75).

Network Safeguards

Network safeguards are defined as relational or structural mechanisms that limit opportunism among an actor's set of relations. In this research, the opportunistic behavior of interest is whether network partners seek to gain an advantage via knowledge spillovers. Network safeguards can either be formal or informal, with formal safeguards defined as "economic hostages created intentionally to control opportunism by aligning the economic incentives of the transactors" (Dyer & Singh, 1998, p. 669). For example, the use of joint ventures is considered as a formal safeguard as all parties in the joint venture have a financial investment that may deter opportunistic behaviors, for if the relationship is not successful there will be significant negative consequences (Kang et al, 2009). In contrast, informal safeguards involve social mechanisms, such as the trust developed between partners (Coleman, 1988; Hernandez et al, 2015; Lavie, 2006).

Knowledge Spillover

The third term to be explained is *knowledge spillover*, defined as transfers of knowledge that are unintended, and un- or under-compensated (Agarwal, Audretsch, & Sarkar, 2010). "More specifically, knowledge spillover represents the flow of knowledge from one organization to another and, unlike collaborative forms of knowledge sharing (i.e., knowledge transfer) that involve cross-party compensation due to the exchange, the external benefits from the creation of knowledge in knowledge spillover accrue to the knowledge receivers rather than to the creator" (Ko & Liu, 2015, p. 265). While knowledge spillovers may be considered in a positive light by recipient firms, the firms who developed the knowledge may wish to minimize spillovers and protect their knowledge in order to recover their investment and appropriate all possible value (Hernandez, Sanders, & Tuschke, 2015; Kale, Singh, & Perlmutter, 2000; Mayer, 2006). Thus, knowledge spillovers indicate a loss of value of knowledge for the originator or creator of the knowledge asset, while an opportunistic benefit for the recipient.

Network

Network boundaries must be specified by the researcher with the condition that network members share the same type of relationship (Borgatti & Halgin, 2011). If the network boundaries are not well defined or are too broadly considered, the size of the network may increase to the extent that it makes empirical analysis difficult (Bae, Wezel, & Koo, 2011). Each member of a network is termed an actor or node, with each relationship between members labeled a tie. Thus, a *network* is comprised of multiple actors and ties, with each tie representing a similar form of relationship. In strategy research where the network typically includes other firms, networks have frequently been defined by firms' alliance partners within industries (i.e., Bae et al., 2011; Koka, Madhavan, & Prescott, 2006; Koka & Prescott, 2008; Madhavan, Koka, & Prescott, 1998). In regards to interfirm networks, each actor is a firm, and each tie is an alliance. By using the industry as a network boundary, it ensures that all firms within the network have a valid possibility for engaging with other firms found in the network; that is, it would be highly unlikely that an automobile manufacturing firm would have an opportunity or a need to engage in a relationship with a biotechnology firm. If there is no potential for a relationship between two firms, they should not be considered as being present in the same network.

Network ties: Direct and indirect relationships

Actors within networks will have *direct* and *indirect* relationships. *Direct* relationships are those where the two actors have a relationship with no intermediary. In the case of an alliance network, firms who agree to form an alliance will have a direct relationship with one another. *Indirect* relationships will have at least one intermediary (Borgatti & Halgin, 2011). For example, a firm may be engaged in two alliances, each with different partners. If these two partners do not have a direct relationship between them, they will have an indirect relationship via their common alliance partner. The number of indirect relationships an actor has will depend not only on the volume of direct relationships but also on the number of direct relationships of their direct partners. That is, a firm may be only engaged in one direct relationship, but if that firm has 20 other alliance partners, then the focal firm is considered to have 20 indirect relationships.

Network structure: Strong and weak ties

Strong and *weak* ties indicate the strength, or intensity, of the relationship between actors. Strong ties are considered frequent, repeated relationships that develop trust and norms of behavior (Coleman, 1988). At the firm level, a *strong* tie may be developed by multiple relationships over time between two firms or by a relationship initiated with the goal of a long-term association (Gulati, 1995), involving "close social connections, mutual trust, and reciprocity between partner firms" (De Clercq & Dimov, 2008, p. 590). Strong ties are those that are long-lasting, and in regards to interfirm relationships, those that are formed with long-term goals in mind, such as joint ventures or equity partnerships. The benefit of strong ties is the emergence of trust that occurs between firms, increasing predictability regarding firm behavior (Gulati, 1999). Thus, strong ties can be a function of the form of the relationship, or by the presence of multiple relationships over time between the firms. A network composed of primarily strong ties is likely to tend towards a network of firms where most actors have relationships with each other (i.e., network closure) (Coleman, 1988), as firms introduce their strong ties to each other, creating relationships that were previously absent (Granovetter, 1973), The distinction between a closed network and strong ties is that the strength of a tie is viewed at the relationship level, not the network level, and the strength of tie is determined by the relationship between the two firms, not the composition of the firm network.

In contrast, a *weak* tie is not time intensive, and the actor connected by the weak tie may be only marginally included in the network (Granovetter, 1973). These weak relationships can provide ties between otherwise unconnected groups of actors, resulting in benefits via linkages to far-reaching groups providing access to novel resources, information, and knowledge. Weaker ties may be indicative of lower homogeneity between actors, as stronger ties are either the result of, or result in, similarities in actors (Granovetter, 1973). At the firm level, weak ties can be similar to an arm's-length market transaction depicted by Williamson (1979, 1981), whereby the "identity of the parties to a transaction is treated as irrelevant" (Williamson, 1979, p. 236).

Network structure: Closed networks and structural holes

Interfirm networks can seek to create a cohesive and *closed network* whereby most actors are engaged in relationships with each other (Coleman, 1988). Indeed, if firms choose to associate with their partner's partners due to awareness and knowledge of these potential partners, a closed, cohesive network is created whereby most firms in the network have relationships with each other. The benefits of a closed network include the ability to establish norms of behavior and trust amongst members (Coleman, 1988). When firms within a network are completely (or almost completely) intertwined via relationships, the awareness of firm behavior is known throughout the network, limiting the opportunities for opportunistic behaviors due to the development of norms and standards of behavior. Closure leads to trustworthiness and trust, as firms become socially embedded in the relationships and trust is viewed "as an explicit and primary feature of their embedded ties" (Uzzi, 1997, p. 43). As firms are increasingly embedded in the network of relations, opportunistic behavior declines due to network interdependence (Provan, 1993). Indeed, a closed network "may help ensure collaborative continuity via high levels of trust and reputational lock-ins, both of which can help firms preserve their existing resources" (Tatarynowicz, Sytch, & Gulati, 2016, p. 55). Thus, in a closed network, firms develop behavioral expectations and norms, reducing motivation and opportunities for engaging in deviant behavior. However, while the benefits of a closed network are found in shared norms and increased trust, the disadvantages are the redundancy of resources, knowledge, and information. In a closed network, information becomes redundant as it travels over the same paths multiple times, with eventually all firms having similar knowledge bases or similar access to knowledge.

In contrast, when a firm develops a relationship with another firm that is not already located in the network segment, this relationship spans a *structural hole*, in essence developing a bridge to a new network segment that was previously unconnected (Burt, 1992). This affords the firm the opportunity to gain performance advantages via access to heterogeneous resources, knowledge, and information. While it has been proposed that bridging ties are necessarily weak ties (Granovetter, 1973; Borgatti & Halgin, 2011), the main criteria for a bridging tie is that it provides nonredundant information (Burt, 1992). A relationship that bridges a structural hole can lead to increased firm performance, as a "competitive advantage comes from information access and control; networks that span structural holes provide broad and early access to, and entrepreneurial control over, information' (Burt, 2000, p. 347). Thus, benefits can accrue to those who span structural holes, as brokers have the ability to gain and link knowledge from disparate sources. "Bridging emphasizes advantages derived from timely access to diverse information and resources from nonredundant contacts, and opportunities to broker novel information and resources between unconnected partners" (Baum, McEvily, & Rowley, 2012, p. 530).

Network position: Centrality

A firm's position in their network can be described by the concept of *centrality*, which can be loosely defined as "the contribution the [firm] makes to the structure of the network" (Borgatti, Everett, & Johnson, 2013, p. 164). Having a position of prominence or importance has been viewed as providing firms with multiple benefits, including increased status (Podolny, 1993), and increased access to information (Owen-Smith & Powell, 2004; Podolny, 2001). Indeed, centrality has multiple conceptions that have given rise to multiple measures (Borgatti et al., 2013.) Each centrality measure has implicit assumptions regarding how flows, whether it be information or financial flows, move through the network (Borgatti, 2005). For example, closeness measures focus on a firm's proximity to others, indicating that central actors may be able to locate or disperse information quicker than those with lower centrality (Wasserman & Faust, 1994). In comparison, betweenness centrality (Freeman, 1979) identifies actors on paths between other actors, placing the actor who occupies a position on a well-traveled path in a position of power (Wasserman & Faust, 1994). Eigenvector centrality can be viewed as indicating an actor's risk of both receiving and transmitting the flow of interest, as it measures not only the volume of direct relationships but weighs each direct relationship by their own centrality (Borgatti et al., 2013). Thus, when eigenvector centrality is measured, actors connected to other central actors will have greater centrality than those connected to peripheral actors. While this measure captures the potential connections an actor has, the measure itself does not work well if networks contain disconnected sections or subgroups; as interfirm networks frequently contain subgroups, this measure is not applicable.

A similar measure to eigenvector centrality can be observed in beta centrality, viewed "as a measure of the total amount of potential influence a node can have on all others via direct and indirect channels" (Borgatt et al., 2013, p. 171). Similar to eigenvector centrality, a firm will have a higher beta centrality score to the extent it is connected to many firms who themselves are highly connected (Bonacich, 1987), as it inversely weighs the value of indirect connections by their length. Thus, a direct relationship with a well-connected actor will be weighed stronger than if this popular actor could only be reached by first passing through three other actors. From the perspective of interfirm networks, a central firm may have an increased ability to receive and disseminate information via its network connections (Soh, 2010). For the remainder of this document, the term centrality will refer to beta centrality unless otherwise specifically noted.

To explain the concept beta centrality in more detail, Figure 2.1 depicts a network containing twelve firms, including Firm A and Firm B. These two firms both have one direct relationship; Firm A's direct connection is X, while Firm B's one direction is Y. However, these direct connections are different in that X has 7 direct connections, while Y has only one direct connection. In this network, Firm A is more central than Firm B as Firm A's connections are more connected than Firm B's. While this example only examines relationships comprising two steps from the focal firm, the measure of beta centrality continues through the actors' distal relationships while reducing the weighting of these variables as distance increases. Thus, firms with high centrality scores are considered central in their network when they are directly or indirectly connected to many others. Conversely, firms may have a lower centrality score,

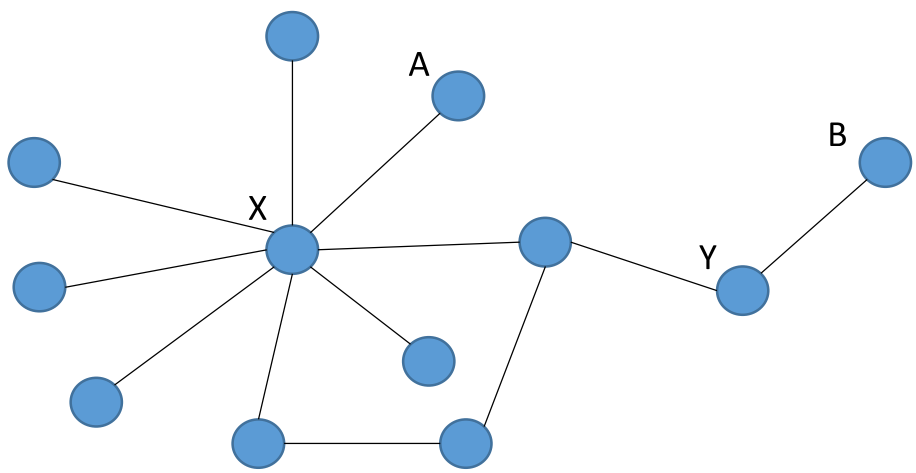


Figure 2.1 Adapted from Borgatti et al., 2013, Figure 10.3, p. 169

indicative of occupying a peripheral position, whereby they have fewer connections that are connected to fewer others.

The network provided in the example above does not encapsulate the complexity required to differentiate eigenvector centrality from beta centrality. When networks are large and more complex, beta centrality allows for the weighting of the indirect relationships, as shown in the following equation:

$$c = (I - \beta A)^{-1} A1$$

If the weighting of β in this equation is equal to 0, the result will be the count of relationships, or degree centrality. The larger the value of β, the more it "reflects the global structure" (Pollock et al., 2015, p. 493) of the network and the closer to eigenvector centrality. For large and potentially disconnected networks, a value for β of three-quarters of the reciprocal of the largest eigenvalue will be utilized, as is the norm in the networks literature (Podolny, 1993; Pollock et al, 2015).

Theoretical Examination of the Literature

This section of the literature review examines the four main approaches that were found in the literature; organizational learning (OL) (Levitt & March, 1988; March, 1991), absorptive capacity (AC) (Cohen & Levinthal, 1989, 1990), the social capital perspective (Burt, 1992, 2000, 2001; Coleman, 1988; Granovetter, 1973), and the knowledge-based view (KBV) of the firm (Grant, 1996a, 1996b; Spender, 1996). This section of the literature review will be organized by each perspective. Within each perspective, the first subsection will present an overview of the approach and how each it informs the relationship between knowledge and networks. Secondly, a discussion of identified themes will be discussed. As the knowledge-based view of the firm most closely aligns with this dissertation's research, a more in-depth view of KBV will be provided as a foundation for this dissertation's research questions and hypotheses. Table 2.3 identifies the literature that includes these core theoretical perspectives, while Table 2.4 provides a brief comparison of how these perspectives view knowledge and interfirm networks, as well as their key firm-level outcomes. The volume of literature that includes (at least) one of the four core perspectives is a subset of the literature found during the search.

Insert Table 2.3 around here

Insert Table 2.4 around here

Knowledge Based View (KBV)

The first perspective to be examined is the Knowledge Based View (KBV) of the firm (Grant, 1996a, 1996b; Spender, 1996). This perspective developed from the early roots of the Resource Based View of the firm (e.g., Barney, 1991, Wernerfelt, 1984) which proposes that for a firm to gain a competitive advantage over other firms, it must have valuable resources that other firms do not have access to, and that these resources cannot be easily replicated, imitated, or substituted. Grant (1996a) argues that knowledge is “the preeminent resource of the firm” (p. 384) as “first, knowledge accounts for the greater part of value added, second, barriers to the transfer and replication of knowledge endow it with strategic importance” (p. 377). From KBV’s perspective, the primary role of the firm is to integrate the knowledge found in individuals, as markets are unable to perform this function due to the difficulties in transferring and sharing knowledge between individuals. The firm can be viewed as “a dynamic, evolving, quasi-autonomous system of knowledge production and application” (Spender, 1996, p. 59). Thus, KBV emphasizes the processes involved in knowledge production while acknowledging the value provided by knowledge via its application.

The barriers to transfer and replication of knowledge can be viewed as both a positive and negative function. While challenges with knowledge transfer *between* firms can sustain a competitive advantage arising from a firm's unique knowledge (Grant, 1996a, 1996b), difficulties in transfer and replication *within* firms can reduce the opportunities to generate a competitive advantage (Kogut & Zander, 1996). This difficulty is increased as frequently valuable knowledge is often not made explicit, or codified, due to the increased risks of transferring knowledge to external sources. Rather, valuable knowledge is often tacit, "deeply rooted in action, commitment, and involvement in a specific context" (Nonaka, 1994, p. 16) and therefore slower to transfer leading to a tendency to perform tacit transfers within firm boundaries (Kogut & Zander, 1996). By keeping knowledge within firm boundaries, the costs of communication and integration are lowered. Thus, it is proposed that "a firm be understood as a social community specializing in the speed and efficiency in the creation and transfer of knowledge" (Kogut & Zander, 1996, p. 503).

Given these conditions of knowledge, "the primary role of firms is in the application of existing knowledge to the production of goods and services" (Grant, 1996b, p. 112). Key to KBV is the proposal that a firm's "potential for establishing and maintaining competitive advantage increases with the span of knowledge integrated" (Grant, 1996a, p. 385), and therefore, increasing the knowledge base of a firm is critical, insofar as to provide knowledge necessary for integration and application. The competitive advantage of a firm is linked to the scope of knowledge found in its capabilities (Grant, 1996a), indicating that a broad knowledge base is necessary.

KBV assumptions. The core assumption within KBV is that knowledge is the "principal productive resource of the firm" (Grant, 1996a, p. 385). Nonetheless, KBV is focused not only on the accumulation of knowledge to develop a key firm asset, but also views the firm as a "knowledge-based activity system" (Spender, 1996, p. 59). As firms require an extensive range of knowledge that requires continuous renewal, the knowledge process is perpetual, especially in conditions of increased competition and technological change (Grant, 1996a).

The superior value of tacit knowledge over explicit is a further assumption of KBV (Grant, 199a), due to its inimitability and limited transferability. Transferring tacit knowledge is a slow process, necessitating interactions between individuals (Kogut & Zander, 1996). Consequently, this process tends to occur within the firm boundaries, increasing the value of the tacit knowledge as it becomes established within the firm's routines yet remains challenging for external firms to replicate or imitate. This results in firm boundaries defining not only knowledge boundaries, but the establishment of a firm identity that captures the knowledge in its values, rules, and learning processes (Kogut & Zander, 1996; Spender, 1996). Thus, "organizations learn and have knowledge only to the extent that their members are malleable beings whose sense of self is influenced by the organization's evolving social identity" (Spender, 1996, p. 53).

The final assumption of KBV is that the firm requires both breadth and depth of knowledge (Grant, 1996a). However, as the volume of knowledge increases, the demands on integrating and applying the knowledge increases (Grant, 1996b). This leads to managerial implications as "if production (and decisions about production) require many types of knowledge, if that knowledge is resident in many individuals, and if integration mechanisms can involve only relatively small numbers of individuals-what organizational structures are possible?" (Grant, 1996b, p. 118) Thus, firms can create an identity that supports the learning processes and coordination activities required to transfer knowledge within the firm, developing a competitive advantage not only through the resultant knowledge, but also within the firm's knowledge and learning capabilities (Kogut & Zander, 1996, Spender, 1996).

KBV view of networks. The majority of theoretical discussions on KBV focus on the integration of knowledge within firm boundaries, without explicitly identifying the originating point of the knowledge (Grant, 1996b, Kogut & Zander, 1996, Spender, 1996). The exception is Grant (1996a), which expressly includes the value of interfirm networks as a source of knowledge, although knowledge integration is still viewed as occurring within firm boundaries. While firms are viewed as more efficient in integrating knowledge as compared to interfirm networks, the benefits of accessing new information can overcome the costs of inefficient knowledge transfer (Grant, 1996a). Networks are especially valuable for increasing the speed of access to new knowledge (Grant, 1996a), indicating that their value may not be comparable across different industries, but rather dependent upon the frequency of knowledge change.

KBV outcomes. As KBV has its roots in RBV, the key outcome for this perspective is the ability for a firm to obtain and sustain a competitive advantage via its knowledge (Grant, 1996a, 1996b). Additionally, theorists have tended to focus on how firms manage internal knowledge processes (Kogut & Zander, 1996; Spender, 1996) as the objective of the firm is to develop systems and structures that lead to knowledge-based returns (Spender & Grant, 1996). Firm capabilities regarding the ability to integrate, transfer, and apply knowledge is a further outcome of interest (Spender, 1996). The boundaries of the firm will include the capabilities and the knowledge that the firm can manage to integrate and apply; as capabilities increase, so can the breadth and depth of the knowledge contained within the firm (Grant, 199b). Thus, firms seek to increase their span of knowledge, continuously improving their capabilities for integrating and applying knowledge, with the ultimate outcome of achieving competitive advantage (Grant, 1996b).

KBV Literature including knowledge and networks. While knowledge acquisition from external sources is acknowledged in KBV, only five articles focused on knowledge and networks returned for this literature review included core discussions covering aspects of KBV. Upon reading and coding these articles, two recurring themes were identified; knowledge sharing and transferability amongst network members and the opportunities and challenges with knowledge application. These two themes will now be discussed.

Theme 1: Knowledge sharing and transferability in networks. KBV identifies the transfer and integration of knowledge as key firm objectives (Grant, 1996a, 1996b; Spender, 1996), though primarily as an intrafirm activity. However, networks provide a valuable source of external information that can be applied internally (Grant, 1996a). Thus, research utilizing KBV as a theoretical base and including interfirm networks as a main construct have identified knowledge sharing and transferability as key relationships. While firms acknowledge the requirement to access external information, interfirm relationships are not a guaranteed form for the occurrence of the sharing and transfer of knowledge. Indeed, there is a potential cost if a firm is only a recipient and does not share their own knowledge, leading to unequal benefits. However, a case study of the Toyota production network identified that provisions can be made so that all firms can benefit from knowledge sharing (Dyer & Nobeoka, 2000). These provisions include increased relationship building between and amongst the network of relationships, developing norms and rules that complied with the view of knowledge as a network resource as compared to a specific firm resource. This capability for firms to support knowledge sharing in interfirm relationships can provide an alliance-level competitive advantage (Mesquita, Anand, & Brush, 2008), broadening KBV's view of knowledge providing a firm-level competitive advantage to a view that includes an alliance-level advantage as well.

However, under conditions of greater uncertainty regarding partner behavior, firms may choose to avoid the use of external partners altogether (Mayer, 2006). Network relationships provide all members with sources of knowledge, equally available to members. Indeed, where a firm considers that the potential loss of its knowledge overrides the possible benefits of gaining new knowledge, the firm may choose not to engage in a relationship. Consequently, a range of options are available to firms as they complete interfirm relationships, from developing knowledge-sharing capabilities that can lead to an alliance competitive advantage (Dyer & Nobeoka, 2000; Mesquita et al., 2008) to avoiding relationships altogether when the risk of losing knowledge is greater than the potential benefits (Mayer, 2006).

Theme 2: Opportunities and challenges with knowledge application. The second theme located in the literature is the ability, as well as the lack thereof, of firms to apply internally the new knowledge gained from their network. On the positive side, research has indicated that while the maximum of benefits from new knowledge acquisition may be at the specific relationship level, there is an improvement benefit that is transferred to all relationships (Mesquita et al., 2008). That is, when firms acquire knowledge from a specific relationship, this knowledge will be applied, to a lesser degree, to other relationships. Note that this view examines how knowledge gained in one relationship is applied to other relationships, versus a focus on how external knowledge is internalized within firm boundaries. This distinction expands the potential benefits of external knowledge acquisition, as firms can achieve internal and external benefits from external knowledge acquisition.

However, new knowledge is not always able to be successfully internalized and applied, especially if that knowledge is not in alignment with the current stock of knowledge (Afuah, 2001). This relates to Grant's (1996a) view that "integration across a wide scope of specialist knowledge is important in sustaining competitive advantage" (p. 382); if firms become too specialized, there may be difficulties in modifying the existing knowledge base and therefore a challenge in adapting to the new technology.

KBV Conclusion. The KBV of the firm (Grant, 1996a, 1996b; Spender, 1996) proposes that knowledge is the key resource of the firm, capable of providing a firm with a competitive advantage. The objective of the firm is to develop internal knowledge assets that are broad in scope, allowing for increased assimilation of new knowledge. Knowledge's value is increased when it is kept in tacit form, indicating that it has not been codified, and thus is more easily maintained within firm boundaries. Not only can a firm achieve a competitive advantage via its knowledge stocks, but alliances and networks can attain a competitive advantage through knowledge-sharing capabilities (Dyer & Nobeoka, 2000; Mesquita et al., 2008). However, the presence of a sizeable internal knowledge stock and available external knowledge stock does not guarantee knowledge application, especially when the new knowledge represents a departure from the content of current knowledge stocks (Afuah, 2001). While there is some attention paid to the potential negatives associated with network partners gaining knowledge via spillovers (e.g., Mayer, 2006), this area of research is still relatively unexplored and represents a fruitful area for future research.

Network / Social Capital Perspective

The second area of the literature to be examined is the social capital perspective, which views relationships as providing more than just resources, as social relationships are developed and provide their own form of capital. Social capital's "effects flow from the information, influence, and solidarity it makes available to the actor" (Adler & Kwon, 2002, p. 23). A core proposition of this perspective is that relationships between actors, whether the actors are individual or firms, contain a social element (Adler & Kwon, 2002; Granovetter, 1985). The social capital perspective examines the forms of capital found in networks based on the structure of the network and the position of the actor. This section of the literature review will first provide an overview of the theories developed within social capital, and then examine the literature within these streams that is focused on knowledge and networks.

Strong ties and network closure. Coleman's (1988) view of social capital focuses on the benefits provided by networks with strong closure, such that actors are strongly interconnected leading to a high number of ties between actors. This network structure leads to social capital in the forms of "obligations and expectations, which depend on trustworthiness of the social environment, information-flow capability of the social structure, and norms accompanied by sanctions" (p. 119). The social capital found in a closed network contributes to bonding of the actors, as the relationships "give the collectivity cohesiveness and thereby facilitate the pursuit of collective goals "Adler & Kwon, 2002, p. 21). Thus, it is within a closed network that these attributes can be cultivated, as the closure allows for information, both positive and negative, to freely flow between network actors. Based on the social capital found in closed networks, productive activity will be increased, as "a group within which there is extensive trustworthiness and extensive trust is able to accomplish much more than a comparable group without that trustworthiness and trust" (p. 101). Implicit in Coleman's view of network closure is that the relationships within this network structure are strong, meaning that they repeated, reciprocated relationships that support the development of norms, trustworthiness, and trust between actors and throughout the network.

Bridging of structural holes. In contrast to Coleman's (1988) view of network closure being necessary for social capital to be developed, Burt (1992, 2000, 2001) views the goal of network actors should be to develop relationships that bridge structural holes as "social capital is created by a network in which people can broker connections between otherwise disconnected segments" (Burt, 2001, p. 31). This perspective views social capital as arising from the availability of nonredundant information, as actors develop strategic relationships that bridge holes in the social network (Adler & Kwon, 2002). In comparison, network closure enables norms and trust to be developed within the network structure, yet the knowledge provided via relationships is frequently redundant as all actors with the network have the same information. However, if an actor can develop a connection to an actor previously unconnected to the network, their information, as well as their relationships' information, is now available to the focal actor. While increasing an actor's network size may seem to provide an alternate path to accessing additional information, if the new relationship only provides information available via other relationships due to interconnections, then this new relationship does not provide information that is not already accessible. Thus, network size only has an effect on the overall volume of information when nonredundancy is considered. Ties that bridge structural holes will not be strong, as "the spread of information on new ideas and opportunities must come through the weak ties that connect people in separate clusters" (Burt, 1992, p. 72). Weak ties that bridge from one network or segment to another allow for information to reach a larger population and travel greater distances (Granovetter, 1973) than would occur if transmitted through a closed network. Bridging structural holes creates a relationship between groups, allowing information to flow between previously disconnected network segments.

Social Resource Theory. The final approach to be discussed under the heading of social capital is Social Resource Theory (SRT) (Lin, 1999, 2002). SRT defines social capital as the "resources embedded in social networks accessed and used by actors for actions" (Lin, 2002, p. 25). Network structure is viewed as hierarchical, "rank-ordered according to certain normatively valued resources such as class, authority, and status" (Lin, 2002, p. 56). Consequently, the theory proposes that actors desire to enhance their position within their network, increasing their ability to access and mobilize social resources (Lin, 1999). This theory provides predictions for new relationships within networks as actors attempt to form relationships with higher-ranked actors in order to improve their own ranking as well as increase their access to other higher-ranked actors (Lin, 2002). This creates a tendency for relative homophily of resource levels found within relationships. In essence, Lin suggests that actors have an upper limit in their ability to reach actors with higher resource levels than their own. Actors with lower resource levels can only reach those actors slightly higher in resource levels than themselves, and this effect holds true for higher resource levels actors as well. Indeed, the result of this proposition is that higher-ranked actors have a structural advantage over lower-ranked actors due to their starting position. As actors with lower levels of resources will not be considered attractive to an actor with higher level of resources; thus, both will form relationships with actors of similar resource levels, resulting in relative homophily within relationships. Thus, SRT proposes that actors are mindful of the maintenance of their current network position, as by doing so they assure their existing level of resources, as well as searching for opportunities for developing relationships that may lead to an increase in network position and thereby provide access to increased levels of resources.

Network / Social Capital Literature including knowledge and networks. Due to the presence of multiple perspectives within the social capital literature, this next section will utilize the perspectives themselves as a method of categorizing the literature. Nine articles were coded as including social capital. Five included arguments focused on strong ties or network closure, two included the benefits of bridging or weak ties, and while none expressly included SRT, three articles included core elements of this perspective and thus are categorized within this perspective.

Theme 1: Strong ties and Closure. The literature that includes arguments related to Coleman's (1988) strong tie perspective discuss contextual elements that affect the relationship between organizational knowledge and networks. For example, while increased tie strength has been linked to increased performance, this relationship is increased when connections are diverse (Patel & Terjesen, 2011). Additionally, the presence of bridging ties in an alliance can support strong ties when knowledge integration is the objective (Tiwana, 2008). While the presence of strong ties seems somewhat necessary for positive outcomes, diversity of ties and bridging ties can support these benefits. The positive outcomes from strong ties include knowledge transfer, knowledge creation, and problem solving (Hardy et al., 2003). However, over time the benefits from strong ties may diminish performance outcomes, especially if the environment demands new and novel information (Goerzen, 2007). Interestingly, while diversity of ties and tie strength is associated positively with performance, the relationship is altered when firm distinctiveness is included. That is, firms with distinctive products generate positive outcomes as network closure increases, while firms that are not distinctive in their offerings benefit more when their network is not closed (Echols & Tsai, 2005). While this study did not determine causality, it could be proposed that network closure was the impetus for a firm to develop distinctive products of services with the objective of distinguishing itself within their tight-knit community.

Theme 2: Structural holes. The second perspective to be discussed includes how social capital is developed via structural holes and bridging ties (Burt, 1992, 2001; Granovetter, 1973). Structural holes indicate an absence of a tie between two segments of a network; when a tie does appear to link these two segments, a bridge has been created. While bridging ties provide novel and nonredundant information, the benefits of this information is reduced when more proximal and stronger relationships are rich in their own knowledge (Operti & Carnabuci, 2014). This may indicate that a boundary condition exists for when firms should embark on developing bridging ties; namely, only when strong ties cannot provide valuable information. As actors cannot always predict or even ascertain levels of knowledge found in partners, a strategic alternative may be to maintain both strong and weak ties in a network (Burt, 2000), allowing for both current and future knowledge needs. A mix of strong and weak ties may also benefit intrafirm networks when external information is sparse, as the lack of network closure allows for diversity to be sustained internally (Funk, 2014). Thus, while theoretically the arguments for the benefits of closure seem to be opposed to those supporting structural holes, research advocates that while benefits are different, elements of both structures within a firm's network can support positive performance outcomes.

Theme 3: Social resource theory. SRT focuses on the resources available to network actors as well as the benefits afforded to those actors occupying a higher rank within the network structure (Lin, 1999, 2002). The benefits of rank can be realized in times of technological change, as firms linked to other highly ranked firms are better able to drive new standards within the network (Soh, 2010), indicating that this positional advantage not only provides greater access to resources, but also increased ability to influence others within the network. Even when the connection to a valued resource is indirect, the presence of a connection increases the opportunity for access to the valued resource (Zhang, Soh, & Wong, 2010). Furthermore, if the direct connections that create the indirect connection are strong ties, the possibility for resource access increases further. Thus, benefits not only arise to those with a high ranking, but also to those able to access highly ranked firms.

Network / Social Capital Perspective Conclusion. The social capital perspective examines the outcomes generated via network structures, including the outcomes of strong ties and network closure (Coleman, 1988), weak ties and bridging structural holes (Burt, 1992; Granovetter, 1973), and the outcomes produced by occupying a higher-ranked position within a network hierarchy (Lin, 1999, 2002). The research examined in this section supports the benefits of networks in regards to performance outcomes (Patel & Terjesen, 2011; Hardy et al., 2003), including network size and centrality benefits towards knowledge outcomes (Soh, 2010). However, this area of research has not yet examined how the firm's level of knowledge asset value may affect these relationships. For example, the research conducted by Soh (2010) focused on firms that were competing to establish technological standards, necessitating knowledge sharing to generate support for their standard. In a similar vein, the research by Hardy and colleagues (2003) focused on a small non-profit organization with no benefit or motivation to protect its knowledge, while Patel and Terjesen's research (2011) examined entrepreneurs' social networks, including friends and mentors. Thus, a gap exists in our understanding of how firms sensitive to potential knowledge spillovers may approach their networks. Nonetheless, these studies indicate the potential value located in networks, even while leaving unanswered the question of whether the presence of valuable knowledge assets may impact how firms manage their network.

Organizational Learning (OL)

The third perspective to be explored in this literature is Organizational Learning (OL) (Levitt & March, 1988; March, 1991). The focus for OL is primarily on the process of organizational learning. Thus, OL seeks to explain how organizations learn, both from direct experiences as well as learning from the experiences of others. From this perspective, organizations are viewed as interpretation systems (Daft & Weick, 1984), whereby the primary actions of firms are to scan the environment for data, interpret the data, and indicate learning by taking action. OL proposes that gathering and applying information should be the main focus of a firm as this is where firm structure provides the greatest value (Levitt & March, 1988). However, the process by which firms scan the environment may alter the outcomes from learning (March, 1991). Specifically, if firms chose to exploit their current knowledge via proximal searches for new information, the short-term benefits are more certain, yet over time, restricting search for exploitation can result in a competency trap (Levitt & March, 1988) as firms become unwilling to leave behind their expertise to develop new capabilities (March, 1991). In contrast, searching distal areas provides for exploration which can result in a competitive advantage for a firm if successful, as it includes the possibility for generating innovations (March, 1991). However, "returns from exploration are systematically less certain, more remote in time, and organizationally more distant" (March, 1991, p. 73), increasing the risk for firms focused on exploratory activities. Indeed, OL is not concerned with organizational knowledge per se, but rather focuses on the processes how organizations gather, interpret, and apply information (Daft and Weick, 1984), including balancing the scope of the learning (March, 1991).

Networks are not a focal interest in OL, though it is acknowledged that external firms play a role in the learning process. For Levitt and March (1988), interfirm networks are a source for firms to learn from the experiences of other firms; however, the prime focus of this perspective is the internal processes associated with organizational learning. Additionally, exploitation and exploration necessitate external sources of information, though the specific sources for locating and accumulating knowledge are not identified.

Within OL, outcomes of interest will vary depending on the specific perspective of the research area of interest. That is, from Levitt and March's (1988) perspective, outcomes of interest are linked to the process of learning; for example, internal and external conditions which support organizational learning (e.g., Hardy, Phillips, & Lawrence, 2003; Lam, 2003). In March's (1991) focus on the scope of organizational learning, outcomes of interest include impacts and outcomes of exploratory and exploitative searches (e.g., Coombs, Deeds, & Ireland, 2009; Schildt, Maula, & Keil, 2005). Nonetheless, OL is primarily focused on the process of learning, indicating that OL is frequently an antecedent to an outcome of interest.

OL Literature including knowledge and networks. Of the literature located for this review of research conducted on knowledge and networks, nine articles included organizational learning as a focal perspective of interest. Interestingly, a large number of these included knowledge spillovers, indicating that opportunistic learning is of interest to OL researchers. After coding these articles, two major themes emerged. First, networks are a source of learning for firms, though this can be viewed as both a positive and a negative outcome. Secondly, firms can choose to either exploit or explore via their interfirm networks indicating that breadth and depth can be included in network design. These two themes will be discussed further in the following paragraphs.

Theme 1: Networks provide opportunity for learning. The first theme that emerged from the segment of the literature was the role of networks in supporting organizational learning. Firms have opportunities to learn directly from their network relationships (Lam, 2003), indirectly via intermediaries (Wagner, Hoisl, & Thoma, 2014), as well as the opportunity to learn via spillovers from other firms (Operti & Carnabuci, 2014; Yang, Phelps, & Steensma, 2010; Zhang, Li, & Li, 2014). Direct learning from networks cannot be assumed, however, as firms must be open to new information, allowing integration to occur (Lam, 2003). If firms have not learned how to learn (Levitt & March, 1988), the value of the knowledge located in interfirm networks will not be internalized. Firms can adopt a strategic approach to establishing a network that contains valuable and accessible knowledge, supporting its learning objectives (Operti & Carnabuci, 2014). This network may contain relationships with firms who have benefited themselves from spilled knowledge, indicating that learning, as well as knowledge development, may be a circular process and iterative in nature.

The connections between actors are also a factor in supporting learning from networks. For example, network actors who are involved in their network via frequent interactions and are able to develop interpersonal (not only interfirm) relationships can increase their organizational learning (Hardy et al., 2003), indicating that not only is the presence of a network necessary for organizational learning to occur, but that relationships beyond the contract are required. The involvement and interactions amongst network members "facilitates the transmission of this knowledge beyond the boundaries of the collaborative relationship to distribute learning more widely in the community" (Hardy et al., 2003, p. 340).

While six of the nine articles included core elements of OL, not all proposed that the ability for networked firms to learn from their partners was a positive outcome. This opposing line of research indicates that while interorganizational learning may be of interest for networked firms, the originator of the knowledge may not be as willing to allow their knowledge to be spread via the network (Hernandez et al., 2015). If potential leakage of proprietary and valuable knowledge to rivals can occur via networks, a strategic approach to identifying and severing those potential connections may be necessary. However, this view of networks which explores the opportunity for knowledge to be lost, as well as gained, is still limited in volume and scope, indicating a gap in our understanding of the positive and negative effect of networks.

Theme 2: Firms can choose to explore or exploit via networks. The second theme located in this segment of the literature follows March's (1991) view of firms as having opportunities to exploit and explore to increase and develop organizational learning. From this perspective, and by including the focal construct of interfirm networks, firms can develop their network to support both exploitation and exploration to further organizational learning (Coombs et al., 2009; Schildt et al., 2005). This perspective includes the geographical distance of networks as a contextual element (Coombs et al., 2009), as local searches may increase expertise and thus exploit current knowledge, while international searches may provide increased exploration via new and diverse knowledge.

The form of relationship also has an effect on organizational learning, as less integrated forms of relationships (i.e., alliances or joint ventures as compared to acquisitions) increase explorative learning (Schildt et al., 2005). While explorative learning is risky (March, 1991), forming alliances and joint ventures involves reduced expenditures mitigating a degree of the risk. Furthermore, a lack of formal integration of the relationship into the organization may increase opportunities for the freedom necessary for explorative learning to occur (Lam, 2003). Thus, these two articles indicate that learning on the fringes can increase exploratory learning, both geographically and by relationship type.

Organizational Learning (OL) Conclusion. OL provides a view of organizations as motivated to locate, interpret, and utilize knowledge (Levitt & March, 1988). While networks are not a focal aspect of OL, this research has indicated that networks provide a valuable source of information, via both direct and indirect contacts (Lam, 2003; Wagner et al., 2014). Though the threat of network partners gaining knowledge spillovers is acknowledged within the OL literature (e.g. Hernandez et al., 2015), OL is focused on the learning firm's perspective, and thus spillovers are viewed in a positive light. This literature additionally addresses how firms may strategically utilize networks in order to achieve the greatest learning outcomes. Specifically, a line of research within OL literature has examined how firms may strategically develop a network containing valuable knowledge (Operti & Carnabuci, 2014), as well as have the ability to reabsorb previously spilled knowledge (Yang et al., 2010). While both these articles employ the term 'network' conceptually, the network used is a patent network, not an interfirm network. Thus, their focus is on accessing publicly available knowledge versus exploiting network relationships to gain private knowledge. Nonetheless, this line of research acknowledges that firms are strategically scanning the external environment to locate valuable external knowledge, yet a gap still exists in our understanding of whether knowledge-originating firms may be aware of this capability and seek to protect their knowledge. Another implicit assumption located in this literature is the increased value of knowledge in high-technology industries (Operti & Carnubuci, 2014; Schildt et al., 2005; Yang et al., 2010). However, our understanding of whether knowledge is valued differently between industries and how this may affect firms' network safeguards is still lacking.

Absorptive Capacity (ACAP)

The fourth perspective to be examined is Absorptive Capacity (ACAP) (Cohen & Levinthal, 1989, 1990). ACAP is the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990, p. 128). As its name indicates, the focus for ACAP is whether firms are able to absorb new knowledge and apply it, not just locate new knowledge. ACAP is viewed as a firm-level capability, and "is largely a function of the firm's level of prior related knowledge" (Cohen & Levinthal, 1990, p. 128). Thus, it is proposed that as a firm's level of internal, related knowledge increases, their ability to absorb new knowledge will increase.

Firms will choose to invest in increasing their level of ACAP when the availability of related external knowledge is high and when knowledge protection is high, increasing the ability of firms to appropriate value from the knowledge (Cohen & Levinthal, 1990). Cohen and Levinthal (1989) view research and development (R&D) activities as the method of increasing ACAP. In part, incentives to increase R&D spending “will be shaped by the quantity of knowledge to be assimilated” (Cohen & Levinthal, 1989, p. 570). While R&D activities are linked to new product development activities, R&D also “enhances the firm's ability to assimilate and exploit existing information” (Cohen & Levinthal, 1989, p. 569). ACAP’s emphasis is firmly on the process of absorbing and applying new knowledge in conditions where the incentives for applying new knowledge are high (Cohen & Levinthal, 1989, 1990). Thus, there are two primary conditions for firms to invest in ACAP; high availability of external related information, and industry incentives for investing in ACAP.

As previously noted, the ability to absorb external information necessitates related internal information, indicating a path dependency of knowledge. “By having already developed some absorptive capacity in a particular area, a firm may more readily accumulate what additional knowledge it needs in the subsequent periods in order to exploit any critical external knowledge that may become available” (Cohen & Levinthal, 1990, p. 136). ACAP thereby assists firms in identifying key external knowledge that can be absorbed and exploited. However, ACAP does not expressly state where external information is sourced; that is, the external information may be derived from external relationships via an interfirm network or via other channels. It does indicate that the external knowledge gained may not be gathered via knowledge transfer activities with other firms, but rather may be obtained via opportunistic means. “A key assumption in the model is that exploitation of competitors' research findings is realized through the interaction of the firm's absorptive capacity with competitors' spillovers. This interaction signifies that a firm is unable to assimilate externally available knowledge passively" (Cohen & Levinthal, 1990, p. 141). Therefore, the necessity for networks is noted in regards to developing the ability to identify sources of key knowledge, acknowledging the value of both internal and external networks (Cohen & Levinthal, 1990). A key element in predicting the need for and development of ACAP is the availability of external information, indicating that a firm must be aware of external firms' knowledge activities.

Key outcomes for ACAP include innovation output via the application of external knowledge, leading to increased performance (Cohen & Levinthal, 1990; Zahra & George, 2002) as well as the development of ACAP itself (Cohen & Levinthal, 1989, 1990). Interestingly, firms who invest in high ACAP in a specific area may be put at higher risk during periods of technological change, as their ability to identify, absorb, and apply unrelated information may be reduced if they do have a specific ACAP in that area (Cohen & Levinthal, 1990). Accordingly, based on the necessity for measuring the relatedness of knowledge in order to correctly ascertain levels or efficiencies of ACAP, relevant outcomes are difficult to measure at a network level (Lane & Lubatkin, 1998). In regards to the key consequences of ACAP, the level of ACAP itself is a key outcome, especially when contextual elements at the industry level are included, such as knowledge protection mechanisms (Cohen & Levinthal, 1989, 1990). Thus, ACAP can be considered both an antecedent to innovation and performance outcomes in addition to an outcome in itself.

ACAP Literature including knowledge and networks. While there is an extensive literature stream focused on ACAP (see Lane, Koka, & Pathak, 2006; Zahra & George, 2002 for reviews), the majority of extant literature does not specifically include networks. Thus, only nine articles coded for this literature review contained ACAP as a focal perspective. While a small absolute number, it represents over 15 percent of the articles returned for this literature review, indicating its theoretical power in explaining relationships between knowledge and networks. During coding, three themes emerged from this subset of ACAP literature; first, contextual factors that support ACAP, secondly, contextual factors that diminish ACAP, and thirdly, ACAP and knowledge spillovers.

Theme 1: Contextual factors that support ACAP outcomes. A prominent theme (three of nine articles) located in the literature was how and when internal contextual factors impact a firm's ACAP. For example, the diversity of internal knowledge has the ability to increase outputs via increased ACAP, indicating that "heterogeneity leads to the creation of more original and valuable exploratory ideas" (Alexiev, Jansen, Van den Bosch, & Volberda, 2010, p.1349). Thus, while knowledge stocks can increase ACAP, the breadth of current knowledge has an additional impact on ACAPs outcomes. The benefits of diversity also translate to network members, even though external diversity can strain the limits of ACAP. In order to benefit from external diversity, internal diversity must be supported in order to benefit from diverse external knowledge (Wuyts & Dutta, 2014). Thus, when firms have diverse internal knowledge and have access to diverse external information, an increase in positive outcomes is obtained as "past internal knowledge creation is a source of experiences that contribute to a firm's ability to manage portfolio diversity and leverage extramural knowledge" (Wuyts & Dutta, 2014, p. 1669). This advantage is found the network diversity is examined geographically; that is, diverse geographic locations provide benefits as well as diverse network partners (Penner-Hahn & Shaver, 2005).

Theme 2: Contextual factors that diminish ACAP outcomes. A further theme emerging from the literature focuses on the contextual factors that diminish ACAP. Interestingly, one study contradicts previous research by finding that increased partner diversity decreases knowledge utilization as it strains ACAP (Vasudeva & Anand, 2011). Specifically, while Wuyts and Dutta (2014) found a U-shaped relationship between diversity and ACAP indicating the presence of positive returns at high levels of diversity and ACAP, Vasudeva & Anana (2011) found an inverted U-shaped relationship. However, as neither the industries nor outcomes utilized in the two studies are directly comparable, it is unclear if this discrepancy is due to conflicting implications of diversity on ACAP or due to differences in industry-level factors or measures.

While firms may have extensive ACAP, there still remains the option for firms to choose to absorb newly available information (Fu, 2012). Thus, when new knowledge becomes available, firms have agency in deciding whether to assimilate this knowledge internally. This intriguing proposition may explain previous contradictory results regarding network diversity and knowledge outcomes by indicating that certain industries may use more discretion in absorbing new knowledge as compared to others. While it has been noted that there is a requirement for the firm to already have related knowledge in order to absorb new knowledge (Cohen & Levinthal, 1989, 1990), this research is unique in proposing that firms may actively choose not to absorb new knowledge.

Theme 3: Knowledge spillovers. The final theme that surfaced from the literature coding was the impact of knowledge spillovers on ACAP's outcomes. From this perspective, network members' levels of ACAP increases the potential for identifying and internalizing knowledge spillovers, as their ability to absorb knowledge is greater (Giarratana & Mariani, 2014; Martinez-Noya, Garcia-Canal, & Guillen, 2013). Thus, while firms want to increase their own levels of

ACAP in order to absorb greater amounts of external knowledge, this capability in network partners may be viewed as a negative, as opportunistic behaviors may ensue. Nonetheless, if spillovers do occur, firms still have available options to recover their loss of knowledge value. First, firms can choose to form an alliance with the recipient of the knowledge spillover (Phene & Tallman, 2014), as the spillover may indicate a similar knowledge base and thus opportunities for both firms to gain in knowledge once an alliance is formed. Secondly, firms may retrieve their spilled knowledge after the recipient has added to the knowledge, viewed as the re-absorption of knowledge (Alnuaimi & George, 2016). This point of view could result in spillovers being regarded as ultimately positive, as the re-absorbed knowledge will have additional new components that may further the originator's knowledge base and knowledge outcomes.

Absorptive Capacity (ACAP) Conclusion. ACAP focuses on a firm's capability to learn (Cohen & Levinthal, 1989, 1990), as compared to OL's view of how firms learn (Levitt & March, 1988; March, 1991). Thus, the focus is on when firms will want to invest in increasing R&D spending, and thereby increase their ACAP based on the availability of external knowledge and industry incentives for applying the knowledge. Key to ACAP is the necessity for external information to be related to existing firm knowledge in order for assimilation to occur, indicating that firms may strategically select specific areas in which to develop ACAP. Research has supported that diversity of internal and external knowledge increases positive outcomes (Alexiev et al., 2010; Wuyts & Dutta, 2014), potentially leading to the ability to identify specific areas of ACAP. While a goal to internalize external knowledge is somewhat assumed in ACAP, research has shown that firms can and do choose what knowledge to absorb (Fu, 2012). Finally, ACAP research identifies that the threat of knowledge spillovers exists, identifying avenues for firms to recoup lost knowledge value (Alnuaimi & George, 2016; Phene & Tallman, 2014).

Particularly relevant for this literature review is how the construct of spillover was defined in the research examining spillovers (e.g. Alnuaimi & George, 2016; Phene & Tallman, 2014). The literature discussed in this section predominantly viewed spillovers occurring when one firm used another firm's publicly available knowledge (via patent citations). Thus, while the knowledge recipient did not compensate the knowledge originator for the use of the knowledge, the knowledge spilled was not private. The use of publicly available knowledge allows firms to gain from spillovers without necessitating a direct relationship with the knowledge-generating firm. Research has examined the use of safeguards in alliances to reduce spillovers (Martinez-Noya et al., 2013), indicating an interest and awareness of the perils of spilling privately-held information. Indeed, these lines of research leads to an interesting avenue for future research examining how the threat of spillovers of privately-held knowledge may impact knowledge-originating firms' networks.

Literature Review Conclusion

The four perspectives examined in this chapter each explain why and how firms will seek knowledge from their interfirm networks. KBV provides an explanation for why knowledge is critical to a firm's success by arguing that firms have capabilities to develop knowledge internally beyond what could be acquired through markets (Grant, 1996a, 1996b), enabling firms to gain a competitive advantage via their knowledge resources. Thus, firms who focus on knowledge development and creation and the processes that contribute to knowledge may gain advantages due to the difficulties other firms will have in replicating their knowledge-based resources. In contrast, OL is primarily focused on the internal processes involved with organizational learning (Levitt & March, 1988), as well as understanding the benefits and pitfalls of focusing learning on proximal knowledge as compared to exploring (March, 1991). While OL is concerned with the questions of ‘how’, ACAP asks ‘how much’. That is, ACAP views the firm’s ability to recognize, assimilate and apply new knowledge as a capability that can be extended and increased (Cohen & Levinthal, 1989, 1990), and the answer to ‘how much’ is determined by the levels of prior related knowledge. As internal knowledge is increased, the firm is more able to identify and utilize new knowledge. Therefore, these three perspectives view interfirm networks simply as a method to access external knowledge, rather than networks being a primary consideration.

It is the network and social capital perspectives that specifically address the value and benefits of networks, including the availability of knowledge. However, in social capital research the emphasis is not solely on how firms obtain resources via networks, but also how networks can provide value via the structure of relationships. For example, closed networks include the development of trust, norms, and sanctions between network members, indicating strong relationships amongst network actors (Coleman, 1988). The benefits provided by this structure include increased productivity, reliability, cooperation, as well as increased information sharing (Baum et al., 212; Coleman, 1988; Patel & Terjesen, 2011). In contrast, networks that contain multiple structural holes may not develop norms or obligations between members, but rather afford members the opportunity to gather novel information not found in closed networks (Burt, 1992, 2000). Thus, the social capital perspective allows for both relational outcomes and resource outcomes. In sum, this dissertation primarily concentrates on KBV and social capital perspectives by viewing the strategic value of knowledge and how social capital resources embedded within firm networks are utilized to obtain further knowledge resources.

CHAPTER III: THEORY AND HYPOTHESES

Based on the research questions posed in Chapter I and the literature review presented in Chapter II, this chapter presents ten hypotheses organized into three broad sections in line with the three research questions from Chapter I. In response to the first research question, "how does the value of a firm's knowledge assets relate to their subsequent network size, intensity, structure, and position", the first section presents hypotheses focused on how the presence of knowledge assets is related to a firm's network in terms of its size, structure, and firm position. In line with the second research question, "how do industry and environmental characteristics affect the relationship between a firm's knowledge asset value and subsequent network size, intensity, structure, and position", the second section examines how environmental elements may impact these relationships. Finally, regarding the third research question, "how do network safeguards impact subsequent knowledge asset value", the third and final section focuses on the firm level outcomes of the afore-mentioned relationships. Figure 3.1 depicts the research model discussed in this chapter, portraying a visual representation of the constructs and their relationships.

Insert Figure 3.1 around here

Knowledge Asset Value and Network Size, Intensity, Structure, and Position

This section includes four hypotheses examining how a firm's valuable knowledge assets (i.e. firm knowledge asset value) may impact their network size, intensity, structure, and position due to knowledge protection goals. As a firm's level of knowledge increases, they may strategically alter their network in order to safeguard their knowledge from unintended knowledge spillovers. Four network safeguards are explored in this section; the size of the firm network, the intensity of the relationships, the structure of the network, and the firm's position within their network. While the theoretical arguments may overlap across hypotheses, these are distinct safeguards available to firms, and thus are hypothesized separately.

As will be noted in the arguments for each hypothesis, the network characteristics discussed in this dissertation are each directly linked to knowledge accumulation. Consequently, these network attributes are highly relevant for discussions regarding firms who may seek to safeguard their knowledge asset value. Specifically, network size has been positively associated with firm knowledge (Lipparini et al., 2014; Mahmood et al., 2011), while weak ties have been shown to increase access to knowledge (Wagner et al, 2014). Furthermore, structural holes provide benefits of nonredundant and diverse information to a firm (Koka & Prescott, 2008), whereas central positions benefit knowledge accumulation, as breadth and range of knowledge resources is increased (Owen-Smith & Powell, 2004). Viewed from the opposing viewpoint, these network features provide the potential to safeguard knowledge when firms are concerned with the risks of spilling knowledge as compared to the benefits of gaining knowledge.

Knowledge Asset Value and Network Size

Firm networks afford learning opportunities for firms within the network, as both tacit and explicit knowledge can be transferred via interfirm relationships (Dyer & Nobeoka, 2000). Relationships may be established with knowledge transfer as a prime objective (Hardy et al, 2003), indicating that the originator of the knowledge is compensated for and agrees to the transfer. However, interfirm relationships also present opportunities for unintended knowledge transfer, or knowledge spillovers, between firms (Agarwal et al, 2010). In this situation, the knowledge originator is not compensated for the knowledge exchange, and may have desired to protect that knowledge from use by others. As assets erode over time (Dierickx & Cool, 1989; Le Breton-Miller & Miller, 2015), curtailing spillovers while the knowledge assets are still deemed valuable can provide a competitive advantage. Furthermore, as knowledge development is considered path dependent (Dierickx & Cool, 1989; Grant, 1996a), protecting current levels of knowledge asset value that will generate future value may allow for a competitive advantage to be extended beyond the value of the current knowledge assets. Thus, firms with sizeable value in their knowledge assets (i.e., firm knowledge asset value) may choose to restrict knowledge spillovers (Giarratana & Mariani, 2014) in order to appropriate maximum rents from the asset.

One mechanism for protecting knowledge asset value is by reducing the number of interfirm relationships, resulting in a smaller network. By reducing the count of relationships, the number of direct network partners who could potentially gain from the originator's knowledge is restricted. Additionally, a smaller network can increase trust and trustworthiness between partners as the relationship becomes stronger due to the increased time available for the relationships (Coleman, 1988). With a smaller network the time spent on the relationships increases, creating trust relationships whereby the opportunities for knowledge spillovers are reduced and positive knowledge transfer may be increased (Ireland, Hitt, & Vaidyanath, 2002). Indeed, a focus on a smaller number of relationships can allow trust to be a governance mechanism (Uzzi, 1996), lessening the risk of knowledge spillovers to indirect network members via direct partners. Furthermore, as a large network takes more time and energy to manage (Ahuja, 2000; Burt, 2000), this may increase the potential for partners to engage in opportunistic behaviors such as actively pursuing knowledge spillovers due to minimal oversight. While a firm may have achieved their strong knowledge asset value via a large network (Lipparini et al, 2014; Mahmood et al, 2011; Wagner et al, 2014), once this competitive advantage is achieved the firm may choose to strategically manage their network to limit opportunities for spillovers (Hernandez et al, 2015). Therefore, a firm with high knowledge asset value is likely to have a smaller network in order to protect its knowledge assets, by both reducing the absolute volume of spillover opportunities and increasing the governance of network relationships due to the smaller number of relationships. Hence,

H1: There is a negative relationship between firm knowledge asset value and subsequent network size

Knowledge Asset Value and Intensity of Ties

Another aspect of firm networks is the strength of the ties present in the network, as a firm network can consist of both strong and weak ties. As previously described in Chapter II, strong ties are a result of repeated, frequent relationships that foster trust between partners (Coleman, 1988). The presence of trust found in strong ties increases predictability of partner actions and reduces opportunistic behaviors (Gulati, 1999). Strong ties increase opportunities for resource acquisition and knowledge sharing between partners (Dyer & Nobeoka, 2000; Patel & Terjesen, 2011; Zhang et al, 2010). Contrastingly, weak ties are less intensive relationships, and provide external ties outside the core of a firm’s network. Thus, weak ties allow for intermittent relations between partners, and may include links to network segments that would otherwise not be connected. Indeed, weak ties can provide linkages to information not otherwise present in the network, though this form of tie reduces the expectation of trust and the ability to enforce sanctions (Lazzarini, Claro, & Mesquita, 2008).

For firms with high levels of knowledge asset value, the desire to protect their knowledge may lead to an increase in the strength of ties in their network. That is, a firm may seek stronger tie relationships in order to take advantage of the informal governance structure that provides safeguards including goodwill, mutual trust, and norms of reciprocity (Gulati, 1995, Uzzi, 1997). The informal safeguards found with strong ties via repeated or long-term relationships may reduce opportunistic behaviors (Dyer & Nobeoka, 2000). Moreover, the combination of informal and formal safeguards found in strong tie relationships may also mitigate the opportunity for undesired knowledge spillovers (Owen-Smith & Powell, 2004). In contrast, weak ties may provide increased access to information (Burt, 2000, 2001), yet the lack of protection mechanisms may reduce the attractiveness of these relationships for firms with high knowledge asset value. Thus, the following relationship is hypothesized:

H2: There is a positive relationship between firm knowledge asset value and the subsequent average strength of ties (i.e., network intensity) in the firm network

Knowledge Asset Value and Network Structure

Interfirm networks can seek to create a cohesive and closed network whereby most relationships are in the form of strong ties (Coleman, 1988). Indeed, firms can choose to associate with partners that are known to their other partners, creating a closed, cohesive network whereby most firms in the network are interrelated. In contrast, firms can choose the alternative and develop relationships with firms that do not have relationships with other firms in their existing network, thereby gaining access to information not present in the existing network (Burt, 2000, 2001). A relationship that links two networks or network segments is viewed as spanning a structural hole, also termed a bridge (Burt, 2001). By bridging structural holes, a firm generates a link to a network or network segment that was previously unconnected, opening up avenues to new and novel information (Burt, 2000; Granovetter, 1973).

The benefits of a closed network include the generation of trust, whereby “trustworthiness is taken for granted and trade can occur with ease” (Coleman, 1988, p. 99). Norms of behavior provide rewards for positive dealings and sanctions to constrain counterproductive actions (Coleman, 1988), reducing the concern for opportunistic behaviors (Provan, 1993). Indeed, trust can provide a governance mechanism, facilitating “the exchange of resources and information that are crucial for high performance but are difficult to value and transfer via market ties” (Uzzi, 1996, p. 678). When firms within a network are completely (or almost completely) intertwined via relationships, the awareness of firm behavior is known throughout the network. As a result, an informal governance structure develops that limits the chances for opportunistic behaviors. Closure leads to trustworthiness, as firms become socially embedded in the relationships and trust is viewed “as an explicit and primary feature of their embedded ties” (Uzzi, 1997, p. 43). As firms are increasingly embedded in the network of relations, opportunistic behavior declines due to network interdependence (Provan, 1993). Thus, in a closed network, firms develop behavioral expectations and norms, reducing motivation and opportunities for engaging in deviant behavior.

However, while the benefits of a closed network are found in shared norms and increased trust, the disadvantages are the redundancy of resources, knowledge, and information (Burt, 2000, 2001). In a closed network, information become redundant as it travels over the same paths multiple times, with eventually all firms having similar access. However, if a firm develops a relationship with another firm external to the core network, in essence developing a bridge to a new position (Burt, 1992), this affords the firm the opportunity to gain performance advantages via heterogeneous resources, knowledge, or information. A bridging tie spans a structural hole, as before the bridging tie there was no connection, either direct or indirect, between the two firms. Bridging ties can lead to increased firm performance, as "competitive advantage comes from information access and control; networks that span structural holes provide broad and early access to, and entrepreneurial control over, information' (Burt, 2000, p. 347). Thus, Burt (2000, 2001) argues that benefits accrue to actors that broker between otherwise disconnected networks due to the ability to gain and link knowledge from disparate sources.

While Burt's (2000, 2001) perspective of social capital proposes increased benefits when firms actively seek new sources of information via linking to diverse networks, the ability to gain knowledge via bridging structural holes may be viewed as increasing the potential threat of knowledge spillovers to firms already in possession of significant knowledge asset value. Specifically, weak ties enable knowledge to reach a larger number of actors and travel greater distances (Granovetter, 1973). To firms with high value knowledge assets, the potential benefit for accessing novel knowledge via spanning structural holes may be more than offset by the risk that their knowledge may be spilled to those in other networks. Bridging structural holes increases the potential for knowledge to be spread *between* networks, reducing the rarity of the knowledge (Burt, 2001) and potentially the appropriability of the knowledge's value. While a closed network will facilitate knowledge transfer *within* the network structure, the norms of trust limits opportunistic behaviors (Coleman, 1998). Specifically, a closed network "may help ensure collaborative continuity via high levels of trust and reputational lock-ins, both of which can help firms preserve their existing resources" (Tatarynowicz, Sytch, & Gulati, 2016, p. 55).

Thus, relationships that span networks tend not to develop the informal governance and norms that can reduce opportunistic behaviors due to the lack of interconnected ties amongst the network participants. While networks that bridge structural holes may improve the potential for increasing knowledge assets, the protective mechanisms to reduce knowledge spillovers are not present, intensifying the opportunities for knowledge spillovers to unknowingly, and undesirably, occur. For these reasons, firms already in possession of valuable knowledge assets may select a network that limits the volume of structural holes in their network, resulting in a more closed, cohesive network structure whereby firms develop norms and standards of behavior (Baum, McEvily, & Rowley, 2012). Formally stated,

H3: There is a negative relationship between firm knowledge asset value and subsequent volume of structural holes

Knowledge Asset Value and Network Position

A firm's position in their network can be expressed by their centrality, viewed as their prominence, and contributing to their control, visibility, and power (Borgatti et al, 2013). A central position benefits knowledge accumulation (Owen-Smith & Powell, 2004), due to the breadth and range of knowledge resources located in the connections. Nonetheless, from the perspective of firms with valuable knowledge assets, the more central the position that a firm occupies, the greater the risk of knowledge being transmitted throughout the network (Soh, 2010). Both direct and indirect ties provide conduits for knowledge and information to flow through the network (Vanhaverbeke et al., 2002), indicating that a direct connection is not required for firms to gain access to valuable resources.

While there are many forms of centrality, ranging from a simple count of relationships (degree) to the measurements of the shortest paths between all firms in the network (betweenness centrality), this study will focus on a measure known as beta centrality (Bonacich, 1987). This measure is well suited to the study of knowledge transfer and spillover, as beta centrality can be conceptualized as a measure of relative influence among actors in a social network (Borgatti et al, 2013). Beta centrality is “a measure of global centrality that considers the focal actor’s centrality, its connected actors’ centralities, their connected actors’ centralities, and so on” (Pollock, Lee, Jin & Lashley, 2015, p. 493). Power and influence are associated with beta centrality, though these benefits will weaken as the firms are more distant. That is, a high beta central firm may have significant power and influence over its direct relationships, but less so over their indirect relationships, and at a decreasing scale as the relationship become more distal. Since firms with high beta centrality are connected to other firms that have high beta centrality, the volume of distant connections increases. In this situation, the focal firm has many direct connections to firms that also have many direct connections, which exponentially increases the volume of distant indirect relationships. However, if the focal firm forms relationships with less beta central firms, decreasing their own beta centrality, their power and influence may be able to reach more distal relationships, thereby decreasing spillover opportunities. Furthermore, by associating with less central firms, the disparity in power and influence provides a further disincentive for the less beta central firm to engage in behaviors that may threaten the relationship (Castellucci & Ertug, 2010). Indeed, when viewing this concept in regards to knowledge spillovers, the beta centrality of the firm will indicate both the visibility of a firm’s knowledge and how quickly knowledge can be transmitted to multiple firms (Borgatti, 2005).

Thus, for firms with high levels of knowledge asset value, two mechanisms are present for safeguarding knowledge assets via reduced network beta centrality. First, a less beta central position will reduce the number of relationships a firm must manage, which enables the firm to focus on exercising increased power and influence over its partners, while simultaneously increasing effort by their partners in order to maintain the relationship (Castellucci & Ertug, 2010). Secondly, firms with reduced beta centrality will have fewer potential knowledge spillover recipients and reduced visibility of its knowledge due to the decreased number of indirect and distant relationships. Indeed, a firm with high knowledge asset value may choose to be less beta central in their network, as high beta centrality not only increases the visibility of the knowledge, but also increases the volume of potential knowledge spillover recipients. Not only may firms select a smaller network as discussed in H1, but they may also select direct partners that are themselves less beta central, reducing the focal firm's beta centrality. For these reasons, a firm with high knowledge asset value may adopt a less beta central network position to both reduce visibility of their knowledge and reduce spillover opportunities via indirect relationships. Stated more formally:

H4: There is a negative relationship between firm knowledge asset value and their subsequent beta centrality

The Impact of Industry and Environmental Characteristics

Industry and environmental characteristics are frequently included in management research yet typically as control variables (i.e., Batjargal et al, 2013; Baum et al, 2012; Sarkar et al, 2009). However, industry and environmental characteristics may impact how firms respond to spillover threats to their knowledge, and are, therefore, considered to be of theoretical interest. First, knowledge as an asset does not have the same value across industries, as industries with fewer technological changes may see reduced value in their knowledge as compared to industries where technological change is rapid and frequent (Alnuaimi & George, 2016; Appleyard, 1996; Mayer, 2006). Secondly, environmental characteristics such as dynamism and munificence (Dess & Beard, 1984) impact the level of uncertainty that firms face which may impact their network safeguards. Dynamism refers to “change that is hard to predict and that heightens uncertainty” (Dess & Beard, 1984, p. 56) potentially increasing the need to safeguard knowledge assets. Conversely, munificence indicates the environmental capacity for growth and stability (Dess & Beard, 1984); when munificence is high, uncertainty and competition will be reduced and may subsequently reduce the need to protect knowledge asset value.

The emphasis in this section of the dissertation is on three specific industry and environmental characteristics; 1) the value placed on knowledge assets by differing industries, 2) the level of dynamism, and 3) the level of munificence faced by firms. The next sections will examine these three characteristics in detail, exploring the theoretical relationships between these characteristics and the focal relationships, and hypothesizing how these factors will affect the direct relationships examined in the previous section (depicted in Figure 3.1).

Industry Characteristics

Schmalansee’s (1985) early research brought to the forefront the relevance of industry, finding support for his proposition that at least 75% of the variance of firm outcomes was due to industry effects. The subsequent work that examined the relationship between industry and firm outcomes produced varying results, supporting the impact of industry to varying degrees (i.e., Karniouchina et al, 2013; McGahan & Porter, 1997; Rumelt, 1991; Short, Ketchen Jr, Bennett, & du Toit, 2006). For example, research conducted on industries such as semiconductors (i.e.

Alnuaimi & George, 2016; Appleyard, 1996; Jiang, Tan & Thursby, 2010) and steel (i.e., Koka & Prescott, 2008; Madhavan, Koka, & Prescott, 1998) provides a suggestion that the speed of technological change is different between the two industries, inviting a comparison of their network safeguards, as well as comparisons including other industries. The semiconductor industry was (and is) characterized by rapid technological change, increasing uncertainty as "uncertainty surrounds the pay-off to a particular piece of knowledge due to difficulties in predicting: its useful life; the breadth of its applicability across the industry; the ease with which it [c]an be incorporated into another company's process flow; and whether it can be reverse engineered" (Appleyard, 1996, p. 140). In contrast, the slower moving steel industry has a slower rate of technological change, and with that, reduced uncertainty (Koka & Prescott, 2008). In the semiconductor industry, firms protected their knowledge to the extent possible, while in the steel industry knowledge was shared between firms more frequently. While this study only examined two industries, it indicates that industries will place dissimilar values on their knowledge. In regard to this dissertation, the findings indicate that industries may uniquely value knowledge and therefore network safeguards may not be similar across industries. In industries characterized by rapid technological change, all knowledge may be deemed valuable, as it is unclear which knowledge will contribute to future positive outcomes (Coff, 1999).

Thus, the value of knowledge between industries may differ based on the pace of technological change. Indeed, in situations where firms are in possession of valuable knowledge assets, the determination of the value of these assets may be, in part, driven by the industry's value of knowledge. While firms with high knowledge asset value may have different network size, intensity, structure, and position in order to safeguard knowledge, the pressure to do so is expected to be stronger in industries where knowledge is deemed valuable, as compared to industries where knowledge is not viewed as a key resource (Tatarynowicz et al., 2016). Formally stated;

H5: In industries where knowledge is perceived as more valuable (i.e., high technology), the relationships between firm knowledge asset value and subsequent network size (H5a), network intensity (H5b), network closure (H5c), and beta centrality (H5d) will be stronger.

Environmental Characteristics

Dynamism and munificence can affect the uncertainty in the environment surrounding firms, and therefore may impact how they value their knowledge asset and thus their network size, intensity, structure, and position. Dynamism indicates a rapidly changing environment indicated by the frequency, intensity, and unpredictability of changes (Castrogiovanni, 2002; Child, 1972), increasing the uncertainty felt by firms in a highly dynamic environment. Firms in a dynamic environment will not be able to predict which knowledge assets will be valuable in the future (Coff, 1999), potentially leading to firms guarding all knowledge. Firms may seek to protect any present or potential competitive advantage gained by their knowledge assets by safeguarding their knowledge, as knowledge assets cannot be quickly or easily replicated due to time requirements and the path dependent nature of knowledge creation (Alexy, George, & Salter, 2013; Boland et al., 2007; Ireland et al., 2002). Dynamic environments may increase the potential for knowledge to become a key resource (Fang, 2011; Wang & Chen, 2010) and lead firms to intensify their knowledge protection efforts. Conversely, in environments characterized by low dynamism, the uncertainty is low. While firms may still seek to protect their knowledge asset value, the pressure to protect all knowledge will be reduced, as the slower-paced environment allows firms to clearly view future possibilities for competitive advantage. Again, the need to protect knowledge can still be present but will be reduced as all firms are able to identify future possibilities for competitive advantage. While knowledge will be protected, the efforts can be focused, and thereby reduced in comparison to environments characterized by high dynamism. Thus, firms may seek to protect their knowledge asset value through network safeguards (i.e., network size, network intensity, network closure, and beta centrality) in order to hedge when faced with an unpredictable future. Formally stated,

> *H6: The level of dynamism in the industry will moderate the relationships between firm knowledge asset value and subsequent network size (H6a), network intensity (H6b), network closure (H6b), and beta centrality (H6d), such that the strength of the relationships will increase with the level of dynamism.*

In a similar fashion, munificent environments affect firms as munificence influences "the survival and growth of firms sharing that environment" (Castrogiovanni, 1991, p. 543) and thereby, the level of uncertainty. Highly munificent environments are characterized by high availability of resources, and indicate the ability of the environment to support growth (Boyd & Gove, 2006; Dess & Beard, 1984), in essence, the environment's 'carrying capacity' (Castrogiovanni, 2002). In a highly munificent environment, competition for resources will be reduced as the availability is not restricted. Indeed, a highly munificent environment may be characterized by low knowledge protection efforts as firms do not feel pressures to safeguard their resources due to the high availability. While munificence is a broad concept referring to all resources and not knowledge resources specifically, it is argued that highly munificent environments have reduced competitive forces (Schoonhoven et al, 1990) which will influence network safeguards. In environments characterized by high munificence and thereby reduced competition, firms will not implement knowledge protection efforts as would be found in low munificence environments. When resources are not freely available and competition is high, network safeguards (i.e., network size, network intensity, network closure, and beta centrality) will be increased in order to protect the value of the knowledge (indicated by the shaded box in Figure 3.1). Formally stated;

> *H7: The level of munificence in the industry will moderate the relationships between firm knowledge asset value and subsequent network size (H7a), network intensity (H7b), network closure (H7b), and beta centrality (H7d), such that the strength of the relationships will decrease with the level of munificence.*

Network Safeguards and Future Knowledge Asset Value

Firms derive multiple benefits from their interfirm network, and specifically in regards to knowledge assets (Ahuja, Polidoro Jr, & Mitchell, 2009). Knowledge benefits may be obtained as a result of direct and indirect ties (Ahuja, 2000b; Tiwana, 2008), providing firms with the ability to create value and gain a knowledge-based advantage over their competitors (DeCarolis & Deeds, 1999). As a firm’s knowledge base increases, their ability to absorb knowledge is amplified (Grant 1996a, 1996b; Cohen & Levinthal, 1989, 1990; Yang et al., 2010). Indeed, participation in interfirm networks can increase firm learning as firms realize the benefits accrued to those who increase knowledge at a faster rate than competitors (Dyer & Nobeoka, 2000). Thus, as firms' access to knowledge resources are increased via network size, structural holes, and beta centrality, their knowledge assets will be subsequently increased via the breadth and depth of available knowledge to the firm.

Nonetheless, this positive relationship may have its limits. First, as firms increase their breadth and depth of connections, their capacity to internalize and utilize the available knowledge will at some point be saturated, reducing the benefits (Laursen & Salter, 2006). With extensive knowledge resources available, firms are challenged to select which knowledge to explore, to provide the necessary attention to absorb knowledge and to utilize knowledge when it is most relevant (Koput, 1997). As knowledge levels increase, these capabilities will be under excessive demand, leading to diminishing returns beyond an optimal point. At the same time, the firm's knowledge will be widely available via interfirm networks, allowing greater numbers of external firms to build upon the knowledge (Alcacer & Oxley, 2014). Firms seeking the benefits of knowledge spillovers will pursue both direct and indirect connections to firms with valuable knowledge assets in search of spillover opportunities (Ahuja, 2000; Appleyard, 1996). When knowledge is spilled to external firms, this allows them to gain value that otherwise would have been appropriated by the knowledge-originating firm, reducing the value of present and future firm knowledge assets. In combination, these two mechanisms will constrain firms' abilities to increase their knowledge asset value beyond an optimal point, thereby producing a curvilinear relationship between network safeguards (i.e., network size, intensity, structural holes, and beta centrality) and knowledge assets. Formally stated:

H8: Network size (H8a), network intensity (H8b), structural holes (H8c), and beta centrality (H8d) have a curvilinear (inverted-U) relationship with subsequent knowledge *asset value.*

CHAPTER IV: METHODS

Sample

To test the hypotheses in Chapter III, data was collected to form a sample of publicly traded firms having at least one interfirm relationship, indicating the presence of a firm network. The necessity for the use of publicly traded firms is due to the availability of data regarding interfirm networks, as well as the availability of financial data. The sample includes all manufacturing firms, as “technology competition and patenting are more prevalent in manufacturing than in service firms” (Wang & Chen, 2010, p. 145). As this dissertation is focused on the perceived effect of knowledge asset value on network size, intensity, structure, and position, selecting manufacturing firms focuses the analysis on industries where knowledge can play a role in achieving or maintaining competitive advantage.

Data were collected from multiple sources. First, data regarding firm networks were gathered from the SDC Platinum Worldwide Mergers, Acquisitions, and Alliances Database (SDC), and covered the years 1985 – 2010, as prior to 1985 there was negligible alliance activity found in the SDC database. Secondly, data providing information on firm knowledge asset value were utilized from two separate sources: The National Bureau of Economic Research’s (NBER) Patent Data Project (https://sites.google.com/site/patentdataproject/Home) (Hall et al, 2001), and a dataset also using NBER data (https://iu.app.box.com/v/patents) from Kogan and colleagues (2017). Finally, financial information was gathered from Compustat, which provides extensive information on publicly-traded companies.

Dependent Variables

Firm Networks

For hypotheses 1 through 7, the dependent variables are derived from firm networks. As the focus of this research is the perceived need for network safeguards, firm networks were defined by the presence of strategic alliances between firms. While firms may have multiple networks, such as customer networks and networks based on board interlocks, interfirm alliances generate a network rich in knowledge (Kale, Singh, & Perlmutter, 2000; Koka & Prescott, 2008; Oliver, 1990; Vanhaverbeke et al., 2002). A criterion for the boundary of the network was adopted whereby each included firm had formed at least one alliance during the period of study (Koka & Prescott, 2002). Furthermore, each firm network was classified by the Standard Industrial Classification (SIC) code used for the alliance. While firms use SIC codes to categorize their lines of business, SIC codes are also used to categorize the focus of the alliance. By using the alliance SIC versus the business SIC, firms engaged in similar alliance business were considered to be in the same network, as firms frequently engage in diversifying product lines. Therefore, each firm in the network has the ability to engage in a relationship with any other firm in the network. Additionally, using the alliance SIC as the delineation of each network provides a reasonable network boundary, necessary for network research (Borgatti et al, 2013). A moving window of 5 years was utilized based on prior research (i.e., Bae & Gargiulo, 2003; Gulati & Gargiulo, 1999; Lavie & Rosenkopf, 2006; Stuart, 2000; Sytch & Tatarynowicz, 2014), as alliance terminations are rarely reported (Bae & Gargiulo, 2003), and prior research indicates that the normal duration of most alliances is no more than 5 years (Sytch & Tatarynowicz, 2014). Therefore, even though data were collected from 1985, analysis began in 1989 to address left-censoring issues, as each network includes alliances from the previous five years.

Network size. Network size (also termed degree centrality) was measured as a firm's total count of network partners at time *t* (Mahmood et al, 2011).

Volume of structural holes. Structural holes indicate that firms in the network are relatively unconnected to others in the network, increasing access to different and potentially novel information (Burt, 2001). The common method for computing structural holes is to use the inverse of Burt's (1992) constraint measure which measures the level of closure found in an actor's network. "Because the pursuit of closed ego networks involves forming ties to partners that are connected to one another, firms that exhibit this behavior should have higher levels of constraint" (Tatarynowicz, Sytch, & Gulati, 2016, p. 58). As constraint indicates a dense network, the inverse of constraint indicates a sparsely connected network (Koka & Prescott, 2008). Thus, the measure for structural holes was the inverse of the constraint measure calculated using UCINET software.

$$\text{Structural Holes}_{it} = 1 - \mathcal{C}_{it}\ . \qquad (1)$$

Network intensity. Nohria and Garcia-Pont's (1991) 9-point scale for measuring the "strength of strategic linkage" (p. 117) was used, whereby "[h]igher scores indicate higher levels of intensity of cooperation and interdependence, indicating a potential for a greater amount and a higher quality of information flow than alliances with lower scores." (Koka & Prescott, 2008, p. 648). The scale rates alliances from 1-9 based on the level of commitment required between alliance partners as follows: 1. Distribution agreements. 2. Know-how and patent licensing agreements. 3. Component sourcing agreements. 4. Second source agreements. 5. Broad R&D Agreements. 6. Minority Equity. 7. Limited Cross Equity Ownership. 8. Independent Joint Ventures. 9. Mergers and acquisitions. Each alliance was separately coded based on the above scale. The information provided by SDC includes indicators for the items (e.g., Distribution =

yes/no), allowing for coding. In situations where indicators cannot be utilized, the text description of the alliance was used. The average intensity of all of each firm's alliances at time *t* was used as the measure of network intensity.

Beta (Bonacich) centrality. Beta centrality is a variation of degree centrality, whereby a firm will have a higher score to the extent it is connected to many firms who themselves are highly connected (Bonacich, 1987; Borgatti et al, 2013; Podolny, 1993). Beta centrality can be viewed as a measure of "the total amount of potential influence a [firm] can have on all others via direct and indirect channels" (Borgatti et al, 2013, p. 171), appropriate for these hypotheses. The following formula was used to calculate the beta centrality measure (Bonacich, 1987):

$$c(\alpha, \beta) = \alpha \sum_{k=1}^{\infty} \mathcal{B}^{k} \mathcal{R}^{k+1} \tag{2}$$

where $c(\alpha, \beta)$ is a vector of centrality scores for the firms, α is an arbitrary scaling factor, β is a weight, and 1 denotes a column-vector of ones. Where β is 0, this measure provides degree centrality, as only those firms directly connected to the focal firm are included in the measure. Where β is greater than 0, the measure accounts for the centrality of the firm's connections. For these analyses, β was set to be equal to three-quarters of the reciprocal of the largest eigenvalue of *X*, as is the norm in the networks literature (Podolny, 1993; Pollock et al, 2015).

Knowledge Asset Value

For hypothesis 8, the dependent variable is subsequent knowledge asset value. This measure is also an independent variable for hypotheses 1 through 7. Patent data was the base for knowledge measures as a patent, "by definition, represents a unique and novel element of knowledge" (Ahuja & Katila, 2001, p. 201), and therefore can provide indications of knowledge asset levels (Chung & Yeaple, 2008; Coombs et al, 2009; DeCarolis & Deeds, 1999).

First, a measure of each firm's patent originality level was utilized as in indication of firm knowledge asset value. Patents including citations from a wide range of fields are considered more original (Hall et al, 2001) and more diverse (Wuyts & Dutta, 2014). The originality measure has been used extensively in research as predictors (e.g., Hoetker & Agarwal, 2007) and outcomes of interest (e.g., Guerzoni, Aldridge, Audretsch, & Desai, 2014), as originality is viewed as "the synthesis of divergent ideas defined by technological sourcing from a broad spectrum of technology domains" (Corradini & De Propris, 2017).

The National Bureau of Economic Research (NBER) supported research by Hall and colleagues (2001) to track patent citations and their level of originality, resulting in the Patent and Patent Citations Data Set. The originality measure uses the following equation:

$$Generality_i = 1 - \Sigma_j^{ni} s_{ij}^2,$$

where s_{ij} indicates the percentage of citations made by patent i that belong to patent class j, out of n_i patent classes (the sum is the Herfindahl concentration index). Therefore, a patent that uses a wide range of fields in its citations will result in a high value, while a patent with citations that are concentrated in a limited number of fields will have a lower value.

Second, a measure totaling the economic importance of each firm's patents was included (Kogan, Papanikolauo, Seru, & Stoffman, 2017) as an indicator of a firm's knowledge asset value. This measure is based on stock market reactions to patent grants, indicating the market's perception of the future commercialization potential of the patent. While this measure is strongly related to the scientific value of patents (as measured by forward citations), it provides a clearer view of knowledge performance via its use of an economic outcome (Kogan et al, 2017). The measure first analyzes the stock market reactions when a patent is granted. The cumulative abnormal returns (CAR) are measured using a three-day announcement window, adjusting for market returns. Thus, the first step is to gather the firm's idiosyncratic return, calculated as the firm's return based on the patent issuance minus the return on the market portfolio. The second step is to calculate the economic value of the patent as the estimate of the stock return due to the value of the patent multiplied by the market capitalization of the firm on the day prior to the announcement. If multiple patents are awarded to one firm on the same day, each patent is assigned a fraction of the total value accumulated. The measure is the additive value of each firm's patent value at time *t*. This measure is relatively new and has not been cited yet in management literature, although it is a subject of interest based on the accumulation of 66 cites in working papers in other disciplines (Google Scholar, November 3rd, 2017).

Independent Variables

Knowledge Asset Value

As noted above, the measure developed for the dependent variable in Hypothesis 8 is also used for the independent variable utilized in hypotheses 1 through 8.

Industry characteristics

High Technology Industry. Hypothesis 5 includes a measure indicating whether an industry is considered high-technology or not. Based on extant strategic research (e.g., Certo, Covin, Daily, & Dalton, 2001; Moore, Bell, & Filatotchev, 2010; Moore, Bell, Filatotchev, & Rasheed, 2012), the following 2-digit SIC codes were classified as high-technology: biotechnology, pharmaceuticals & specialty chemicals (SIC 28), computer hardware (SIC 35), semiconductors and printed circuits (SIC 36), aerospace (SIC 37), telecommunications (SIC 48), and computer software (SIC 73). The measure was operationalized as a dichotomous variable, assigning a score of 1 if the firm was in a high-technology industry, and 0 if otherwise.

Environmental characteristics

Hypotheses 6 and 7 include moderating variables that reflect the environmental characteristics of the industries included in this research. The environmental characteristics of *dynamism* and *munificence* (Dess & Beard, 1984) was measured using the following basic equation (Bergh & Lawless, 1998: Lin et al, 2009):

$$Y_t = b_0 + b_1 t + a_t \tag{3}$$

where *Y* = industry sales, *t* = year, and *a* = residual. As recommended by Boyd and Gove (2006), a 5-year time window was utilized (e.g., industry sales from 1995 through 1999 was used in the regression equation leading to dynamism and munificence for 1999). Dynamism was measured as the standard error of the regression slope coefficient divided by the mean of sales to create a standardized index of industry dynamism using the above regression equation (Lin et al, 2009). Environmental *munificence* was measured as the regression slope coefficient divided by mean sales from the above regression equation.

Control Variables.

Control variables are necessary in order to rule out alternative explanations as well as to reduce error terms (Becker, 2005). The following controls are deemed necessary due to their potential effect on the dependent variables and also based on their inclusion in previous research.

Firm size, measured as the natural logarithm of the firm's total assets normalized to the industry median (Gulati, 1999), was included as a control variable as the size of the manufacturer may have an impact on knowledge asset volume and value.

Firm age, measured as the natural logarithm of the number of years from founding (Alexiev et al., 2010), was included as a control, as previous research has acknowledged that incumbent manufacturers have fewer information asymmetries, potentially impacting the necessity and efficacy of signals (Etzion & Pe'er, 2014).

Firm patenting volume, a count of all patents assigned to each firm by year was measured, including those patents applied for but not yet granted to include all knowledge in development (Coombs et al, 2009).

Patenting age, measured as the number of years from the firm's first patent application, was included as a proxy for patenting experience (e.g., Bhas & Hedge, 2014), as greater experience may improve the firm's ability to generate knowledge asset value.

Firm performance measured as return on assets normalized to the industry median (Gulati, 1999) was included as a control as strong performance may affect both the perceived need to protect knowledge as well as firm alliance behavior (Ahuja et al., 2009).

Firm slack was measured using a firm's current ratio, calculated as current assets over current liabilities (Yang et al, 2010). The availability of slack may allow for increased expenses on R&D, thereby increasing knowledge asset values, and may also decrease pressures to safeguard knowledge, influencing the variables of interest.

Firm Research & Development (R&D) expenses were included as these are considered investments in knowledge creation (Cohen & Levinthal, 1989) and contribute to the ability of firms to absorb external knowledge (Cohen & Levinthal, 1990). The natural logarithm of the R&D expenditure was used as the measure.

Network size was included as a control variable, as the number of firms present in the network indicates the number of relationship opportunities. Furthermore, as network statistics are generated by the network, this control variable partitions out the variance introduced by non-equal network sizes.

Analysis

In this dataset, the cases are hierarchically nested, as firms are present across multiple years, and multiple firms are present in each industry. In this situation, there is a lack of independence of errors within the dataset, as firm-level effects impact analyses as well as industry-level effects (Tabachnick & Fidell, 2013). Thus, to accommodate the multilevel nature of this data, a mixed effects regression model was employed that includes random effects for repeated firm and industry segments. This model is conceptually similar to regression models while including additional variance terms to account for the nested structure of the data (Bliese & Ployhart, 2002). Even though this research is focused on first-level variables, acknowledging the multilevel nature of the data avoids issues with both Type I and Type II errors (Bliese & Hanges, 2004). The mixed effects regression model used in this research simultaneously estimates within and between firm and industry effects, while controlling for auto-correlation across time by using an auto-regressive error covariance structure.

While a multilevel model has been proposed, the data are not strictly hierarchical. There are multiple observations for each firm over time, yet firms are not strictly nested in an industry hierarchy. This is an artifact of using alliance industry to define networks, as firms appear in multiple alliance industries. Firms are present in an average of approximately 9 industries, with a range from 1 to 17 (the maximum number possible is 20). Therefore, to analyze the data, a cross-classified model was employed (Leckie, 2013). A cross-classified model allows for a non-hierarchical dataset (firms are not strictly nested in industries). A three-level model was formulated whereby firm-years (Level 1) are nested within firms (Level 2) nested within a single artificial super industry cluster (Level 3). It may improve understanding to view this super cluster as being the complete manufacturing industry, within which the 20 2-digit manufacturing

SIC codes are nested.

Thus, the model, formulated as a constrained three-level model, is written as follows:

$$\boldsymbol{Network}_{ijk} = \beta_0 + \boldsymbol{s1}_{ijk}v_{1k} + \boldsymbol{s2}_{ijk}v_{2k} + \cdots + \boldsymbol{s20}_{ijk}v_{20k} + u_{jk} + e_{ijk}$$

Where $\boldsymbol{Network}_{ijk}$ is the observed network characteristic value of firm-year *i* in firm *j* in the single artificial super cluster (manufacturing industry) *k*, β_0 is the mean score across all firms and all industries, $\boldsymbol{s1}_{ijk}, \boldsymbol{s2}_{ijk}, \ldots, \boldsymbol{s20}_{ijk}$ are the specific industry indicator variables, one for each industry, $v_{1k}, v_{2k}, \ldots v_{20k}$ are the level 3 random coefficients which give the industry effects, u_{jk} is the effect of firm *j* and e_{ijk} is the firm-year level residual error term. Thus, the cross-classified model employed in this dissertation allows for the non-hierarchical nature of the data.

A hierarchical modeling approach was utilized, allowing for comparisons of nested models. The first model contained only control variables, while subsequent models added one theoretical variable of interest. As each model was compared, "evidence of incremental prediction beyond all recognized controls is strong evidence that an IV has utility" (Carlson & Wu, 2012, p. 418). Model fit was compared using a Likelihood Ratio test, which indicates if the nested model provides a significant improvement over the previous model. This structure of modeling also allows for multicollinearity to be observed, as if an added variable is not significant, yet there is a significant improvement in the model, there may be evidence of multicollinearity (Rowley et al., 2005). This approach was applied to all models necessary for the testing of the hypotheses. That is, for each unique dependent variable, a baseline model containing only control variables was first run and then compared to subsequent models which added variables of interest.

CHAPTER V: RESULTS

The purpose of this chapter is to provide results of the analyses. First, the descriptive statistics and correlations are provided. Subsequently, the results for each hypothesis are reported, along with a short interpretation of results. For reference purposes, a summary of all hypothesis tests can be found in Table 5.9. The discussion chapter (Chapter VI) discusses the general findings in more detail.

The descriptive statistics and correlations for the overall sample of firms are presented in Table 5.1. It is worth noting that all 25 years of data were utilized in Table 5.1, thus it presents the descriptive statistics and meaningful correlations for all data analyzed. Within the data, there were multiple correlations above 0.70, indicating potential issues with multicollinearity. Four correlations were greater than 0.98, indicating almost a perfect correlation. The four sets of highly correlated variables were as follows: 1) between the firm network size (t+5) and firm network beta centrality (t+5) (r = 0.995), 2) between firm patent volume and firm knowledge asset value (patent originality) (r = 0.991), 3) between firm patent age and firm age (r = 0.988), and 4) between firm network size (t1) and firm network beta centrality (t1) (r = 0.993). The high correlation between firm network size and firm network beta centrality is not an issue for analysis, as these two dependent variables are not present in the same models. Two other sets of variables were also highly correlated: 1) Firm size and R&D expenses (r = 0.825) and 2) knowledge asset value (patent originality) and the future value of knowledge asset value (patent originality, t+5) (r = 0.881).

Consequently, variance inflation factors (VIFs) for these variables were obtained to ascertain if multicollinearity was an issue. Firm network size and firm network beta centrality resulted in a VIF of 33.55, exceeding 10.0 and indicating collinearity (Hair et al., 2010). The result for the collinearity tests of firm patent volume and knowledge asset value (patent originality) was a VIF equal to 60.33, again outside of the boundaries. The result for the collinearity tests of firm patent age and firm age also indicated an issue with multicollinearity (VIF = 31.97). VIFs were tested with each dependent variable used in the first section (network degree, intensity, structural holes, and beta centrality) with similar results. Furthermore, it was noted that firm performance was collinear with the intercept term. This is indicating that the intercept is capturing the variance found in firm performance. Since running the models with either effect omitted returned the same pattern of results, the intercept was included and firm performance was dropped from all models. There were two correlations that were highly significant (r >0.80), yet results from collinearity tests revealed that both VIF values were within guidelines. First, the variables Firm size & Firm R&D resulted in a VIF value of 4.40, while analysis on the variables of patent originality and patent originality (t +5, used in H8) resulting in a VIF value of 4.78. Therefore, these variables were included in all models. In summary, it was determined that the four variables of firm network beta centrality, firm patenting volume, firm performance, and firm age would be omitted from models.

As discussed in the Methods chapter, a multilevel model is proposed due to the nested nature of the data. To confirm that a multilevel model is appropriate, inter-class correlations (ICCs) were calculated for all dependent variables (Table 5.2). ICCs for both levels combined (industry and firm) range from 17% to 65%, indicating that a significant portion of the variance is accounted by the group levels. ICCs at each level ranged from 0% to 63%. The low level of the variance reported at the industry level may due to biases in reporting ICCs in cross-classified models, which can result in underestimation of this higher level, and “substantial overestimation of the variance component at the lower level" (Im et al, 2016, p. 12). Thus, as significant variance is explained by both levels, the three-level model was employed for all hypotheses.

Results for Knowledge Asset Value—Network Safeguard Relationships

The first section of the dissertation assessed the relationships between firm knowledge asset value and network safeguards. As discussed previously in the methods chapter, four (4) different network measures were utilized as dependent variables; network size, relationship intensity, structural holes, and beta-centrality. As such, multiple tables are included (Tables 5.3 – 5.6), each depicting results for a separate dependent variable. The independent variables of interest are the two measures of firm knowledge asset value; the first measuring the patent originality, and the second measuring the patent market value[6].

Hypothesis 1 stated that there is a negative relationship between firm knowledge asset value and subsequent network size. As discussed in the methods section, this is a 2-level model, with industry at Level-1, firm at Level-2, and the firm-year observations as fixed effects. Model 1 (Table 5.3) included all control variables, and indicates significant relationships between firm network size (t=0) (β = 0.324, p < 0.001), and firm network structural holes (t=0) (β = 2.045, p < 0.001), on subsequent firm network size (t+5). Furthermore, the number of firms present in the whole network (all firms in alliances within the SIC code) has a significant relationship with subsequent firm network size (β = 0.003, p < 0.001). For Hypothesis 1 (Table 5.3, Model 2), results indicate the presence of a significant negative relationship between firm knowledge asset value and network size for patent originality (β = -0.01050, p < 0.001) as well as patent market

[6] From this point forward, the knowledge asset value variable using a measure of patent originality will be referred to as 'patent originality', while the knowledge asset value variable using a measure of patent market value will be referred to as 'patent market value'.

value (β = -0.00017, p < 0.001), indicating support for Hypothesis 1.

Hypothesis 2 hypothesized a negative relationship between firm knowledge asset value and subsequent network intensity, indicating that the network will be comprised of higher-intensity relationships. Model 1 (Table 5.4) included all control variables, applying the same 3-level model as utilized in Hypothesis 1, and indicates multiple significant relationships between the control variables and subsequent firm network intensity. Interestingly, as compared to the Model 1 in Table 5.3 (subsequent firm network size), many firm-level variables were significant with the dependent variable, including firm R&D expenses (β = -0.329, p < 0.001), firm size (β = 0.236, p < 0.01), and firm slack (β = -0.442, p < 0.01). The network intensity measure uses the mean intensity of all relationships for firm *j* in year *t* and industry *i*. Thus, the interpretation requires that the beta coefficient will be positive in order to support the hypotheses, indicating an increase in the intensity of relationships. Results provided in Model 2 indicate that neither independent variable is significantly related to subsequent firm network intensity, and thus, hypothesis 2 is not supported.

Hypothesis 3 stated that there is a negative relationship between firm knowledge asset value and subsequent volume of structural holes, measured as the level of constraint in the network. Model 1 (Table 5.5) included all control variables, applying the same 3-level model as previous hypotheses. Multiple significant relationships are present in the control model. Of interest are significant relationships between firm network size (t=0) (β = 0.011, p < 0.001), and firm network structural holes (t=0) (β = 0.171, p < 0.001), on subsequent firm network structural holes (t+5), indicating the role of path dependence on network structure. Results depicted in Model 2 indicate that neither firm knowledge asset value measure is significantly related to subsequent firm network structural holes, indicating no support for Hypothesis 3.

Hypothesis 4 stated that there is a negative relationship between firm knowledge asset value and subsequent network beta centrality. Model 1 (Table 5.6) included all control variables, applying the same 3-level model as previous hypotheses, and shows a similar pattern of network characteristics impacting subsequent firm network beta centrality (network size $\beta = 0.391$, $p < 0.001$, network structural holes $\beta = 2.586$, $p < 0.001$). Results in Model 2 suggest a significant negative relationship between patent originality and network beta centrality ($\beta = -0.01273$, $p < 0.001$), as well as a significant negative relationship with patent market value ($\beta = -0.00009$, $p < 0.05$), resulting in full support for Hypothesis 4.

Summary and Interpretation

In summary of the results of the direct hypotheses, both Hypothesis 1 and 4 were fully supported. Hypothesis 1 stated that a negative relationship is present between firm knowledge asset value and subsequent network size, which was supported by both knowledge asset value measures. For this hypothesis, the results indicate that a one-unit increase in patent originality will decrease subsequent firm network intensity by -0.01050 units. The measure of patent originality is not easily interpretable, as it measures the range of fields referenced in patent citations. Thus, a patent that cites a wide set of technologies will have a higher originality score. The measure used in this analysis is the total firm originality score (sum of all patents' originality scores), as it endeavors to capture the full originality present in the firm's knowledge. The range of values was from 0 to 1067 (before centering) with an average of 44, and a standard deviation of 107, indicating most firms had a lower patent originality value. The outcome is that firms having a patent originality value one standard deviation higher than average would have a network size approximately one member smaller than average, suggesting a practically significant outcome.

Hypothesis 1 was also supported by the measure of patent market value, which is measured in dollars. Thus, the outcomes propose that for each dollar increase in firm knowledge asset value, firm network size will decrease by 0.00017. While the coefficient is small, the patent market value measure has a standard deviation of approximate 3,300. Thus, for a firm with an overall knowledge asset value of $5,300 above average, the subsequent network size will be reduced by ½ a member. As the range of possible values is over $100 million, higher values of patent market value could negatively impact network size to a significant level.

Hypothesis 4 stated that a negative relationship is present between firm knowledge asset value and subsequent firm beta centrality, which was supported by both knowledge asset measures. The relationship between patent originality and subsequent firm beta centrality results in a 1.3-unit decrease in subsequent firm beta centrality for a firm one standard deviation above the mean in patent originality (subsequent firm beta centrality *mean*= 5, *s.d.*=6.74). The practical significance is more difficult to ascertain, as firm beta centrality is a relative value, however, this indicates that firms with higher than average patent originality value will have less densely connected networks. The relationship between patent market value and subsequent firm beta centrality is not as strong, as only a 0.3-unit decrease is found if a firm's patent market value is one standard deviation above average. Thus, a strong increase in patent market value is necessary to practically impact a firm's subsequent beta centrality.

Results for Industry Moderating Effects

High-technology industries

Hypothesis 5 proposes a moderating relationship, such that in industries where knowledge is perceived as more valuable (i.e., high technology industries), the relationships between firm knowledge asset value and subsequent network size (H5a), network intensity (H5b), network closure (H5c), and beta centrality (H5d) will be stronger. As the measure for high-tech industry is coded as 1 for high-technology industries and 0 for non-high-technology industries, a negative interaction term will indicate support, except for H5b where higher values of network intensity indicate an increase in network safeguards. For example, if the regression coefficient for an interaction term is -0.87 and we assumed all observed values were equal except high- vs low-tech industry. Then, the predicted value for a network safeguard measure (e.g., network size) would 0.87 smaller for firms in high-tech industries compared to low-tech industries (industries were coded as 1 for high tech and 0 for low-tech).

Results for H5a (Model 3, Table 5.3) indicates high tech industry has a significant *positive* moderating effect on the patent originality—firm network size relationship ($\beta = 0.00627$, $p < 0.001$), and thus in the opposite direction hypothesized. Furthermore, there was not a significant relationship present with the patent market value x high-technology measure. Thus, H5a is not supported.

Results for H5b (Model 3, Table 5.4) indicates that high tech industry significantly moderates the relationship between firm knowledge asset value variables and subsequent firm network intensity (patent originality x high-technology industry $\beta = 0.00226$, $p < 0.001$; patent market value x high-technology industry $\beta = -0.00006$, $p < 0.01$), though the relationship with patent originality value is in the opposite direction of what was hypothesized. Thus, Hypothesis 5b is partially supported by the patent originality IV.

Results for H5c (Model 3, Table 5.5) indicates that high-tech industry does not significantly moderate the relationship between patent originality and subsequent firm network structural holes, while high-tech industry did significantly moderate the relationship between patent market value and subsequent firm network structural holes ($\beta = 0.00001$, $p < 0.01$), though in the opposite direction of what was hypothesized. The figure (Figure 5.1, third row) indicates that the variance is located in firms that are in industries not considered high-technology industries, counter to the relationship hypothesized. Therefore, H5c is not supported.

Results for H5d (Model 3, Table 5.6) indicates a significant relationship between patent originality and subsequent firm network centrality when moderated by high-tech industry (patent originality $\beta = 0.00760$, $p < 0.001$), though the relationship is in the opposite direction of what was hypothesized. Therefore, H5d is not supported.

Summary and Interpretation. Overall, there is limited support for Hypothesis 5a-d, with only one hypothesis supported by one measure. All significant relationships are shown in Figure 5.1, including those not in support of the hypotheses. The outcome for the supported hypothesis is that firms in high-technology industries have a positive relationship between patent originality and subsequent network intensity (as shown in Figure 5.1, second row and column), indicating that overall, firms in high-technology industries do not have a stronger relationship between knowledge asset value and network safeguards than firms in non-high-technology industries.

Figure 5.1 depicts significant relationships that did not support the hypothesized relationships, yet still tell an interesting story. For example, while firms in high-technology industries do not have a significantly stronger negative relationship between knowledge asset value and subsequent firm network size than firms in non-high-technology industries. The coefficient for the high-tech industry variable indicates that high-technology firms have, on average, 3.5 fewer relationships than their non-high-technology counterparts ($\beta = -3.510$, $p < 0.001$). Another interesting result is found for non-high-technology industries is the relationship between patent market value and network intensity. As Figure 5.1 (second row & column) indicates, firms not in low-technology industries show an increase in network intensity as patent market value increases. Thus, counter to expectations, low-technology firms have stronger network relationships as their knowledge value increases. Also, the volume of structural holes decreases as patent market value increases for low-technology firms, but not for high-technology firms. These results will be discussed further in the discussion chapter.

Industry dynamism

Hypothesis 6 proposes that the level of industry dynamism will moderate the relationships between firm knowledge asset value and subsequent network size (H6a), network intensity (H6b), network closure (H6c), and beta centrality (H6d), such that the strength of the relationships will increase with the level of dynamism. Results for H6a (Model 6, Table 5.3) indicates a significant relationship between the patent originality–dynamism interaction term and subsequent firm network size ($\beta = 0.00295$, $p < 0.01$), though not in the proposed direction. H6a is not supported.

Results for H6b (Model 4, Table 5.4) indicates no significant relationships between the variables of interest, and is therefore not supported. Results for H6c (Model 4, Table 5.5) indicates that dynamism has a positive significant relationship on the relationship between patent originality and subsequent network structural holes ($\beta = 0.00021$, $p < 0.001$), though again not in the hypothesized direction. Furthermore, dynamism did not significantly impact the relationship between patent market value and subsequent network structural holes. The graph in the third row of Figure 5.2 indicates that firms in industries with low dynamism have a stronger relationship between firm knowledge asset value and subsequent structural holes compared to firms in industries with high levels of dynamism, a relationship that will be discussed further in the next chapter. Results for H6d (Model 4, Table 5.6) indicates a significant relationship with the moderated patent originality and subsequent network structural holes (β =0.00405, p < 0.01), though again not in the hypothesized direction, and no significant relationship with patent market value. Thus, Hypothesis H6d is not supported.

Summary and Interpretation. Overall, there is no support for Hypotheses 6a-d. Figure 5.2 depicts all significant relationships and indicates that while the high levels of dynamism do not impact the relationship between knowledge asset value and subsequent network safeguards as hypothesized, there is a significant difference in intercept for network safeguards (except network intensity). This indicates that firms in more dynamic industries have significantly smaller subsequent firm network size ($t_{(10664)}$=-2.37, p>0.05), structural holes ($t_{(10662)}$=-2.55, p>0.05) and beta centrality ($t_{(10636)}$=-2.13, p>0.05). Furthermore, as Figure 5.2 depicts, dynamism moderates the relationship between knowledge asset value and structural holes predominantly for firms located in industries depicting low dynamism, counter to the hypothesized relationship. This may indicate that firms in industries characterized by lower dynamism may be able to gain value from their knowledge over a longer time and thus can reduce their structural holes with the goal of protecting their knowledge.

Industry munificence.

Hypothesis 7 proposes that the level of industry munificence will moderate the relationships between firm knowledge asset value and subsequent network safeguards (size (H7a), network intensity (H7b), network closure (H7b), and beta centrality (H7d)), such that the strength of the relationships will *decrease* with the level of industry munificence. That is, munificent environments will lead to a reduction in network safeguards, as all firms can benefit under conditions of munificence (Schoonhoven et al, 1990). Thus, a positive coefficient (except for network intensity) is hypothesized. Results for H7a (Model 5, Table 5.3) indicates that munificence significantly moderates the relationship between patent originality and subsequent firm network size (β = 0.00022, p< 0.05). However, a slope difference test indicates that the slopes are not significantly different (t=1.71, p>0.05) leading to the hypothesis being rejected. Additionally, including munificence as a moderator does not significantly affect the relationship between patent market value and subsequent firm network size. Thus, H7a is not supported.

Results for H7b (Model 6, Table 5.4) and H7c (Model 5, Table 5.5) indicate that munificence does not have a significant effect on the relationship between either knowledge asset value measure and the subsequent network safeguards of interest, and therefore these hypotheses are not supported.

Results for H7d (Model 5, Table 5.6) indicates that munificence has a significant effect on the relationship between patent originality and subsequent beta centrality (β = 0.00025, p < 0.05). Figure 5.3 depicts the relationships found in H7d for the patent originality measure, yet a slope difference test indicates that there is no significant difference between slopes (t=0.003, p>0.05). However, results for H7d utilizing the patent market value measure do indicate a significant relationship in the opposite direction hypothesized (β = -0.00002, p < 0.001), with a significant difference in slopes (t=3.93, p>0.001). Thus, counter to expectations, it is firms occupying industries characterized by low munificence (and thus, increased competition) who illustrate a stronger relationship between knowledge asset value and subsequent beta centrality as compared to firms in highly munificent industries.

The intercept for firms in highly munificent environments is lower than firms in environments characterized by low munificence, specifically for subsequent network size (β = -

0.22, $p>0.01$), structural holes (β = -0.03, $p>0.05$), and beta centrality (β = -1.79, $p>0.01$). While intercept differences were not hypothesized, the argument in this dissertation focused on the lack of knowledge protection necessary in highly munificent environments, leading to a weaker relationship between knowledge asset value and subsequent network beta centrality for firms in highly munificent environments. However, this result was not supported by in the data, but rather an overall increase in multiple network safeguards for firms in highly munificent environments as compared to firms in less munificent environments. This finding may indicate that firms in highly munificent environment may not rely on interfirm networks to gain knowledge due to the lack of competitive pressure. These findings will be discussed further in the discussion chapter.

Summary and Interpretation. Overall, there is little to no support for Hypothesis 7, with only H7d having a significant relationship in the hypothesized direction, yet post hoc analysis did not find a significant difference between the slopes of firms in highly munificent environments as compared to those characterized by low munificence. These findings will be discussed further in the next chapter.

Results for Relationships between Firm Network Characteristics and Future Knowledge Asset Value

Hypothesis 8 states that network size (H8a), network intensity (H8b), structural holes (H8c), and beta centrality (H8d) have a curvilinear (inverted-U) relationship with subsequent knowledge asset value. For Hypothesis 8, a separate dataset was created to allow for analysis of how network characteristics that may safeguard knowledge can impact future knowledge asset value (See Chapter IV - Methods for details). Models were run for each knowledge asset value (patent originality & patent market value) independently. As these variables are not highly correlated (*r*=0.086), it was not possible to create a factor variable. Furthermore, multivariate analysis is not possible due to the cross-classified structure of the data.

Table 5.7 (Models 1 – 5) provides results for the relationships for the dependent variable of subsequent knowledge asset value based on patent originality. Only two network characteristics produced significant results; network size (network size squared β = -0.025, $p <$ 0.01) and network beta centrality (network beta centrality squared β = -0.015, p < 0.01). Applying Aiken & West's (1991) equation allows for the determination of the maximum point ($X = -b_1/2b_2$) to determine the maximum point results in a value of 36.3 for network size. For network size, the inflection point is 36.3, within the meaningful range (range = 1 – 108), while for network beta centrality, the inflection point is 48.4, which is also within the meaningful range (range = 1 – 124).

Table 5.8 provides results for the relationships that used the dependent variable of subsequent knowledge asset value based on patent market value. Only one subsequent network characteristic, structural holes, had significant relationships (network intensity squared β = 4753, p < 0.05). However, this relationship is in the opposite direction of what was hypothesized, as is illustrated in Figure 5.4 (third row). The figure illustrates that while there is a reduction in subsequent knowledge asset value at low numbers of structural holes, there is a strong increase in a firm's subsequent knowledge asset value as structural holes are added to a firm's network. This finding will be examined further in the discussion chapter.

Summary and interpretation. Figure 5.4 (first row and last row) provide graphs that illustrate the relationship. As proposed in H8a, there is a curvilinear relationship present whereby neither small nor large network sizes provide the optimal results regarding future knowledge asset value.

These charts indicate that firms with very large interfirm networks (low protection) have a reduced future firm knowledge asset value while smaller interfirm networks (high protection) have higher levels of future knowledge. However, as hypothesized, there is a tail whereby an interfirm network that is too restricted reduces future firm knowledge asset value, possibly due to limiting the availability of external knowledge. This finding, and the opposite finding for the relationship between structural holes and subsequent firm knowledge asset value, will be discussed further in the next chapter.

Results of Post Hoc Tests

Based on the inconsistent and predominantly non-significant findings for the network intensity safeguard, two post hoc tests were conducted. The first post hoc test dichotomized the Nohria & Garcia-Pont (1991) scale to categorize equity vs non-equity investments. Therefore, distribution agreements, know-how and patent licensing agreements, component sourcing agreements and broad R&D agreements (items 1-5) were all categorized as 0, while minority equity, limited cross-equity ownership, and independent joint ventures (items 6- 8) were categorized as 1 (item 9 is mergers and acquisitions, not included in this research). This measure resulting in two significant results. For Hypothesis 2 (Table 5.10, Model 2), results indicate the presence of a significant positive relationship between firm knowledge asset value (patent originality) and network intensity ($\beta = 0.00024$, $p < 0.05$). The only other significant result was not in the hypothesized direction.

The second post hoc test used a different measure of network intensity, which indicated whether the relationship was a joint venture or an alliance. The SDC dataset includes flags for whether the relationship is categorized as a strategic alliance or a joint venture. These flags are mutually exclusive in the data included in this research. Thus, a dichotomous measure was created that was 0 if the relationship was a strategic alliance, and 1 if the relationship was a joint venture. Results using this measure were somewhat more consistent, with three significant relationships, two of which are supporting the hypotheses. For Hypothesis 2 (Table 5.11, Model 2), results indicate the presence of a significant positive relationship between firm knowledge asset value (patent originality) and network intensity, based ($\beta = 0.02755$, $p < 0.05$). Additionally, results indicate that the high technology industry measure significantly moderates the relationship between firm knowledge asset value and subsequent levels of equity relationships (patent originality x high-technology industry $\beta = 0.04099$, $p < 0.05$), indicating the firms operating in high-technology industries significantly increase their levels of equity relationships as their knowledge asset value increases. Finally, results indicate that the munificence significantly moderates the relationship between firm knowledge asset value and subsequent levels of equity relationships (market value x munificence $\beta = 0.00008$, $p < 0.05$). As most significant results in this research that included the moderator of munificence were in the opposite direction of what had been hypothesized, the presence of this relationship does not indicate an issue with the measure, but rather the theoretical explanation provided in this dissertation.

Summary. The post hoc tests indicate that the measure developed using the SDC information regarding whether the relationship was considered a joint venture or not provided an increased volume of significant results. However, as found with all the network safeguards included in this research, there is still extensive research necessary to understand the nature of these relationships. Future research may improve our understanding of network intensity by measuring the intensity level of interfirm networks using primary or case study data.

CHAPTER VI

DISCUSSION AND CONCLUSION

Networks provide access to knowledge, supporting knowledge acquisition and generation via relationships intended to exchange knowledge. Conversely, knowledge can be shared unintentionally with network partners through knowledge spillovers. Knowledge spillovers are generally considered as a positive outcome for the recipient of the knowledge, and a broad stream of research has examined both the firm and the geographical levels of analysis (e.g., Agarwal et al, 2007, 2010; Audretsch & Keilbach, 2007; Delmar et al, 2011). However, this dissertation seeks to examine gaps in extant research regarding possible negative outcomes from the perspective that networks may provide the potential for firms to lose knowledge, whereby the knowledge originator is un- or under-compensated (Agarwal et al, 2010). As firms learn and gain knowledge from each other, the knowledge transfer that occurs may be unintended, resulting in a loss of both knowledge and the rents resulting from the knowledge assets (Peteraf, 1993) for the knowledge-originating firm. While firms seeking knowledge may strategically broaden their interfirm network, those firms already in possession of valuable knowledge may aim to protect their knowledge asset and restrict opportunities for knowledge spillovers by utilizing network safeguards. Indeed, while knowledge spillovers generate benefits for the recipients (Agarwal et al, 2007, 2010; Audretsch & Keilbach, 2007; Delmar et al, 2011), research has been relatively silent on the negative effects on the knowledge originating firms.

In this chapter, the first section discusses the findings and potential contributions of this research. Next, the limitations of the study are considered, followed by the implications for both research and practice. Finally, the conclusion of this dissertation is provided.

Network Safeguards: Direct Effects

After testing the direct relationships between firm knowledge asset value and networks safeguards, results indicated two significant relationships. Specifically, the results indicate that both measures of firm knowledge asset value (i.e., patent originality and patent market value) were negatively related to network size and beta centrality. These findings suggest that firms seek to protect their knowledge by restricting the volume of interfirm relationships as well as limiting their indirect contact to external firms. Thus, firms with higher levels of knowledge asset value had smaller network size and reduced beta centrality, protecting their knowledge via reducing the risk of knowledge spillovers. An examination of how network safeguards (or the lack thereof) impact future knowledge asset value is discussed further in this chapter.

There was no significant relationship found between knowledge asset value and network intensity. A general explanation may be explained by the significant relationships between knowledge asset value and network size and beta centrality. That is, firms may choose the option of reducing their network size to produce the same outcomes as increased intensity though via a different mechanism. Indeed, a smaller network can increase the monitoring capability of the firm, in essence utilizing monitoring of a restricted number of partners versus employing relational governance mechanisms based on strong-tie relationships that promote trust and reciprocity between partners. Future research may support this suggestion that decreasing network size diminishes the necessity to increase relationship intensity.

There was also no significant relationship found between knowledge asset value and structural holes, though there may also be an explanation found in the significant relationship between firm knowledge asset value and beta centrality. A reduction in beta centrality indicates that the number of indirect relationships has been decreased, which would also occur with a reduction in the number of structural holes. While a reduction in structural holes would signify that firms are aware of the potential for knowledge spreading to other networks and not only other firms, a reduction in beta centrality suggests that indirect relationships are a concern for firms, regardless of their location within the complete network.

Network Safeguards: Moderated Effects

The first hypothesis examining industry characteristics hypothesized the relationship between knowledge asset value and network safeguards would be stronger in high-tech industries compared to non-high-tech industries. Only one supported relationship was found (high technology industry moderated the relationship between patent originality and network intensity). However, the results supporting the hypothesis are somewhat problematic, as the results for the patent market value measure are opposite of what was found with the patent originality measure. The graph depicting the supported relationship (Figure 5.1, second row) indicates that firms in high technology industries had a *stronger* relationship between patent originality and future network intensity as compared to firms in non-high-technology industries, while the opposite relationship was found with the patent market value measure. The divergence in results produced by the two knowledge asset value measures is potentially worthy of future research and is discussed further in the limitations section.

Except for the network intensity dependent variable, there were multiple significant relationships found with the high-technology moderator. Hypotheses stated that firms in high-technology industries would have a stronger relationship between firm knowledge asset value and network safeguards. This may indicate that firms in high-technology industries value knowledge higher than firms in non-high technology industries (Tatarynowicz et al., 2016). By protecting their knowledge, firms would have the ability to increase and extend their competitive advantage, as knowledge generation is a long, slow process due to its path-dependent nature and the time involved in generating knowledge. However, results indicate a stronger relationship between firm knowledge asset value and the network safeguards of network size, structural holes, and beta centrality in non-high-technology industries. These results seem to indicate that it is firms in non-high-technology industries that seek to protect their knowledge as their knowledge value increases. While this is counter to the hypotheses, the picture becomes somewhat clearer when it is noted that the intercept for firms in high-technology industries is significantly lower than for firms in non-high-technology industries. These results suggest that firms in high-technology industries may be aware of the risk of knowledge spillovers via their interfirm network and therefore employ network safeguards due to the competitive environments typically found in high-technology industries (Appleyard, 1996). In contrast, firms in non-high-technology industries become increasingly aware of the need for network safeguards as their knowledge value increases. As this finding was not hypothesized, it may be worthy of further research.

There were no supported hypotheses when industry dynamism was included as a moderator, though there were three significant relationships with network safeguards (i.e., network size, beta centrality, and structural holes). While dynamism significantly affects the relationship between knowledge asset value and firm network size and beta centrality, there were no significant slope differences present. For the network safeguard of structural holes, the inclusion of industry dynamism did significantly moderate the relationship, though not in the predicted direction. Indeed, there was a stronger negative relationship between knowledge asset value and structural holes for firms in industries characterized by *low* dynamism (Figure 5.2). This is counter to the hypothesized relationship which proposed that higher levels of industry dynamism would strengthen the relationships between knowledge asset value and network safeguards. Based on these findings, it is firms in less dynamic industries that have a stronger relationship between knowledge asset value and network safeguards (i.e., reduced structural holes) in contrast to the firms in highly dynamic industries. Firms in highly dynamic industries may be aware of the risk and the negative effects of knowledge spillovers regardless of their knowledge asset value, which is indicated by the significant difference in the intercept. As dynamism indicates a rapidly changing environment as illustrated by the frequency, intensity, and unpredictability of changes (Castrogiovanni, 2002; Child, 1972), all firms in highly dynamic industries may be responding to the uncertainty by increasing their protection of their knowledge. In contrast, the risk of losing knowledge may only become important to firms in less dynamic industries as they are amassing higher levels of knowledge asset value. Thus, firms in less dynamic industries with low levels of knowledge asset value may not be concerned with knowledge spillovers and can explore new knowledge sources via structural holes, yet once they accumulate higher levels of knowledge asset value, the threat of knowledge spillovers leads to stronger network safeguards. Similar to the results for the high-technology moderator, differences in the intercepts were not hypothesized but may be worthy of future attention.

The hypotheses regarding industry munificence stated that industry munificence would weaken the negative relationship between knowledge asset value and network safeguards, as highly munificent environments would reduce the need to implement network safeguards and protect knowledge. While the results indicated the presence of three significant relationships, tests revealed that two had no significant difference between the slopes of the highly munificent industries as compared to the less munificent industries (network size and beta centrality using patent originality measure). The third significant relationship was in the opposite direction of what had been hypothesized (the patent market value—beta centrality relationship), indicating that industry munificence significantly affected the relationship between knowledge asset value and beta centrality, yet the relationship did not weaken for firms in highly munificent industries. In contrast, it was firms in *less* munificent environments that increased their beta centrality as their knowledge asset value increased. Firms in *high* munificent environments maintain their focus on the risk of knowledge spillovers, maintaining the negative relationship between knowledge asset value and beta centrality. An explanation may be that the munificence measure is more reflective of another industry characteristic, specifically industry age. Munificence is negatively related to the age of an industry (Castrogiovanni, 2002), suggesting that industries with high munificence may also be young industries. As firms are highly protective of their knowledge in a new industry due to the advantages of establishing prominence (Argyres, Bigelow, & Nickerson, 2015; Lieberman & Montgomery, 1988), the munificence measure may be operating as a proxy for industry age. In partial support of this argument, there is a negative correlation between munificence and firm age (r=-0.183, p<0.001), indicating that younger firms are in more munificent environments. Further research examining the impact of industry age on network safeguards may provide clearer answers to the impact of munificence on the relationship between knowledge asset value and network safeguards. Firms may also be entering into new markets due to their munificent environments (Zachary, Gianiodis, Payne, & Markman, 2014), which may be confounding results.

Overall, findings on the moderated relationships suggest, counter to the hypotheses, that the relationship between firm knowledge asset value and network safeguards is impacted by industry characteristics in environments typically regarded as less concerned with the risk of knowledge spillovers (Tatarynowicz et al., 2016). For example, firms in non-high-technology industries indicate a stronger negative relationship between knowledge asset value and structural holes, while firms in high-technology industries had a positive relationship between knowledge asset value and network structural holes. Moreover, dynamism increased the strength of the negative relationship between knowledge asset value and structural holes for firms in *less* dynamic environments as compared to firms in highly dynamic environments. And finally, munificence moderated the relationship between knowledge asset value and beta centrality such that for firms in *less* munificent environments there was a positive relationship, while firms in highly munificent environments had a negative relationship between knowledge asset value and beta centrality. These findings may lead to avenues for future research whereby the impact of increased knowledge value on network safeguards can be explored for firms in low-technology, less dynamic, and highly munificent environments.

Network Safeguards: Future Knowledge Asset Value

The final section of this discussion focuses on the question of whether network safeguards impact future knowledge asset value. As research indicates that interfirm networks support knowledge creation (Patel & Terjesen, 2011; Soh, 2010), network safeguards could negatively impact future knowledge asset value due to restricted networks, and thus, reduced access to knowledge and information. The results support the hypotheses with the presence of a curvilinear effect (inverted U-shape with local maxima) of network size and of beta centrality. Graphs illustrating these relationships (Figure 5.4) suggests patent originality is maximized at intermediate levels of network safeguards that prevent knowledge spillovers. Thus, when network protection is low (network size is high) or when network protection is high (network size is low), future patent originality will be reduced as compared to the inflection point. For both network safeguards (network size and beta centrality), the inflection point is closer to the high protection (low network size) end of the curve, potentially indicating the knowledge protection can play a significant role in safeguarding future knowledge asset value. That is, while research has supported the effect of interfirm networks on knowledge creation and innovation (e.g., Hardy et al, 2003; Soh, 2010), my findings suggest firms find that maintaining key relationships while simultaneously confining network size and firm beta-centrality within the network may provide optimum results. Thus, this research supports both findings; interfirm networks can facilitate knowledge creation, yet large networks may also negatively impact future knowledge creation due to knowledge spillovers. While there are other factors that impact knowledge creation which have not been addressed in this study, such as a firm's absorptive capacity (Penner-Hahn & Shaver, 2005; Wuyts & Dutta, 2014), these early results may provide future avenues for research.

Another opportunity for future research would be the inclusion of environmental moderators while examining the curvilinear relationship. As results from the moderated results indicate that the industry characteristics and environment play a role in the relationship between firm knowledge asset value and network safeguards, this finding could be examined in more detail to potentially explain the results counter to those hypothesized. That is, would both high- and non-high-technology industries illustrate this same curvilinear relationship? For example, firms in high-technology and highly dynamic industries may not have this curvilinear relationship (or a weaker tail) as the need to develop new knowledge pushes firms to develop networks capable of generating new knowledge, regardless of the potential for negative knowledge spillovers.

Interestingly, the curvilinear relationship between structural holes and future knowledge asset value is the opposite of what had been hypothesized for the patent market value measure of knowledge asset value, with a U-shaped outcome, versus an inverted U-shape as hypothesized. With structural holes as the predictor, the balanced approach results in the lowest future value of knowledge assets. Figure 5. 4 (second column) indicates that firms produce the highest levels of patent market value when structural holes are at their greatest (low protection) and that lower volume of structural holes (higher protection) produce higher values of patent market value as compared to the inflection point. While these findings support theory that proposes a positive relationship between structural holes and innovation levels (Burt, 2000, 2001), the findings additionally support that infirm networks with highly limited structural holes may gain more future knowledge asset value as compared to the balanced approach, perhaps due to the protection mechanism. Again, this analysis was conducted with the full dataset, leaving unanswered the question of whether this relationship will be sustained under various environmental conditions. This finding is worthy of future research in order to understand the drivers behind this unexpected curvilinear relationship.

Limitations

This dissertation does have limitations that could be addressed by future research. The goal of the dissertation was to delve into the relationships between a firm's knowledge asset value and network safeguards. While initial results are promising, this stream of research provides many opportunities for future research. By acknowledging the limitations present in this study, future research may lead to a more precise finding. Four primary limitations are addressed in this section.

The first limitation is the intensity measure utilized in this research (Nohria & Garcia-Pont, 1991). The intensity scale was originally developed for use within the auto manufacturing industry (scale provided in Table 6.1), though this measure has been used in management research in other industries (e.g., Gnyawali, He & Madhavan, 2006; Koka & Prescott, 2008). However, the categorization of low to high alliance intensities may be somewhat specific to the automotive industry and could be argued to not apply directly to other industries, specifically high-technology industries that are often removed from discrete manufacturing processes. Specifically, the categorizations of ‘component sourcing agreements’ and ‘second source agreements’ do not apply to all industries, leading to gaps in the rankings. Furthermore, the higher levels of intensity relate to whether equity is involved, rather than the scope of the alliance; this may be a separate measure of intensity. For future research, it is proposed that this one measure may be capturing two separate constructs; the primary objective of the relationship and the level of integration. Hence, separating this scale into two measures could provide one measure that indicates the type of alliance (e.g., distribution or co-development), and a separate measure providing the level of integration (e.g. non-equity or joint-venture). The conflating of these two elements of intensity into one measure may have contributed to the lack of coherence in the results. Recent research has examined the impact of non-equity relationship vs equity relationships on the relationship between knowledge protection and knowledge spillovers (Shu et al, 2014), yet did not include the purpose or type of the relationships (distribution, licensing, etc.). The inclusion of industry measures in the analysis could clarify the relationships between the key constructs of interest.

The second limitation may be considered an avenue for future research, more than a limitation, and was the decision to only examine a subset of potential network safeguards. While these characteristics were included due to their theoretical relevance, there are other network safeguards that may also be explained by the presence of firm knowledge asset value. For example, betweenness centrality is a measure that has been included in strategic management research (e.g. Baum, Cowan & Jonard, 2014; Wincent, Anokhin, Ortqvist, & Autio, 2010), and which may provide further understanding of network safeguards due to their nuanced view of actor centrality. Betweenness centrality measures how often an actor occupies a position along the shortest path between two other actors (Borgatti et al, 2013; Freeman, 1979). With betweenness comes the ability to have some control over the relationship between the other actors (Wasserman & Faust, 2009). This measure can indicate the level of access an actor has to information as well as indicate the degree of control over other actors, both of which are key for discussions focusing on the transfer of knowledge between firms. If overall firm networks were examined, the diversity of the network members (Bruyaka & Durand, 2012) may provide avenues for future research, as the diversity of relationships can increase access to new and novel information. Furthermore, the inclusion of acquisitions by network members may be relevant to this research, as though acquisitions may impact firm performance negatively (Zorn, Sexton, Bhussar, Lamant, forthcoming), acquisition increase firm knowledge. Thus, acquisitions may be an attempt for the focal firm to gain knowledge without the risk of knowledge spillovers, or acquisitions may increase the attractiveness of a potential interfirm relationship due to the increase in the partner's knowledge breadth.

A further network safeguard that could be examined would be the presence of clusters within networks. Clusters could be compared to one another based on the members of the clusters and their attributes, with predicted outcomes. For example, it is intuitive to expect actors within a cluster would share relational characteristics in their interfirm network; either viewed as a source of new knowledge or as a potential for knowledge spillovers. However, empirical research has yet to be undertaken. As this dissertation suggests a balanced approach to interfirm networks is best to gain the future knowledge asset value, variation within and between clusters may benefit from different relational characteristics or network safeguards. While these are avenues for future research, they can also be acknowledged as limitations of this dissertation.

A third limitation is that the two measures of firm knowledge asset value produced different, albeit thought-provoking results. As the correlation between the two measures is low ($r = 0.13$, $p < 0.001$), it is not unexpected that the results diverge. What is surprising is the low correlation between these two measures, which at face value captured the same construct. The knowledge asset value measure based on patent originality is based on the range of patent citations, measuring the breadth and range of knowledge utilized in the patent. However, its high correlation with patent volume may indicate that it is a proxy for the count of patents a firm produces in a given year rather than actually measuring patent innovativeness. If the patent originality measure indicates firm patent volume, it may not be measuring the quality of knowledge produced by a firm as desired, but rather the quantity. Nonetheless, this measure may still be valid, yet indicating the volume, not value, of a firm's knowledge asset. Grant (1985) proposed that there is a relationship between volume of knowledge and a firm's competitive advantage, though the arguments of this dissertation have been primarily viewed from the lens of firms seeking to protect the value of their knowledge, versus the volume. The second knowledge asset value measure used the patent market value of patents, capturing the patent market value added to a firm when the granting of a patent is announced. However, while shareholders may be positive regarding a firm's announcement of a patent granting, the firm itself may not put the same value on the patent. Thus, this measure captures the external value of a firm's' knowledge asset, not an internal measure. While both these knowledge measures have limitations, the inclusion of both measures has provided interesting initial results and avenues for future research to further explore the relationship between these two measures.

Finally, while the dissertation implicitly suggests that firms may choose to alter their network configurations based on their knowledge asset value as a means to safeguard their knowledge, neither change in knowledge or network change was included. While control variables of network safeguards at a previous time period were included to partially respond to this issue, it does not address the implicit goal of firms adapting their networks due to increases in knowledge asset value. Knowledge asset value change was not measured, prohibiting the conclusion that firms *change* their networks due to increases in firm knowledge asset value.

The implicit objective of this area of research is to discover whether firms modify their interfirm networks as their interfirm knowledge increases. To achieve this objective, the researcher would have to measure both knowledge asset value change as well as network safeguard change. If this was achieved, firms' interfirm networks at t_1 (e.g., from low knowledge asset value) could be analyzed, as well as along their path to t_2 (e.g., to high knowledge asset value). This dissertation provides an initial step by examining the relationships between different levels of knowledge asset value and interfirm networks of differing characteristics.

Implications for research

This dissertation sought to examine the relationship between firm knowledge asset value and the subsequent structure of their interfirm network. Specifically, this dissertation was driven by the under-researched question of whether firms in possession of high knowledge asset value may have network structures motivated by knowledge protection goals. This section of the chapter will discuss the theoretical and methodological implications for research in greater detail.

Theoretical implications

The Knowledge Based View of the Firm (KBV) (Grant, 1996a, 1996b; Kogut & Zander, 1996) proposes that knowledge is the preeminent resource of the firm, and further suggests that interfirm networks "may be well suited to the transfer and integration of … knowledge" (p. 383, Grant, 1996b). However, while Grant's (1996b) view of KBV extolls the benefits of networks for quickly accessing external knowledge, it views this relationship solely from the perspective of the knowledge spillover recipient, and does not address the potential loss of knowledge due to knowledge spillovers from the perceptive of the knowledge-originating firm. This afforded an opportunity to draw insights from network perspectives to complement KBV. Interfirm networks allow for knowledge transfer between all firms present in the network and support both intentional and unintentional knowledge transfer. Due to the nature of knowledge, knowledge value may not be appropriated solely by the knowledge originating firm, as value may be gained by other firms from knowledge spillovers due to interfirm relationships. Indeed, firms with high knowledge asset value may seek to implement network safeguards in order to protect their knowledge assets. While this dissertation did not specifically address network change, the results indicate that firms with high knowledge asset value have networks that are smaller and that these firms occupy a less central position, indicative of network safeguards. Thus, this dissertation has provided an indication that while firms use networks to gather and develop knowledge, firms in possession of high knowledge asset value may be seeking to protect their knowledge, realizing the potential for knowledge spillovers. While recent research has supported that firms are aware of the risk of knowledge spillovers (e.g., Phene & Tallman, 2014), research examining knowledge protection has been more focused on the choice between internal and external resources (e.g. Hernandez et al, 2015, Mayer, 2006) as compared to the application of relational and structural network safeguards.

This dissertation also informs network perspectives as it explores conditions under which firms may exhibit different network structures, specifically the possession of high knowledge asset value. This research suggests that network structures are not consistent between firms, but rather that firms may be using their network structure to acquire key firm assets and to subsequently employ network safeguards when protection is a motivator. Network perspectives tend to adopt a static viewpoint regarding network structures. That is, network perspectives seek to explain why actors choose to be part of a dense network along with the commensurate benefits and restrictions, or why actors will choose to have a network that includes multiple structural holes, again with the corresponding rewards and drawbacks. However, these explanations seem to imply that this choice is not revisited over time, but rather is stable once chosen. This dissertation suggests that firms may, and in many cases, should revisit their network structure as this dissertation illustrates different knowledge outcomes of firms with varying levels of network safeguards. Extant research has supported that a firm seeking to increase its knowledge asset value may benefit from an increased network size by providing more options for knowledge acquisition. In contrast, this dissertation's findings suggest firms seeking to protect their knowledge implement network safeguards such as having a smaller network and a less central position in order to protect their knowledge. While recent research has found that firms modify their board networks to protect knowledge from rivals (Hernandez et al, 2015), this research examined the presence of network safeguards to protect their knowledge from their interfirm relationships. While our understanding of the benefits of networks is relatively strong[7], scant attention has been paid to the dark side of interfirm networks. This implies that networks might serve different purposes dependent upon firm's goals of either knowledge acquisition or knowledge protection. Future research may seek to examine network configurations, acknowledging that while certain network configurations increase knowledge outcomes, there may be suboptimal equifinality situation that exists (Payne, 2006) when network safeguards are examined over a long-term period.

Finally, this research includes both KBV and network theoretical perspectives, suggesting that while firms continuously strive to maintain or improve upon their competitive advantage, they are also aware of how other firms may seek to gain an advantage via knowledge spillovers generated in interfirm relationships. By acknowledging that firms may be driven to protect their competitive advantage via their interfirm network, this research combines the economic-focused KBV with the socialized network perspectives, indicating that firms are aware of how network structures may impact their ability to both gain and protect their valuable assets. Attention to the potential for negative outcomes from interfirm networks has increased recently (e.g., Hernandez et al, 2015; Mayer, 2006). This research is an initial attempt to discover if a firm's possession of significant assets is related to their network structure. Future research might also investigate if firms alter their networks as their knowledge assets accumulate, providing a stronger indication of network safeguards at work. This line of research may uncover a wave pattern of network safeguards, as firms may begin by reducing network safeguards as knowledge accumulation and development are the primary drivers, then once knowledge asset value has been increased, firms may implement network safeguards to protect knowledge. However, if the balance of

---

[7] See the literature review by Phelps et al., 2012, and examples of empirical research Dyer and Nobeoka, 2000; Kogut, 2000; Laursen and Salter, 2006 as well as Chapter II)

knowledge accumulation and knowledge protection is not maintained, knowledge asset value may be reduced, indicating a necessity for a reduction of network safeguards once again.

Methodological Implications

Regarding methodological implications, there are three main areas that are important to mention. First, this dissertation included two different measures of knowledge asset value. Measuring firm knowledge is problematic (Ketchen et al, 2013), as knowledge is embedded in both the individuals with the firm and the firm itself can hold valuable information (Spender, 1996), creating challenges to capturing firm knowledge. Furthermore, as knowledge can be in both tacit and explicit forms, measuring the full breadth of knowledge value located within a firm is not feasible beyond the case-study level. Indeed, the goal of this dissertation was not to hypothesize how a firm's ability to generate knowledge would differentiate their network structure, but rather whether a firm's knowledge asset value would be related to their network structure. To address these issues, two different measures of knowledge asset value were included in this research, with the patent originality measure examining the range of knowledge sourced, and the market value measure capturing the potential future value of knowledge as established by the market. The inclusion of two knowledge asset measures allowed for comparisons of findings, but also provided stronger support for the hypotheses when the two measures both indicated significant relationships with the dependent variables. Also relevant is when the two measures diverged in their predictive outcomes, such as the counter-intuitive finding in the relationship between structural holes and subsequent knowledge asset value in the form of the market value measure. While examining validity and reliability of these two measures was outside the scope of this dissertation, the inclusion of multiple knowledge asset value measures has provided intriguing results that may be further explained by future research.

The challenges in measuring firm knowledge have been well documented (i.e., Ketchen et al, 2013) and this research attempted to partially mitigate these concerns by the inclusion of two measures, as well as providing an initial examination of the use of the patent market value measure.

Secondly, the use of the intensity measure in the dissertation and the post hoc tests has implications for future research. As noted in the limitations section, the lack of consistent results found with the Nohria & Garcia-Post (1991) intensity measure may indicate that the measure is capturing both the goal and the structure of the relationship. The majority of issues with this measure were not resolved with the first post hoc test (dichotomizing relationships into equity or non-equity relationships, averaged by firm-year). However, the second post hoc test provided more consistent results, utilizing a dichotomous measure indicating whether each interfirm relationship was a strategic alliance or a joint venture (averaged by firm-year), resulting in multiple significant relationships. These results were in the hypothesized direction, indicating that this measure has a stronger relationship with previous knowledge asset value, the theoretical groundings of this relationship requires further examination. Thus, the use of the Nohria & Garcia-Pont (1991) measure did not seem applicable to multiple industry analysis, as across industries it did not capture network intensity. However, the second post hoc test's network intensity measure did support that firms with high knowledge asset value have higher levels of equity relationships, perhaps to reduce the potential for opportunistic behaviors (e.g., Kale et al, 2000; Lipparini et al, 2014. The use of alliances in interfirm networks as compared to joint ventures in an attempt to protect knowledge may be a fruitful avenue for future research, both qualitative and quantitative, increasing our understanding of how firms view their ability to protect (and gain) knowledge via these two relationship structures.

Finally, the use of the cross-classified dataset may increase the opportunities for researchers to theorize and examine multiple firm networks. By acknowledging that firms have more than one network, this research examines firm relationships focused in specific industry areas, analyzing whole networks whose members can be logically considered as able to engage in relationships with other network members. Specifically, the cross-classified structure acknowledges that firm relationships may reach across internal boundaries, such as diversified business lines, and are not always strictly hierarchical in nature. By analyzing alliance networks, the network included only firm relationships that were focused on the same industry. This necessitated a cross-classified dataset, as firms could be present in multiple industries. Indeed, while the majority of firms were present in only one alliance network (88%), the remainder of firms ranged from two to nineteen alliance networks. The cross-classified dataset allowed for acknowledging the ability for firms to be present in multiple alliance networks, and this dissertation may increase the practice of this methodological approach.

Conclusion

In conclusion, network research is a relatively recent phenomenon of interest, garnering increasing attention in recent years (Phelps et al, 2012). This dissertation sought to expand our understanding of the ‘dark side’ of interfirm networks by acknowledging the risk of losing knowledge value via knowledge spillovers, whereby firm knowledge is transferred without compensation (or with little compensation) to the knowledge originating firm. By viewing networks as both a positive and negative source of knowledge for firms, future research may uncover additional conditions under which firms expand (restrict) their interfirm networks in order to acquire (protect) knowledge. Methodologically, this dissertation broadened the use of multiple network safeguard measures, allowing for comparisons of effects between characteristics.

This dissertation examined the degree to which firms with high levels of knowledge assets implement network safeguards indicative of knowledge protection. Furthermore, it acknowledged the potential effect of industry characteristics on the above-noted relationships, and also examined the long-term effect of network safeguards on future knowledge asset value. A key finding of this dissertation suggests that firms with high knowledge asset value implement network safeguards, suggesting that these firms are protecting their knowledge by reducing the potential for knowledge spillovers. In particular, knowledge asset value had a significant, negative relationship with network size and network beta centrality. This is a central contribution of this dissertation as it acknowledges the awareness of firms that networks can produce negative outcomes in addition to the known, published positive outcomes (e.g., Echols & Tsai, 2005, Hardy et al, 2003, Patel & Terjesen, 2011, Wagner et al., 2014). Indeed, while knowledge spillovers are certainly positive for recipient firms and the regional development of geographic locations (Agarwal et al, 2007, 2010; Alcacer & Chung, 2014; Audretsch & Keilbach, 2007; Delmar et al, 2011), to date, research has been relatively silent on the negative effects of knowledge spillovers for the knowledge originating firms.

While industry characteristics did not impact the relationship between a firm's knowledge asset and network safeguards as hypothesized, the findings do indicate potentially interesting relationships worthy of future research. Finally, a contribution has been made towards uncovering the presence of a curvilinear relationship between network safeguards and future firm knowledge asset value. The goal of these hypotheses was to uncover a situation whereby firms must balance their network safeguards with the goals of gaining and protecting knowledge.

Results suggest that there is an optimum level of network safeguards that allow for interfirm networks to be used as a knowledge resource, while still providing protection for valuable knowledge assets.

REFERENCES

Afuah, A. (2001). Dynamic boundaries of the firm: Are firms better off being vertically integrated in the face of a technological change? *Academy of Management Journal, 44*(6), 1211-1228.

Audretsch, D. B. & Keilbach, M. (2007). The theory of knowledge spillover entrepreneurship. *Journal of Management Studies*, *44*: 1242–1254.

Agarwal, R., Audretsch, D., & Sarkar, M. (2007). The process of creative construction: Knowledge spillovers, entrepreneurship, and economic growth. *Strategic Entrepreneurship Journal*, 1(3-4), 263-286.

Agarwal, R., Audretsch, D., & Sarkar, M. (2010). Knowledge spillovers and strategic entrepreneurship. *Strategic Entrepreneurship Journal*, 4, 271-283.

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, 45(3), 425-455.

Ahuja, G., & Katila, R. (2001). Technological acquisitions and the innovation performance of acquiring firms: A longitudinal study. *Strategic Management Journal*, 22, 197.

Alcacer, J., & Oxley, J. (2014). Learning by supplying. *Strategic Management Journal, 35*(2), 204-223.

Aldrich, H. (1979). *Organizations and Environments*. Englewood Cliffs, NJ: Prentice-Hall.

Alexiev, A. S., Jansen, J., Van den Bosch, F., & Volberda, H. (2010). Top Management Team Advice Seeking and Exploratory Innovation: The Moderating Role of TMT Heterogeneity. *Journal of Management Studies*, 47(7), 1343-1364.

Alexy, O., George, G., & Salter, A. I. (2013). Cui bono? The selective revealing of knowledge and its implications for innovative activity. *Academy of Management Review*, 38, 270-291.

Alnuaimi, T., & George, G. (2016). Appropriability and the retrieval of knowledge after spillovers. *Strategic Management Journal*, 37(7), 1263-1279.

Appleyard, M. M. (1996). How Does Knowledge Flow? Interfirm Patterns in the Semiconductor Industry. *Strategic Management Journal*, *17*(Special Issue: Knowledge and the Firm), 137-154.

Arrow, K. (1962). Economic welfare and the allocation of resources for invention. In *The rate and direction of inventive activity: Economic and social factors* (pp. 609-626): National Bureau of Economic Research, Inc.

Bae, J., Wezel, F. C., & Koo, J. (2011). Cross-cutting ties, organizational density, and new firm formation in the us biotech industry, 1994-98. *Academy of Management Journal*, 54(2), 295-311.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management, 17*(1), 99-120-199-120.

Batjargal, B., Hitt, M., Tsui, A., Arregle, J., Webb, J., & Miller, T. (2013). Institutional polycentrism, entrepreneurs' social networks, and new venture growth. *Academy of Management Journal*, 56(4), 1024-1049.

Baum, J. A. C., McEvily, B., & Rowley, T. J. (2012). Better with Age? Tie Longevity and the Performance Implications of Bridging and Closure. *Organization Science*, 23(2), 529-546.

Bergh, D. D., & Lawless, M. W. (1998). Portfolio restructuring and limits to hierarchical governance: The effects of environmental uncertainty and diversification strategy. *Organization Science*, 9(1), 87-102.

Bliese, P. D. & Hanges, P. J. (2004). Being both too liberal and too conservative: The perils of treating grouped data as though they were independent. *Organizational Research Methods*, 7, 400-417.

Bliese, P. D., & Ployhart, R. E. (2002). Growth modeling using random coefficient models: Model building, testing, and illustrations. *Organizational Research Methods*, 5, 362-387.

Boland, R. J., Lyytinen, K., Yoo, Y. (2007). Wakes of innovation in project networks: The case of digital 3-D representations in architecture, engineering, and construction. *Organization Science, 18*(4), 631-647.

Bonacich, P. (1987). Power and centrality: A family of measures. *American Journal of Sociology*, 92(5), 1170-1182.

Borgatti, S. (2005). Centrality and network flow. *Social Networks, 27*(1), 55-71.

Borgatti, S. P., & Everett, M. G. (2006). A graph-theoretic perspective on centrality. *Social Networks*, 28(4), 466-484.

Borgatti, S., Everett, M. G., & Johnson, J. C. (2013). *Analyzing social networks*. London: SAGE Publications Limited.

Borgatti, S. & Halgin, D. (2011). On Network Theory. *Organization Science, 22*(5), 1168-1181.

Boyd, B., & Gove, S. (2006). Managerial Constraint: The Intersection Between Organizational Task Environment and Discretion. In D. Ketchen & D. Bergh (Eds.), *Research Methodology in Strategy and Management* (57-95): Emerald Group Publishing Limited.

Brown, S. L., & Eisenhardt, K. M. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative*

Science Quarterly, 42(1), 1-34.

Bruyaka, O., & Durand, R. (2012). Sell-off or shut-down? Alliance portfolio diversity and two types of high tech firms' exit. *Strategic Organization*, *10*(1), 7-30.

Burt, R. (1992). *Structural Holes: The Social Structure of Competition*. Cambridge, MA: Harvard University PRess.

Burt, R. (2000). The network structure of social capital. *Research in Organizational Behavior, Vol 22, 2000*, *22*, 345-423.

Burt, R. (2001). Structural holes versus network closure. In N. Lin, K. Cook, and R. S. Burt (Eds.), *Social Capital: Theory and Research* (31-56). New Brunswick, NY: Transaction Publishers.

Carpenter, M. A. & Westphal, J. D. (2001). The strategic context of external network ties: Examining the impact of director appointments on board involvement in strategic decision making. *Academy of Management Journal*, *44*(4), 639-660.

Castrogiovanni, G. J. (1991). Environmental munificence - a theoretical assessment. *Academy of Management Review*, 16(3), 542-565.

Castrogiovanni, G. J. (2002). Organization task environments: Have they changed fundamentally over time? *Journal of Management*, 28(2), 129-150.

Certo, S.R., Covin, J., Daily, C, & Dalton, D. (2001) Wealth and the effects of founder management among IPO-stage new ventures. *Strategic Management Journal*, 22, 641-658.

Child, J. (1972). Organizational structure, environment and performance: The role of strategic choice. *Sociology*, 6(1), 1-22.

Chung, W., & Yeaple, S. (2008). International knowledge sourcing: Evidence from US firms expanding abroad. *Strategic Management Journal*, 29(11), 1207-1224.

Ciborra, C. U. (1996). The platform organization: Recombining strategies, structures, and surprises. *Organization Science, 7*(2), 103-118.

Coff, R. W. (1999). When competitive advantage doesn't lead to performance: The resource-based view and stakeholder bargaining power. *Organization Science, 10*(2), 119-133.

Cohen, W. & Levinthal, D. (1989). Innovation and Learning: The two faces of R&D. *The Economic Journal*, 99(397), 569-596.

Cohen, W. & Levinthal, D. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, 128-152.

Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of*

Sociology, 94, S95-S120.

Coombs, J. E., Deeds, D. L., & Ireland, D. R. (2009). Placing the choice between exploration and exploitation in context: A study of geography and new product development. *Strategic Entrepreneurship Journal*, 3(3), 261-279.

Corradini, C., De Propris, L. (2017). Beyond local search: Bridging platforms and inter-sectoral technological integration. *Research Policy* 46(1):196-206

Cruz-Gonzalez, J., Lopez-Saez, P., Navas-Lopez, J. E., and Delgado-Verde, M. (2015). Open search strategies and firm performance: The different moderating role of technological environmental dynamism. *Technovation, 35*, 32-45.

Daft, R. L., Weick, K. E. (1984). Toward a Model of Organizations as Interpretation Systems. *Academy of Management Review*, *9*(2), 284-295.

De Clercq, D., Dimov, D. (2008). Internal knowledge development and external knowledge access in venture capital investment performance. *Journal of Management Studies, 45*(3), 585-612.

DeCarolis, D. M., & Deeds, D. L. (1999). The impact of stocks and flows of organizational knowledge on firm performance: An empirical investigation of the biotechnology industry. *Strategic Management Journal*, 20(10), 953-968

Delmar, F., Wennberg, K., & Hellerstedt, K. (2011) Endogenous growth through knowledge spillovers in entrepreneurship: An empirical test. *Strategic Management Journal*, 5, 199-226.

Dess, G. G., & Beard, D. W. (1984). Dimensions of Organizational Task Environments. *Administrative Science Quarterly*, 29(1), 52-73.

Devers, C. E., Dewett, T., Mishina, Y., & Belsito, C. A. (2009). A General Theory of Organizational Stigma. *Organization Science*, *20*(1), 154-171.

Dierickx, I., & Cool, K. (1989). Asset stock accumulation and sustainability of competitive advantage. *Management Science*, 35(12), 1504-1511.

Dyer, J. H., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: The Toyota case. *Strategic Management Journal*, 21(3), 345-367.

Dyer, J. H., & Singh, H. (1998). The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *The Academy of Management Review*, 23(4), 660-679.

Echols, A., & Tsai, W. (2005). Niche and performance: The moderating role of network embeddedness. *Strategic Management Journal*, 26(3), 219-238.

Fang, E. (2011). The Effect of Strategic Alliance Knowledge Complementarity on New Product

Innovativeness in China. *Organization Science*, *22*(1), 158-172.

Figueiredo, P. N. (2011). The Role of Dual Embeddedness in the Innovative Performance of MNE Subsidiaries: Evidence from Brazil. *Journal of Management Studies, 48*(2), 417-440.

Fjeldstad, O. D., Sasson, A. (2010). Membership Matters: On the Value of Being Embedded in Customer Networks. *Journal of Management Studies, 47*(6), 944-966.

Freeman, L. C. (1979). Centrality in social networks conceptual clarification. *Social Networks, 1*(3), 215-239.

Frost, T. S. (2001). The geographic sources of foreign subsidiaries' innovations. *Strategic Management Journal, 22*(2), 101-123.

Fu, X. L. (2012). Foreign Direct Investment and Managerial Knowledge Spillovers through the Diffusion of Management Practices. *Journal of Management Studies, 49*(5), 970-999.

Funk, R. J. (2014). Making the most of where you are: Geography, networks, and innovation in organizations. *Academy of Management Journal*, *57*(1), 193-222.

Furr, N. R., Snow, D. C. (2015). Intergenerational Hybrids: Spillbacks, Spillforwards, and Adapting to Technology Discontinuities. *Organization Science*, *26*(2), 475-493.

Garud, R., Kumaraswamy, A. (1993). Changing competitive dynamics in network industries: An exploration of sun microsystems open systems strategy. *Strategic Management Journal, 14*(5), 351-369.

Gay, B., & Dousset, B. (2005). Innovation and network structural dynamics: Study of the alliance network of a major sector of the biotechnology industry. *Research Policy*, 34(10), 1457-1475.

Giarratana, M. S., & Mariani, M. (2014). The relationship between knowledge sourcing and fear of imitation. *Strategic Management Journal*, 35(8), 1144-1163.

Goerzen, A. (2007). Alliance networks and firm performance: The impact of repeated partnerships. *Strategic Management Journal, 28*(5), 487-509.

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology, 78*(6), 1360-1380.

Granovetter, M. S. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology*, *91*, 481-510.

Grant, R. (1996a). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science, 7*(4), 375-387.

Grant, R. (1996b). Toward a Knowledge-Based Theory of the Firm. *Strategic Management*

Journal, 17(Special Issue: Knowledge and the Firm), 109-122.

Guerzoni, M., Aldridge, T., Audretsh, D. Desai, S. (2014). A new industry creation and originality: Insight from the funding sources of university patents. *Research Policy, 43,* 1697-1706.

Gulati, R. (1995). Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. *Academy of Management Journal*, *38*(1), 85-112.

Gulati, R. (1999). Network location and learning: The influence of network resources and firm capabilities on alliance formation. *Strategic Management Journal*, 20(5), 397.

Gulati, R., & Gargiulo, M. (1999). Where do Interorganizational Networks Come From? *American Journal of Sociology*, 104(5), 1439-1493.

Gulati, R., Nohria, N., and Zaheer, A. (2000). Strategic networks. *Strategic Management Journal, 21*(3), 203-215.

Hall, B. H., A. B. Jaffe, and M. Trajtenberg (2001). "The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools." NBER Working Paper 8498.

Hardy, C., Phillips, N., and Lawrence, T. B. (2003). Resources, knowledge and influence: The organizational effects of interorganizational collaboration. *Journal of Management Studies, 40*(2), 321-347.

Hernandez, E., Sanders, W. G., & Tuschke, A. (2015). Network defense: Pruning, grafting, and closing to prevent leakage of strategic knowledge to rivals. *Academy of Management Journal*, 58(4), 1233-1260.

He, J., & Wang, H. C. (2009). Innovative knowledge assets and economic performance: The asymmetric roles of incentives and monitoring. *Academy of Management Journal*, 52(5), 919-939.

Hite, J. M., and Hesterly, W. S. (2001). The evolution of firm networks: From emergence to early growth of the firm. *Strategic Management Journal*, 22(3), 275-286.

Hoetker, G., Agarwal, R. (2007). Death hurts, but it isn't fatal: The postexit diffusion of knowledge created by innovative companies. *Academy of Management Journal, 50*(2), 446-467.

Ireland, R. D., Hitt, M. A., and Vaidyanath, D. (2002). Alliance management as a source of competitive advantage. *Journal of Management, 28*(3), 413-446.

Jiang, L., Tan, J., Thursby, M. (2011). Incumbent firm invention in emerging fields: Evidence from the semiconductor industry. *Strategic Management Journal, 32*(1), 55-75.

Kale, P., Singh, H., Perlmutter, H. (2000). Learning and protection of proprietary assets in strategic alliances: Building relational capital. *Strategic Management Journal, 21*(3), 217-237.

Kang, M., Mahoney, J., & Tan, D. (2009). Why firms make unilateral investments specific to other firms: The case of OEM suppliers. *Strategic Management Journal, 30(2)*, 117-135.

Karniouchina, E. V., Carson, S. J., Short, J. C., & Ketchen, D. J. (2013). Extending the firm vs. industry debate: Does industry life cycle stage matter? *Strategic Management Journal*, 34(8), 1010-1018.

Ketchen, D. J., Ireland, R. D., Baker, L. T., (2013). The use of archival proxies in strategic management studies: Castles made of sand? *Organizational Research Methods*, 16(1), 32-42.

Kirchhoff, B. A., Newbert, S. L., Hasan, I., Armington, C. (2007). The influence of university R and D expenditures on new business formations and employment growth. *Entrepreneurship Theory and Practice, 31*(4), 543-559.

Ko, W. W., Liu, G. (2015). Understanding the Process of Knowledge Spillovers: Learning to Become Social Enterprises. *Strategic Entrepreneurship Journal, 9*(3), 263-285.

Kogan, L., Papanikolaou, D., Seru, A., & Stoffman, N. (2017). Technological innovation, resource allocation, and growth. *The Quarterly Journal of Economics*, *132*(2), 665-712.

Kogut, B. (2000). The network as knowledge: Generative rules and the emergence of structure. *Strategic Management Journal, 21*(3), 405-425.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization science, 3*(3), 383-397.

Kogut, B., & Zander, U. (1996). What firms do? Coordination, identity, and learning. *Organization Science, 7*(5), 502-518.

Koka, B. R., & Prescott, J. E. (2008). Designing alliance networks: The influence of network position, environmental change, and strategy on firm performance. *Strategic Management Journal*, 29(6), 639-661.

Koka, B. R., Madhavan, R., & Prescott, J. E. (2006). The evolution of interfirm networks: Environmental effects on patterns of network change. *Academy of Management Review, 31*(3), 721-737.

Koput, K.W. (1997). A chaotic model of innovative search: Some answers, many questions. *Organization Science*, 8(5), 528-542

Kotha, S. (2010). Spillovers, spill-ins, and strategic entrepreneurship: America's first commercial jet airplane and Boeing's ascendancy in commercial aviation. *Strategic Entrepreneurship Journal, 4*(4), 284-306.

Lam, A. (2003). Organizational learning in multinationals: R&D networks of Japanese and US

MNEs in the UK. *Journal of Management Studies, 40*(3), 673-703.

Lane, P. J., Koka, B. R., & Pathak, S. (2006). The reification of absorptive capacity: A critical review and rejuvenation of the construct. *Academy of Management Review, 31*(4), 833-863.

Lane, P. J., &Lubatkin, M. (1998). Relative absorptive capacity and interorganizational learning. *Strategic Management Journal*, 19(5), 461-477.

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal*, 27(2), 131-150.

Lavie, D. (2006). The competitive advantage of interconnected firms: An extension of the resource-based view. *Academy of Management Review, 31*(3), 638-658.

Lavie, D., & Rosenkopf, L. (2006). Balancing exploration and exploitation in alliance formation. *Academy of Management Journal*, 49(4), 797-818.

Lazzarini, S. G., Claro, D. P., & Mesquita, L. F. (2008). Buyer-supplier and supplier-supplier alliances: Do they reinforce or undermine one another? *Journal of Management Studies, 45*(3), 561-584.

Levitt, B., & March, J. G. (1988). Organizational Learning. *Annual Review of Sociology*, 14, 319-340.

Lin, N. (1999). Social networks and status attainment. *Annual Review of Sociology, 25*, 467-487.

Lin, N. (2002). *Social capital: A theory of social structure and action*. NY, NY: Cambridge University Press.

Lin, Z., Yang, H., & Arya, B. (2009). Alliance partners and firm performance: Resource complementarity and status association. *Strategic Management Journal*, 30(9), 921-940.

Lipparini, A., Lorenzoni, G., & Ferriani, S. (2014). From core to periphery and back: A study on the deliberate shaping of knowledge flows in interfirm dyads and networks. *Strategic Management Journal*, 35(4), 578-595.

Liu, X. H., Wright, M., Filatotchev, I., Dai, O., & Lu, J. Y. (2010). Human mobility and international knowledge spillovers: Evidence from high-tech small and medium enterprises in an emerging market. *Strategic Entrepreneurship Journal, 4*(4), 340-355.

Love, J. H., Roper, S., & Vahter, P. (2014). Learning from openness: The dynamics of breadth in external innovation linkages. *Strategic Management Journal, 35*(11), 1703-1716.

Madhavan, R., Koka, B. R., & Prescott, J. E. (1998). Networks in transition: How industry events (re)shape interfirm relationships. *Strategic Management Journal*, *19*(5), 439-459.

Mahmood, I. P., Zhu, H. J., & Zajac, E. J. (2011). Where can capabilities come from? Network ties and capability acquisition in business groups. *Strategic Management Journal*, 32(8), 820-848.

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, *2*(1), 71-87.

Martinez-Noya, A., Garcia-Canal, E., Guillen, M. F. (2013). R&D Outsourcing and the Effectiveness of Intangible Investments: Is Proprietary Core Knowledge Walking out of the Door? *Journal of Management Studies, 50*(1), 67-91.

Mayer, K. J. (2006). Spillovers and governance: An analysis of knowledge and reputational spillovers in information technology. *Academy of Management Journal*, *49*(1), 69-84.

McGahan, A. M., & Porter, M. E. (1997). How much does industry matter, really? *Strategic Management Journal*, 18, 15-30.

Merton, R. K. (1936). The unanticipated consequences of purposive social action. *American Sociological Review*, *1*(6), 894-904.

Mesquita, L. F., Anand, J., & Brush, T. H. (2008). Comparing the resource-based and relational views: Knowledge transfer and spillover in vertical alliances. *Strategic Management Journal*, *29*(9), 913-941.

Moore, C.B., Bell, R.B., & Filatotchev, I.. (2010). Institutions and Foreign IPO Firms: The Effects of "Home" and "Host" Country Institutions on Performance. *Entrepreneurship Theory and Practice, 34(3),* 469-490.

Moore, C.B., Bell, R.B., Filatotchev, I., & Rasheed, A. (2012). Foreign IPO capital market choice: Understanding the institutional fit of corporate governance. *Strategic Management Journal, 33,* 914-937.

Moore, C.B., Payne, G.T., Autry, C.W., & Griffis, S. E. (2016). Project complexity and bonding social capital in network organizations. *Group & Organization Management*, 1-25.

Motohashi, K., & Yuan, Y. (2010). Productivity impact of technology spillover from multinationals to local firms: Comparing China's automobile and electronics industries. *Research Policy, 39*(6), 790-798.

Nohria, N., & Garcia-Pont, C. (1991). Global strategic linkages and industry structure. *Strategic Management Journal*, 12, 105-124.

Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science, 5*(1), 14-37.

Operti, E., & Carnabuci, G. (2014). Public Knowledge, Private Gain: The Effect of Spillover Networks on Firms' Innovative Performance. *Journal of Management*, *40*(4), 1042-1074.

Owen-Smith, J., & Powell, W. W. (2004). Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. *Organization Science*, 15(1), 5-21.

Oxley, J. E., & Sampson, R. C. (2004). The scope and governance of international R&D alliances. *Strategic Management Journal*, *25*(8-9), 723-749.

Pacheco-de-Almeida, G., & Zemsky, P. B. (2012). Some like it free: Innovators' Strategic use of Disclosure to slow down Competition. *Strategic Management Journal*, *33*(7), 773-793.

Patel, P. C., & Terjesen, S. (2011). Complementary effects of network range and tie strength in enhancing transnational venture performance. *Strategic Entrepreneurship Journal*, 5(1), 58-80.

Payne G. (2006). Examining configurations and firm performance in a suboptimal equifinality context. *Organization Science*. 2006;17(6):756-770.

Penner-Hahn, J., & Shaver, J. M. (2005). Does international research and development increase patent output? An analysis of Japanese pharmaceutical firms. *Strategic Management Journal*, *26*(2), 121-140.

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda. *Journal of Management*, *38*(4), 1115-1166.

Phene, A., & Tallman, S. (2014). Knowledge Spillovers and Alliance Formation. *Journal of Management Studies*, *51*(7), 1058-1090.

Plummer, L. A., & Gilbert, B. A. (2015). The Effect of Defense Agency Funding of University Research on Regional New Venture Creation. *Strategic Entrepreneurship Journal*, *9*(2), 136-152.

Podolny, J. M. (1993). A status-based model of market competition. *American Journal of Sociology*, 98(4), 829-872.

Podolny, J. M. (2001). Networks as the pipes and prisms of the market. *American Journal of Sociology*, *107*(1), 33-60.

Podolny, J. M., & Phillips, D. J. (1996). The dynamics of organizational status. *Industrial and Corporate Change*, *5*(2), 453-471.

Pollock, T., Lee, P. M., Jin, K., & Lashley, K. (2015). (Un)Tangled: Exploring the Asymmetric Coevolution of New Venture Capital Firms' Reputation and Status. *Administrative Science Quarterly*, 60(3), 482-517.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, 41(1), 116-145.

Provan, K. G. (1993). Embeddedness, interdependence, and opportunism in organizational supplier-buyer networks. *Journal of Management, 19*(4), 841-856.

Riccaboni, M., and Pammolli, F. (2002). On firm growth in networks. Research Policy, 31(8-9), 1405-1416.

Rumelt, R. P. (1991). How much does industry matter? *Strategic Management Journal*, 12(3), 167-185.

Sarkar, M. B., Aulakh, P. S., & Madhok, A. (2009). Process Capabilities and Value Generation in Alliance Portfolios. *Organization Science*, 20(3), 583-600.

Schildt, H. A., Maula, M. V. J., & Keil, T. (2005). Explorative and exploitative learning from external corporate ventures. *Entrepreneurship Theory and Practice, 29*(4), 493-515.

Schoonhoven, C. B., Eisenhardt, K. M., & Lyman, K. (1990). Speeding products to market: Waiting time to first product introduction in new firms. *Administrative Science Quarterly*, 35(1), 177-207.

Shipilov, A. V., & Li, S. X. (2008). Can you have your cake and eat it too? Structural holes' influence on status accumulation and market performance in collaborative networks. Administrative Science Quarterly, 53(1), 73-108.

Short, J. C., Ketchen, D. J., Bennett, N., & du Toit, M. (2006). An examination of firm, industry, and time effects on performance using random coefficients modeling. *Organizational Research Methods*, 9(3), 259-284.

Shu, C., Liu, C., Gao, S., & Shanley, M. (2014). The Knowledge Spillover Theory of Entrepreneurship in Alliances. *Entrepreneurship Theory and Practice*, 38(4), 913-940.

Soh, P.-H. (2010). Network patterns and competitive advantage before the emergence of a dominant design. *Strategic Management Journal*, 31(4), 438-461.

Spender, J. C. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal, 17*, 45-62.

Spender, J. C., & Grant, R. M. (1996). Knowledge and the firm: Overview. *Strategic Management Journal, 17*(Special Issue: Knowledge and the Firm), 5-9.

Stuart, T. E. (1998). Network positions and propensities to collaborate: An investigation of strategic alliance formation in a high-technology industry. *Administrative Science Quarterly, 43*(3), 668-698.

Stuart, T. E., & Podolny, J. M. (1996). Local search and the evolution of technological capabilities. *Strategic Management Journal, 17,* 21-38.

Sytch, M., & Tatarynowicz, A. (2014). Exploring the locus of invention: The dynamics of network communities and firms' invention productivity. *Academy of Management*

Journal, 57(1), 249-279.

Tatarynowicz, A., Sytch, M., & Gulati, R. (2016). Environmental demands and the emergence of social structure: Technological dynamism and interorganizational network forms. *Administrative Science Quarterly*, 61(1), 52-86.

Teece, D. J (1998). Capturing value from knowledge assets: The new economy, markets for know-how, and intangivle assets. *California Management Review, 40(3)*, 55-79.

Tiwana, A. (2008). Do bridging ties complement strong ties? An empirical examination of alliance ambidexterity. *Strategic Management Journal*, *29*(3), 251-272.

Uotila, J., Maula, M., Keil, T., & Zahra, S. A. (2009). Exploration, exploitation, and financial performance: analysis of S&P 500 corporations. *Strategic Management Journal*, 30(2), 221-231.

Uzzi, B. (1996). The sources and consequences of embeddedness for the economic performance of organizations: The network effect. *American Sociological Review*, *61*(4), 674-698.

Uzzi, B. (1997). Social structure and competition in interfirm networks: The paradox of embeddedness. *Administrative Science Quarterly, 42*(1), 35-67.

Uzzi, B., & Gillespie, J. J. (2002). Knowledge spillover in corporate financing networks: Embeddedness and the firm's debt performance. *Strategic Management Journal, 23*(7), 595-618.

Vanhaverbeke, W., Duysters, G., & Noorderhaven, N. (2002). External technology sourcing through alliances or acquisitions: An analysis of the application-specific integrated circuits industry. *Organization Science, 13*(6), 714-733.

Vasudeva, G., & Anand, J. (2011). Unpacking absorptive capacity: A study of knowledge utilization from alliance portfolios. *Academy of Management Journal*, *54*(3), 611-623.

Wagner, S., Hoisl, K., & Thoma, G. (2014). Overcoming localization of knowledge: The role of professional service firms. *Strategic Management Journal*, 35(11), 1671-1688.

Wang, H. L., & Chen, W. R. (2010). Is firm-specific innovation associated with greater value appropriation? The roles of environmental dynamism and technological diversity. *Research Policy*, 39(1), 141-154.

Wasserman, S., & Faust, K. (1994). *Social Network Analysis: Methods and Applications* (M. Granovetter Ed.). NY, NY: Cambridge University Press.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic management journal, 5*(2), 171-180.

Williamson, O. E. (1979). Transaction-cost economics: the governance of contractual relations. *Journal of law and economics*, 233-261.

Williamson, O. E. (1981). The economics of organization: The transaction cost approach. *American journal of sociology*, 548-577.

Wuyts, S., & Dutta, S. (2014). Benefiting From Alliance Portfolio Diversity: The Role of Past Internal Knowledge Creation Strategy. *Journal of Management*, 40(6), 1653-1674.

Yang, H. Y., Phelps, C., & Steensma, H. K. (2010). Learning from what others have learned from you: The effects of knowledge spillovers on originating firms. *Academy of Management Journal*, 53(2), 371-389.

Yang, H., Zheng, Y., & Zhao, X. (2014). Exploration or exploitation? Small firms' alliance strategies with large firms. *Strategic Management Journal*, 35(1), 146-157.

Zachary, M. A., Gianiodis, P. T., Payne, G. T., & Markman, G. D. (2015). Entry Timing: Enduring Lessons and Future Directions. *Journal of Management*, *41*(5), 1388-1415.

Zahra, S. A., George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review*, *27*(2), 185-203.

Zhang, J., Soh, P.-H., & Wong, P.-k. (2010). Entrepreneurial Resource Acquisition through Indirect Ties: Compensatory Effects of Prior Knowledge. *Journal of Management*, 36(2), 511-536.

Zhang, Y., Li, Y., & Li, H. Y. (2014). FDI spillovers over time in an emerging market: The role of entry tenure and barriers to entry. *Academy of Management Journal*, *57*(3), 698-722.

Zorn, M., Sexton, J., Bhussar, M., Lamont, B. (forthcoming). Unfinished business: Nested acquisitions, managerial capacity, and firm performance. *Journal of Management*.

Table 2.1. Knowledge and Network Research in Major Management Journals

Academy of Management Journal (*AMJ*)
Afuah, 2001
Bae, Wezel, and Koo, 2011
Carpenter and Westphal, 2001
Funk, 2014
Hernandez, Sanders, and Tuschke, 2015
Hoetker and Agarwal, 2007
Mayer, 2006
Vasudeva and Anand, 2011
Yang, Phelps, and Steensma, 2010
Zhang, Li, and Li, 2014

Organization Science (*OS*)
Baum, McEvily, and Rowley, 2012
Boland, Lyytinen, and Yoo, 2007
Fang, 2011
Furr and Snow, 2015
Owen-Smith and Powell, 2004
Vanhaverbeke, Duysters, and Noorderhaven, 2002

Strategic Management Journal (*SMJ*)
Alnuaimi and George, 2016
Appleyard, 1996
Dyer and Nobeoka, 2000
Echols and Tsai, 2005
Garud and Kumaraswamy, 1993
Giarratana and Mariani, 2014
Goerzen, 2007
Jiang, Tan, and Thursby, 2011
Kale, Singh and Permutter, 2000
Koka and Prescott, 2008
Lipparini, Lorenzoni, and Ferriani, 2014
Mahmood, Zhu, and Zajac, 2011
Mesquita, Anand, and Brush, 2008
Penner-Hahn and Shaver, 2005
Soh, 2010
Tiwana, 2008
Uzzi and Gillespie, 2002
Wagner, Hoisl, and Thoma, 2014

Entrepreneurship Theory and Practice (*ET&P*)
Kirchhoff, Newbert, Hasan, and Armington, 2007
Mosey and Wright, 2007
Schildt, Maula, and Keil, 2005

Journal of Management (*JOM*)
Operti and Carnabuci, 2014
Wuyts and Dutta, 2014
Zhang, Soh, and Wong, 2010

Journal of Management Studies (*JOMS*)
Alexiev, Jansen, Van den Bosch, and Volberda, 2010
De Clercq and Dimov, 2008
Figueiredo, 2011
Fjeldstad and Sasson, 2010
Fu, 2012
Hardy, Phillips, and Lawrence, 2003
Lam, 2003
Lazzarini, Claro, and Mesquita, 2008
Martinez-Noya, Garcia-Canal and Guillen, 2013
Phene and Tallman, 2014

Strategic Entrepreneurship Journal (*SEJ*)
Coombs, Deeds, and Duane Ireland, 2009
Ko and Liu, 2015
Kotha, 2010
Parker, 2010
Patel and Terjesen, 2011
Plummer and Gilbert, 2015

Table 2.2. Terms and Definitions

Term	Key Definitions	Cite
Knowledge Asset	Knowledge resident within a firm that creates value due to its characteristics of transferability, capacity for aggregation, and appropriability	Grant, 1996a, 1996b Kogut & Zander, 1992, 1996
Network Safeguard	Relational or structural mechanisms that limit opportunism among an actor's set of relations	Dyer & Singh, 1998, Lavie, 2006
Knowledge Spillover	unintended, un- or under-compensated transfers of knowledge	Agarwal et al., 2010
	"represent external benefits gained from the creation of knowledge that accrue to parties other than the creator"	Kotha, 2010, p. 284
Network	"A network consists of a set of actors or nodes along with a set of ties of a specified type (such as friendship) that link them."	Borgatti and Halgin, 2011, p. 2
	"consists of a finite set or sets of actors and the relation or relations defined on them"	Wasserman and Faust, 1994, p. 20
Network ties		
Direct ties	Direct ties indicate a relationship formed between two actors: for example, Firm A has a formal relationship with Firm B	Wasserman and Faust, 1994
Indirect ties	Indirect relationships are those that have (at least) 1 intermediary between the actors. Firm A has a formal relationship with Firm B and Firm C, therefore, Firm B and Firm C have an indirect relationship via Firm A	Wasserman and Faust, 1994
Network structure		
Strong ties	Strong ties are considered long-lasting, repeated relationships that develop trust and norms of behavior	Coleman, 1988
Weak ties	"essential to the flow of information that integrates otherwise disconnected social clusters into a broader society"	Burt, 1992, p. 73
Network closure	A network comprised of a multitude of ties between actors via repeated, reciprocal relationships developing obligations and expectations, information flow, and norms accompanied by sanctions	Coleman, 1988
Structural holes	A single connection that provides a linkage between two groups (not individual actors)	Burt, 2000
	"Structural holes separate nonredundant sources of information, sources that are more additive than overlapping."	Burt, 2000, p. 353
Network position		
Beta centrality	"In a power hierarchy, one's power is a positive function of the powers of those one has power over"	Bonacich, 1987, p. 1171
	"A measure of the total amount of potential influence a node can have on all others via direct and indirect channels"	Borgatti et al., 2013, p. 171

Table 2.3. Knowledge and Network Literature and Core Perspectives

Perspective	Key Research	Focal Outcomes
Organizational Learning	Coombs et al., 2009	A firm's geographical context can impact success of search strategies
	Hardy et al., 2003	The form of network relationship (involvement and embeddedness) increases learning
	Hernandez et al., 2015	Modifying board membership to prevent knowledge spillovers to indirectly linked rivals
	Lam, 2003	Increased autonomy of international R&D facilities increases firm learning via extending the learning systems across institutional boundaries
	Operti and Carnabuci, 2014	Firms can learn from other firms' public knowledge, strategically developing a spillover pool
	Schildt et al., 2005	Decreased integration of firm alliances and technological relatedness increases explorative learning
	Wagner et al., 2014	Organizational learning may occur via indirect linkages
	Yang et al., 2010	Firms can regain knowledge benefits after knowledge has been spilled
	Zhang et al., 2014	Foreign direct investment can lead to knowledge spillovers to domestic firms
Absorptive Capacity (ACAP)	Alexiev et al., 2010	Heterogeneous TMTs may have larger ACAP, increasing exploratory innovation
	Alnuaimi and George, 2016	ACAP increases knowledge retrieval capabilities (regaining knowledge after a spillover has occurred)
	Fu, 2012	Firms are selective in which knowledge they choose to absorb, even when knowledge spillovers are available
	Giarratana and Mariani, 2014	Firms select internal resources over external resources in locations high in ACAP
	Martinez-Noya et al., 2013	Suppliers have a relative ACAP level for each client, depending on firm similarity and previous knowledge transfer. As ACAP increases, so do appropriability hazards.
	Penner-Hahn and Shaver, 2005	Firms who internationalize R&D will generate increased innovation output when they have internal research capabilities (ACAP)
	Phene and Tallman, 2014	Firms form alliances subsequent to knowledge spillovers when firms have similar specialization, and therefore, absorptive capacity
	Vasudeva and Anand, 2011	Diverse knowledge found in alliances increases demand on firms' ACAP

	Wuyts and Dutta, 2014	ACAP impacts the relationship between a firm's alliance portfolio's diversity and innovation
Network / Social Capital	Echols and Tsai, 2005	Firms with distinct products or services perform better when network embeddedness is high
	Funk, 2014	When knowledge spillovers are not available, inefficient internal networks increase innovation output
	Goerzen, 2007	Repeated relationships decrease performance, increasingly in environments of greater technological uncertainty
	Hardy et al., 2003	Levels of embeddedness and involvement in an interfirm relationship leads to knowledge transfer and new knowledge creation
	Operti and Carnabuci, 2014	Firms' innovative performance tends to be higher when their spillover network is either munificent or rich in structural holes
	Patel and Terjesen, 2011	Network range and tie strength increase firm performance
	Soh, 2010	Firms that are highly central and have large networks increase innovation outputs
	Tiwana, 2008	Strong ties as well as bridging ties increase knowledge integration
	Zhang et al., 2010	Indirect ties increase likelihood of resource acquisition
Knowledge-Based View	Afuah, 2001	Firms will adapt to new technology more efficiently when new technology knowledge (but not old) is found within firm boundaries
	DeClerq and Dimov, 2008	Firms' existing knowledge impacts ability to internalize external knowledge
	Dyer and Nobeoka, 2000	Examines Toyota's ability to create and manage knowledge-sharing processes
	Mayer, 2006	The threat of knowledge spillovers may lead to selecting internal vs external resources
	Mesquita et al., 2008	Knowledge gained at the alliance level can be applied to other relationships

Table 2.4. Comparisons of Core Perspectives

Perspective	View of Knowledge	View of interfirm networks	Key Firm-level Outcomes
Knowledge-Based View (Grant, 1996a, 1996b; Spender, 1996)	Knowledge as a key resource that provide firms with competitive advantages	"Firm networks based upon relational contracts are an efficient and effective basis for accessing knowledge" (Grant, 1996a, p. 385)	Firm performance (competitive advantage)
Organizational Learning (Levitt and March, 1988; March, 1991)	Firms learn from direct experience as well as from the experiences of other firms. Learning can include exploring for new knowledge or exploiting existing knowledge	Networks as a source of knowledge	Innovation Firm performance
Absorptive Capacity (Cohen and Levinthal, 1989, 1990)	Absorptive capacity is the ability for firms to locate, assimilate and commercialize external knowledge	External sources of knowledge via networks and spillovers	Innovation
Social Capital perspective (Burt, 1992; Coleman, 1988; Granovetter, 1973; Lin, 1999)	Networks are social structures that provide actors with resources, including knowledge	Network as antecedent to outcome of interest or network as outcome	Firm performance, innovation, and partnering choices

Figure 3.1. Research Model

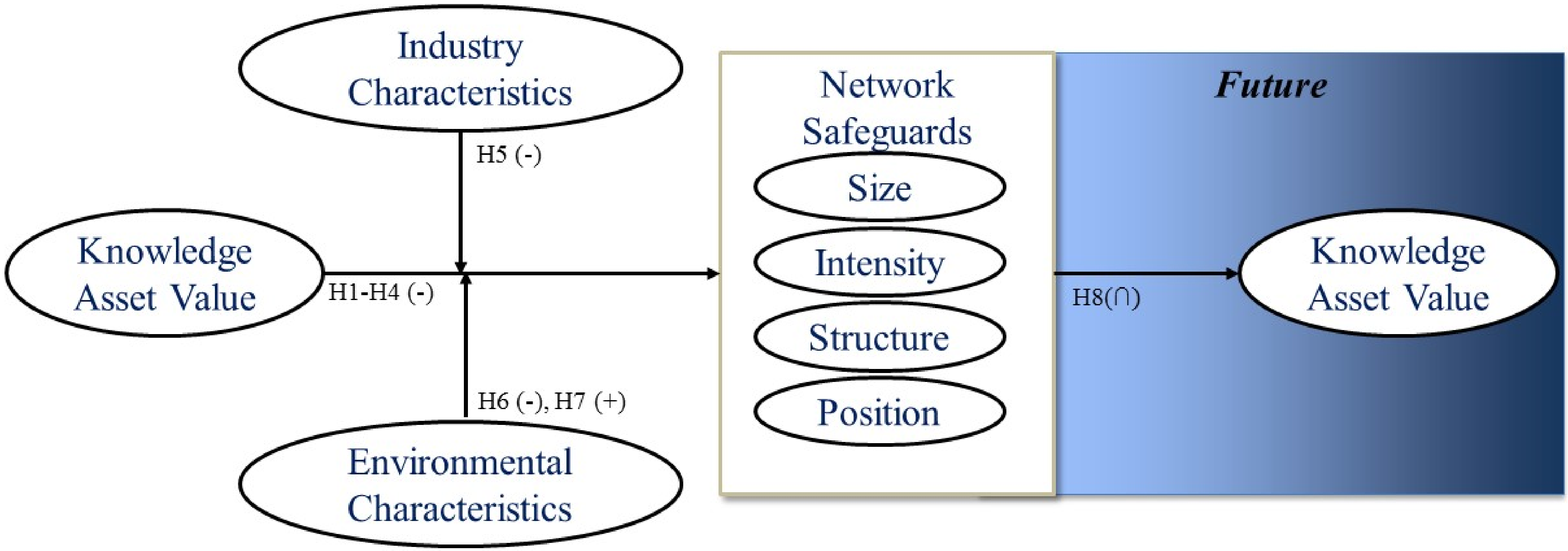


Table 5.1. Descriptive statistics and correlations.

Variables	*N*	Mean	S.D.	1	2	3	4	5	6	7	8	9
1. Subsequent Firm Network Size (t+5)	2815	5.220	8.420									
2. Subsequent Average Firm Network Intensity (t+5)	2750	5.837	1.906	-0.064 *								
3. Subsequent Firm Network Structural Holes (t+5)	2814	1.425	0.369	0.585 ***	-0.069 *							
4. Subsequent Firm Network Beta Centrality (t+5)	2815	7.534	10.254	0.995 ***	-0.066 *	0.585 ***						
5. Subsequent Knowledge Asset Value (patent originality, t+5) (H8 DV)	986	155.174	224.171	0.258 ***	-0.085 **	0.087 **	0.297 ***					
6. Subsequent Knowledge Asset Value (market value, t+5) (H8 DV)	986	3133.06	7730.37	0.176 ***	-0.125 ***	0.139 ***	0.182 ***	0.086 **				
7. Knowledge Asset Value (patent originality)	2815	11.275	166.277	0.215 ***	-0.034	0.059	0.248 ***	0.881 ***	0.032			
8. Knowledge Asset Value (patent market value)	2815	-156.551	5248.93	0.001	-0.086 **	0.033	0.001	0.131 ***	0.303 ***	0.128 ***		
9. Firm Network Beta Centrality	2805	8.906	10.976	0.465 ***	-0.153 ***	0.327 ***	0.472 ***	0.403 ***	0.328 ***	0.400 ***	0.243 ***	
10. Firm Network Size	2815	6.391	9.089	0.456 ***	-0.161 ***	0.328 ***	0.460 ***	0.368 ***	0.344 ***	0.369 ***	0.253 ***	0.993 ***
11. Firm Average Network Intensity	2815	6.152	1.726	-0.103 **	0.248 ***	-0.047	-0.105 **	-0.121 ***	-0.092 **	-0.115 ***	-0.105 ***	-0.161 ***
12. Firm Network Structural Holes	2813	1.510	0.366	0.340 ***	-0.158 ***	0.326 ***	0.338 ***	0.193 ***	0.209 ***	0.169 ***	0.168 ***	0.576 ***
13. Firm Performance	2815	10.161	0.000	-0.022	-0.101 **	0.018	-0.027	-0.069 *	0.292 ***	-0.111 ***	0.240 ***	0.047
14. Firm patenting volume	2815	208.916	371.321	0.229 ***	-0.045	0.069 *	0.265 ***	0.897 ***	0.027	0.991 ***	0.115 ***	0.383 ***
15. Firm patenting age	2815	31.929	14.603	-0.098 **	0.154 ***	-0.090 **	-0.106 ***	-0.087 **	0.097 **	0.029	0.135 ***	0.011
16. Firm age	2815	31.663	14.710	-0.096 **	0.146 ***	-0.080 *	-0.104 **	-0.080 *	0.101 **	0.033	0.137 ***	0.009
17. Firm R&D expenses	2815	5.402	1.705	0.341 ***	-0.071 *	0.231 ***	0.361 ***	0.607 ***	0.266 ***	0.641 ***	0.265 ***	0.451 ***
18. Firm size	2815	8.422	1.776	0.186 ***	0.117 ***	0.084 **	0.211 ***	0.536 ***	0.176 ***	0.599 ***	0.206 ***	0.319 ***
19. Firm slack	2815	1.035	0.341	0.012	-0.220 ***	0.010	0.004	-0.091 **	0.019	-0.164 ***	0.016	-0.044
20. Network count	2815	1734.81	1121.70	0.357 ***	-0.072 *	0.334 ***	0.324 ***	-0.121 ***	-0.016	-0.142 ***	-0.134 ***	0.051
21. Dynamism	2815	.62203	0.532	0.148 ***	-0.289 ***	0.084 **	0.157 ***	0.269 ***	0.104 **	0.191 ***	0.047	0.222 ***
22. Munificence	2815	14.321	70.567	0.017	-0.244 ***	0.029	0.013	0.257 ***	0.120 ***	0.204 ***	0.146 ***	0.305 ***
23. High-technology industry	2815	0.803	0.398	0.169 ***	-0.099 ***	0.209 ***	0.129 ***	-0.022	0.017	-0.0240 *	-0.004	0.191 ***

Variables	10		11		12		13		14		15		16		17		18		19		20		21		22	
11. Average Firm Network Intensity	-0.165	***																								
12. Lagged Firm Network Structural Holes (control)	0.581	***	-0.252	***																						
13. Firm Performance	0.064	*	-0.076	*	0.049																					
14. Firm patenting volume	0.349	***	-0.129	***	0.161	***	-0.114	***																		
15. Firm patenting age	0.016		0.163	***	-0.042		0.136	***	-0.013																	
16. Firm age	0.014		0.175	***	-0.050		0.132	***	-0.008		0.988	***														
17. Firm R&D expenses	0.437	***	-0.110	***	0.309	***	0.133	***	0.637	***	0.155	***	0.151	***												
18. Firm size	0.302	***	0.041		0.182	***	0.099	**	0.589	***	0.313	***	0.306	***	0.825	***										
19. Firm slack	-0.036		-0.218	***	0.021		0.036		-0.146	***	-0.496	***	-0.505	***	-0.268	***	-0.466	***								
20. Network count	0.072	*	-0.061		0.134	***	-0.065	*	-0.118	***	-0.226	***	-0.228	***	-0.123	***	-0.300	***	0.216	***						
21. Dynamism	0.227	***	-0.193	***	0.155	***	0.020		0.213	***	-0.281	***	-0.284	***	0.117	***	-0.114	***	0.200	***	0.250	***				
22. Munificence	0.324	***	-0.193	***	0.320	***	0.101	**	0.218	***	-0.172	***	-0.183	***	0.218	***	-0.003		0.100	***	0.285	***	0.489	***		
23. High-tech industry	0.220	***	-0.140	***	0.236	***	-0.086	***	-0.022	*	-0.151	***	-0.153	***	-0.016		-0.122	***	0.120	***	0.657	***	0.290	***	0.378	***

* p<0.05, ** p<0.01, ***p<.001

Table 5.2. Intraclass Correlation Coefficient (ICC) results

Firm Network Size	
Industry level	0.038
Firm level	0.134
Both levels	0.172
Average Firm Network Intensity	
Industry level	0.050
Firm level	0.504
Both levels	0.553
Firm Network Structural Holes	
Industry level	0.097
Firm level	0.241
Both levels	0.338
Firm Network Beta Centrality	
Industry level	0.029
Firm level	0.138
Both levels	0.167
Knowledge Asset Value (patent originality) *	
Industry level	0.021
Firm level	0.629
Both levels	0.650
Knowledge Asset Value (market value) *	
Industry level	0.000
Firm level	0.375
Both levels	0.375

* Analyses were conducted without the industry level present, without substantive differences

Table 5.3 Relationship between Firm Knowledge Asset Value with Moderators and Subsequent Firm Network Size

Group Variables: Industry segment, Firm	Model 1	Model 2 (H1)	Model 3 (H5a)	Model 4 (H6a)	Model 5 (H7a)
Intercept	0.326	-3.273	-2.577	-3.231	-3.020
Firm network size	0.324***	0.324***	0.313***	0.318***	0.326***
Average network intensity	0.015	-0.003	-0.009	-0.002	0.006
Firm network structural holes	2.045***	1.998***	2.079***	1.989***	1.975***
Firm patenting age	-0.020	-0.012	-0.016	-0.014	-0.016
Firm R&D expenses	0.168	0.612**	0.763***	0.722**	0.805***
Firm size	0.386	0.409	0.295	0.332	0.296
Firm slack	0.393	0.637	0.559	0.601	0.829
Network size	0.003***	0.003***	0.003***	0.003***	0.003***
Year					
1990	-2.220**	-2.195**	-2.374**	-2.015**	-1.787*
1991	-5.061***	-4.890***	-5.032***	-4.711***	-4.014***
1992	-6.592***	-6.373***	-6.509***	-6.451***	-5.286***
1993	-7.885***	-7.654***	-7.673***	-7.933***	-6.497***
1994	-8.971***	-8.796***	-8.641***	-8.435***	-7.720***
1995	-9.308***	-9.209***	-8.864***	-8.506***	-7.841***
1996	-9.341***	-9.174***	-8.801***	-8.493***	-7.442***
1997	-9.505***	-9.314***	-8.814***	-9.052***	-7.182***
1998	-9.521***	-8.952***	-8.348***	-8.961***	-6.503***
1999	-8.895***	-8.211***	-7.500***	-8.177***	-5.945***
2000	-8.658***	-7.338***	-6.558***	-6.945***	-5.718***
2001	-8.185***	-7.319***	-6.511***	-6.813***	-5.810***
2002	-8.433***	-7.714***	-6.867***	-7.177***	-6.535***
2003	-8.058***	-7.451***	-6.610***	-6.853***	-6.677***
2004	-7.800***	-7.261***	-6.500***	-7.140***	-6.866***
2005	-7.343***	-6.939***	-6.146***	-6.749***	-6.724***
Knowledge Asset Value (patent originality)		-0.01050***	-0.01530***	-0.01369***	-0.01412***
Knowledge Asset Value (market value of knowledge)		-0.00017***	-0.00020*	-0.00016**	-0.00005
High-tech industry			-3.50968***		
Dynamism				-1.53295***	
Munificence					-0.22118***
H-T Industry x Patent Orig.			0.00627***		
H-T Industry x Market Value			0.00003		
Dyn x Patent Orig.				0.00295**	
Dyn x Market Value				-0.00002	
Mun x Pat. Orig.					0.00022*
Mun x Market Value					-0.00001
Random Effects					
Industry	2.359	1.827	0.692	1.410	0.878
Firm	3.329	5.494	5.424	5.592	5.393
Residual	34.400	32.500	32.264	32.094	31.843
N	2,813	2,813	2,813	2,813	2,813
Wald χ^2	1566.05***	1628.33***	1690.36***	1680.33***	1738.26***
	(24)	(26)	(29)	(29)	(29)
Log likelihood	-9063.96	-9019.32	-9003.95	-9002.55	-8987.15
LR-test (χ^2)[*]		89.27***	120.01***	122.82***	153.62***
AIC	18183.92	18098.64	18073.91	18071.09	18040.29

***p<.001, ** p<.01, *p<.05
***p<.001, ** p<.01, *p<.05
***p<.001, ** p<.01, *p<.05

[*] Models 2 – 5 use Model 1 as the comparison model

Table 5.4 Relationship between Firm Knowledge Asset Value with Moderators and Subsequent Average Firm Network Intensity

Group Variables: Industry segment, Firm	Model 1	Model 2 (H2)	Model 3 (H5b)	Model 4 (H6b)	Model 5 (H7b)
Intercept	6.227***	6.203***	6.395***	6.171***	6.241***
Network size	-0.002	-0.002	-0.005	-0.003	-0.003
Average network intensity	-0.004	-0.004	-0.009	-0.005	-0.005
Network structural holes	0.397***	0.396***	0.431***	0.402***	0.411***
Firm patenting age	0.011	0.011	0.010	0.011	0.011
Firm R&D expenses	-0.329***	-0.325***	-0.326***	-0.303***	-0.325***
Firm size	0.236**	0.235**	0.232**	0.222**	0.227**
Firm slack	-0.442**	-0.439**	-0.475**	-0.442**	-0.455**
Network size	0.000***	0.000***	0.000***	0.000***	0.000***
Year					
1990	0.144	0.145	0.144	0.140	0.106
1991	-0.042	-0.041	-0.032	-0.041	-0.116
1992	-0.002	-0.001	0.013	0.005	-0.096
1993	-0.150	-0.149	-0.133	-0.128	-0.239
1994	-0.471**	-0.471**	-0.455*	-0.452*	-0.547**
1995	-0.840***	-0.839***	-0.820***	-0.826***	-0.936***
1996	-0.957***	-0.956***	-0.945***	-0.941***	-1.086***
1997	-1.178***	-1.177***	-1.177***	-1.147***	-1.341***
1998	-1.147***	-1.143***	-1.155***	-1.090***	-1.341***
1999	-1.079***	-1.072***	-1.107***	-1.018***	-1.246***
2000	-1.019***	-1.003***	-1.058***	-0.969***	-1.120***
2001	-0.936***	-0.927***	-0.954***	-0.910***	-1.045***
2002	-0.915***	-0.910***	-0.929***	-0.916***	-1.002***
2003	-0.760**	-0.758**	-0.758**	-0.762**	-0.798**
2004	-0.937***	-0.936***	-0.939***	-0.885***	-0.926***
2005	-0.996***	-0.996***	-1.020***	-0.955***	-0.966***
Knowledge Asset Value (patent originality)		-0.00001	-0.00180***	-0.00058	-0.00030
Knowledge Asset Value (market value of knowledge)		0.00000	0.00005*	-0.00001	0.00000
High-tech industry			-0.14880		
Dynamism				0.04269	
Munificence					0.01824
H-T Ind x Patent Orig.			0.00226***		
H-T Ind x Market Value			-0.00006**		
Dyn x Patent Orig.				0.00050	
Dyn x Market Value				0.00001	
Mun x Patent Orig.					0.00002
Mun x Market Value					0.00000
Random Effects					
Industry	0.351	0.352	0.333	0.363	0.423
Firm	1.707	1.708	1.772	1.731	1.708
Residual	1.920	1.920	1.888	1.913	1.914
N	2,748	2,748	2,748	2,748	2,748
Wald χ^2	143.77*** (24)	143.91*** (26)	178.56*** (29)	148.84*** (29)	149.14*** (29)
Log likelihood	-5096.45	-5096.38	-5079.71	-5093.87	-5093.76
LR-test (χ^2)*		0.14	33.34**	5.16	5.38
AIC	10248.89	10252.75	10225.43	10253.73	10253.51

Table 5.5 Relationship between Firm Knowledge Asset Value with Moderators and Subsequent Firm Structural Holes

Group Variables: Industry segment, Firm	Model 1	Model 2 (H3)	Model 3 (H5c)	Model 4 (H6c)	Model 5 (H7c)
Intercept	1.266***	1.236***	1.227***	1.233***	1.225***
Network size	0.011***	0.011***	0.010***	0.010***	0.011***
Average network intensity	-0.001	-0.001	-0.001	-0.001	-0.001
Network structural holes	0.171***	0.170***	0.169***	0.172***	0.173***
Firm patenting age	-0.002*	-0.002*	-0.002*	-0.002*	-0.002*
Firm R&D expenses	0.032**	0.037***	0.043***	0.043***	0.041***
Firm size	0.005	0.005	0.000	0.001	0.002
Firm slack	-0.039	-0.038	-0.038	-0.038	-0.034
Firm network count	0.000***	0.000***	0.000***	0.000***	0.000***
Year					
1990	-0.072*	-0.073*	-0.075*	-0.071*	-0.070
1991	-0.153***	-0.153***	-0.154***	-0.150***	-0.143***
1992	-0.219***	-0.218***	-0.218***	-0.221***	-0.205***
1993	-0.254***	-0.253***	-0.231***	-0.257***	-0.238***
1994	-0.345***	-0.345***	-0.339***	-0.331***	-0.327***
1995	-0.359***	-0.359***	-0.349***	-0.335***	-0.334***
1996	-0.399***	-0.398***	-0.388***	-0.375***	-0.368***
1997	-0.463***	-0.462***	-0.446***	-0.446***	-0.424***
1998	-0.506***	-0.501***	-0.482***	-0.488***	-0.459***
1999	-0.502***	-0.497***	-0.475***	-0.482***	-0.455***
2000	-0.496***	-0.487***	-0.462***	-0.467***	-0.452***
2001	-0.478***	-0.472***	-0.452***	-0.452***	-0.438***
2002	-0.478***	-0.470***	-0.451***	-0.455***	-0.442***
2003	-0.447***	-0.440***	-0.423***	-0.423***	-0.416***
2004	-0.415***	-0.409***	-0.394***	-0.392***	-0.389***
2005	-0.409***	-0.404***	-0.388***	-0.387***	-0.386***
Knowledge Asset Value (patent originality)		-0.00011	-0.00020*	-0.00034***	-0.00020*
Knowledge Asset Value (market value of knowledge)		0.00000	-0.00001**	0.00000	0.00000
High-tech industry			-0.00962		
Dynamism				-0.03243**	
Munificence					-0.00282*
H-T Ind x Patent Orig.			0.00013		
H-T Ind x Market Value			0.00001**		
Dyn x Patent Orig.				0.00021***	
Dyn x Market Value				0.00000	
Mun x Patent Orig.					0.00001
Mun x Market Value					0.00000
Random Effects					
Industry	0.002	0.002	0.003	0.001	0.001
Firm	0.016	0.015	0.015	0.015	0.015
Residual	0.068	0.068	0.068	0.068	0.068
N	2,812	2,812	2,812	2,812	2,812
Wald χ^2	1360.26*** (24)	1369.94*** (26)	1384.96*** (29)	1431.33*** (29)	1399.42*** (29)
Log likelihood	-365.91	-364.47	-357.64	-352.95	-361.19
LR-test (χ^2)†		2.89	16.54**	25.92***	9.44
AIC	787.82	788.93	781.28	771.89	788.39

* Models 2 – 5 use Model 1 as the comparison model

† Models 2 – 5 use Model 1 as the comparison model

Table 5.6. Relationship between Firm Knowledge Asset Value with Moderators and Subsequent Network Beta Centrality

Group Variables: Industry segment, Firm	Model 1	Model 2 (H4)	Model 3 (H5d)	Model 4 (H6d)	Model 5 (H7d)
Intercept	1.668	-1.777	-0.916	-1.699	-1.218
Network size	0.391***	0.391***	0.375***	0.382***	0.395***
Average network intensity	-0.016	-0.029	-0.030	-0.025	-0.006
Network structural holes	2.586***	2.557***	2.620***	2.553***	2.480***
Firm patenting age	-0.034*	-0.026	-0.030	-0.030	-0.030
Firm R&D expenses	0.247	0.671*	0.889**	0.737**	0.837**
Firm size	0.536*	0.555*	0.400	0.513	0.471
Firm slack	0.610	0.779	0.699	0.757	1.021
Firm network count	0.003***	0.003***	0.004***	0.003***	0.003***
Year					
1990	-2.838**	-2.861**	-3.079**	-2.618**	-2.246*
1991	-6.296***	-6.168***	-6.328***	-5.920***	-4.957***
1992	-7.941***	-7.767***	-7.908***	-7.803***	-6.275***
1993	-9.412***	-9.226***	-9.222***	-9.509***	-7.717***
1994	-10.799***	-10.660***	-10.436***	-10.267***	-9.376***
1995	-11.107***	-11.045***	-10.581***	-10.311***	-9.516***
1996	-11.060***	-10.924***	-10.426***	-10.229***	-8.966***
1997	-11.382***	-11.261***	-10.578***	-11.092***	-8.863***
1998	-11.447***	-10.946***	-10.123***	-11.148***	-8.193***
1999	-10.487***	-9.952***	-8.987***	-10.164***	-7.490***
2000	-10.181***	-9.279***	-8.226***	-9.085***	-7.801***
2001	-9.466***	-8.796***	-7.752***	-8.474***	-7.482***
2002	-10.258***	-9.561***	-8.471***	-9.226***	-8.643***
2003	-9.890***	-9.179***	-8.119***	-8.758***	-8.741***
2004	-9.660***	-9.041***	-8.086***	-9.111***	-9.056***
2005	-9.053***	-8.578***	-7.577***	-8.610***	-8.850***
Knowledge Asset Value (patent originality)		-0.01273***	-0.01859***	-0.01706***	-0.01865***
Knowledge Asset Value (market value)		-0.00009*	-0.00022*	0.00000	0.00025**
High-tech industry			-5.13913***		
Dynamism				-1.79205***	
Munificence					-0.29242***
H-T Ind x Patent Orig.			0.00760***		
H-T Ind x Market Value			0.00014		
Dyn x Patent Orig.				0.00405**	
Dyn x Market Value				-0.00009	
Mun x Patent Orig.					0.00035**
Mun x Market Value					-0.00002***
Random Effects					
Industry	5.764	4.894	1.830	3.378	1.895
Firm	5.443	8.266	8.249	8.539	8.406
Residual	51.204	49.147	48.755	48.548	47.814
N	2,813	2,813	2,813	2,813	2,813
Wald χ^2	1466.89*** (24)	1483.79*** (26)	1530.17*** (29)	1526.20*** (29)	1601.97*** (29)
Log likelihood	-9631.99	-9604.06	-9587.67	-9587.95	-9563.42
LR-test (χ^2)[*]		55.84***	88.62***	88.06***	137.14***
AIC	19319.97	19268.13	19241.35	19241.90	19192.83

***p<.001, ** p<.01, *p<.05

[*] Models 2 – 5 use Model 1 as the comparison model

Table 5.7. Relationship between Firm Network Characteristics and Subsequent Knowledge Asset Value (Patent Originality)

Group Variables: Industry segment, Firm	Model 1 (Controls)	Model 2 (Degree)	Model 3 (Intensity)	Model 4 (Structural Holes)	Model 5 (Beta Centrality)
Intercept	-2262.170 *	-112.902 *	-178.518 **	-118.539	-116.349
Patent Originality	0.637 ***	0.656 ***	0.632 ***	0.638 ***	0.652 ***
Market Value of Knowledge	0.002 ***	0.002 ***	0.002 ***	0.002 ***	0.002 ***
Firm patenting age	1.077 *	-1.044 *	-1.130 *	-1.058 *	-1.061 *
Firm R&D expenses	15.693 *	13.001	16.547 *	15.510 *	13.176
Firm size	7.048	7.247	5.771	6.801	7.298
Firm slack	19.216	21.438	19.963	19.154	21.707
Network size	0.013 *	0.015 *	0.015 **	0.013 *	0.015 *
Year					
1990	-5.141	-6.560	-6.531	-4.509	-6.683
1991	0.837	-3.603	1.074	1.851	-3.074
1992	-6.571	-11.380	-3.674	-4.745	-11.553
1993	21.674 *	16.637	27.195 *	24.282 *	16.931
1994	26.761 *	22.416	34.598 **	30.132 **	22.865 *
1995	42.022 ***	39.059 **	50.932 ***	46.298 ***	39.586 **
1996	33.880 **	31.298 *	43.902 **	39.141 **	32.029 *
1997	52.434 ***	50.827 ***	64.485 ***	58.703 ***	51.585 ***
1998	46.506 **	44.429 **	61.614 ***	53.632 **	45.979 **
1999	38.053 **	39.407 *	56.877 **	46.619 **	41.025 *
2000	-11.290	-7.024	10.653	-1.624	-5.154
Firm Network Size		1.815 **			
Firm Network Size^2		-0.025 **			
Average network intensity			12.915		
Average network intensity ^2			-0.505		
Firm Network SH				-1.273	
Firm Network SH^2				2.198	
Firm Network centrality					1.451 **
Firm Network centrality^2					-0.015 **
Random Effects					
Industry	463.928	639.852	502.772	470.332	650.668
Firm	5767.253	5581.274	5857.073	5716.968	5595.461
Residual	4402.884	4299.427	4298.102	4356.959	4358.138
N	980	990	986	990	980
Wald χ^2	511.74 ***	692.81 ***	681.91 ***	669.44 ***	682.97 ***
	(22)	(24)	(24)	(24)	(24)
Log Likelihood	-5644.036	-5690.490	-5668.877	-5696.394	-5639.307
LR-test (χ^2)*		-92.9	-49.682	-104.716	9.458 *
AIC	11332.07	11428.98	11385.75	11440.79	11326.61

***p<.001, ** p<.01, *p<.05

* Models 2 – 5 use Model 1 as the comparison model

Table 5.8. Relationship between Firm Network Characteristics and Subsequent Knowledge Asset Value (Patent Market Value)

Group Variables: Industry segment, Firm	Model 1 (Controls)	Model 2 (Degree)	Model 3 (Intensity)	Model 4 (Structural Holes)	Model 5 (Beta Centrality)
Intercept	21069.157 *	-8134.315 *	-9552.06 **	-146000	-8565.968 **
Patent Originality	-0.819	-3.543	-0.828	-0.346	-3.481
Market Value of Knowledge	-0.048	-0.067	-0.048	-0.054	-0.064
Firm patenting age	-15.767	20.005	18.305	17.124	20.298
Firm R&D expenses	1472.249 **	1285.868 **	1367.895 **	1306.797 **	1320.548 **
Firm size	196.021	144.217	284.337	211.827	142.847
Firm slack	761.433	1160.305	622.914	886.689	1148.076
Network size	0.042	-0.406	-0.012	-0.146	-0.340
Year					
1990	476.729	381.716	525.998	493.845	434.850
1991	788.789	333.787	795.971	618.243	506.528
1992	1885.969	1167.397	1783.544 *	1602.954 *	1326.639
1993	2601.249 **	1467.530 *	2370.533 **	2097.537 *	1729.290 *
1994	4021.251 ***	2379.115 **	3738.767 ***	3390.400 ***	2757.981 **
1995	6932.156 ***	4794.303 ***	6622.998 ***	6150.746 ***	5310.508 ***
1996	3574.870 ***	1374.924	3249.532 ***	2773.808 **	1967.292 *
1997	2527.270	125.284	2149.551 *	1653.129	715.133
1998	1314.820	-1117.272	862.091	333.086	-444.762
1999	1415.177	-610.772	863.530	466.515	-40.676
2000	1369.750	-128.313	757.200	495.392	248.479
Firm Network Size		105.067 **			
Firm Network Size^2		0.276			
Average network intensity			173.133		
Average network intensity ^2			-38.700		
Firm Network SH				-12900.000 *	
Firm Network SH^2				4753.706 *	
Firm Network centrality					75.998 **
Firm Network centrality^2					0.252
Random Effects					
Industry	0.000	0.000	0.000	0.000	0.000
Firm	1.5e+07	1.4e+06	1.5e+07	1.5e+07	1.4e+07
Residual	2.7e+07	2.6e+07	2.7e+07	2.7e+07	2.7e+07
N	980	990	986	990	980
Wald χ^2	165.40 ***	206.84 *	170.27 *	174.12 *	199.07 *
	(22)	(24)			
Log Likelihood	-9872.593	-9951.735	-9928.328	-9965.411	-9858.43
LR-test (χ^2)[*]		-158.284	-111.47	-185.636	28.326 ***
AIC	19789.19	19951.47	19904.66	19978.82	19764.86

***p<.001, ** p<.01, *p<.05

[*] Models 2 – 5 use Model 1 as the comparison model

Table 5.9. Hypotheses Results

Hypothesis Statement	Independent Variable	Level of Support	β	
H1: There is a negative relationship between firm knowledge asset value and subsequent network size				
	Patent originality	Supported	-0.01050	***
	Market value	Supported	-0.00017	***
H2: There is a positive relationship between firm knowledge asset value and the subsequent average strength of ties (i.e., network intensity) in the firm network				
	Patent originality	Not supported	-0.00001	
	Market value	Not supported	0.00000	
H3: There is a negative relationship between firm knowledge asset value and subsequent volume of structural holes				
	Patent originality	Not supported	-0.00011	
	Market value	Not supported	-0.00000	
H4: There is a negative relationship between firm knowledge asset value and their subsequent beta centrality				
	Patent originality	Supported	-0.01273	***
	Market value	Supported	-0.00009	*
H5: In industries where knowledge is perceived as more valuable (i.e., high technology), the relationships between firm knowledge asset value and subsequent network characteristics will be stronger.				
H5a: subsequent network size				
	Patent originality	Not supported	0.00627	***
	Market value	Not supported	0.00003	
H5b: subsequent average network intensity				
	Patent originality	Supported	0.00226	***
	Market value	Not supported	-0.00006	**
H5c: subsequent volume of structural holes				
	Patent originality	Not supported	0.00013	
	Market value	Not supported	0.00001	**
H5d: subsequent beta centrality				
	Patent originality	Not supported	0.00760	***
	Market value	Not supported	0.00014	
H6: The level of dynamism in the industry will moderate the relationships between firm knowledge asset value and subsequent network characteristics, such that the strength of the relationships will increase with the level of dynamism.				
H6a: subsequent network size				
	Patent originality	Not supported	0.00295	***
	Market value	Not supported	-0.00002	
H6b: subsequent average network intensity				
	Patent originality	Not supported	0.00050	
	Market value	Not supported	0.00001	
H6c: subsequent volume of structural holes				
	Patent originality	Not supported	0.00021	**
	Market value	Not supported	0.00000	
H6d: subsequent beta centrality				
	Patent originality	Not supported	0.00405	**
	Market value	Not supported	-0.00009	

H7: The level of munificence in the industry will moderate the relationships between firm knowledge asset value and subsequent network characteristics, such that the strength of the relationships will decrease with the level of munificence.				
H7a: subsequent network size				
	Patent originality	Not supported	0.00022	*
	Market value	Not supported	-0.00001	
H7b: subsequent average network intensity				
	Patent originality	Not supported	0.00002	
	Market value	Not supported	0.00000	
H7c: subsequent volume of structural holes				
	Patent originality	Not supported	0.00001	
	Market value	Not supported	0.00000	
H7d: subsequent beta centrality				
	Patent originality	Not supported	0.00035	**
	Market value	Not supported	-0.00002	***

Dependent Variable	Patent Originality	β		Market Value	β	
H8: Network safeguards will have a curvilinear (inverted-U) relationship with subsequent knowledge asset value.						
H8a: network size	Supported	-0.025	**	Not supported	0.276	
H8b: average network intensity	Not supported	-0.505		Not supported	-38.700	
H8c: network closure	Not supported	2.198		Not supported	4753.706	*
H8d: beta centrality	Supported	-0.015	**	Not supported	0.252	

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5.10 Post Hoc #1: Firm Knowledge Asset Value with Moderators and Subsequent Firm Network Intensity

Group Variables: Industry segment, Firm	Model 1	Model 2 (H2)	Model 3 (H5b)	Model 4 (H6b)	Model 5 (H7b)
Intercept	0.231	0.281	0.314***	0.265	0.259***
Network size	-0.001	-0.001	-0.002	-0.001	-0.001
Average network intensity	0.023**	0.022**	0.020*	0.023**	0.022*
Network structural holes	0.053	0.057*	0.054	0.056	0.056
Firm patenting age	0.001	0.000	0.000	0.001	0.000
Firm R&D expenses	-0.119***	-0.126***	-0.117***	-0.116***	-0.123***
Firm size	0.100***	0.100**	0.095***	0.094***	0.100***
Firm slack	-0.087	-0.090	-0.098*	-0.093	-0.091
Network size	0.000	0.000	0.000	0.000	0.000
Year					
1990	0.030	0.031	0.028	0.036	0.032
1991	-0.020	-0.018	-0.022	-0.010	-0.014
1992	-0.006	-0.005	-0.004	-0.008	0.000
1993	0.009	0.009	0.012	0.003	0.016
1994	-0.014	-0.013	-0.007	0.000	-0.004
1995	-0.064	-0.063	-0.048	-0.043	-0.052
1996	-0.063	-0.062	-0.049	-0.044	-0.048
1997	-0.098	-0.097	-0.083	-0.088	-0.079
1998	-0.058	-0.068	-0.054	-0.052	-0.046
1999	-0.036	-0.041	-0.028	-0.025	-0.022
2000	-0.097	-0.107	-0.080	-0.084	-0.075
2001	-0.086	-0.093	-0.068	-0.066	-0.061
2002	-0.089	-0.105	-0.088	-0.088	-0.078
2003	0.050	0.021	0.034	0.040	0.033
2004	-0.012	-0.031	-0.016	-0.011	-0.012
2005	0.036	0.005	0.017	0.019	0.016
Knowledge Asset Value (patent originality)		0.00024*	-0.00021	0.00010	0.00032*
Knowledge Asset Value (market value of knowledge)		0.00000	0.00000	-0.00001	-0.00001
High-tech industry			-0.05181		
Dynamism				-0.03493	
Munificence					-0.00025
H-T Ind x Patent Orig.			0.00050**		
H-T Ind x Market Value			0.00000		
Dyn x Patent Orig.				0.00011	
Dyn x Market Value				0.00000	
Mun x Patent Orig.					-0.00001
Mun x Market Value					0.00000
Random Effects					
Industry	0.017	0.017	0.016	0.013	0.017
Firm	0.034	0.033	0.035	0.033	0.033
Residual	0.073	0.073	0.072	0.073	0.073
N	863	863	863	863	863
Wald χ^2	92.52*** (24)	98.58*** (26)	107.11*** (29)	106.91*** (29)	101.20*** (29)
Log likelihood	-203.956	-201.57	-197.04	-198.63	-200.06
LR-test (χ^2)[*]		4.77	13.83*	10.65	7.79
AIC	463.91	463.13	460.09	463.26	466.11

***p<.001, ** p<.01, *p<.05

Table 5.11 Post Hoc #2: Firm Knowledge Asset Value with Moderators and Subsequent Firm Network Intensity

[*] Models 2 – 5 use Model 1 as the comparison model

Group Variables: Industry segment, Firm	Model 1	Model 2 (H2)	Model 3 (H5b)	Model 4 (H6b)	Model 5 (H7b)
Intercept	12.338	18.867	19.040	17.102	15.949
Network size	-0.039	-0.088	-0.153	-0.091	-0.096
Average network intensity	2.244**	2.154**	1.946*	2.190**	2.080**
Network structural holes	2.081	2.562*	2.157	2.448	2.580
Firm patenting age	0.126	0.104	0.092	0.127	0.102
Firm R&D expenses	-12.770***	-13.675***	-12.798***	-12.615***	-13.334***
Firm size	11.177***	11.252**	10.840***	10.597***	11.130***
Firm slack	-7.009	-7.463	-8.097	-7.748	-8.052
Network size	-0.007**	-0.008**	-0.007*	-0.007**	-0.007**
Year					
1990	7.066	7.158	7.255	7.408	6.835
1991	2.187	2.310	2.361	2.809	1.844
1992	4.952	5.020	5.517	4.727	4.410
1993	6.969	6.924	7.501	6.556	6.678
1994	6.085	6.220	6.824	7.172	6.194
1995	1.429	1.444	2.847	2.971	1.625
1996	1.690	1.687	2.771	3.108	1.724
1997	-2.195	-2.236	-1.062	-1.312	-2.221
1998	1.714	0.359	1.197	2.258	0.107
1999	0.170	-0.759	-0.262	1.208	-1.036
2000	-8.949	-10.747	-8.475	-8.517	-7.990
2001	-3.531	-4.816	-2.981	-1.908	-2.154
2002	-5.516	-7.741	-7.189	-6.252	-5.975
2003	7.963	4.411	4.620	6.110	5.232
2004	5.015	2.627	3.103	4.755	4.749
2005	8.419	4.847	5.248	6.371	6.280
Knowledge Asset Value (patent originality)		0.02755*	-0.00838	0.01513	0.03756*
Knowledge Asset Value (market value of knowledge)		-0.00003	-0.00065	-0.00070	-0.00168*
High-tech industry			2.53072		
Dynamism				-2.34640	
Munificence					0.20695
H-T Ind x Patent Orig.			0.04099*		
H-T Ind x Market Value			0.00060		
Dyn x Patent Orig.				0.00931	
Dyn x Market Value				0.00049	
Mun x Patent Orig.					-0.00072
Mun x Market Value					0.00008*
Random Effects					
Industry	115.5	160.9	153.1	137.2	174.3
Firm	442.1	434.6	447.5	439.2	445.1
Residual	688.3	684.4	674.0	679.2	674.2
N	863	863	863	863	863
Wald χ^2	115.51***	122.69***	130.46***	129.82***	128.71***
	(24)	(26)	(29)	(29)	(29)
Log likelihood	-4170.87	-4167.79	-4163.88	-4164.93	-4164.33
LR-test (χ^2)[*]		6.15	13.97*	11.87*	13.07*
AIC	8397.73	8395.58	8393.76	8395.86	8394.67

***p<.001, ** p<.01, *p<.05

[*] Models 2 – 5 use Model 1 as the comparison model

Figure 5.1: Graphs of Interaction of Firm Knowledge Asset Value and Industry with Network Safeguards

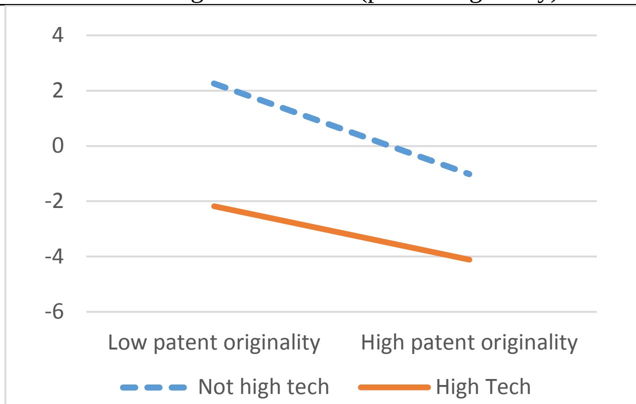
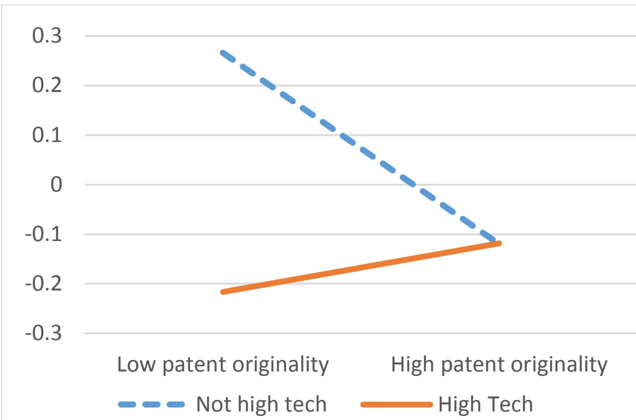
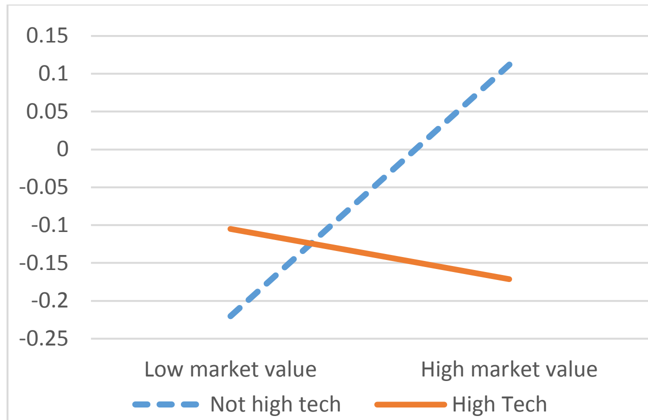
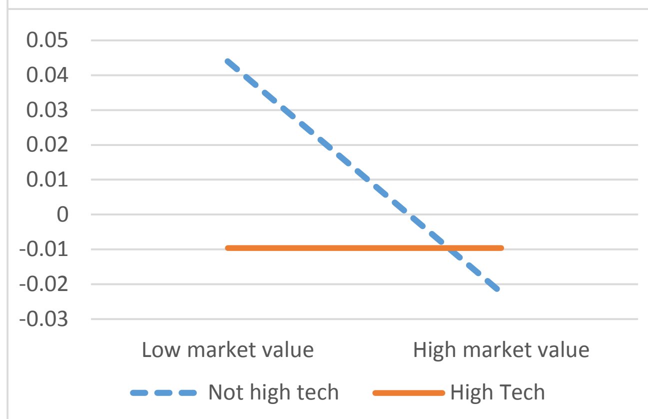
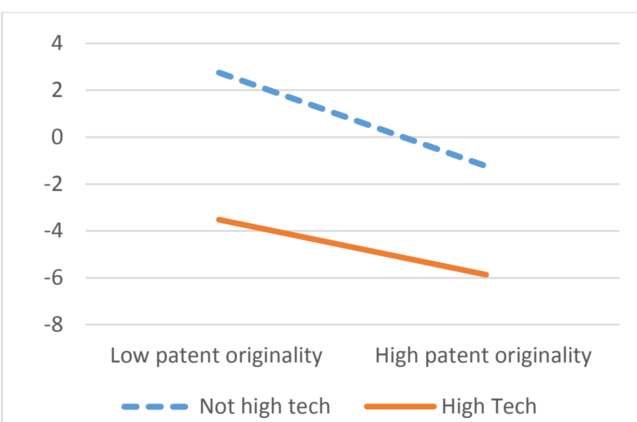
	Knowledge Asset Value (patent originality)	Knowledge Asset Value (market value)
Firm Network Size		Not significant
Firm Network Intensity		
Structural Holes	Not significant	
Beta Centrality		Not significant

Figure 5.2: Graph of Interaction of Firm Knowledge Asset Value and Dynamism with Network Safeguards

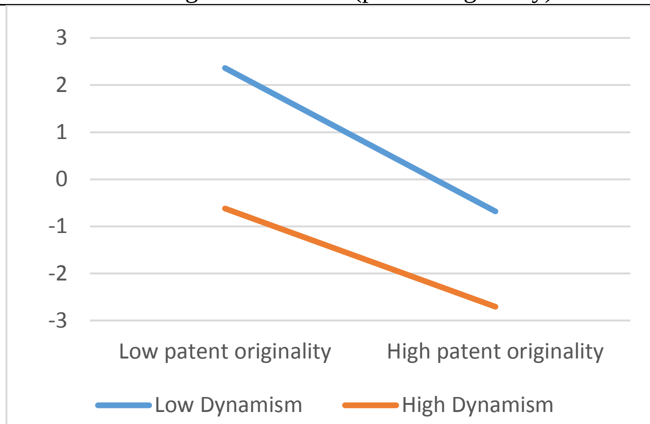
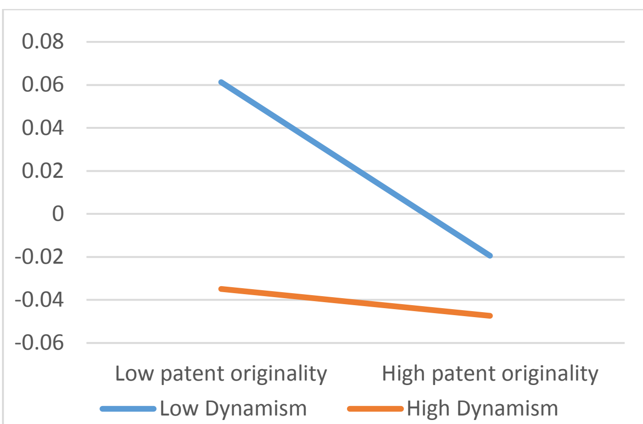
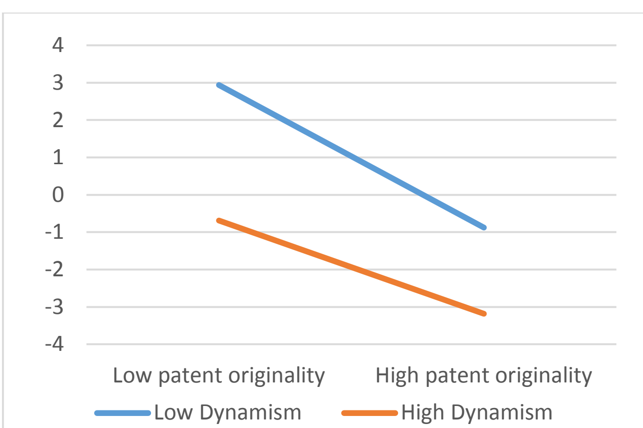
	Knowledge Asset Value (patent originality)	Knowledge Asset Value (market value)
Firm Network Size		Not significant
Firm Network Intensity	Not significant	Not significant
Structural Holes		Not significant
Beta Centrality		Not significant

Figure 5.3 Graph of Interaction of Firm Knowledge Asset Value and Munificence with Network Safeguards

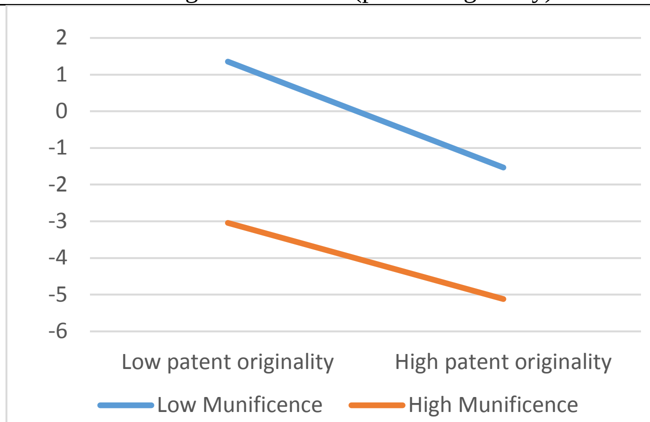
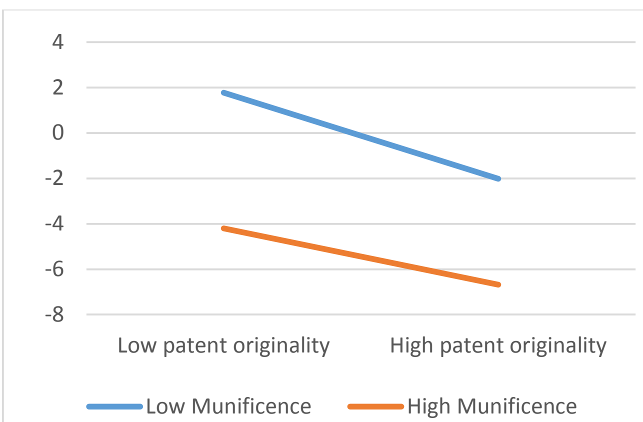
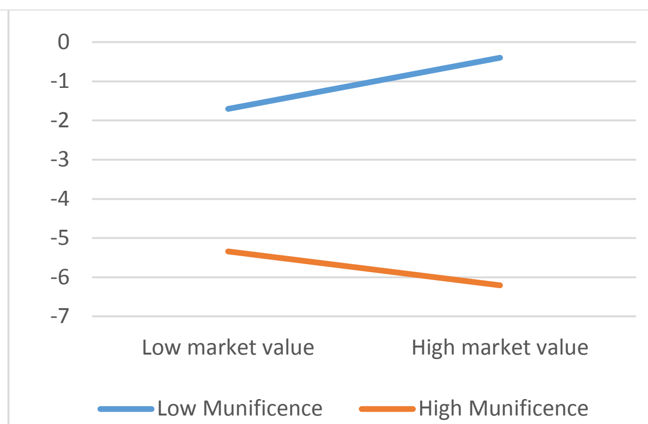
	Knowledge Asset Value (patent originality)	Knowledge Asset Value (market value)
Firm Network Size		Not significant
Firm Network Intensity	Not significant	Not significant
Structural Holes	Not significant	Not significant
Beta Centrality		

Figure 5.4: Graphs of Curvilinear Effects of Network Safeguards and future Firm Knowledge Asset Value

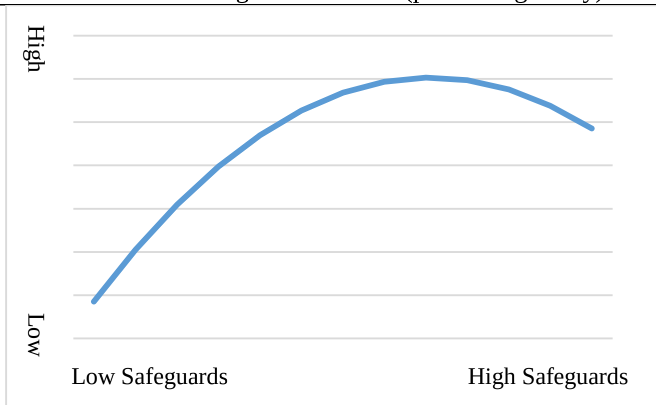
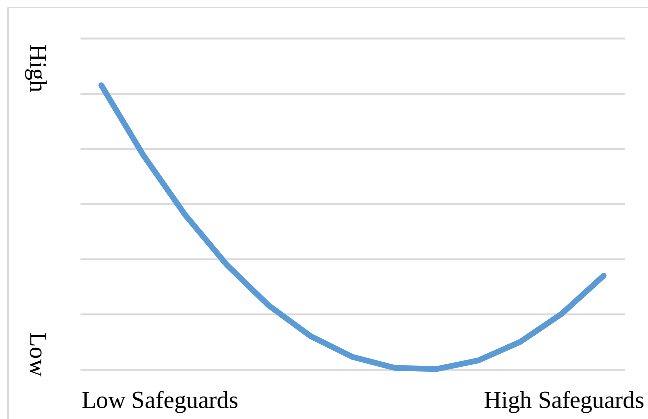
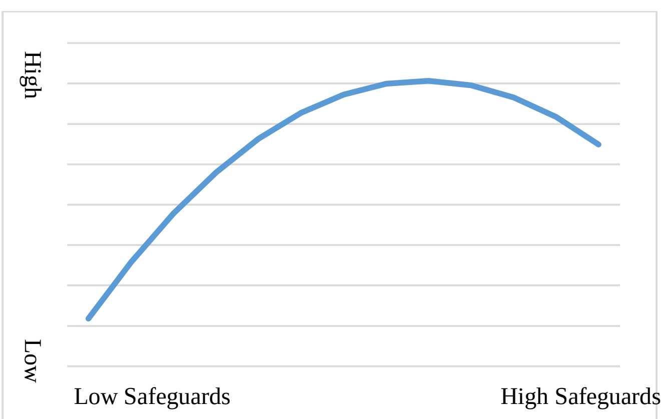
	Future Knowledge Asset Value (patent originality)	Future Knowledge Asset Value (market value)
Firm Network Size		Not significant
Firm Network Intensity	Not significant	Not significant
Structural Holes	Not significant	
Beta Centrality		Not significant

Table 6.1. Nohria and Garcia-Pont's (1991) scale of relationship intensity

Mergers and Acquisitions	9
Independent Joint Ventures	8
Limited Cross Equity Ownership	7
Minority Equity	6
Broad R&D Agreements	5
Second source agreements	4
Component sourcing agreements	3
Know-how and patent licensing agreements	2
Distribution agreements	1