Motivations and Outcomes of Firms' Leveraging of Alliance Knowledge

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ABSTRACT

Nowadays, firms increasingly rely on strategic alliances to reach out for unique technological knowledge that firms cannot develop internally. However, in previous literature, we find inconsistent findings regarding the drivers and outcomes of a firm's leverage of alliance partners' technological knowledge. In this dissertation, I consider opposite propositions in prior studies simultaneously and examine two research questions: 1) what motivates a firm to search technological knowledge from alliance partners? And 2) how configurations of alliance knowledge and alliance network affect firm innovation?

I argue that alliance knowledge search motivation is determined by the allocation of managerial attention to local domains and distant domains. While distant attention motives alliance knowledge search, local attention suppresses the motivation. I hypothesize that innovation performance below the aspiration level intensifies both local and distant attentions and has an inverted U-shaped relationship with alliance knowledge search intensity. This curvilinear relationship is moderated by the focal firm's knowledge stock size since firms with large knowledge stock are more likely to develop distant attention in the presence of poor innovation performance.

I further argue that exploration and exploitation play key roles in the configurations of both alliance knowledge and alliance network. Alliance knowledge leveraging can contribute more to firm innovation, if the firm can establish a balance between exploration and exploitation. I propose that balancing exploration and exploitation within a single domain (e.g., search

moderately explorative alliance knowledge) generates great managerial costs. However, firms can balance exploration and exploitation across domains: they can leverage explorative knowledge through exploitative alliances, such as repeated partnerships and strong ties.

I test related hypotheses using longitudinal data from the U.S. biopharmaceutical industry. Results show that: 1) innovation performance below the aspiration level has an inverted U-shaped relationship with alliance knowledge search, demonstrating that both distant and local attention play important roles in developing the motivation for alliance knowledge search; 2) increasing knowledge stock size increases both positive and negative effects of innovation performance below aspiration; 3) technological distance of searched alliance knowledge has a linear negative effect on firm innovation; and 4) leveraging explorative knowledge from repeated partnership, but not strong ties, leads to superior innovation performance, supporting the idea of establishing the balance across domains. The findings make important contributions to alliance knowledge leveraging, aspiration, and exploration-exploitation literatures. The managerial implications of the study are also discussed.

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GENERAL AUDIENCE ABSTRACT

Nowadays, firms increasingly rely on strategic alliances to reach out for unique technological knowledge that firms cannot develop internally. By absorbing and utilizing these unique technologies, firms leverage alliance knowledge for their own technological innovation. However, in previous literature, we find inconsistent findings regarding the drivers and outcomes of alliance knowledge leverage. In this dissertation, I consider opposite propositions in prior studies simultaneously and examine the motivations and outcomes of a firm's alliance knowledge leverage.

First, I propose that the firm's poor innovation performance is an important antecedent of alliance knowledge leverage. I hypothesize that, when a firm's innovation performance is below the aspiration level, *i.e.*, below the firm's past innovation performance and/or the average innovation performance of peer firms, further innovation performance decrease would first increase and then decrease the firm's alliance knowledge search intensity. Moreover, a firm with a larger knowledge stock would conduct more alliance knowledge search to respond to innovation performance decrease than a firm with a smaller knowledge stock. Second, I examine how alliance knowledge leverage influence firm innovation. I argue that alliance knowledge leveraging can contribute more to firm innovation, if the firm can establish a balance between exploration, which is captured by terms such as search, variation, risk-taking, and experimentation, and exploitation, which is defined as items regarding experiential refinement and reusing existing knowledge. I propose that balancing exploration and exploitation within a

single domain (e.g., search moderately explorative alliance knowledge) generates great managerial costs. However, firms can balance exploration and exploitation across domains: they can leverage explorative knowledge through exploitative alliances, such as repeated partnerships and strong ties.

I test related hypotheses using longitudinal data from the U.S. biopharmaceutical industry. Results of data analysis generally support the hypotheses.

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DEDICATION

I dedicate this dissertation to my parents, grandparents, parents-in-law, and my loving wife, Xi Liu, for their constant encouragement and endless love during the past years. It is impossible for me to complete this monumental task without your support. I would also like to dedicate this dissertation to my paternal grandmother in heaven who are proud of her grandson.

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1.0 INTRODUCTION

1.1. Research motivation

Firms leverage technological knowledge from alliance partners by searching, recognizing and acquiring knowledge embedded in the partner firms and appropriating innovation-related benefits from the searched knowledge. Alliance knowledge leveraging is an important avenue through which external knowledge exploration occurs (Ahuja, Lampert, and Tandon, 2008; Easterby-Smith, Lyles, and Tsang, 2008; Rosenkopf and Almeida, 2003), and using knowledge from partner firms has become an increasingly important enabler of firm innovation (Ahuja, 2000; Ahuja et al., 2008; Phelps, Heidl, and Wadhwa, 2012; Powell, Koput, and Smith-Doerr, 1996; Schilling and Phelps, 2007). For example, according to the SDC Platinum™ database, in the biopharmaceutical industry, 10,721 alliances were formed between 1996 and 2013. According to Schildt, Keil, and Maula (2012), leveraging alliance knowledge is "at least an implicit objective in all alliances" (p1155). The importance of alliance knowledge leveraging is demonstrated by both the increased use of knowledge-related alliances in a variety of industries (Hagedoorn, 2002; Sampson, 2007) and the increased studies of knowledge-driven alliance behaviors (Phelps et al., 2012).

Although alliance knowledge leveraging has received increasing attention in recent years (Ahuja et al., 2008; Phelps et al., 2012), why firms differ in their motivations for leveraging alliance knowledge, and why alliance knowledge leveraging leads to a variance in innovation-related outcomes remain unclear in the literature. The motivation for alliance knowledge leveraging is critical because knowledge is not likely to flow automatically between firms (Simonin, 1999). Without the motivation, the focal firm would be unable to recognize, transfer,

assimilate and apply knowledge embedded in its alliance partners (Easterby-Smith et al., 2008; Simonin, 2004; Tsang, 2002). The heterogeneity, in terms of the outcome of alliance knowledge leveraging, is also important because it explains why alliance knowledge leveraging can be used as a strategy to sustain a competitive advantage: If alliance knowledge leveraging brings the same innovation-related benefits to all firms, it would lead to competitive parity, instead of competitive advantages.

Both the motivation for alliance knowledge search and the outcomes of the search are rather unclear in the literature. One of the most important challenges is to understand the contradictions and conflicts inherent in alliance knowledge leveraging. For example, on the one hand, studies have identified that firms are more motivated to leverage alliance knowledge in the presence of poor performance (Ben-Oz and Greve, 2015; Tyler and Caner, 2015), are able to leverage alliance knowledge more effectively when have strong knowledge-related resources (Cohen and Levinthal, 1990; Estrada, de la Fuente and Martín-Cruz, 2010) and inter-firm learning tends to be more intensive when the knowledge similarity between the focal firm and partners is high (Lane and Lubatkin, 1998; Lane, Salk, and Lyles, 2001). On the other hand, scholars also found that, poorly performing firms may reduce rather than increase external directed R&D activities (Gaba and Bhattacharya, 2012), knowledge-related resources and alliance knowledge leveraging could be substitutional but not complementary (Laursen and Salter, 2006), and inter-firm learning is likely to be prompted by knowledge dissimilarity rather than similarity between partners (Bierly, Damanpour, and Santoro, 2009). These inconsistent findings reflect a variety of contradictions including focusing on distant alliance knowledge *vs* local knowledge (Laursen, 2012), acquiring valuable alliance knowledge *vs* protecting existing knowledge (Kale, Singh and Perlmutter, 2000, Li, Eden, Hitt, Ireland and Garrett, 2012),

sourcing similar *vs* dissimilar technologies (Rosenkopf and Nerkar, 2001), and partnering with old *vs* new partners (Lavie and Rosenkopf, 2006).

These inconsistencies make it difficult to predict a firm's motivation for alliance knowledge leveraging as well as the outcomes. Focusing on one side of the contradiction leads to an incomplete understanding of alliance knowledge leveraging. For example, empirical evidence shows that alliance knowledge may have positive effect (Ahuja, 2000), none effect (Love and Roper, 2001), or negative effect (Tsai, 2009) on firm innovation. If researchers only focus on the benefits of alliance knowledge leveraging, it would be difficult for them to explain these inconsistent findings. To address this issue, I built an integrative framework of alliance knowledge leveraging that considers the opposite propositions simultaneously.

I focus on three critical elements in alliance knowledge leveraging: the motivation for searching alliance knowledge, the configuration of alliance knowledge, and the configuration of alliance network. The *motivation for alliance knowledge search* refers to the extent to which the focal firm distributes its attention and cognitive resources to the knowledge-related resources embedded in its alliance partners, and therefore, makes the decision about how much alliance knowledge the firm is going to purposefully search and utilize. While having search motivation is a prerequisite for alliance knowledge leveraging (Hamel, 1991; Simonin, 2004), surprisingly little is known about what serves as a motivator and why firms differ in search motivation.

Configurations of alliance knowledge and alliance network are examined because they are key influential factors of alliance knowledge leveraging outcome. The *configuration of alliance knowledge* describes the characteristics of the technological knowledge that is embedded in partner firms; characteristics such as "novelty", "diversity", and "tacitness" are

included. The *configuration of alliance networks* describes the characteristics of the network primitives (Ahuja, Soda, and Zaheer, 2012), including the number of partners of the focal firm, tie strength, and the network structure through which the alliance knowledge is transferred. Although researchers point out that the alliance knowledge and alliance networks jointly determine the outcome of alliance knowledge leveraging (Inkpen, 2000), studies have rarely examined the interaction between these two domains.

I argue that because the inconsistencies in the prior studies, both motivations and outcomes of alliance knowledge leveraging are not clear. Thus, in this study, I attempt to answer the following two research questions:

1. *What motivates a firm to leverage knowledge from its partners?*
2. *How do configurations of alliance knowledge and alliance network influence firm innovation?*

1.2 Conceptual Overview

To address these research questions, I advance a conceptual model (Figure 1.1) that suggests what motivates alliance knowledge leveraging, and how configurations of alliance knowledge and alliance network influence firm innovation, which is generally viewed as the immediate outcome of using external knowledge (Ahuja, 2000; Phelps et al., 2012). The alliance knowledge leveraging firm needs to develop motivation for searching alliance knowledge first ("Alliance knowledge search motivation" in Figure 1.1), then it can leverage the alliance knowledge. Once the alliance knowledge search is conducted, the configuration of searched alliance knowledge ("Searched alliance knowledge" in Figure 1.1) combined with the

configurations of alliance network ("Alliance network" in Figure 1.1) shape the innovation-related outcomes of the leveraging ("Firm innovation" in Figure 1.1).

In developing my conceptual model, I focus on the contradictions mentioned above and integrate opposite propositions in the previous literature. The core contradiction in the motivation for alliance knowledge leveraging is the tension between allocating managerial attention to local domains and distant domains (Laursen, 2012). On the one hand, firms are often motivated to leverage alliance knowledge, because it is helpful to them in exploring distant technological domains (Rosenkopf and Almeida, 2003) and in generating novel and high-impact innovations (Phelps, 2010; Sampson, 2007). On the other hand, alliance knowledge often involves a high degree of knowledge uncertainty (Simonin, 1999; van Wijk, Jansen and Lyles, 2008) and increases the likelihood of knowledge leakage (Kale, et al., 2000; Li, Eden, Hitt, and Ireland, 2008). These concerns can suppress distant attention and make the firm focus on local solutions (Gilbert, 2005); thereby, effectively reducing alliance knowledge search motivation.

I build on the core underpinnings of the behavioral strategy literature (Cyert and March, 1963; Greve, 2003) to develop theoretical insights about the motivation for alliance knowledge leveraging. The behavioral strategy is widely used to explain managerial motivation (Tyler and Caner, 2015). In particular, recent behavioral studies found that unsatisfactory innovation performance feedback, *i.e.*, innovation performance below aspiration, shapes the motivations for knowledge search behaviors, such as R&D alliance formation (Tyler and Caner, 2015) and R&D externalization (Gaba and Bhattacharya, 2012). In addition, the focal firm's knowledge stock size would influence its attention allocation by shaping the firm's perception of performance feedback (Audia and Greve, 2006). Therefore, I develop a hypothesis about how the focal firm's innovation performance feedback and its knowledge stock size, influence the contradiction of

distant and local attention in alliance knowledge search motivation, and empirically test how these two factors jointly impact the focal firm's alliance knowledge search intensity (as depicted in the left side of the model in Figure 1.1).

I argue that the relationship between poor performance relative to aspiration and knowledge search intensity is curvilinear (inverted U-shaped), because poor performance could simultaneously intensify the motivation for reaching out (Ben-Oz and Greve, 2015; Tyler and Caner, 2015) and exacerbate the concerns about uncertainty and potential knowledge leakage (Gaba and Bhattacharya, 2012; Staw, Sandelands, and Dutton, 1981), which suppress distant attention and accordingly reduce the motivation for search.

Furthermore, I argue that the focal firm's knowledge stock size has a moderating effect on the relationship between poor innovation performance and alliance knowledge search intensity: increasing knowledge stock size will increase the positive effect of poor innovation performance, and reduce the negative effect of poor innovation performance. First, firms with large knowledge stock could be more capable of generating value from distant alliance knowledge (Volberda, Foss, and Lyles, 2010). When the firm has more confidence to benefit from searching distant knowledge domains, it would be more motivated to conduct alliance knowledge searches in the presence of poor innovation performance. Second, for a firm with declining innovation performance, if it has a rather small knowledge stock, further knowledge loss could appear devastating, but having a large knowledge stock would provide the buffer (Audia and Greve, 2006)— the ability to withstand knowledge loss. The buffering effect, thus reduces the negative impacts of poor innovation performance on alliance knowledge search.

As for the effect of configurations of alliance knowledge and alliance network on firm innovation, I propose that both knowledge and network can be categorized into two types: explorative and exploitative. Since both of exploration and exploitation are important for firm innovation (Katila and Ahuja, 2002; March, 1991), firms need to strike a balance between these two entities in alliance knowledge leveraging (Andriopoulos and Lewis, 2009; Rothaermel and Deeds, 2004). However, because embracing exploration and exploitation in one domain creates managerial costs (Lavie, Kang, and Rosenkopf, 2011), I propose that the balance between exploration and exploitation needs to be established across domains (Lavie and Rosenkopf, 2006): firms can leverage explorative knowledge through exploitative alliances.

I test how striking a balance between exploration and exploitation in alliance knowledge and alliance network, influences the innovation outcomes of alliance knowledge leveraging (as depicted in the right side of the model in Figure 1.1). I propose that alliance knowledge leveraging generates the lowest innovation-related benefits when the degree of exploration is moderate, since a moderate degree of exploration the generates greatest managerial costs (Lavie et al., 2011). To maximize firm innovation, a firm can also balance exploration and exploitation across domains by leveraging explorative knowledge from repeated partners and/or strong ties (Lavie and Rosenkopf, 2006). Furthermore, since alliance knowledge may not be fully utilized by the focal firm, I propose that searched alliance knowledge has a stronger impact on firm innovation than total alliance knowledge.

I tested the hypotheses using data from the U.S. biopharmaceutical industry where both alliance and innovation activities are highly intense (Hagedoorn, 1993; Rothaermel and Deeds, 2004). The results show that, as predicted, innovation performance below aspiration has an inverted U-shaped relationship on the intensity of alliance knowledge search. The focal firm's

size of knowledge stock moderates the curvilinear relationship between poor innovation performance and alliance knowledge search intensity. However, although increasing the focal firm's knowledge stock increases the positive effect of poor innovation performance on alliance knowledge search intensity, the negative effect of poor innovation performance is also intensified by large knowledge stock.

Then, I test how searched alliance knowledge and alliance network jointly influence firm innovation. The results show that exploration in searched alliance knowledge has a linear negative effect on firm innovation, which means the predicted curvilinear relationship is not supported by the data. Repeated partners do positively moderate the relationship between exploration in searched alliance knowledge and firm innovation, but the moderating effect of strong ties is negative. Finally, results also show that searched alliance knowledge does have a stronger effect on firm innovation than total alliance knowledge.

1.3 Contributions

This study aims to accomplish three main objectives. First, this study develops a more integrative framework to examine motivations and outcomes of alliance knowledge leveraging. My framework consider opposite propositions in prior studies simultaneously and therefore helps researchers to resolve the inconsistent findings in the previous literature (Poole and van de Van, 1989). Researchers such framework tend to see one side of alliance knowledge leveraging and to neglect the other. For example, prior studies have found that firms tend to search external distant knowledge more intensively when experiencing poor performance (Ben-Oz and Greve, 2015), which implies a positive relationship between negative performance feedback, and alliance knowledge search. However, employing the framework of this study, researchers might discover

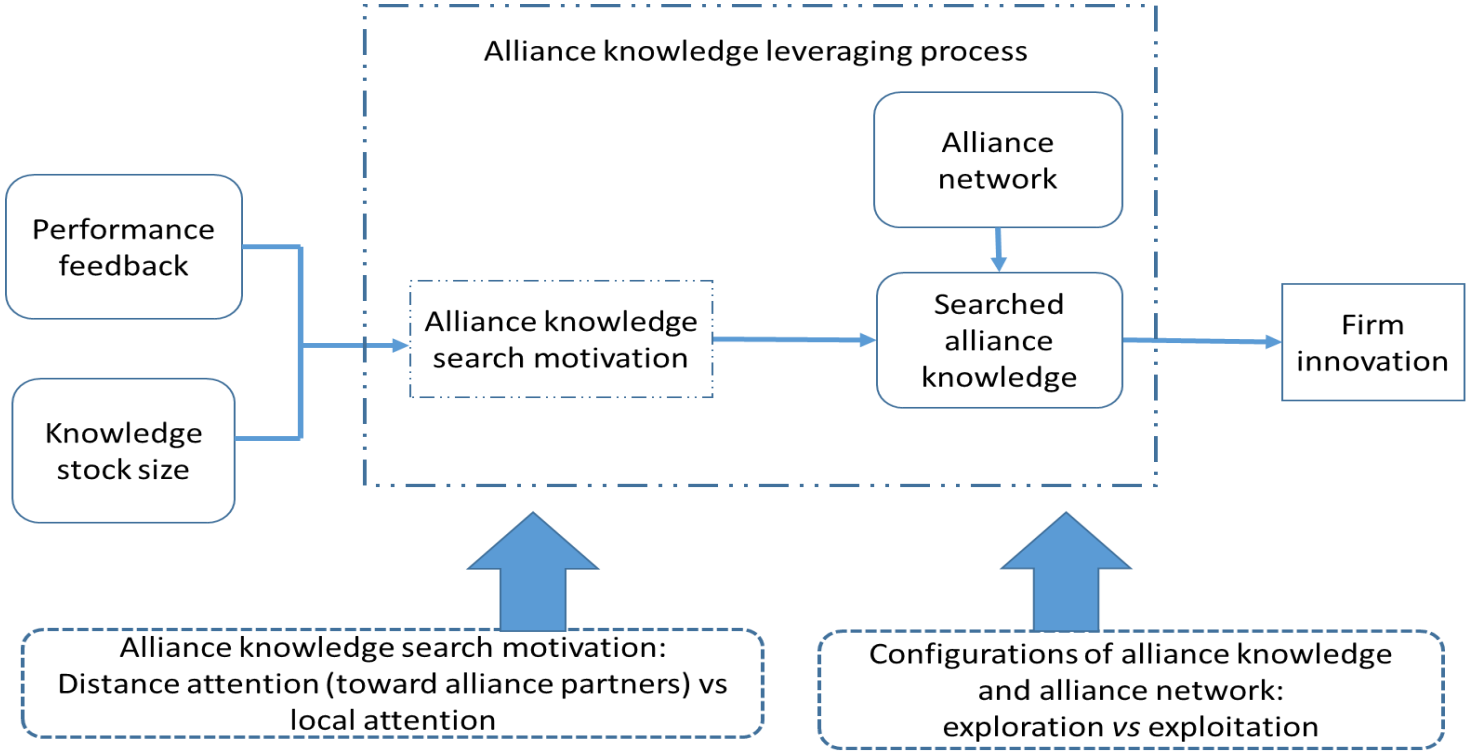
the opposite argument; *i.e.*, that poor performance leads to local attention (Gilbert, 2005; Staw, Sandelands, and Dutton, 1981), which indicates a negative relationship between poor performance and external knowledge sourcing (Gaba and Bhattacharya, 2012). The opposite arguments imply that the relationship between poor performance and alliance knowledge leveraging might be more sophisticated than a linear relationship proposed in previous studies. This study helps researchers to perceive this unrealized inconsistency in alliance knowledge leveraging and pushes us to think about the opposite propositions holistically, as well as to explore the relationship between such opposite propositions.

Second, this study advances the understanding of motivation for alliance knowledge leveraging. I show that that poor innovation performance is critical to trigger of alliance knowledge leveraging. While previous studies often discuss alliance knowledge leveraging motivation from an economic perspective and argue that firms search alliance knowledge when they see a complementarity between alliance knowledge and the firms' existing knowledge (Vasudeva and Anand, 2011). However, a few recent studies indicate that there might be behavioral motivators of alliance knowledge leveraging (Gaba and Bhattacharya, 2012; Lungeanu, Stern, and Zajac, 2015; Tyler and Caner, 2016), which means that firms' decisions on alliance knowledge leveraging could be bounded rational. This study confirms the impact of performance feedback on alliance knowledge search intensity, providing a solid support for the existence of behavioral motivation for alliance knowledge leveraging.

Third, this study enables a more nuanced understanding of the balance between exploration and exploitation in the context of alliance knowledge leveraging. While knowledge-related alliance studies often discuss the balance of exploration and exploitation in one alliance network domain (Gilsing, Nooteboom, Vanhaverbeke, Duysters, and van den Oor, 2008;

Rothaermel and Alexandre, 2009), these studies often fail to consider the managerial costs generated from embracing exploration and exploitation in one domain (Lavie et al., 2011). To resolve this problem, recent studies call for additional research take the multiple domains into consideration, *i.e.*, resources, node, tie, and network structure, of inter-firm relationship, when examining the balance between exploration and exploitation (Lavie and Rosenkopf, 2006; Lavie, Stettner, and Tushman, 2010). I answer this call by discussing the approach that enables firms to establish a balance between exploration and exploitation cross the alliance knowledge and alliance network domains. Examining cross-domain balancing strategies is critical, because it enables us to view alliance knowledge leveraging in a more holistic manner, and to pay more attention to the interaction among different domains in inter-firm relationships.

Figure 1.1 Conceptual Model



Note: Solid lines represent constructs that are directly predicted in the empirical model.

Dotted lines represent constructs that are implied in the study.

2.0 LITERATURE REVIEW

In this chapter, I review the literature on innovation and alliance knowledge leveraging. The first section of this chapter presents a review of alliance knowledge leveraging. I discuss what alliance knowledge leveraging is, why it is important for innovation, and how knowledge search motivation, alliance knowledge and alliance network configurations influence the process and outcomes of alliance knowledge leveraging. In the second section, I review the literature that is related to alliance knowledge search motivation and discuss the contradictions in alliance knowledge search motivation (distant vs local attention). The third section of this chapter reviews the literature that is related to configurations of alliance knowledge and alliance network and I discuss the contradictions in configurations of alliance knowledge and network (exploration vs exploitation). In the fourth section of this chapter, based on the literature review, I identify a few research gaps in the current literature.

2.1 Leveraging Knowledge from Alliance Partners

2.1.1 Alliance Knowledge Leveraging and Innovation

Innovation is a key factor for organization success (Ahuja et al., 2008; Schumpeter, 1934). Firms leverage knowledge from alliance partners to enhance performance; more specifically, when the knowledge is technology-related, the goal of knowledge sourcing is to enhance innovation performance (Ahuja et al., 2008). According to Damanpour (1991), the term, “innovation”, is often associated with change: organizations that conduct innovative activities because they want to adapt to the changing environments. The change could emerge in both internal and external to the firm. The evolutionary economists point out that innovating is necessary because firms need new routines to replace old ones in changing environments

(Nelson and Winter, 1982). Those firms who make the change first (innovator) may develop a competitive advantage based on the first-mover effect (Lieberman and Montgomery, 1988).

The Austrian economists have a more proactive view of innovation. According to Schumpeter (1934), innovation is the core driver of economic development, because innovative products and ideas are economically more viable than existing products and ideas. The innovation literature examines the process of innovation and propose that innovation is by combining and recombining knowledge elements (Fleming, 2001; Kogut and Zander, 1992). The process of combination and recombination is highly uncertain, and firms need to use both unfamiliar or new knowledge (Fleming, 2001) and old knowledge (Nerkar, 2003) to generate innovative ideas, technologies, and products.

Patents and new products are two widely used measurements of innovation (Hagedoorn and Cloodt, 2003)[1]. Scholars use patents to measure innovation, because patents reflect core technologies, are relatively homogeneous, are observable, and are easier to access (Acs, Anselin, and Varga, 2002; Patel and Pavitt, 1987). Although a patent is accepted as a credible measure of innovation in many knowledge-related alliance studies (Ahuja, 2000; Katila and Ahuja, 2002; Phelps, 2010; Sampson, 2007), this measure also has limitations because it only captures codified knowledge and firms may have different patenting propensities (Patel and Pavitt, 1987). As an alternative measure, many other research used new products as a measure of innovation (Cardinal, 2001; Bierly and Chakrabarti, 1996; Tyler and Caner, 2015; Wuyts and Dutta, 2014). New product represents a firm's innovation that is eventually introduced in the marketplace.

[1] It is important to note that, while this dissertation mainly discusses product innovation, which entails the development of new goods and services. Process innovation, which "involves creating or improving methods of production, service or administrative operations" (Khazanchi, Lewis and Boyer, 2007, p871), is not included in the discussion.

Prior studies found that patents and new products are correlated with each other (Comanor and Scherer, 1969; Hagedoorn and Cloodt, 2003), and they are also correlated with other innovation measures such as R&D input and literature-based innovation counts (Basberg, 1987; Hagedoorn and Cloodt, 2003).

Research suggests that leveraging alliance knowledge against innovation is important for at least two reasons. First, alliance knowledge leveraging helps the focal firm to overcome learning myopia (Laursen, 2012; Rosenkopf and Nerkar, 2001). Due to path-dependencies, firms may fail to conduct distant search by scanning their own knowledge base (Levitt and March, 1988). The failure to conduct distant search creates myopia and inertia (Levinthal and March, 1993), and becomes a core barrier to organizational change. Accessing of new opportunities necessitates learning from external sources rather than from internal experiences (Baum and Dahlin, 2007; Gavetti and Levinthal, 2000). Furthermore, several studies found that distant knowledge tends to be more valuable than local knowledge. According to Sørensen and Stuart (2000), while firms could create more innovations by heavily exploiting their own knowledge, these innovations are less relevant to other firms in the technological community. Similarly, Rosenkopf and Nerkar (2001) found that distant search spans organizational boundaries and has a larger impact on subsequent innovation than local search.

Second, the existence of formalized relationships and knowledge sharing mechanisms in an alliance facilitates knowledge utilization. Because an alliance is a semi-hierarchical system and thus, is a stronger governance mechanism than is a market-based exchange (Gulati and Singh, 1998), alliances allow reduction of transaction costs, provide mechanisms to coordinate inter-firm communications, and enable the development of common understanding between partners (Gulati and Singh, 1998; Kogut, 1988). These conditions provide the basis for the

development and use of knowledge-sharing mechanisms (Dyer and Singh, 1998), which increase the ease of knowledge transfer (Almeida, Song, and Grant, 2002; Gomes-Casseres, Hagedoorn and Jaffe, 2006).

2.1.2 An integrative framework of alliance knowledge leveraging

To further understand alliance knowledge leveraging, I build an integrative framework to illuminate the relationship between leveraging alliance knowledge and firm innovation, which is summarized in Equation (1).

$$\text{Firm Innovation}_{\text{alliance-related}} = f(U', \Theta, \Theta) \quad (1)$$

I argue that the potential innovation performance improvement through leveraging alliance knowledge (Firm Innovation $_{\text{alliance-related}}$) is a function of three factors: the amount of *alliance knowledge* that is accessible to the focal firm (U'); the focal firm's *motivation for* search alliance knowledge (Θ), and the *configuration of the alliance network*, which influences the effectiveness of leveraging alliance knowledge (Θ). I develop these concepts further below.

The first concept I develop is the motivation for alliance knowledge search. Motivation matters for alliance knowledge search. Due to the fact that alliance knowledge is somewhat distant and unfamiliar to the focal firm and may be protected by the knowledge holder (Simonin, 1999), the focal firm needs to invest in learning capacities to recognize, transact, and assimilate alliance knowledge (Cohen and Levinthal, 1990). Lack of motivation leads to underinvestment in learning capacities and therefore, becomes a key barrier to alliance knowledge search (Simonin, 2004; Tsang, 2002). Further, studies have found that, in many alliances, participants want to access, but not acquire each other's knowledge (Grant and Baden-Fuller, 2004), and consequently, alliance formation can lead to co-specialization, rather than learning and

leveraging (Mowery Oxley, and Silverman, 1996). As a result, firms with weak search motivation would be unable to fully leverage their knowledge-related alliance resources (Srivastava and Gnyawali, 2011).

Motivation is tightly related to *attention* (Greve, 2008; Ocasio, 1997; 2011). Firms are more motivated to conduct an activity, if senior managers pay attention to the activity. Because managers have different cognitions and attentional structures (Eggers and Kaplan, 2013; Tyler and Gnyawali, 2009), they may pay attention to different aspects of alliance knowledge leveraging. As I will discuss later, leveraging alliance knowledge is inherently beneficial and challenging at the same time. Therefore, while a firm that focuses on the benefits of leveraging would be motivated to search more alliance knowledge, a firm that is more concerned about the challenges tends to search less.

The second component of alliance knowledge leverage is the configuration of *alliance knowledge* in the focal firm's alliance network. Once a firm has the motivation to leverage the technological knowledge in its alliance partners, it would actively search alliance knowledge. The innovation-related benefits generated from alliance knowledge leveraging would be influenced by how much knowledge the focal firm can potentially access and what is the configuration (e.g., knowledge diversity, technological distance, and tacitness) of the knowledge. The importance of alliance knowledge can be explained by the resource-based view of knowledge-related alliances, which suggests that a firm's competitive advantage is largely determined by the resources it possesses (Barney, 1991). Knowledge-related alliance studies show that accessing more alliance knowledge (Ahuja, 2000; Eisenhardt and Schoonhoven, 1996) and accessing knowledge with certain features, such as high degrees of diversity (Vasudeva and

Anand, 2011) and novelty (Phelps, 2010), would bring more innovation-related benefits to the focal firm.

Finally, alliance network configuration is important because it could influence the effectiveness of alliance knowledge leveraging (Phelps et al., 2012). Alliance network configuration refers to the characteristics of a firm's alliance network, including the characteristics of nodes, network ties and network structures (Ahuja et al., 2012). I propose that, although a firm which has a strong alliance knowledge search motivation and rich alliance knowledge resource would have a great potential of alliance knowledge leveraging, whether the firm can actually realize such potential to appropriate alliance knowledge is influenced by the configuration of its alliance network.

Existing knowledge-related alliance studies have paid attention to the relationship between alliance network configuration and the effectiveness of alliance knowledge leveraging (Ahuja et al., 2008; Inkpen, 2000). According to these studies, firms form alliance networks to obtain social capital and relational rents, which can enhance partner-specific absorptive capacity and enable the development of mutual understanding (Dyer and Singh, 1998; Hoang and Rothaermel, 2005; Lane and Lubatkin, 1998). These studies also emphasize sociological outcomes of alliance networking, such as trust and reciprocity (Gulati, 1995; Uzzi, 1997), and find that these outcomes also facilitate knowledge appropriation (Inkpen and Dinur, 1998; Inkpen and Tsang, 2005; van Wijk, Jansen, and Lyles, 2008).

In sum, I propose that the three most important components of alliance knowledge leveraging are the motivation for alliance knowledge search, the alliance knowledge

configuration, and the alliance network configuration. I summarize these components in Table 2.1.

In the following sections, I will review the prior literature related to an examination of these three components. More specifically, I demonstrate that *contradictions* and conflicting elements widely exist in all of three components.

Table 2.1 Three Components of Alliance Knowledge Leveraging

Construct	Definition
Alliance knowledge search motivation (Ɵ)	The strength of a firm's intention to search technological knowledge from its alliance partners
Alliance knowledge (U̓)	The characteristics of knowledge embedded in partner firms, such as knowledge novelty, diversity and the quality of knowledge
Alliance network (Θ)	The characteristics of alliance network primitives, including nodes, ties, and network structures

2.2 Alliance Knowledge Search Motivation

2.2.1 Distant vs Local Attention and Alliance Knowledge Search Motivation

As mentioned earlier, the motivation for searching for technological knowledge among alliance partners is often the first step of the leveraging process, and the motivation is often influenced by senior managers' attention to alliance knowledge. Firms may have multiple options when they choose their innovation strategy, and leveraging alliance knowledge is one of them (Stettner and Lavie, 2013; Van De Vrande, 2013). Alliance knowledge leveraging has both advantages and disadvantages (Arend, Patel, and Park 2013): it provides the focal firm with a

cheaper way to obtain access to knowledge than internal development, but also imposes weaker control over knowledge (Gomes-Casseres et al., 2006; Stettner and Lavie, 2013). The advantages motivate alliance knowledge leveraging, and the disadvantages demotivate the leveraging. Both advantages (benefits) and disadvantages (challenges) are real, but if senior managers do not attend to the advantages, knowledge-related resources embedded in alliance partners are likely to be ignored, even if the potential value of the knowledge is high. In line with this argument, empirical studies show that firms may ignore valuable knowledge in their alliance networks and fail to conduct alliance knowledge leveraging, even when they have a superior ability to absorb alliance knowledge (Srivastava and Gnyawali, 2011).

In the development of alliance knowledge search motivation, the contradiction between local and distant attention is critical. Managers with local attention tend to focus more on the firm's internal environment and search opportunities in proximate domains. Conversely, managers with distant attention are likely to focus more on the external environment and search business opportunities that are further from the company's current domain. In general, managers have a tendency to pay more attention to local goals and resources (Gavetti and Levinthal, 2000) because they are often more accessible (Kahneman, 2003).

Alliance knowledge leveraging is more likely to be motived by distant attention since alliance knowledge is embedded in partner firms and therefore, tends to be somewhat distant from the focal firm (Rosenkopf and Almeida, 2003). Thus, when the focal firm has focused its attention on distant knowledge domains, alliance knowledge search is more likely to occur. Prior studies show that distant attention is often cognition-based (Gavetti and Levinthal, 2000): senior managers often allocate attention to distant domains purposefully, because opportunities in distant domains are likely to generate superior solutions which are novel and difficult to spot

(Gavetti and Levinthal, 2000; Gavetti, 2012). Similarly, leveraging alliance knowledge could lead to superior technological solutions, because it could help the focal firm to explore distant technological domains (Rosenkopf and Almeida, 2003) and to generate novel and high-impact innovations (Phelps, 2010; Sampson, 2007). Therefore, distant attention would motivate the focal firm to conduct more alliance knowledge leveraging.

Although the benefits of alliance knowledge leveraging motivate senior managers to allocate attention to distant domains, such motivation would be suppressed by local attention when senior managers worry about *uncertainty* and *potential knowledge loss*. First, decision makers generally have a natural tendency to avoid uncertainties (Camerer and Weber, 1992; Cyert and March, 1963) and are hesitant to undertake uncontrollable actions (March and Shapira, 1987). Thus, distant opportunities that are perceived as unfamiliar and uncertain are less likely to be picked than local solutions that have more certain outcomes. Second, some distant opportunities represent large variation in performance (Gavetti and Levinthal, 2000), which means large potential gains can be associated with large potential losses. Decision makers who are security-minded would be very sensitive to the potential losses (Lopes, 1987) and choose more safe solutions.

Alliance knowledge leveraging is likely to be hindered by local attention because it often involves a high degree of uncertainty and leads to large potential knowledge losses. First, leveraging alliance knowledge generally involves high levels of uncertainty. Since alliance knowledge is embedded in partner firms, it tends to involve a very high level of casual ambiguity and become difficult for the focal firm to ascertain its value (Simonin, 1999; van Wijk et al., 2008). Second, alliance knowledge leveraging can also create a large knowledge loss. Because knowledge flows in an alliance are often bidirectional, the mechanisms that allow the focal firm

to source knowledge from its alliance partners also provide opportunities to its alliance partners to utilize the focal firm's knowledge (Kale et al., 2000; Li et al., 2008; Li et al., 2012). Thus, a firm may be especially vulnerable to imitation when it engages in alliance knowledge leveraging (Laursen and Salter, 2014). Once knowledge resources are imitated by partners, especially competitive partners; they lose value and do not afford competitive advantages to the focal firm (Barney, 1991; Liebeskind, 1996). Because alliance knowledge search involves a high uncertainty and is likely to lead to knowledge imitation, the distant attention that guide managers to alliance knowledge is often suppressed.

2.2.2 Interrelation Between Local and Distant Attention

The above literature review shows that attention, and the contradiction between distant and local attention, in particular, play important roles in the development of alliance knowledge search motivation. On the one hand, distant attention is necessary for alliance knowledge search, because it enable the managers to interpret the external environment and recognize opportunities in inter-firm relationships. Furthermore, managers with distant attention will do a better job of recognizing the value of explorative knowledge and overcoming learning myopia (Ben-Oz and Greve, 2015; Laursen, 2012; Srivastava and Gnyawali, 2011). On the other hand, managers concern about uncertainty and potential losses associated with distant search (Gilbert, 2005; Staw et al., 1981) and accordingly, their behaviors may be directly by local attention.

Local and distant attention are interrelated and would jointly influence the motivation for alliance knowledge leveraging. Whether a manager will decide to search alliance knowledge, and how much alliance knowledge he or she will search, depends upon whether he or she can recognize the existence of the knowledge and has a positive attitude toward the value of the

knowledge (e.g., low integration cost, and high commercialization potential). On the one hand, managerial behaviors directed by distant attention facilitate managers to realize distant opportunities and be more attentive to potential gains. On the other hand, local attention could help the managers to be sensitive to risk: managers with local attention pay more attention to the potential risk (e.g., uncertainty and potential knowledge loss) than to the potential gain when they make knowledge search decisions. If the perceived uncertainty or potential loss is large, search motivation would be suppressed (Giarratana and Mariani, 2014) and the intensity of alliance knowledge leveraging would be diminished. Because gains and risks need to be considered comprehensively in search-related decisions (Giarratana and Mariani, 2014), local and distant attention are often interrelated.

Moreover, although local and distant attention both contribute to alliance knowledge search motivation and are related to each other, embracing both of these concepts at the same time creates managerial tensions, which lead to strains and cognitive discomfort. First, local and distant attention competes for managers' cognitive resources. However, managers' cognitive resources are limited, and therefore, it is hard for them to equally allocate attention to both local and distant domains (Ocasio, 1997; 2011). Additionally, attempting to keep an eye on both domains will create a sense of cognitive overloading. Second, managers with local and distant attentional structure show different behavioral patterns. For example, local attention may lead to exploitation and distant attention may lead to exploration. However, since these behavioral patterns are incompatible (March, 1991), for those managers who realize the importance of balancing local and distant attention, the process of decision making will be slow down, due to the amount of time that is required to deal with the contradictions. Finally, managers with local and distant attention could have conflicting goals. For example, alliance knowledge leveraging

guided by local attention is likely to be conducted to reinforce the focal firm's existing innovation projects (Andriopoulos and Lewis, 2009), but alliance knowledge leveraging guided by distant attention may help the firm to reposition itself and generate innovation projects in new areas (Dittrich, Duysters, and de Man, 2007). Thus, the new and old innovation projects can compete for organizational resources and create a tension for the senior managers of the firm (Gander, Habererg, and Rieple, 2007).

2.3 Configurations of Alliance Knowledge and Alliance Network

2.3.1 Exploration and Exploitation in Alliance Knowledge Configuration

The second component of alliance knowledge leveraging is the configuration of alliance knowledge, *i.e.*, the characteristics of the knowledge embedded in partner firms. Knowledge can have many different features (see Ahuja and Lampert, 2001; Simonin, 1999). In this study, I focus on the "newness" dimension, which is critical for innovation (Laursen, 2012) and categorize knowledge into two types: *explorative* and *exploitative*. March (1991) defined exploration as items captured by terms such as search, variation, risk-taking, experimentation, and defined exploitation as items regarding experiential refinement and reusing existing knowledge. Based on the previous literature, I argue that firms can source explorative or exploitative knowledge, which bring different costs and benefits to the focal firm.

Leveraging explorative knowledge is beneficial, because such knowledge tends to be more valuable to firm innovation, but it is also more challenging and costly to absorb. Existing studies were found that exploring new knowledge domains through alliance knowledge search brings non-local knowledge to the firm, facilitates the knowledge recombination process (Fleming, 2001; Rosenkopf and Nerkar, 2001), and helps the firm to overcome familiarity and

propinquity traps (Ahuja and Lampert, 2001). Consistent with these studies, Bierly et al (2009) found that firms utilize more alliance knowledge when that knowledge is dissimilar to their own knowledge base. However, when the knowledge is explorative, its ambiguity increases as well. Increasing ambiguity indicates a possible "lack of understanding of the logical linkages between actions and outcomes, inputs and outputs, and causes and effects" (Simonin, 1999, p597) and could consequently increase the stickiness of knowledge and create knowledge appropriation problems (Szulanski, 1996).

In contrast, leveraging exploitative alliance knowledge contributes to knowledge appropriation, but limits the focal firm's ability to explore new knowledge combinations. Exploitive alliance knowledge helps the firm develop new knowledge based on its existing knowledge—which makes the knowledge creation process more efficient (Lane and Lubatkin, 1998; Nerkar, 2003)—and facilitates knowledge integration (Katila and Ahuja, 2002). Nonetheless, over-emphasizing exploitation could hurt performance, because continuous relying on old knowledge could make alliance knowledge highly redundant to the focal firm and therefore, to become less valuable (Tiwana, 2008).

Thus, the configuration of alliance knowledge has an important impact on the outcome of alliance knowledge leveraging, and choosing to source explorative or exploitive knowledge is a key contradiction a firm needs to address.

2.3.2 Exploration and Exploitation in Alliance Network Configuration

A firm's alliance network configuration describes the characteristics of the nodes, ties, and structures of the focal firm's alliance network, and could significantly influence the effectiveness of knowledge acquisition and appropriation. Firms' knowledge-related networks

have multiple primitives (Ahuja et al, 2012), including network nodes, ties, and structure. I discuss them as separated alliance network dimensions. Similar as alliance knowledge, I categorize alliance networks into two types: explorative networks and exploitative networks. I argue that firms can conduct exploration and exploitation in all the three primitives of the network.

2.3.2.1 Node (partner firm)

In a firm's alliance network, each node in a firm's network represents a partner firm. Alliance network literature view repeated partners as exploitative, and new partners as explorative (Lavie et al., 2011; Lin, Yang, and Demirkan, 2007). Forming alliances with repeated partners contributes to exploitation and alliance knowledge appropriation in several ways. First, having repeated relationships means that the focal firm will have developed a partner-specific absorptive capacity to utilize its partners' knowledge (Hoang and Rothaermel, 2005). Developing such an absorptive capacity requires that firms build long-term relationships, invest in relational-specific assets, and develop partner-specific knowledge-sharing routines (Al-Laham, Tzabbar and Amburgeyy, 2011; Dyer and Singh, 1998). Lorenzoni and Lipparini (1999) discussed how partner stability enhances partner-specific absorptive capacity and suggest that firms could build partner-specific absorptive capacities by developing interaction capabilities with a specific partner.

Second, having repeated partnerships promotes inter-firm trust and social capital, which cannot be achieved in an unstable social structure (Coleman, 1988). Trust and social capital are important facilitators of knowledge leveraging (Lane et al., 2001; Nielsen and Nielsen, 2009). Knowledge transfer is not likely to occur when knowledge is not perceived as reliable

(Szulanski, 1996). Transferring knowledge from a trusted source increases the credibility of the knowledge, makes the interactions between knowledge seeker and provider more frequent, and therefore, makes knowledge transfers more effective (Al-Laham et al., 2011; Lane et al., 2001). Furthermore, partners may be reluctant to share knowledge with the focal firm, if they regard their alliance as a learning race (Hamel, 1991). Social capital, trust and relational commitment are important factors that encourage partners to undertake cooperative action and be less sensitive with respect to sharing knowledge (Inkpen and Tsang, 2005; Larsson, Bengtsson, Henriksson, and Sparks, 1998). Therefore, forming repeated alliances makes partners more willing to share knowledge with the focal firm (Al-Laham et al., 2011; Dhanaraj and Parkhe, 2006; Frank, Hagedoorn and Letterie, 2012; Inkpen and Tsang, 2005).

Although forming repeated alliances enhances the focal firm's knowledge-appropriating ability, its downside is also obvious. Several studies have found that relying on existing relationships creates networking inertia, leading to collective blindness and inhibiting the focal firm's ability to exchange and recombine knowledge (Lane et al., 2001; Yli-Renko, Autio, and Sapienza, 2001). Thus, in the long run, forming too many repeated partnerships can hinder the focal firm's capability of exploring new knowledge domains.

Although forming new partners may hinder exploitation and prompt the challenging of alliance knowledge acquisition and integration due to lack of social support, new partners facilitate exploration, and are therefore beneficial to firm innovation. Having new partners enables exploration, even when the new partners have similar knowledge as the old ones, because they oftentimes structure knowledge in different ways. For example, Yayavaram and Ahuja (2008), and Yayavaram and Chen (2013) defined the extent to which a firm is likely to combine elements from two domains as "coupling", and investigated how changing knowledge-

coupling structures leads to exploration. They found that a new "coupling" of knowledge elements can facilitate the firm in combining knowledge in a novel way and generating high-impact innovation. Thus, when different partners organize and couple knowledge elements in different manners, the focal firm can at least access novel knowledge "couplings", even when this knowledge involves the identical knowledge elements. Therefore, partnering with new firms contributes to the exploration of new knowledge.

2.3.2.2 Tie strength

The knowledge-related alliance literature often depicts the forming of strong ties as exploitation and forming of weak ties as exploration. Tie strength can be classified in the following way: a firm can form strong ties with its partners by increasing the safeguarding functions of the alliance contract (Reuer and Arino, 2007), or by holding equity in the partner firm (Gulati and Singh, 1998; Oxley, 1997). A non-equity alliance with fewer safeguarding functions tends to be viewed as a weak tie.

The duality of exploration and exploitation in the tie strength dimension is also important for alliance knowledge leveraging. Strong ties are often viewed as exploitive, and the key benefit of strong ties is they often promote knowledge appropriation. To transfer technological knowledge from alliance partners, the R&D staff of the focal firm and the partner firm need to have frequent interactions (Inkpen and Tsang, 2005; Szulanski, 1996). Strong ties provide more opportunities for inter-firm interaction, which supports knowledge exchange. Furthermore, knowledge sharing and transfer require effective coordination between and within R&D teams, and a high level of trust between the knowledge recipient and provider (Levin and Cross, 2004; Szulanski, 2000). These conditions are not likely to be achieved in an inter-firm setting because

alliances do not impose strong controls on partners' R&D teams (Gulati and Singh, 1998). Because strong ties often offer partners more opportunities to become involved in the decision making of the partner firms (Gulati and Singh, 1998; Oxley, 1997), they impose a more hierarchical governance over the collaborative activities than weak ties; they enhance the effectiveness of coordination and trust building, and they thus promote knowledge appropriation (Kogut, 1988; Gomes-Casseres et al, 2006; Sampson, 2004).

The downside of a strong tie is its negative effect on exploring new knowledge domains. Granovetter (1973) found that weak ties are more useful than strong ties in seeking information. Hansen (1999) developed Granovetter's work and found that weak ties are often better in searches for novel knowledge because actors can use weak ties, which is easier to maintain than strong ties, to connect distant knowledge sources in the network, whereas strong ties often tend to be restricted to local learning.

Weak ties are superior to strong ties in knowledge exploration because weak-tie relationships are more flexible than strong-tie relationships (Granovetter, 1973; Hansen, 1999). Network theory posits that the more ties an actor has in a network, the more knowledge the actor can access (Borgatti, 2005). An actor can access diverse information by being connected with a large group of people, but it would be difficult for he or she to connect with the same amount of people using strong ties, which is much more costly to maintain. Similarly, maintaining strong inter-firm ties (such as joint ventures) generates a much higher management cost and switch cost than maintaining weak inter-firm ties (such as contractual alliances) (Park and Ungson, 2001). In addition, strong ties are difficult to dissolve (Polidoro, Ahuja and Mitchell, 2011). Thus, when the proportion of strong ties in a network is very high, the network tends to be rigid and difficult

to change (Kim, Oh and Swaminathan, 2006), leading to the inability to explore new knowledge domains.

2.3.2.3 Network structure

Finally, firms can conduct exploration by creating a closed network, and conduct exploitation by creating a network with rich structural holes. There are two primary ways to structure a firm's knowledge network. On the one hand, network closure stresses the role of cohesive networks (high embeddedness and high density) (Gargiulo and Benassi, 2000). On the other hand, structural hole theory argues that firms build knowledge networks to capture brokerage opportunities, which are created by dispersed ties (Burt, 1992).

In an alliance network where nodes (partners) are all connected with each other, such network is viewed as a network with high degree of closure. Network closure contributes more to exploitation than to exploration. As noted above, a high level of trust between the focal firm and its partners is a critical factor for knowledge appropriation. Network closure enhances knowledge appropriation, because it promotes inter-firm trust and enhances inter-firm collaboration and coordination (Burt, 2005; Gargiulo and Benassi, 2000). An important feature of a closed network is that all of the firms are highly embedded in the network and share many common ties. Sharing common ties leads to structural embeddedness. Prior studies suggest that firms can impose social monitoring effectively in a social structure with high embeddedness (Coleman, 1988; Jones, Hesterly and Borgatti, 1997). Thus, members in such a network can conduct market transactions with low transaction costs (Jones et al., 1997). Furthermore, shared common ties and network stability lead to knowledge redundancy, which creates a common understanding between a knowledge seeker and a knowledge provider, and improves knowledge

transfer efficiency (Gilsing et al., 2008; Hansen, 1999; Vanhaverbeke, Gilsing, Beerkens and Duysters, 2009).

However, although network closure contributes to exploitation, it may hinder exploration. Trust may lead to collective blindness (Lane et al., 2001; Yli-Renko et al., 2001), and knowledge redundancy reduces the novelty of knowledge (Vanhaverbeke et al., 2009), which implies a negative relationship between network closure and the total amount of valuable alliance knowledge the focal firm can potentially access. Compared with closed networks, networks with rich structural holes brings more novel and valuable knowledge (Burt, 2005).

2.3.3 Interrelation Between Exploration and Exploitation

Since the duality between exploration and exploitation exists in both alliance knowledge and alliance network, here I discuss them together. Exploration and exploitation in alliance knowledge leveraging serve opposite purposes. Managers search explorative alliance knowledge or form explorative alliance network to obtain new and distant knowledge elements (Ahuja, 2000; Rosenkopf and Almeida, 2003). Exploitive networks are generally viewed as social systems, which provide contexts that facilitate knowledge exchange among the members of the system (Gilsing et al., 2008; Nielsen and Nielsen, 2009; Uzzi, 1997). In order to build social capital and achieve social support, repeated interactions are required, and “newness” may not be valued (Uzzi, 1997), which means exploration and exploitation are conflicted with each other (March, 1991; Lavie et al., 2010).

Furthermore, exploration and exploitation are interrelated in alliance knowledge leveraging. While exploration focuses on enlarging the total amount of alliance knowledge resources the focal can potentially access, and exploitation focuses on the appropriation of the

alliance knowledge, these two independent concepts need to be viewed holistically. The logic is simple: value appropriation cannot be maximized, if little value is created in the first place, and the realization of the value will be embarrassed, if firms have major concerns with regard to value appropriation (Lavie, 2006). Exploration also brings new knowledge to the focal firm, but integrating such knowledge is both difficult and costly (Katila and Ahuja, 2002; Laursen and Salter, 2006). Thus, developing knowledge exploitation and appropriation capabilities becomes even more important for firms having an explorative network, than for those firms having a non-explorative network (Phelps, 2010; Sampson, 2007). Likewise, a firm cannot create a network-based competitive advantage, if it merely relies on exploitive networking, because knowledge embedded in an exploitive network is highly redundant (Luo and Deng, 2009; Vanhaverbeke et al., 2009), and the value of redundant knowledge depreciates very quickly (Argote and Ingram, 2000). As a consequence, if the firm fails to conduct some explorative activities in its knowledge-related alliance behaviors, the value of alliance knowledge will depreciate to zero in the long run.

Moreover, because exploration and exploitation are both important, managers who want to embrace them simultaneously often perceive managerial tension, which lead to strains and cognitive discomfort. First, tensions in alliance knowledge leveraging can result from the inability to achieve competing goals simultaneously. For some firms, managers may realize the importance of both knowledge appropriating and knowledge exploration. However, they will also realize that it is very difficult to achieve these two goals at the same time (Gargiulo and Benassi, 2000), which creates stress and slows down the decision making process. Second, because knowledge-related alliance activities often involve different decision makers and executors such as top managers, engineers, and lawyers (Argyres and Mayer, 2007), these people

may have different goals and objectives in the process of making network configuring decision. For example, alliance managers may prefer to form repeated partnerships, because these situations are easier to manage (Gulati and Gargiulo, 1999; Gulati 1995), but engineers may want to create new partnerships, in order to gain novel knowledge, especially when they have the passion to contribute breakthrough innovations (Andriopoulos and Lewis, 2009). Thus, the conflicted goals become an important source of tension.

In sum, I review the key features of alliance knowledge search motivation, configuration of alliance knowledge and configuration of alliance network in Table 2.2.

2.4 Research Gaps

As we can know from my literature review, several inconsistent theoretical perspectives and empirical findings have been found in studies related to alliance knowledge leveraging. These inconsistencies imply research gaps, and I will discuss some of these gaps below.

An important research gap in the literature is that the current alliance knowledge leveraging literature lacks the understanding of the role of motivation, and seldom do studies systemically discuss how the duality of local and distant attention influences alliance knowledge search motivation. The behavior strategy literature uses performance feedback as a proxy for gaining attention and indicated that attention and cognition can direct external knowledge leverage (Baum and Dahlin, 2007; Ben-Oz and Greve, 2015; Gaba and Bhattacharya, 2012). However, findings of these studies are not consistent with each other. While Baum and Dahlin (2007), and Ben-Oz and Greve (2015) found that poor performance generates distant attention and more external knowledge search, Gaba and Bhattacharya (2012) implied that poor performing firms rely on external knowledge less than other firms do. In this regard, the findings

of these studies indicate a paradoxical relationship between attention (triggered by poor performance) and alliance knowledge search intensity, a relationship that has not been examined yet.

Second, although a growing body of literature discusses the exploration-exploitation balance in alliance knowledge leveraging (see Lavie et al., 2010; Lavie and Rosenkopf, 2006), scholars are still debating whether simultaneously embracing exploration and exploitation will enhance the outcome of knowledge leveraging (Junni et al, 2013; O'Reilly and Tushman, 2013). The empirical evidence is not consistent across studies. Although a number of studies has found a positive relationship between exploration-exploitation balance and firm performance (e.g., Capaldo, 2007; Phelps, 2010; Luo and Deng, 2009; Sampson, 2007; Schilling and Phelps, 2007), many studies found that embracing both exploration and exploitation simultaneously hurts firm performance (Lavie et al., 2011; Lin et al., 2007). The key argument is that, while establishing the balance brings benefits to innovation performance**,** sustaining the balance would generate tensions and managerial costs. Accordingly, several novel approaches have been discussed to help firms achieve the balance between exploration and exploitation, without triggering excessive tensions and managerial costs. Cross-domain balance, which suggests that firms can conduct exploration in one alliance network domain and exploitation in the other, is one of these approaches (Lavie and Rosenkopf, 2006). However, since this approach has just been introduced recently, our understanding of this new approach is still insufficient (Lavie et al., 2010). I will discuss how firms can use cross-domain balance in alliance knowledge leveraging and achieve more innovation-related benefits from the leveraging.

Finally, previous studies that have examined the relationship between alliance knowledge leveraging and firm performance, have primarily focused on the configuration of the knowledge

a firm can potentially access in its knowledge stock, rather than the configuration of the knowledge the firm actually searched (Gilsing et al, 2008; Nooteboom et al., 2007; Phelps, 2010; Sampson, 2007). It is important to note that a firm may have a large stock of network resources, but is unable, or unwilling to use these resources (Srivastava and Gnyawali, 2011). In that case, the findings based on the examination of knowledge stock could be biased. Therefore, the inconsistent findings regarding the exploration-exploitation balance in alliance knowledge may be inherent in the biased empirical design. To address this issue, I attempt to differentiate the effect of searched alliance knowledge on firm innovation from the effect of total alliance knowledge on innovation.

Table 2.2 Key Components in Alliance Knowledge Leveraging (AKL)

AKL component	Contradiction (opposite elements)	
Alliance knowledge search motivation	Managers with local attention are more concerned about uncertainty and potential knowledge loss (Gilbert, 2003), which may in term minimize the risk of AKL (Andriopoulos and Lewis, 2009)	Managers with distant attention do a better job in terms of recognizing the value of distant knowledge and overcoming learning myopia (Ben-Oz and Greve, 2015; Laursen, 2012)
Alliance knowledge	Exploitative knowledge (knowledge that is similar to the focal firm's knowledge base) is relatively easy to be appropriated and integrated (Katila, 2002; Katila and Ahuja, 2002; Nerkar, 2003)	Sourcing explorative (novel) knowledge can enhance the firm's ability to generate high-impact innovation and overcome learning myopia (Sørensen and Stuart, 2000; Rosenkopf and Nerkar, 2001)
Alliance network	*Node (partner):* Forming knowledge-related alliances with old partners would facilitate the development of partner-specific absorptive capacity and social capital, which enhance knowledge appropriation (Dhanaraj and Parkhe, 2006; Inkpen and Tsang, 2005)	Forming knowledge-related alliances with new partners may enable the focal firm to structure and organize its knowledge elements in a novel manner (Yayavaram and Ahuja, 2008; Yayavaram and Chen, 2013)
	Tie: Using strong ties to connect partners enables the focal firm to coordinate with the partners better and integrate alliance knowledge effectively (Kogut, 1988; Gomes-Casseres, et al, 2006)	Using weak ties to connect partners enables the focal firm to have more network flexibility and increase the novelty of acquired knowledge (Borgatti, 2005; Hansen, 1999)

	Contradiction (opposite elements)	
	Structure: Developing a closed network facilitating trust building and social monitoring, and thereby promotes knowledge appropriating (Coleman, 1988; Gilsing et al., 2008)	Developing a network with rich structural holes helps the focal firm to capture brokerage opportunities and brings new knowledge (Burt, 1992; 2005; Zaheer and Bell, 2005)

3.0 CONCEPTUAL DEVELOPMENT AND HYPOTHESES

In this chapter, I develop a integrative framework of alliance knowledge leveraging, building on the literature on knowledge-related alliances and innovation. Based on the framework, I develop specific hypotheses to test the two research questions: (1) what motivates a firm's leveraging of alliance knowledge? And (2) how do the configurations of alliance knowledge and alliance network influence firm innovation?

3.1 The Empirical Model

In this section, I provide an overview of the empirical model of this study. Corresponding to the two research questions, the empirical model has two parts. One part will be used to examine the motivation for alliance knowledge leveraging. The other model will examine the impact of configurations of alliance knowledge and alliance networks on firm innovation.

3.1.1 Conceptual Relationship between Two Empirical Models

I have discussed the relationship between alliance knowledge leveraging and firm innovation in 2.1 and develop an Equation (1) to describe the relationship.

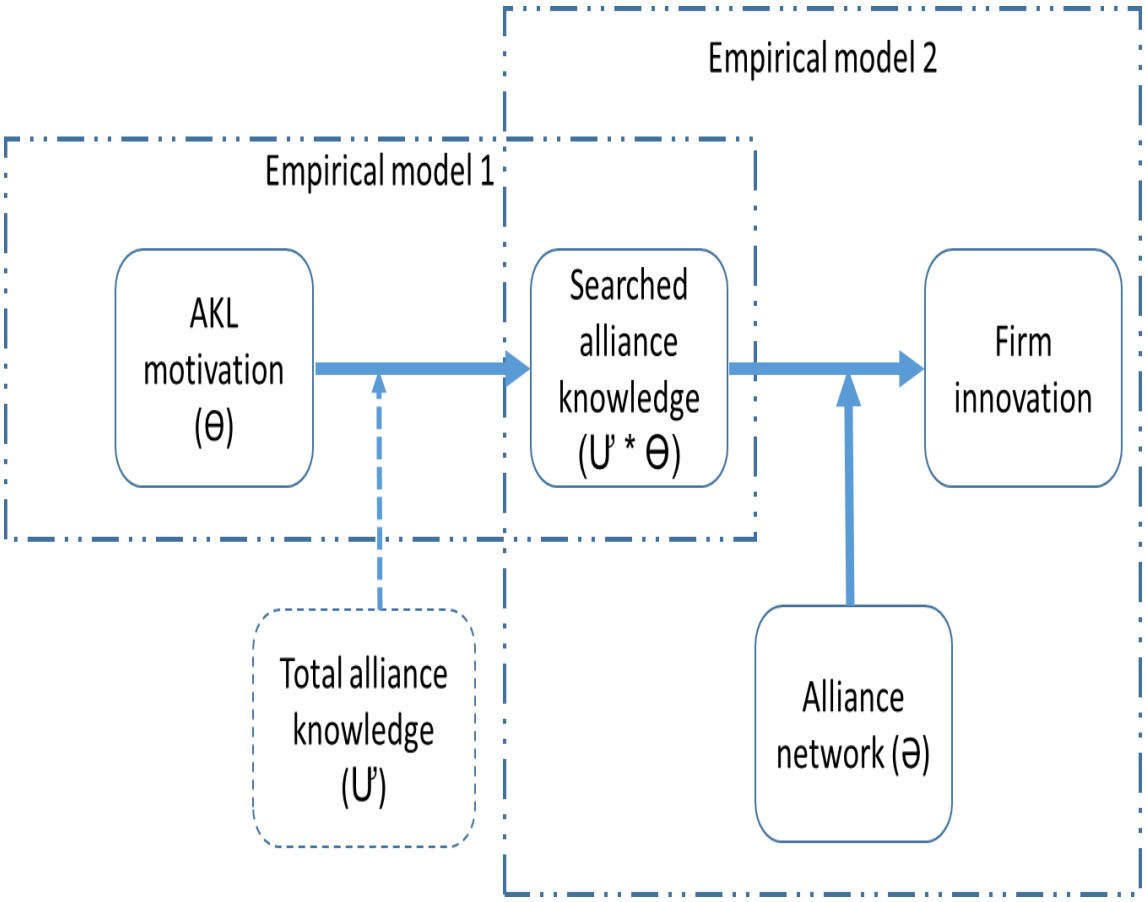
$$\text{Firm Innovation}_{\text{alliance-related}} = f(U', \Theta, \Theta) \quad (1)$$

In this model, U' represents the total alliance knowledge that can be potentially accessed by the focal firm, Θ represents the focal firm's motivation for leveraging alliance knowledge, and Θ is the configuration of alliance network, including the configurations of nodes (partners), ties, and network structure. The configuration of alliance network could influence the effectiveness of alliance knowledge acquisition.

In particular, I am interested in the *searched alliance knowledge* (represented as $U' * \Theta$), rather than the total amount of alliance knowledge. In the research setting of many knowledge-related alliance network studies (e.g., Phelps, 2010; Sampson, 2007; Srivastava and Gnyawali, 2011), because the focal firm has already selected its partners, the total amount of alliance knowledge is given. However, having knowledge in an alliance network (U') does not mean a firm is going to search and utilize it. As mentioned previously, the focal firm needs to have the motivation to launch an alliance knowledge search (Θ), so that the knowledge can be utilized (Easterby-Smith et al., 2008). Thus, I argue that the searched alliance knowledge would be determined by both the total amount of alliance knowledge and the motivation for leveraging such knowledge. Accordingly, *searched alliance knowledge* can be represented as ($U' * \Theta$).

In the empirical test, I will focus on three constructs: the motivation for alliance knowledge leveraging, the searched alliance knowledge, and alliance network. In Figure 3.1, I depict how these constructs relate to each other and how the empirical test of this study helps us to develop a better understanding of these constructs.

Figure 3.1 Conceptual Relationship between the Two Empirical Models



Note: AKL = "alliance knowledge leveraging"

Solid lines represent constructs that are directly predicted in the empirical model.

Dotted lines represent constructs that are implied or controlled in the study.

As Figure 3.1 indicates, the empirical Model 1 identifies how the motivation for alliance knowledge leveraging impacts a firm's alliance knowledge search intensity, controlling for the total alliance knowledge the firm can potentially access. Then, the searched alliance knowledge is used as the independent variable in the empirical Model 2. In the latter model, I examine how the configuration of the searched alliance knowledge, together with the configuration of alliance network, influence the focal firm's innovation performance.

3.1.2 A Summary of the Hypotheses

I develop specific hypotheses to examine how alliance knowledge leveraging motivation develops, and how searched alliance knowledge and alliance network configuration influence firm innovation. In particular, I consider the opposite findings and propositions in the past alliance knowledge leveraging literature in an integrative manner. I summarize the key arguments of the hypotheses below and present the empirical model of the study in Figure 3.2.

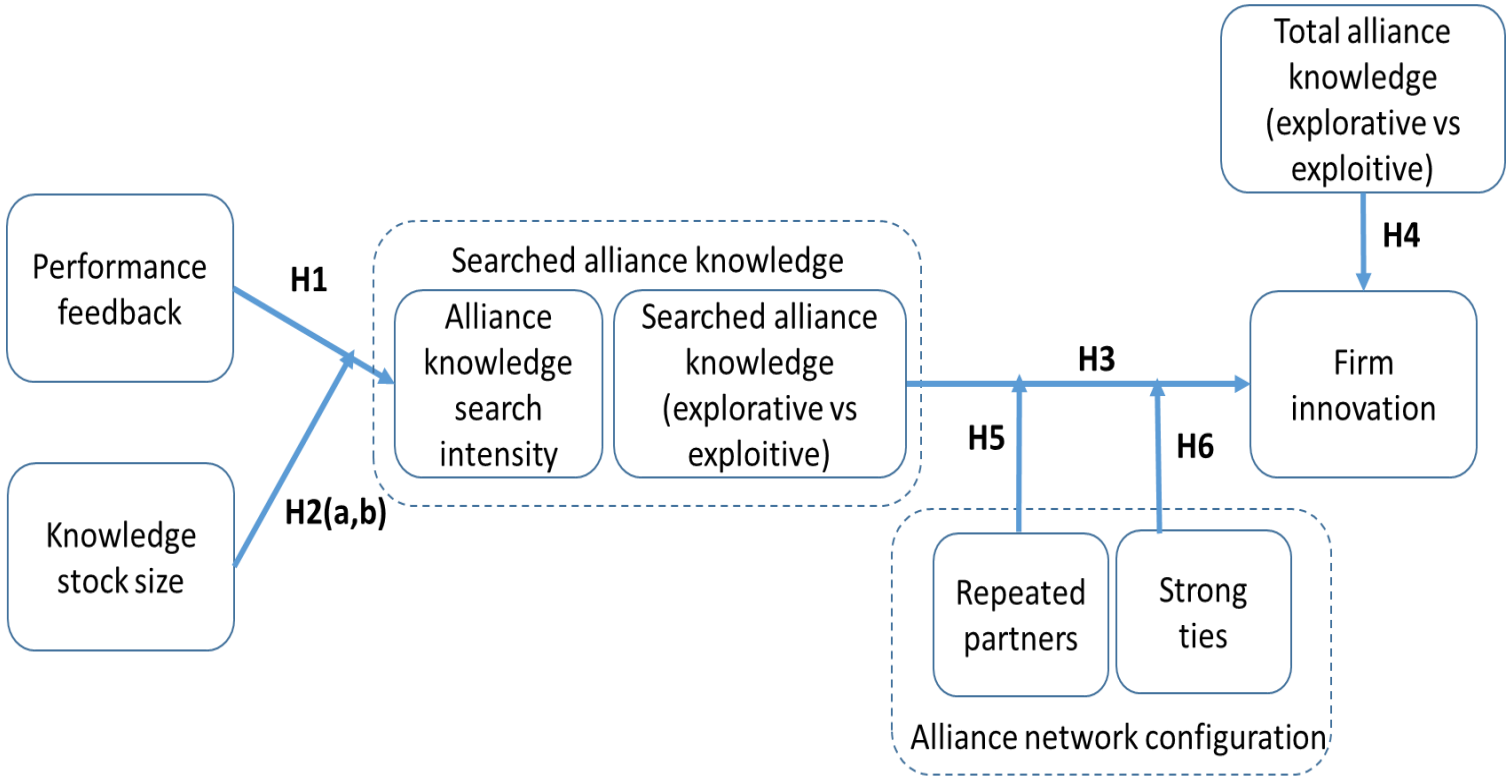
A firm's intensity with which it decides to pursue an alliance knowledge search is largely determined by its motivation for leveraging (Simonin, 1999) and the key contradiction in alliance knowledge search motivation is the duality of local and distant attention. Since attention is difficult to be measured directly, I, therefore, examine the effects of performance feedback, which is widely viewed as an important antecedent of managerial motivation (Lopes, 1987; Greve, 2003; Tyler and Caner, 2015). Furthermore, performance feedback is also related to attention (Greve, 2008), and provides a meaningful context in which to understand the development of the motivation for alliance knowledge leveraging.

I propose that poor performance has a curvilinear relationship (inverted U-shaped) with alliance knowledge search intensity, and the focal firm's knowledge stock size positively moderates that relationship. While some studies found that poor performance feedback intensities the motivation for reaching out (Tyler and Caner, 2015), other studies have identified that poor performance prompts local attention, because firms in such situations would be more concerned about uncertainty and potential losses associated with the search (Gilbert, 2005; Staw et al., 1981). Therefore, I argue that the relationship between poor performance, relative to aspiration and knowledge search intensity, is curvilinear (*Hypothesis 1*). Furthermore, I argue that the curvilinear relationship between poor performance and alliance knowledge search is

moderated by the focal firm's knowledge stock size (*Hypothesis 2*). First, firms with large knowledge stock could be more capable of generating value from distant alliance knowledge (Volberda et al., 2010), thus, increasing alliance knowledge search in the presence of poor innovation performance (*Hypothesis 2a*). Second, for a firm with innovation performance below aspiration and a rather small knowledge stock, further knowledge loss could appear devastating. On the other hand, if the firm has a large knowledge stock, such resources would provide the buffer (Audia and Greve, 2006) to withstand knowledge loss. The buffering effect, thus reduces the negative effects of poor innovation performance on alliance knowledge search (*Hypothesis 2b*).

While empirical Model 1 predicts the intensity of alliance knowledge search, the empirical Model 2 of this study examines how the configuration of the searched knowledge influences firm innovation. In empirical Model 2, I test the relationship between searched alliance knowledge and firm innovation. Because exploration and exploitation are contradictory, embracing both of them at the same time generates great managerial tensions and costs (Lavie et al., 2011). Therefore, I propose that balancing exploration and exploitation in a single domain is not beneficial to the focal firm, which means that searching moderately explorative alliance knowledge leads to minimum firm innovation (*Hypothesis 3*). However, I argue that firms can strike the balance by combining explorative alliance knowledge search with an exploitive alliance network. An exploitive alliance network can be formed by either having repeated partners (*Hypothesis 5*) or establishing strong ties with existing partners (*Hypothesis 6*). In addition, I also test the argument which states that searched alliance knowledge has a stronger impact on firm innovation than the total amount of alliance knowledge (*Hypothesis 4*).

Figure 3.2 The Empirical Model and Hypotheses



3.2 Motivation for Alliance Knowledge Leveraging and Alliance Knowledge Search Intensity

First, I test how distant and local attention influence a firm's alliance knowledge leveraging motivation, and accordingly influence the intensity of alliance knowledge search.

I have reviewed the literature that is related to the motivation for alliance knowledge leveraging. The review shows that distant and local attention plays a key role in the development of such motivation. On the one hand, alliance knowledge leveraging is helpful in exploring distant technological domains (Rosenkopf and Almeida, 2003) and in generating novel and high-impact innovations (Phelps, 2010; Sampson, 2007). On the other hand, distant attention and alliance knowledge leveraging motivation would be suppressed, because alliance knowledge often involves a high degree of uncertainty (Simonin, 1999; van Wijk et al., 2008), and because leveraging knowledge could increase the likelihood of knowledge leakage (Kale, et al., 2000; Li et al., 2012).

Distant and local attention are opposite in nature and therefore having them at the same time creates a perception of tension, which drags down managerial cognitive resources and thereby plays a critical role in decision making (Smith, 2014). More specifically, firms do struggle with the tension of making technological knowledge search decisions (Giarratana and Mariani, 2014). However, previous studies have not yet examined how the motivational tension influences the decision of search.

3.2.1 Innovation Performance below Aspiration

To examine motivation and attention, I build upon the behavioral strategy theory, which is grounded on managerial cognition and psychology theories (Powell, Lovallo, and Fox, 2011).

The behavioral theory suggests that the motivation for search is often stimulated by a problem (Cyert and March, 1963; Greve, 2003). Typically, a problem is detected when the firm's performance is below aspiration, which is "the smallest outcome that would be deemed satisfactory" (Schneider, 1992: 1053). Performance below aspiration has been found to be a precursor to a variety of search-related behaviors, including R&D investment increase (Chen and Miller, 2007), innovation (Greve, 2003), organizational learning (Baum and Dahlin, 2007), and alliance formation (Baum, Rowley, Shipilov and Chuang, 2005). Further, recent search studies indicate that a firm's technological knowledge search is influenced by its innovation performance below aspiration (Gaba and Bhattacharya, 2012; Lungeanu et al., 2015; Tyler and Caner, 2015). Innovation performance and aspiration matter, because they are strategically important for firms (Fiegenbaum, Hart, and Schendel, 1996), especially for firms in high-tech industries (Lungeanu et al., 2015), and are more specific to knowledge-related behaviors than general performance and aspiration (Gaba and Bhattacharya, 2012).

Therefore, drawing upon the behavioral strategy theory (Cyert and March, 1963; Gilbert, 2005; Greve, 2003; Lopes, 1987), I discuss how innovation performance below aspiration level influences distant and local attention, and accordingly influences the focal firm's motivation to search technological knowledge embedded in its partners.

3.2.2 Performance below Aspiration and Alliance Knowledge Search

Alliance knowledge search is a typical organizational search behavior, whereas allocating attention to distant or local domains is a classical tension in organizational search (Gavetti and Levinthal, 2000). Firms could search in local domains for solutions that are proximate to existing solutions, or in distant domains for solutions that are distant and unfamiliar (Gavetti and Levinthal, 2000). On the one hand, cognition-based distant searches often generate superior

solutions which are novel and difficult to spot (Gavetti and Levinthal, 2000; Gavetti, 2012). On the other hand, managers tend to have a natural tendency to conduct local searches (Camerer and Weber, 1992; Cyert and March, 1963; March, 1991). Uncertainty avoidance and the fear of potential losses are two primary concerns that guides guide the firm's attention to local domains and demotivates distant search. First, firms tend to avoid the necessity of confronting uncertainty (Cyert and March, 1963). In particular, while the goal of search is to pursue large potential gains, search motivation decreases with the increase in uncertainty regarding such gain. Second, the worry about potential loss also reduces search motivation. Decision makers have a natural tendency to be loss averting (Tversky and Kahneman, 1991; Lopes, 1987).

Managers may try to allocate attention relatively equally in distant and local domains simultaneously (Gupta, Smith, and Shalley, 2006). However, searches in different directions compete for managers' cognitive resources (Gavetti and Levinthal, 2000) and require incompatible organizational processes (Lavie et al., 2011). Thus, the duality of distant and local attention can be viewed as a tension.

I further advocate that performance below aspiration can be viewed as a stimulus that intensifies the tension of local and distant attention. On the one hand, when a firm's current performance is not satisfactory, senior managers may view local solutions as being less legitimized, and therefore, value distant searches more than local searches (Baum and Dahlin, 2007). To convert the poor performance above aspiration level, managers tend to be risk-takers (Bromiley, 1991; Singh, 1986), selecting distant solutions with high potential gains. On the other hand, poor performance can threaten the survival of the organization, hurt the decision makers' private interests, such as compensation and reputation; and consequently, increase the psychological stress on the decision makers to look for certain and controllable opportunities

(Gilbert, 2005; Greve, 2011; March and Shapira, 1987; Staw et al., 1981). Poor performance directs managers' attention toward conserving the diminishing current resources; thereby, generating a strong preference for local search (Gilbert, 2005; Staw, et al., 1981). Consequently, decision makers face a salient conflict between a security-minded loss concern, and an aspiration-driven desire for gain in the presence of poor performance (Lopes and Oden, 1999), which means the tension of distant and local attention becomes more significant in the presence of poor performance.

3.2.3 Innovation Performance below Aspiration and Alliance Knowledge Search

How does innovation performance below aspiration shape the focal firm's alliance knowledge search intensity? To answer this question, I first discuss the relationship between innovation performance decrease and distant attention in general, since alliance knowledge search is commonly viewed as a typical mode of distant search (Rosenkopf and Almeida, 2003). In fact, poor performance could encourage distant search (Baum and Dahlin, 2007; Ben-Oz and Greve, 2012). The fact that the firm's innovation performance is declining below aspiration would make senior managers become more aware of problems in current knowledge-related behaviors and local technological solutions, promoting the search for distant technological knowledge (Tyler and Caner, 2015). Moreover, since continued poor innovation performance would erode a firm's competitive advantage, and eventually threaten its survival (Aoki, 1991), firms would have a very strong desire to turn around the poor performance situation. Such desire would consequentially make the firm take more technological risks (Lungeanu et al., 2015), and pay closer attention to technological solutions with high potential gains. Thus, poor innovation performance would prompt technological knowledge search in distant domains, since distant search brings the focal firm new knowledge components, facilitates the process of knowledge

combination (Fleming, 2001; Katila and Ahuja, 2002) and increases the likelihood of the generation of high-impact innovation (Rosenkopf and Nerkar, 2001).

Following these logical suppositions, I propose that in innovation performance below aspiration would lead to more alliance knowledge searches, because an alliance knowledge search is likely to be truly distant (Phelps, 2010; Rosenkopf and Almeida, 2003), provide an effective mechanism for knowledge transfer and appropriation (Ahuja et al., 2008; Gomes-Casseres et al., 2006), and lead to the generation of highly valuable innovations (Phelps, 2010). Therefore, alliance knowledge searches could be viewed as suitable distant search modes, and very attractive prospects for poor innovation performers.

However, taking the unique features of alliance knowledge into account would lead to a competing argument. As discussed above, while decision makers would like to conduct distant knowledge search for superior technological opportunities, they would still have a natural tendency to avoid uncertainty (Camerer and Weber, 1992; Cyert and March, 1963) and losses (Lopes, 1987) that is associated with the search. This tension could be intensified when the firm's innovation performance is unsatisfactory to senior managers. First, poor innovation performance would eventually influence decision makers' compensation (Balkin, Markman, and Gomez-Mejia, 2000; Lerner and Wulf, 2007) and potentially their careers well. These negative outcomes create pressures, making senior managers focus on securing their own status and restricting their attention to solutions that are certain and controllable. In addition, for a firm that is already suffering from poor innovation performance, further knowledge loss could adversely impact the firm's ability to compete. As a result, when innovation performance is poor, managers may further reduce highly uncertain and risky knowledge-sourcing behaviors (Gaba and Bhattacharya, 2012).

Alliance knowledge is embedded in partner firms and involves a higher degree of uncertainty (Simonin, 1999). Therefore, searching for knowledge through alliance relationships is especially vulnerable to imitation and knowledge losses (Giarratana and Mariani, 2014; Laursen and Salter, 2014). Correspondingly, although a firm with poor innovation performance may have a strong motivation to achieve performance turnaround, it may simultaneously reduce its alliance knowledge search, in order to avoid additional knowledge uncertainty and potential losses.

To have a more precise understanding of the tension of distant and local attention, I rely on the propositions in March and Shapira's (1992) shifting-focus model. The shifting-focus model shows that distant attention is more likely to be triggered when the firm perceives poor performance as a shortfall relative to aspired performance, but when the firm perceives poor performance as a serious crisis situation, local attention is more likely to be triggered. This model has been tested and supported by several empirical studies (Audia and Greve, 2006; Chen and Miller, 2007; Desai, 2008; Miller and Chen, 2004; Shimizu, 2007).

Taking the tension of distant and local attention and the shifting-focus model in combination, I propose a curvilinear relationship between poor innovation performance, and alliance knowledge search intensity. When a firm's innovation performance is below aspiration, it will first trigger distant attention, because initial performance decline tends to be perceived as a shortfall and may be viewed as temporary. Distant attention would motivate alliance knowledge search, indicating a positive relationship between poor innovation performance and alliance knowledge search intensity. However, when the performance decreases further, local attention may dominate and suppress the firm's motivation to continue alliance knowledge search. Thus,

the positive effects of innovation performance below aspiration may reach a maximum degree of knowledge search intensity and can expect net loss surpassing this threshold.

There are two important types of aspirations: firms compare current performance with their peers' performance (social aspiration), as well as past performance (historical aspiration) (Cyert and March, 1963). Previous studies have found that performance below social and historical aspiration has a similar impact on organizational search behaviors (e.g., Audia and Greve, 2006; Baum et al., 2005; Greve, 2003; Iyer and Miller, 2008). Thus, I propose the first hypothesis as follows:

Hypothesis 1. Innovation performance below aspiration level has an inverted U-shaped relationship with the intensity of alliance knowledge search.

3.2.4 The Moderating Effect of Knowledge Stock Size

The above discussion illustrates that searching alliance knowledge when innovation performance is below aspiration is a big struggle for firms, especially for those in high-tech industries where innovation performance is critical (Gaba and Bhattacharya, 2012). When firms view alliance knowledge search as an "answer" to poor innovation performance, the tension inherent in the search would be intensified (Gilbert, 2005; Greve, 2011). The conflicted attentions deplete decision makers' cognitive resources, and cause them to them feel anxious (Smith and Lewis, 2011). Such an immense cognitive burden would greatly hinder alliance knowledge search.

I propose that firms may suffer less from this struggle and achieve more consistency in attention allocation in the presence of conditions that would facilitate a firm's ability to endure the uncertainty and potential knowledge losses in alliance knowledge. Under such conditions, poorly performing firms would suffer less from the struggles with alliance knowledge search and

be more motivated to leverage their alliance knowledge resources. I further posit that the size of the focal firm's knowledge stock simultaneously increases distant attention (be confident to achieve gains) and reduces local attention (be insensitive to potential knowledge losses).

I define knowledge stock as the total knowledge a firm has generated in the past. Firms with larger knowledge stocks are more likely to attend knowledge that is distant and embedded in alliance partners, because they have greater abilities to recognize valuable alliance knowledge, assimilate new knowledge, and apply assimilated knowledge to commercial ends (Cohen and Levinthal, 1990). These enhanced abilities to utilize external knowledge will help to reduce gain uncertainty in alliance knowledge search. First, the absorptive capacity literature suggests that firms need to have prior knowledge to be able to notice the value of external knowledge (Cohen and Levinthal, 1990). Firms with a larger knowledge base will have greater abilities to identify knowledge that is useful to them which has been disseminated by their alliance partners. Knowing what is valuable will greatly reduce the uncertainty of potential knowledge gains. Second, having more existing knowledge provides more common grounds for firms to better assimilate knowledge from alliance partners (Luo and Deng, 2009), increasing the firm's potential to learn from its partners. Firms with greater ability to learn will be more confident about realizing gains from alliance knowledge searches. Finally, greater knowledge stock strength also signal a firm's superior capability in applying the assimilated knowledge. A firm's existing knowledge stock demonstrates its past successful experience in knowledge exploitation. Firms develop abilities to harvest and incorporate external knowledge to their own operations from past experiences (Zahra and George, 2002). In sum, having a large knowledge stock indicates the firm has great knowledge absorption capabilities, which help the firm to see more value from alliance knowledge search and accordingly prompt distant attention.

In addition, a large knowledge stock would buffer the failure, and accordingly, make the focal firm less worried about the potential knowledge losses associated with alliance knowledge search, and accordingly be less likely to be restricted by local attention. As discussed, poor performance can generate both distant search attention and loss averting propensity, which intensifies the need to protect existing knowledge. The shifting-focus model demonstrates that risk-averting propensity tends to be salient when the firm perceives the performance decline as a big threat (Audia and Greve, 2006; Desai, 2008; March and Shapira, 1992; Shimizu, 2007). Large knowledge stock matters because it provides a buffer.

Buffering effects refer to a situation that is predicated on the fact that extensive resources allow a firm to endure many periods of performance decrease, with little threat of failure (Audia and Greve, 2006). Past innovation success may help a firm maintain its competitive advantages for a while (Markman, Espina, and Phan, 2004); even when its current innovation performance is below aspiration. Furthermore, past success can make the firm attribute current poor performance as temporary. Thus, a firm with a large knowledge stock tends to view poor innovation performance feedback as unserious and temporary, and thereby, is likely to respond to innovation performance decrease by searching alliance knowledge actively, rather than focusing on existing resources.

In sum, the focal firm's knowledge stock moderates the inverted U-shaped relationship between poor innovation performance and alliance knowledge search, because a large knowledge stock simultaneously enhances the focal firm's confidence of utilizing distant knowledge and buffer the poor innovation performance (Audia and Greve, 2006), allowing the poorly performing firm to worry less about the potential risk in an alliance knowledge search. Therefore, the positive effects of poor innovation performance on the intensity of knowledge

search, is stronger for a firm with large knowledge stock than for a firm with small knowledge stock. At the same time, large knowledge stock reduces the negative effect of poor innovation performance on alliance knowledge search. I therefore propose:

Hypothesis 2. Focal firm's size of knowledge stock moderates the inverted U-shaped relationship between innovation performance below aspiration level and alliance knowledge search in such a fashion that increasing knowledge stock size will: (a) increase the slope of the positive effect of innovation performance below aspiration, and (b) reduce the negative effect of innovation performance below aspiration.

3.3 Configuration of Searched Alliance Knowledge and Firm Innovation

Section 3.2 discussed the motivation behind alliance knowledge searches. In this section, I examine how configuration of searched alliance knowledge influences firm innovation. In particular, since alliance network configuration would influence the effectiveness of utilizing searched knowledge (Inkpen, 2000), I propose that alliance knowledge and alliance network would jointly influence firm innovation. Further, I discuss the roles of exploration and exploitation.

A large body of literature emphasizes the importance of balancing exploration and exploitation (Benner and Tushman, 2003; March, 1991; He and Wong, 2004). Striking such a balance is important to firm performance (Gupta et al., 2006), especially when the performance is innovation-related (Andriopoulos and Lewis, 2009; Rosenkopf and McGrath, 2011; Miron-Spektor et al., 2011). While exploration brings novel knowledge to the focal firm, exploitation is also important, because old knowledge is also valuable (Nerkar, 2003) and is relatively easy to absorb (Katila and Ahuja, 2002). So, striking a balance between exploration and exploitation is

one of the core tasks in alliance knowledge leveraging (Rothaermel and Alexandre, 2009; Van De Vrande, 2013).

This study is different from previous studies in three aspects. First, in this study, I consider both the importance of balancing exploration and exploitation and the cost of establishing such balance. By doing so, I propose that searching moderately explorative/exploitive alliance knowledge would harm, rather than contribute to, firm innovation (Lavie et al., 2011).

Second, instead of focusing on knowledge exploration/exploitation (Gilsing et al., 2008) or network exploration/exploitation (Lavie and Rosenkopf, 2006; Rothaermel and Deeds, 2004), I examine exploration and exploitation in both searched alliance knowledge and alliance network. This operationalization is important because it enables the researcher to investigate alliance knowledge leveraging in a more integrative manner. *Knowledge embedded in alliance partners* and *alliance network*, which includes nodes, ties, and the structure of the network, are two *domains* of knowledge-related alliance network. Inter-firm relationships often involve multiple domains (Ahuja et al., 2012), and recent studies have emphasized that these domains need to be considered holistically, especially when the balance between exploration and exploitation is examined (Lavie and Rosenkopf, 2006). This study thus answers this call by examining the balance between exploration and exploitation across the alliance knowledge and alliance network domains.

Third, while previous studies have examined the impact of total alliance knowledge on firm innovation (e.g., Nooteboom et al., 2007; Phelps, 2010; Sampson, 2007), I investigate exploration and exploitation in searched alliance knowledge. As a large portion of alliance

knowledge may not be noticed by the focal firm at all (Srivastava and Gnyawali, 2011), searched alliance knowledge could have more meaningful implications to firm innovation than total alliance knowledge.

3.3.1 Exploration and Exploitation in Two Domains of Alliance Knowledge Leveraging

To investigate how a firm can balance exploration and exploitation across domains, I briefly discuss what exploration and exploitation mean in the two focal domains in this study: (searched) alliance knowledge and alliance network.

3.3.1.1 Exploration and exploitation in searched alliance knowledge: technological distance

I define knowledge exploration and exploitation based on the concept of newness (March, 1991). Exploration focuses on new activities and knowledge, while exploitation focuses on activities and knowledge which are not as new. Following Lavie's and his Colleagues' (2010)'s suggestion, I theorize exploration and exploitation as two ends of a continuum. Specifically, following Gilsing et al (2008) and Nooteboom et al. (2007), I theorize exploration (exploitation) as searching knowledge from alliance partners in distant (proximate) knowledge space from the focal firm (Jaffe, 1986). In that regard, exploration and exploitation would be captured by a single construct (technological distance between the focal firm's knowledge base and the searched alliance knowledge) in this study: the searched alliance knowledge is more explorative, when it is more distant from the focal firm's knowledge base, and is more exploitative, when it is more proximate to the focal firm's knowledge base in the knowledge space (Gilsing et al, 2008).

3.3.1.2 Exploration and exploitation in alliance network: repeated partners and tie strength

In addition to the exploration and exploitation in alliance knowledge, I also discuss the duality of exploration and exploitation in alliance network configurations. As discussed above, firms can achieve exploration and exploitation in different network primitives: for the node primitive, having a large portion of repeated partners is viewed as "explorative" and having a large portion of new partners is viewed as "exploitive" (Lavie and Rosenkopf, 2006); for the tie primitive, forming strong-tie alliances is viewed as "exploitative" and forming weak-tie alliances is viewed as "explorative" (Tiwana, 2008); for the structure primitive, a network with high density is viewed as "exploitative", and a network rich in structural holes is viewed as "explorative" (Schilling and Phelps, 2007). In this study, I will primarily focus on two network primitives: node and tie.

3.3.2 Difficulties of Balancing Exploration and Exploitation in One Domain

Sourcing both explorative (e.g., distant and unfamiliar) and exploitive (e.g., proximate and familiar) knowledge are beneficial to the focal firm and therefore firms often want to establish a balance between exploration and exploitation in innovation-related activities (Gupta et al., 2006; Katila and Ahuja, 2002). On the one hand, searching explorative knowledge has a positive effect on innovation because it brings more novel and unique knowledge to the focal firm. The ability to gain access to explorative and distant knowledge enables the focal firm to renew its knowledge base rapidly and have access to a large body of non-redundant and novel knowledge. The novelty of knowledge is critical to innovation. It contributes to knowledge combination and recombination (Fleming, 2001; Kogut and Zander, 1992), and generates innovation outcomes that have a larger impact on sequential innovations (Rosenkopf and Nerkar, 2001).

On the other hand, sourcing exploitative and familiar knowledge contributes to the appropriation of knowledge. While there are clear benefits, in terms of bringing more novel and unique knowledge to the focal firm, searching highly explorative and distant knowledge could harm knowledge appropriating due to the increased economic cost of knowledge transfer and integration. Increasing the proportion of new knowledge to be integrated into a firm's knowledge base leads to high costs in knowledge integration (Vasudeva and Anand, 2011). Transferring unfamiliar knowledge increases the degree of knowledge ambiguity, and consequently, increases the "stickiness:" of knowledge and creates knowledge integration problems (Simonin, 1999; Szulanski, 1996). Therefore, searching exploitive and proximate knowledge causes the focal firm to be familiar with the acquired knowledge, and consequently, reduces the level of knowledge ambiguity. In addition to reducing the knowledge integration difficulties, utilizing exploitive knowledge diminishes the knowledge exchange costs. According to the principles of transaction cost economics, the transaction cost increases with the rise in the degree of uncertainty (Williamson, 1985). When knowledge familiarity goes up, the uncertainty of the knowledge would decrease, along with the increase in the familiarity factor, driving down the contracting cost of knowledge transactions (Oxley, 1999; Sampson, 2004).

Although exploration and exploitation are both beneficial to the focal firm, it is difficult to balance them since they are contradictory with each other. Some studies propose that the innovation-related benefits of alliance knowledge leveraging could be optimized when the focal firm sources alliance knowledge that is moderately explorative (Gilsing et al., 2008; Phelps, 2010; Uotila, Maula, Keil and Zahra, 2009), because such knowledge is a mixture of exploration and exploitation. However, this proposition does not consider the fact that establishing a balance

in such way would generate managerial tensions and costs, which were not explicitly considered in many previous studies (Gilsing et al., 2008; Phelps, 2010; Uotila et al., 2009).

Searching moderate distant alliance knowledge is costly because it requires the focal firm to embrace opposite goals and values, which accordingly will deplete managers' cognitive resources and create discomfort, strain and stress. While exploration focuses on new things, exploitation tends to be guided by local attentions. According to the behavioral strategy literature, an actor cannot sustain attention firmly on a stimulus and simultaneously flexibly switch back and forth between stimuli (Ocasio, 2011). A forced switch can create significant cognitive cost (Laureiro-Mart´ınez, Brusoni, Canessa, and Zollo, 2015). Therefore, searching moderately distant alliance knowledge (a mixture of exploration and exploitation) could lead to great cognitive tensions (Smith and Lewis, 2011).

Furthermore, exploration and exploitation require incompatible organizational routines (Lavie et al., 2011). For example, while exploration emphasizes profit generation and tight coupling with customer orientation, exploitation emphasizes the breakthrough of innovation and loose coupling with customer orientation (Andriopoulos and Lewis, 2009). Embracing these incompatible values and routines can generate high managerial cost. To address the problem, managers may devote their time to processing stress and negative emotions rather than performing creative and innovative tasks. As a consequence, managers tend to focus on process- but not task-related issues, which can spur a vicious cycle (Smith & Lewis, 2011).

Because searching moderately distant alliance knowledge generates greatest managerial tensions and costs, it may lead to lowest, rather than highest innovation-related outcomes (Lavie

et al., 2011; Lin et al., 2007), which implies a U-shaped relationship between technological distance of searched alliance knowledge and firm innovation.

I propose that the relationship between technological distance of searched alliance knowledge and firm innovation is U-shaped, because firms need to develop either exploration or exploitation routines. Since it is very difficult for a firm to develop cognitions and routines that support both exploration and exploitation (Andriopoulos and Lewis, 2009), the firm can often develop only one of them (Lavie et al., 2011). On the one hand, when searching alliance knowledge that is proximate to the focal firm, it is likely that exploitation routines were developed. Under such condition, increasing exploration (search distant alliance knowledge) decreases firm innovation since knowledge leveraging routines may not support the absorption of explorative knowledge. Therefore, increasing technological distance would lead to knowledge leveraging costs overweighting exploration benefits. On the other hand, as the technological distance of searched alliance knowledge increases, firms may start to develop specific supporting routines and capabilities (Quintana-García and Benavides-Velasco, 2008). As a result, firms may reach a minimum degree of innovation and can expect net gains surpassing this threshold. Therefore, I propose:

Hypothesis 3. The technological distance between the focal firm's knowledge base and its searched alliance knowledge has a U-shaped relationship with the firm's innovation performance.

3.3.3 Comparison between Searched Alliance Knowledge and Total Alliance Knowledge

While scholars have examined the relationship between the alliance knowledge and firm innovation, their analyses are often based on the stock of knowledge in the focal firm's alliance

network, instead of the knowledge that is actually searched by the focal firm (e.g., Lane and Lubatkin, 1998; Luo and Deng, 2009; Phelps, 2010; Sampson, 2007). However, a large amount of knowledge holding by partners may not be accessible to the focal firm, because partners have a strong tendency to protect unintended knowledge leakage and spillover (Larsson et al., 1998; Sampson, 2004). In addition, as indicated previously, firms may be unable to realize and recognize the knowledge in the alliance network (Srivastava and Gnyawali, 2011), and consequently, a large portion of the alliance knowledge stock could actually have no impact on the focal firm's innovation performance. Incorporating the inaccessible and unused alliance knowledge into the analysis may create noise, because this knowledge may not have an impact upon the focal firm's innovation performance.

Because including unused knowledge into the analysis may create noise in estimating the relationship between alliance knowledge leveraging and firm innovation; in this study, I propose that technological distance of searched alliance knowledge has a stronger impact on firm innovation than technological distance of total alliance knowledge:

Hypothesis 4. The relationship between the technological distance between the focal firm's knowledge base and its total alliance knowledge and firm innovation, is weaker than the relationship predicted in H3.

3.3.4 Balance Exploration and Exploitation across Domains

Exploration and exploitation are both interrelated and contradictory. As mentioned above, although it is important to establish a balance between exploration and exploitation, mixing them together and searching moderately explorative alliance knowledge is likely to be costly. In order to reduce such costs, Lavie and Rosenkopf (2006) propose a domain separation strategy to strike

a balance between exploration and exploitation. According to these researchers, firms can conduct exploration and exploitation simultaneously, by exploring in one domain, and exploiting in another. However, domain separation is a new approach, and thus, only a few studies have examined how adopting this approach influences firm performance (see Lavie, et al., 2010).

The cross-domain balancing approach assumes that an organization can carry out opposite actions in multiple domains, and therefore does not need to reconcile the tension within each domain of an organization, as long as the organization embraces both sides of the duality relationships. Lavie and Rosenkopf (2006) investigated the balance between exploration and exploitation in alliance formation. Three domains of alliance networks were considered in their study: the value-chain function (upstream *vs* downstream alliances), the network structure (existing *vs* new partners), and partner attributes (similarity *vs* dissimilarity to prior partners). These authors found that organizations balance exploration and exploitation across network domains. For example, when firms conduct exploration in value-chain functions (forming upstream alliances), they tend to conduct exploitation in network structures (forming repeated partnerships) and partner attributes (forming partnerships that are similar to prior partnerships).

Building on Lavie and Rosenkopf (2006), I propose that firms can establish the balance between exploration and exploitation across domains, by conducting exploration in one domain, and exploitation in the other. On the one hand, acquiring explorative knowledge brings more novel knowledge to the focal firm. In that regard, explorative knowledge is viewed as having a higher value than exploitative knowledge, because it generates high-impact innovation and facilitates the focal firm's ability to overcome learning myopia (Sørensen and Stuart, 2000; Rosenkopf and Nerkar, 2001). On the other hand, what also should be noted is that appropriate and integrate explorative knowledge are very costly (Katila and Ahuja, 2002). Thus, firms that

seek to acquire explorative knowledge, would be better off to conduct exploitation in the alliance network domain, so that their knowledge-appropriating capabilities can be developed. For alliance network, I focus on two network primitives: node and tie.

3.3.4.1 Searching explorative alliance knowledge from repeated partners

Having repeat partners is viewed as exploitation and facilitates the development of knowledge-appropriating capabilities for three key reasons. First, repeated interactions increase inter-firm trust (Gulati, 1995) and accordingly, foster the focal firm's ability-based confidence in the partner (Muthusamy and White, 2005), which makes the focal firm better able to evaluate whether the partner's distant alliance knowledge is promising. Thus, firms are more likely to recognize the value of distant alliance knowledge from repeated partnerships. Second, the trust and reciprocal commitment in repeated ties can also reduce the likelihood of the partners' opportunistic behavior (Muthusamy and White, 2005) and enables the focal firm to acquire distant alliance knowledge more effectively. Third, firms learn partners' knowledge-sharing routines (Zollo, Reuer, and Singh, 2002) from repeated interactions, and consequently, make knowledge absorption more effective. Moreover, inter-firm trust and knowledge-sharing mechanisms developed through repeated interactions would facilitate the transfer of unfamiliar knowledge (Dyer and Singh, 1998; Becerra, Lunnan, and Huemer, 2008; Hansen, 1999), enabling the focal firm to more effectively utilize distant alliance knowledge.

Thus, combining distant alliance knowledge and repeated partners leads to optimized innovation outcomes. In this scenario, exploration in searched alliance knowledge contributes to the focal firm's non-redundant knowledge seeking, enlarging its technological search scope. A significant amount of repeated partners reduces knowledge exchange costs and enhances partner-

specific absorptive capacity, making the focal firm able to leverage more value from the distant searched alliance knowledge. Therefore, I propose:

Hypothesis 5. Repeated partnerships positively moderate the relationship between searching distant knowledge and firm innovation, i.e., firms generate more innovation from searching distant knowledge via repeat partners, rather than from searching distant knowledge via new partners.

3.3.4.2 Searching explorative alliance knowledge through strong ties

Additionally, to achieve the benefits of exploration and exploitation at the same time, I propose that firms generate more innovation-related value from acquiring explorative knowledge using strong ties, rather than from acquiring explorative knowledge using weak ones. The reasons are as follows.

In addition to conducting exploitation by having repeated partners, a firm can conduct exploration at the knowledge domain and exploitation at the tie domain. Searching explorative knowledge via strong ties leads to superior innovation performance for three reasons. First, when the focal firm builds strong ties with its partners, it can thereby impose control over these relationships and make sure that the partners are willing to share their knowledge. One important barrier to acquire alliance knowledge is that partner firms often want to protect their existing knowledge (Hamel, 1991), because contracts on knowledge-based properties are highly vulnerable to opportunism (Oxley, 1997; 1999). When partner firms protect knowledge, the focal firm's ability to appropriate alliance knowledge would diminish (Simonin, 1999). In strong ties such as equity-based alliances, the focal firm may be able to establish board seats or management

placements in the joint venture or its partner firms (Fee, Hadlock and Thomas, 2006; Sampson, 2004), and is therefore able to force its partners to share knowledge.

Second, forming strong ties increase the stability of alliance networks. Strong ties, which often involve equity transfer, tend to be more stable and more difficult to terminate than weak ties, which are often non-equity alliances (Greve, Baum, Mitsuhashi, and Rowley, 2010). Relationship stability will prompt reciprocity and strengthen the partners' willingness to share knowledge, increasing the focal firm's ability to acquire and utilize partners' knowledge.

Finally, strong ties lead to effective coordination and frequent interaction between the focal firm's research team and its partner's research teams (Sampson, 2007). The knowledge creation process is complex, and requires intensive coordination and communication (Nonaka, 1995). However, inter-firm knowledge transfer can be challenging when the focal firm's research team and partners' research team are physically separated into two entities and report to different superiors. Therefore, in inter-firm knowledge transfer, research teams in different firms cannot coordinate effectively, and have limited opportunities to communicate and exchange ideas. Thus, when the focal firm has strong ties with its partners, it can resolve these problems. For example, the partners in a joint venture are more likely to develop teams to pursue collaborative innovation projects, and the research efforts are likely to be more coordinated.

In sum, when the focal firm can acquire explorative knowledge from strong ties, it balances exploration and exploitation in two domains—knowledge embedded in the network and strength of network ties. Consequently, the firm's accessibility to novel alliance knowledge and appropriating capability of alliance knowledge increase simultaneously, and thus, the innovation outcome can be maximized. Therefore, I propose Hypothesis 6 as follows:

Hypothesis 6. Tie strength positively moderates the relationship between searching distant knowledge and firm innovation, i.e., firms generate more innovation from searching distant knowledge via strong ties, rather than from searching distant knowledge via weak ties.

3.4 Summary of the Key arguments of Hypotheses

In sum, in this chapter, I developed specific hypotheses that examine the two research questions proposed in this study: (1) what motivates alliance knowledge search? And (2) how does configurations of alliance knowledge and alliance network jointly affect firm innovation? Two hypotheses have been developed to examine the first research question, and four hypotheses have been developed to examine the second research question. I summarize these hypotheses in Table 3.1.

Table 3.1 Summery of the Hypotheses

#	Hypothesis Statement	Dependent construct	Explanatory construct	Key argument/logic of the hypothesis
Empirical model 1: alliance knowledge search motivation				
1	Innovation performance below aspiration level has an inverted U-shaped relationship with the alliance knowledge search intensity.	The intensity of knowledge search	Innovation performance below aspiration level	Alliance knowledge search involves high potential innovation-related gains (Phelps, 2010; Sampson, 2007) and high risk (uncertainty and a large potential knowledge loss) (Kale et al., 2000; Li et al., 2008) concurrently Poor innovation performance prompts distant attention and encourages a firm to have a stronger desire for knowledge, with higher potential gains (Greve, 2003), but at the same time, poor performance also prompts local attention, and make the firm more concerned about risk associated with the search (Gilbert, 2005; Staw et al., 1981) Distant attention is more likely to be triggered, when performance is not very poor, but local attention is more likely to be triggered when performance decreases further (March and Shapira, 1992)

#	Hypothesis Statement	Dependent construct	Explanatory construct	Key argument/logic of the hypothesis
H2	Focal firm's size of knowledge stock moderates the inverted U-shaped relationship between innovation performance below aspiration level and alliance knowledge search in such a fashion that	The intensity of alliance knowledge search	Innovation performance below aspiration level; The focal firm's knowledge stock size	
2a	increasing knowledge stock size will (a) increase the slope of the positive effect of innovation performance below aspiration,			A large knowledge stock enables the focal firm to be more capable of appropriating gains from alliance knowledge leveraging (Volberda et al., 2010), guiding more attention to distant alliance knowledge
2b	increasing knowledge stock size will (b) reduce the negative effect of innovation performance below aspiration.			Large knowledge stock provides a buffer, reducing a poorly performing firm's concerns about uncertainty and potential knowledge losses (Audia and Greve, 2006). Accordingly, poor performance would trigger less local attention

#	Hypothesis Statement	Dependent construct	Explanatory construct	Key argument/logic of the hypothesis
Empirical model 2: configurations of alliance knowledge and alliance network and firm innovation				
3	Technological distance between the focal firm's knowledge base and its searched alliance knowledge has a U-shaped relationship with the firm's innovation performance.	The focal firm's innovation performance	Technological distance between the focal firm and its searched alliance knowledge	Embracing exploration and exploitation at the same time generates greatest managerial tension and costs (Lavie et al., 2011). Therefore, balancing exploration and exploitation in one domain (search moderately distant alliance knowledge) may lead to minimum innovation
4	The relationship between the technological distance between the focal firm's knowledge base and its alliance knowledge and firm innovation is weaker than the relationship predicted in H3.	The focal firm's innovation performance	Technological distance between the focal firm and its total alliance knowledge	A firm innovation model based on search alliance knowledge leads to more accurate estimations, than a model based on total alliance knowledge
5	Repeated partners positively moderates the relationship between the technological distance of searched alliance knowledge and firm innovation	The focal firm's innovation performance	Technological distance between the focal firm and its searched alliance knowledge; Average prior partnerships between the focal firm and partners	Having repeated partners enhances exploitation in the alliance network domain (Gulati, 1995; Muthusamy and White, 2005) Searching explorative alliance knowledge from repeated partners enables the firm to balance exploration and exploitation across domains

6	Tie strength positively moderates the relationship between the technological distance of searched alliance knowledge and firm innovation	The focal firm's innovation performance	Technological distance between the focal firm and its searched alliance knowledge; Average tie strength of the alliance network	Having strong ties enhances exploitation in the alliance network domain (Gulati and Singh, 1998; Sampson, 2007) Searching explorative alliance knowledge through strong ties enables the firm to balance exploration and exploitation across domains

4.0 METHODOLOGY

4.1 Research Setting

I tested my hypotheses on a sample of firms from the U.S. biopharmaceutical industry. The selected industry provides an appropriate setting for two reasons. First, biopharmaceutical firms are heavily rely on innovation in competition (Hagedoorn, 1993), making it an ideal context in which to analyze the knowledge-related behavior of biopharmaceutical firms (Hess and Rothaermel, 2011; Hoang and Rothaermel, 2010; Luo and Deng, 2009; Rothaermel and Deeds, 2004). Second, alliance activities are very vigorous in the biopharmaceutical industry (Hagedoorn, 2002; Powell et al., 1996; Powell, White, Koput, and Smith, 2005). One of the most important reasons is that the knowledge required for product development is highly dispersed: the biopharmaceutical companies often need to collaborate in R&D (Pisano, 1991). Moreover, since industries vary in their patenting tendencies (Pavitt, 1982), I conduct the study in a single industry to avoid this problem.

The main product of biopharmaceutical firms is pharmaceuticals drugs. The drug discovery and development process can be broken down into four distinct sequential stages (Giovannetti and Morrison, 2000; Rothaermel and Deeds, 2004). In the first stage, the firm invests heavily in R&D, and discovers several drug candidates. The discovery stage can take anywhere between 2 and 10 years. In the second stage, the firm will develop a lead drug candidate and conduct pre-clinical trials, before launching human testing procedures. The goal of the pre-clinical investigations is to find out whether the lead drug candidate has the potential to cause serious harm in humans and can take up to 4 years. Once this phase is over, the lead drug candidate enters clinical testing, which involves four additional phases. In phase 1, the lead drug

candidate's safety and dosage are evaluated. Phase 1 is administered to 20 to 30 healthy volunteers and can take up to 2 years. Phase 2 involves several hundred people with the disease, which can take up to 2 years. The goal of phase 2 is to check the drug's efficacy and side effects. In phase 3, which can take up to 4 years, the drug is administered to 300 to 3,000 volunteers who have the disease, in order to test the drug efficacy and monitor any potential adverse reactions. In phase 4, the drug will be reviewed by Food and Drug Administration (FDA). If the FDA review is successful, the company will conduct a post-marketing test. The process of obtaining FDA approval, and conducting the post-marketing test can take 2 years.

The drug development process has direct implications to the study. First, the entire development phases can extend more than 15 years, and cost over $500 million to produce a single drug (Rothaermel and Deeds, 2004). And, the failure rate of drug development is high, because drug development problems can occur at any phase. Thus, biopharmaceutical firms have a very strong incentive to collaborate and leverage knowledge from their alliance partners. Second, because drug development requires a large capital investment and very specific knowledge, some biopharmaceutical firms are primarily focused on R&D and, consequently, do very little manufacturing. Thus, innovation (e.g., new drug development, number of patents) becomes a very critical performance indicator for almost all the biopharmaceutical firms (Hagedoorn, 1993). Third, the drug development process shows that the drug development process is precarious. Thus, many biopharmaceutical firms will diversify their collaborative R&D projects by associating with numerous partners (Vassolo, Anand and Folta, 2004). Therefore, the biopharmaceutical industry is an appropriate context in which to test the dualities of local *vs* distant search motivation, and explorative *vs* exploitative knowledge.

4.2 Sample and Data Collection

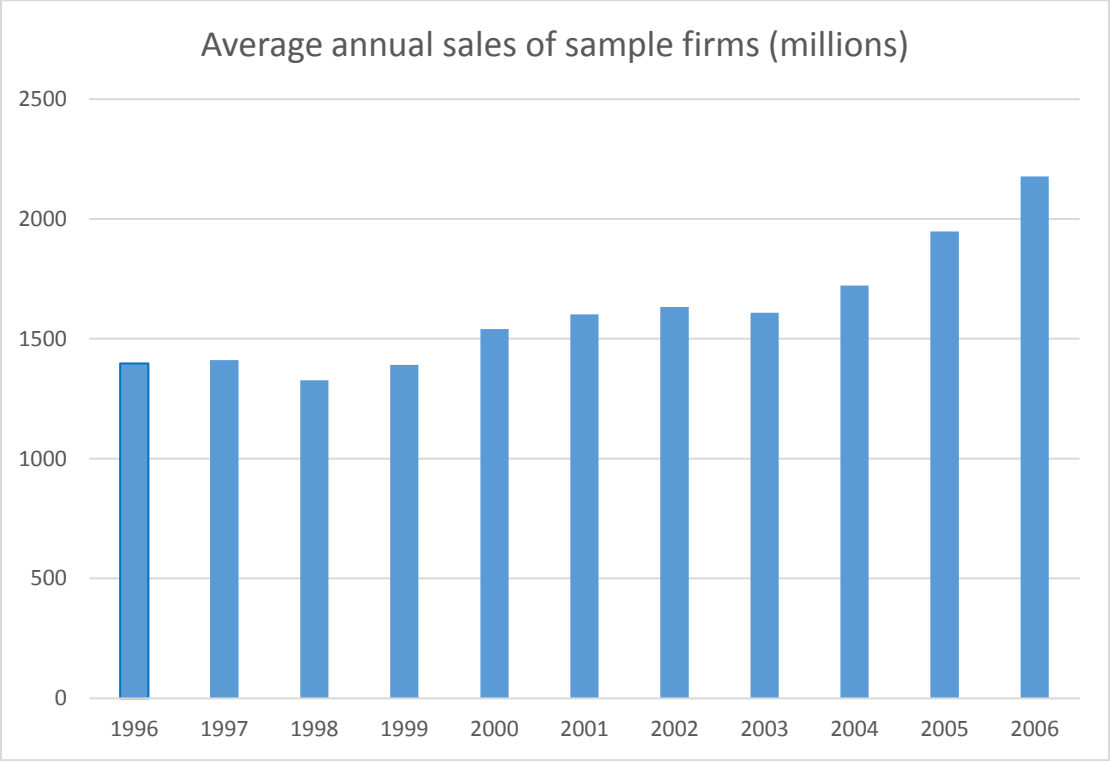
I constructed my sample of the U.S.-based publicly traded firms in the biopharmaceutical industry. Following prior studies (Caner, 2007; Rothaermel, 2001; Shi and Prescott, 2010), I identified the chemical-based biopharmaceutical firms listed under Standard Industrial Classification (SIC) code 2834 'Pharmaceutical Preparations' as sample firms. Data were compiled from multiple sources: focal firms and firms' financial data were collected from the Standard and Poor's Compustat database, alliance data were collected from the SDC database, patent and citation data were collected from the NBER patent database, and new drug approvals data were collected from the Drugs@FDA database.

Because I was not able to collect patent data beyond 2006 from NBER, I restricted the observation period from 1996 to 2006. Using this procedure I obtained an initial list of 463 firms. I collected the financial information of these firms from the Compustat database. However, due to missing data on several important financial variables for multiple years, 44 firms were excluded from the sample. Then, I verified whether a focal firm is primarily a biopharmaceutical company by checking the self-selected SIC code described in the 10-K reports that the firm filed with the Securities and Exchange Commission (SEC). I also dropped firms if they only appear in my data for a very short time period (less than five years). My final sample consisted of 295 biopharmaceutical firms (2727 firm-year observations) which were "active" during the period from 1996 to 2006. Figure 4.1 depicts the average annual sales of the sample firms, showing that the biopharmaceutical industry had a stable growth rate in terms of sales during the observation period of my data.

Table 4.1 Summary Statistics of the Sample Firms

Variable	Obs	#of firms	Mean	Std. Dev.	Min	Max
Annual sales (Millions)	2726	295	1661.1	6062.2	-0.1	61035.0
R&D spending (Millions)	2726	295	247.1	909.2	0.0	12183.0
Total assets (Millions)	2726	295	2601.1	10150.9	0.0	123684.0

Figure 4.1 Sales of Sample Firms



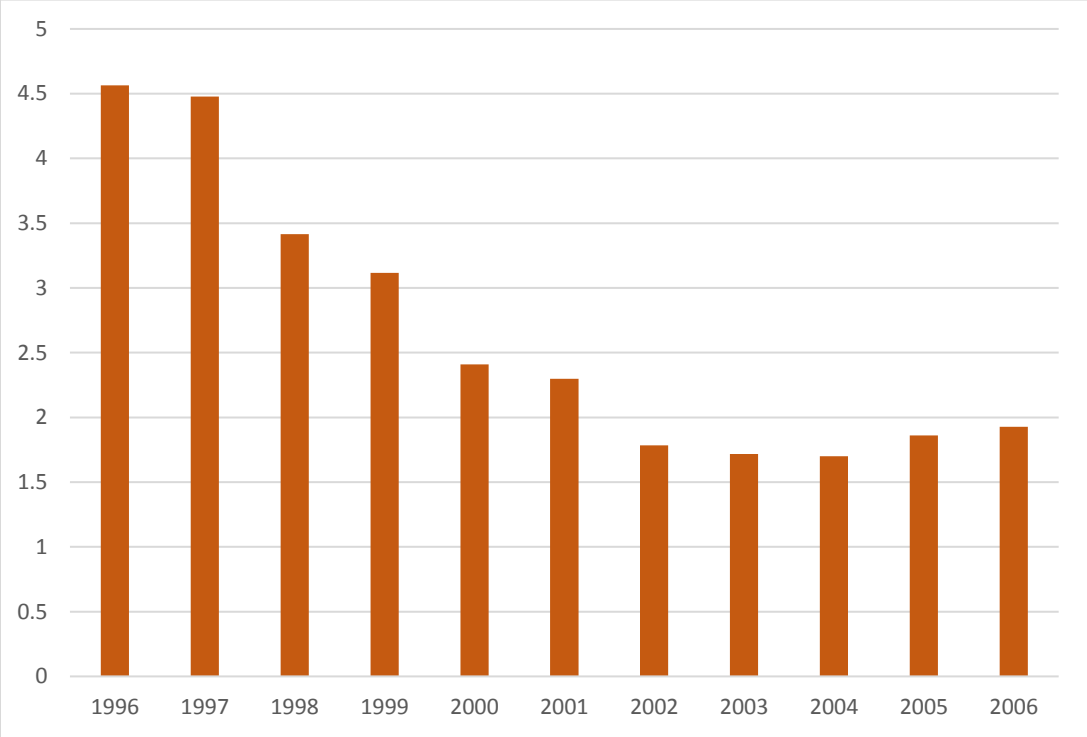
4.3 Alliance Data

I collected the alliance network data of biopharmaceutical firms using the SDC database, which is the most comprehensive alliance database available (Schilling, 2009). Although it was reported that the information in the SDC database is not completely accurate, studies show that the data reliability in general is still reasonably acceptable (Schilling, 2009).

I searched all the alliances that involved at least one biopharmaceutical participant listed under SIC code 2834. The search generated 4238 such alliances that were formed during the period between 1996 and 2006. Following Ahuja (2000) and Srivastava (2007), I converted all multilateral alliances among partners into a set of bilateral alliances between those partners. Alliances typically last for more than one year, but alliance termination dates are rarely reported. Following Schilling and Phelps (2007), I took a conservative approach and assumed the duration of alliances as five years. My alliance dataset includes 6581 alliance ties (dyads) reported by the sample firms during the period between 1996 and 2006.

Figure 4.2 depicts the annual average number of alliance ties formed by a focal firm. The average number of alliance was highest during 1998 to 1999, perhaps reflecting the volatility in technology-news related reporting during the technology bubble (Schilling, 2009). Perhaps due to the burst of the technology bubble, alliance activity significantly decreased in the 2001 to 2004 time period and then shows some flattening after 2004. These data patterns and trends are generally consistent with the data reported in Schilling (2009), providing additional validity of my dataset.

Figure 4.2 Average Number of Alliance formed by Sample Firms



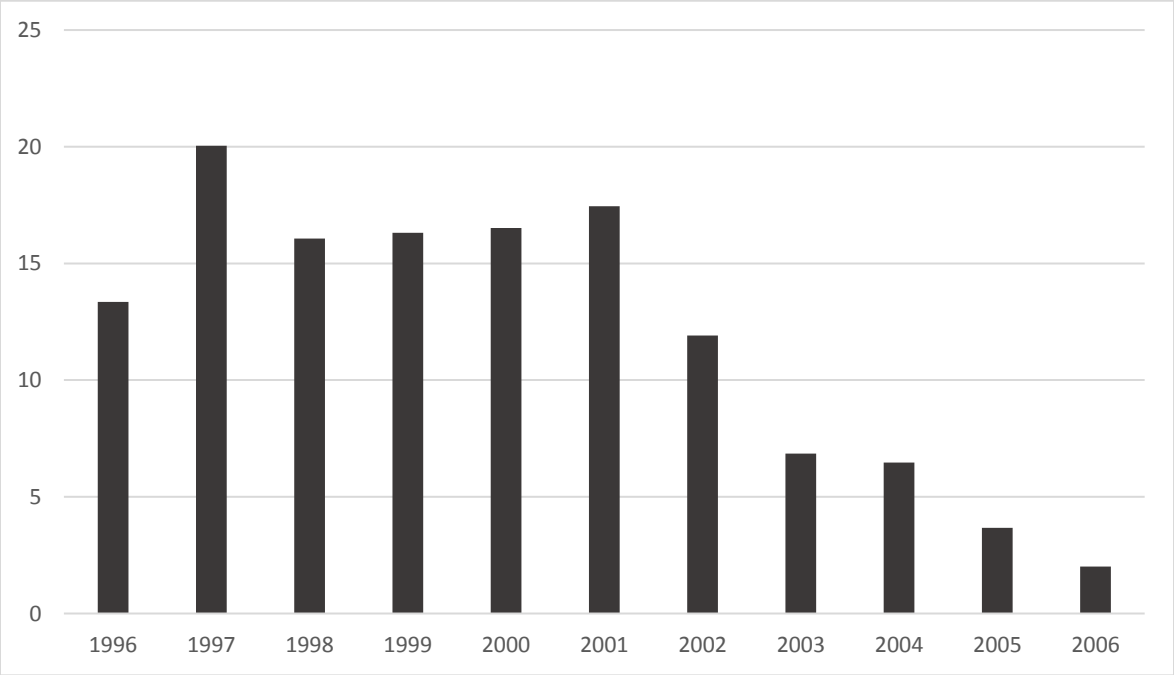
4.4 Patent Data

I collected the patent data following the procedure that is described in Srivastava (2007) (p91-93). Patents are a valid and robust measure of knowledge flow and innovation (Hall et al., 2001; Hagedoorn and Cloodt, 2003; Mowery et al., 1996). I collected the focal firms' and their partners' patent data from the updated NBER patent database (Bessen, 2009; Hall et al., 2001). This database contain patent information such as patent numbers, assignee names, assignee numbers, filing years, and grant years, but does not contain CUSIP numbers used in the Compustat database of the assignee firms. To match the patent data with the firm names in the Compustat file, data providers developed a name matching database (Bessen, 2009). Using this database, I was able to match the patent data with all the Compustat firms in my dataset, including all the sample focal firms. However, many partner firms do not appear in the

Compustat database. In order to collect the patent data of these firms, I developed a name-based matching algorithm to match the partner firms' names with the assignee firms' names that appear in the NBER database. The algorithm ignores the spacing between parts of the names as well as phrases such as "Ltd" and "Co", and is case insensitive.

As discussed, patenting behaviors were very active in the biopharmaceutical industry. A majority of the sample firms (67.4%) received at least one patent during the observation period between 1996 and 2006. Figure 4.3 depicts the patenting activity of the sample firms. The figure shows that firms' patenting activity started to decrease after 2001, following a sharp drop after 2004. The decrease of patenting activity could have two explanations. First, as discussed above, patenting activity could be reduced due to the burst of the technology bubble. Second, the NBER patent data has not been updated since 2006. Therefore, the data after 2004 was not fully updated as many patents though have been filed before 2004 were grated after 2006.

Figure 4.3 Average Number of Patent Granted to Sample Firms



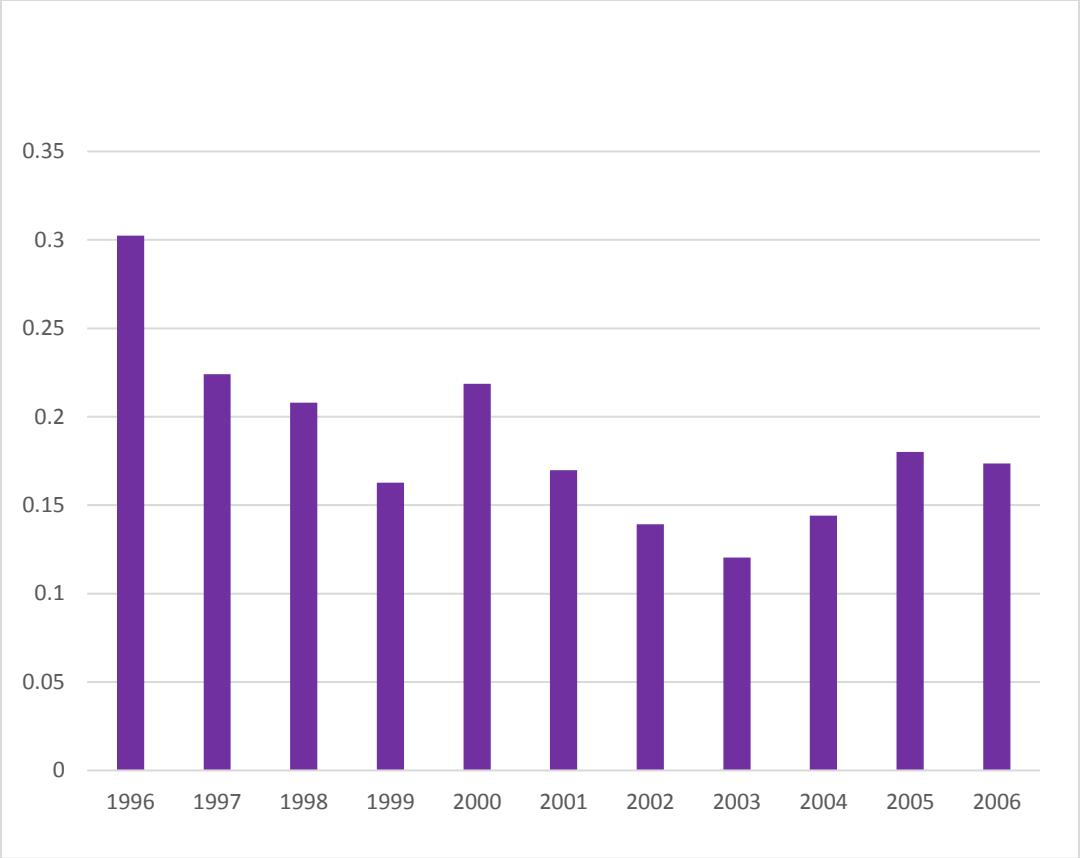
4.5. New Drug Approvals (NDA) data

In addition to the patent data, I collected new drug approvals (NDAs) data as an alternative measure of innovation. I collected NDA data for two reasons. First, scholars have posited that NDA is a good innovation measure (Bierly and Chakrabarti, 1996; Cardinal, 2001; Tyler and Caner, 2015; Wuyts and Dutta, 2014). Second, the biopharmaceutical industry has been highly regulated since the 1930s. New biopharmaceutical products must be approved by the U.S. Food and Drug Administration (FDA) to be marketed and sold. Therefore, the availability and completeness of the NDA data is high.

I collected NDA data during the period between 1996 and 2014. In assembling the data on NDAs, I followed an approach used by Cardinal (2001), Yeoh and Roth (1999) and Tyler and Caner (2015). I used the FDA classification of a biopharmaceutical product as a NDA if it constitutes a novel chemical composition. In order to collect information of such product, I searched all applications that were classified as New Molecular Entities (NMEs) and new biologics in the drug@FDA database.

Because the drug@FDA database does not provide standard identifications of applicant firms, I used the name match program algorithm to match the applicants' names and firm names appear in my dataset. To verify the quality of the match, I also manually searched firm names in drug@FDA. Figure 4.4 depicts the annual average number of NDA of the sample firms. Due to long and uncertain drug development process, a firm might not have a new drug approved every year and therefore the annual average number of NDA is significantly smaller than 1 for all observation years. I used multiple year windows to measure a firm's NDA-based performance (Tyler and Caner, 2015; Wuyts and Dutta, 2014).

Figure 4.4 Average Number of NDA Granted to Sample Firms



4.6 Measures

This study consists of two empirical models. Empirical Model 1 (Hypothesis 1-2) uses innovation performance below aspiration and the focal firm's knowledge stock size to predict alliance knowledge search intensity. Empirical Model 2 (Hypothesis 3-6) uses technological distance between searched alliance knowledge and the focal firm's knowledge, technological distance between total alliance knowledge and the focal firm's knowledge, repeated partners, and tie strength to predict the focal firm's innovation performance. Since the two models have different dependent variables, I discuss their measures separately in the following.

4.6.1 Measures for Empirical Model 1

4.6.1.1 Dependent Variable

The intensity of alliance knowledge search. I identified the intensity of alliance knowledge search as the number of partners' patents cited by the focal firm in the lagged five-year window following an observation year (Vasudeva and Anand, 2011). Using citation data to measure the knowledge flow between firms has been widely adopted by previous studies (Gomes-Casseres et al., 2006; Schildt et al., 2012; Srivastava and Gnyawali, 2011; Vasudeva and Anand, 2011). Absorbing external knowledge and creating innovation based on external knowledge requires time. Thus, a firm will cite its partners' patents in its patent applications submitted in the years after the year the firm gains access to the knowledge embedded in the cited patent. Taking this lag into consideration, I picked a three-year window of cross citation. In the robustness checks, I also computed knowledge search intensity, using a five-year window for robustness check (Vasudeva and Anand, 2011).

Following Schildt et al., (2012), I only counted newly cited patents; that is, only the first citation for every specific patent that was included in the utilization of the knowledge variable. Thus, repeated citations were excluded from the experimental model, because once they were cited by the focal firm, the knowledge embedded in the patent could have been absorbed and exploited. Therefore, only new citations were included, because citing a patent repeatedly does not indicate a re-utilization of knowledge.

4.6.1.2 Explanatory Variables

Innovation performance below aspiration levels. As mentioned, there are two important types of aspirations: social aspiration that compares the focal firm's current performance with that of its peer firms, and historical aspiration that compares the focal firm's current performance

with its own past performance (Cyert and March, 1963). Although some previous studies view historical and social aspirations as two components of a firm's general aspiration (e.g., Chen, 2008), recent studies propose that managers respond social and historical aspirations differently and therefore researchers need to model these two aspiration separately (Bromiley and Harris, 2014). I followed this suggestion and operationalized innovation performance below historical and social aspiration as two distinct variables.

Innovation performance. As discussed, one of the most important indicators of a firm's innovation performance is its patent counts (Acs et al., 2002; Hagedoorn and Cloodt, 2003). Previous studies found patent as a reasonable indicator of innovative performance (Griliches, 1992). In addition, by reading firms' annual reports, industry research reports and other related documents, I have found that the managers of biotechnology firms view the number of patents the firm has received as an important innovation-related goal.

Innovation performance can be measured by patent count or citation-weighted patent (Hagedoorn and Cloodt, 2003). Here I used patent count for two reasons. First, recent studies found that performance feedback based on simple performance measures predict organizational behaviors better than performance feedback based on complex performance measures (Bromiley and Harris, 2014). An explanation is that managers may be able to react to simple performance indictors more immediately and strongly than to complex performance indicators. Second, patent count brings less noise than citation-weighted patents (Hall et al., 2001). While using citation data, researchers can measure the value of patents *ex post* (Hall, Jaffe and Trajtenberg, 2005), setting aspiration is about placing expectations on innovation performance *ex ante*. For managers, the number of citations of a patent is unknown *ex ante*.

To compare firms with various levels of R&D inputs and technological opportunities, innovation performance was measured as the ratio of the focal firm's number of patents, and its total R&D expenditures during a certain year (Gaba and Bhattacharya, 2012; Gompers and Lerner, 2004).

Historical aspiration level (HA). The historical aspiration (HA) level is a mixture of the focal firm's past-period historical aspiration level as well as its past performance (Cyert and March, 1963). Following previous studies (Baum et al., 2005; Greve, 2003; Chen, 2008), I modeled aspirations as an exponentially weighed moving average of past performances as follows (Equation 2).

$$A_{it} = \alpha P_{i\,t-1} + (1 - \alpha) A_{it-1}, \qquad (2)$$

A is the historical aspiration levels, P is the performance, *i* is the focal firm, *t* is the time period, and α is a weight given to performance. Thus, the value α determines how quickly the focal firm updates the aspiration level. However, this updating parameter is an unknown value. Therefore, I estimated specifications based on three values of α: .25, .50, and .75 (Baum et al., 2005). The results are constant across the specifications based on different values of α. Since many prior studies indicate that firms weight recent performance more than old performance (e.g., Audia and Greve, 2006; Greve, 2003; Chen, 2008), I reported the results based on α = .75.

Innovation performance below HA. Following previous studies (Greve, 2003; Chen, 2008; Gaba and Bhattacharya, 2012), I implemented a spline function to model the firm performance relative to aspiration levels. Innovation performance below historical aspiration was defined as the following: equal to 0, if the firm's innovation performance is higher than its historical aspiration, and equal to the difference (attainment discrepancy) between its innovation

performance and the historical aspiration level, if the innovation performance is lower than the aspiration.

Social aspiration level (SA). The focal firm's social aspiration of year *t* was measured as the average innovation performance of all the companies in the sample in year *t* (Chen, 2008; Greve, 2003, 2008).

Innovation performance below SA. Innovation performance below social aspiration was defined symmetrically as innovation performance below historical aspiration.

Size of knowledge stock. Size of the focal firm's knowledge stock was measured as the sum of the number of patents that were granted to the focal firm in the previous three years., and I gave lower weights for the previous two years (0.8, 0.6) (George, Kotha, and Zheng, 2008), because recent knowledge tends to be more influential than old knowledge. The focal firm's unweighted knowledge stock was also calculated. Results based on the alternative measure remained unchanged from the results reported blow.

4.6.1.3 Control variables

Control variables included firm- and alliance-specific variables that influence alliance knowledge search and variables that influence firms' patenting behaviors. First, I controlled for the firm-specific factors, including the focal firm's R&D intensity, financial slack resources, total number of citations received in the focal year, and innovation performance above aspiration level.

R&D intensity. Firms with high R&D intensity may have a strong absorptive capacity (Cohen and Levinthal, 1990), and accordingly be capable to search more technological

knowledge from alliance partners. Therefore, I controlled for the focal firm's R&D intensity, which was measured as the ratio of a firm's R&D spending and its sales.

Financial slack resource. A firm's alliance knowledge search could be influenced by its financial slack resource, because search can be driven by slack (Chen, 2008; Greve, 2003). Thus, I controlled for the impact of the focal firm's financial slack resources, which was measured as the focal firm's current ratio (current assets divided by current liabilities) (Chen, 2008).

Innovation performance above aspiration level. As other performance feedback studies did (e.g., Bromiley and Harris, 2014; Desai, 2008), I controlled for innovation performance above historical and social aspiration levels, and was defined and measured symmetrically as the innovation performance below historical and social aspiration levels.

Total number of citations. To control any bias arising from patent examiner, I included the total number of citation the focal firm made from year $t+1$ to $t+3$ in the analysis (Vasudeva and Anand, 2011).

I also controlled for several alliance network-specific factors, including the alliance knowledge quality, technological distance between the focal firm and its alliance network, repeated partners, the portion of cross-border alliance, tie strength, and partner dissimilarity.

Alliance knowledge quality. A firm is more likely to conduct alliance knowledge search and search more knowledge from alliance partners if the partners have very rich technological knowledge resources. Thus, it is important to control for the quality of alliance knowledge in this model. Alliance knowledge quality was measured by counting the number of patents received by partners in the observation year.

Alliance technological distance. It measured the technological distance between the focal firm and its alliance partners. Technological distance has a great impact on knowledge transfer among the focal firms and its partners (Mowery et al., 1996; Vasudeva and Anand, 2011). The technological distance between a focal firm and its alliance network was calculated as $1 - P_{ij}$, where P_{ij} is the measure of technological similarity (Jaffe, 1986) between the focal firm's technological base and its alliance partners'. Pij is calculated as $V\boldsymbol{i}V'_j/[(V_iV_j)(V_{ji})]^{1/2}$, where V_i is the vector of technological positions for the focal firm ***i***, and V_j is the corresponding vector for firm *i*'s alliance network *j*. The vector V is represented by (V1, V2, V3, . . . Vk), where V_k is the cumulative proportion of patents assigned to patent subclass k. For observations which the focal firm or the alliance network does not have any patent, I assigned a large value of technological distance (e.g., .9, .8 and .7) and use corresponding numbers to do a robustness check.

Tie strength. Firms can access more knowledge from strong ties than weak ties (Oxley, 1997). Therefore, it was found that joint ventures impose a stronger control over the alliance than non-equity alliances (Oxley, 1997, 1999; Sampson, 2004). Thus, I controlled for the average tie strength of the network and measured it as the portion of joint ventures in the total number of alliance relationships the focal firm had in the observation year.

Repeated partners. I controlled for repeated partnerships because it could enhance partner-specific absorptive capacity (Hoang and Rothaermel, 2005) and therefore increase alliance knowledge search intensity. I measured repeated partners as the number of prior alliances between the pair of firms in a focal dyad (Hoang and Rothaermel, 2005). To covert repeatedness at dyadic relation level to alliance portfolio level, I computed the average score of a firm's number of prior ties with its partners in each year

The portion of cross-border alliance. Some scholars suggests that knowledge from foreign countries may be more valuable to the focal firm, but at the same time more difficult to search (Phene, Fladmoe-Lindquist and Marsh, 2006). Thus, cross-border alliance may also influence alliance knowledge search motivation and I controlled the portion of cross-border alliance in total alliance relationships.

Partner dissimilarity. Studies show that firms are more likely to search knowledge from similar partners (Lane, Salk, and Lyles, 2001). Thus, I controlled for the dissimilarity between the focal firm and its partners. Partner dissimilarity was measured as the portion of partner firms which share the same four-digit SIC code which the focal firm (Lavie, 2007).

Inverse Mills ratio. Firms may cite no partner's patent due to the fact that they do not have any alliance partner at all rather than the fact that they have insufficient motivation. Therefore, firm observations with no alliance formation in the observation year were dropped, creating a self-selection bias.

A two-stage model was adopted in order to correct this bias (Heckman, 1979). In the first stage, a probit model was used to estimate the probability of alliance formation. The binary variable of having alliances versus having no alliance was regressed on the firm's size, financial resource, industry alliance formation propensity, and market share (Park, Chen, and Gallagher, 2002). The industry alliance formation propensity measured as the average number of alliances in the firm type which the focal firm belongs to at each year. The result of the probit model was reported in Table 4.3.

The probit model generated an adjustment index, which is often referred to as the Inverse Mills ratio. Then, the index was included as a control variable into the second-stage models,

producing the models used to estimate alliance knowledge search. The inclusion of this control variable corrects the possible selection bias in the second model.

Table 4.2 Probit model of Alliance Formation

	Model 1	
Firm size	0.21***	(0.03)
Financial resource	0.00*	(0.00)
Industry alliance formation propensity	-0.09	(0.06)
Market share	-2.47	(5.90)
Year dummies	Yes	
Constant	-1.18***	(0.30)
Constant	2.12***	(0.18)
Observations	2449	
N (# of firms)	287	
ll	-921.52	
df_m	10.00	
chi2	57.35	
chi2_c	1482.81	

Year dummy. Year dummies were included in the model. Due to citation lag and a result of truncation, more recent patents may have received fewer numbers of citations than patents that were generated earlier (Hall et al., 2001). By adding year dummies, I can control for the effects of systemic differences in the number of citations that were issues for the patents year over year.

4.6.2 Measures for Empirical Model 2

4.6.2.1 Dependent variable

Focal firm innovation. The focal firm's innovation performance was measured in two ways. First, I developed a patent-based measure, measuring firm innovation as the count of patents of the focal firm (Ahuja, 2000). The searched alliance knowledge would take some time to be applied in a patent application. On average, it may take three years (Katila and Chen,

2008). Taking this time lag into account, I used the number of patent received by the focal firm from year *t+3* to *t+5* as a measure of innovation performance. I tried different time windows as robustness check.

Second, I developed a NDA-based innovation performance measure, measuring firm innovation as the number of NDA received by the focal firm. Applying knowledge into a new product would take a longer time than applying knowledge into a patent. In the biopharmaceutical industry, it takes on average 10 years to translate "knowledge" into an approved drug (Nichols, 1994). Thus, I followed Wuyts and Dutta (2014) and considered the configurations of alliance knowledge at time t to influence the generation of NDA in the time window [*t+8, t+12*]. I also tried different time windows as robustness check.

4.6.2.2 Explanatory variables

Technological distance between the searched alliance knowledge and the focal firm's knowledge based. The relative distance between the focal firm's knowledge and its searched alliance knowledge was measured as the distance between the patents that are received by the focal firm in year *t* and all the partners' patents that are cited by the focal firm from year *t* to year *t+3*. Patent received by the focal firm in year *t* represents the focal firm's knowledge base. As described in 4.6.1.1, I used citing partner's patent as the indicator of the focal firm's searched of alliance knowledge.

Then, I calculated the technological distance between the focal firm's patent portfolio and its searched alliance knowledge using Jaffe (1986)'s technological similarity measure, the same procedure will be used as described in 4.6.1.3 (the technological distance between the focal firm and its alliance network variable).

Technological distance between the total alliance knowledge and the focal firm's knowledge based. This variable captures the technological distance between the focal firm's knowledge base and the total knowledge embedded in its alliance partners. Following Vasudeva and Anand (2011), I measured the focal firm's knowledge base as all patents the firm received in the observation year, and measured total alliance knowledge as all patents received by the focal firm's partners in the observation year. Then, I calculated the technological distance between these two patent portfolios using Jaffe (1986)'s technological similarity measure as described above.

Repeated partners. I measured repeated partners as the number of prior alliances between the pair of firms in a focal dyad (Hoang and Rothaermel, 2005). To covert repeatedness at dyadic relation level to alliance portfolio level, I computed the average score of a firm's number of prior ties with its partners in each year.

Total tie strength. Firms form equity-based and non-equity alliances, and the former are viewed to stronger than the latter (Oxley, 1997; 1999; Sampson, 2004). Therefore, I first coded each alliance as equity-based alliance =2, non-equality alliance=1. To covert tie strength at dyadic relation level to total tie strength at the network level, I computed cumulative scores of a firm's alliance ties in each year.

4.6.2.3 Control variables

I controlled for several factors that may influence firm innovation, including firm-level factors such as firm size, financial slack resources and R&D intensity, alliance-specific factors such as the technological diversity of partners, partner dissimilarity, portion of cross-border

alliance, and portion of R&D alliance, and I also included an Inverse Mills ratio in the model to correct the selection bias of alliance formation. Year dummies were also included.

Firm size. Large firms may be more capable to generate innovation (Acs and Audretsch, 1987), because they have more resources to conduct innovation. I measured firm size as the log of sales.

R&D intensity and financial slack. R&D intensity is a critical factor for firm innovation, because (Cohen and Levinthal, 1990). Firms with high R&D intensity are likely to conduct more innovation-related activities. In addition, financial performance may also influence a firm's capability of launching innovation (Greve, 2003). Therefore, I controlled for these two factors and used the same measures as discussed in the previous section.

Technological diversity of partners. Prior studies indicate that accessing diverse technologies from partners may enhance firm innovation, because diverse technologies bring more novel knowledge to the focal firm and therefore tend to be more valuable (Vasudeva and Anand, 2011).

Following Srivastava and Gnyawali (2011) and Vasudeva and Anand (2011), I measured technological diversity of partners using the Herfindahl index. The formulation is as follows: $H_{TD} = \sqrt{1 - \sum_{i=1}^{K} (Xi / \sum X)^2}$, where X_i is the number of patents of the alliance network in the patent subclass i. A minimum value of 0 of H_{TD} indicated that all alliance partners concentrated their patents in one technological subclass, and a maximum value of 1 indicated there was no overlap among partners' technologies.

Portion of R&D alliance, portion of cross-border alliance, partner dissimilarity, and year dummies. As mentioned above, the portion of R&D alliance, portion of cross-border alliance and partner dissimilarity may influence the focal firm's capability of utilizing alliance knowledge. Therefore, these factors can potentially influence the relationship between searched alliance knowledge and firm innovation. I controlled them in the empirical model 2.

4.6.3 Summary of the Measures

I summarize the measures of all the variables in empirical model 1 and 2 in Table 4.3.

Table 4.3 Variables and Measurement

Hypothesis	Variable name	Role in the hypothesis	Measurement	Reference
Empirical model 1: poor innovation performance and alliance knowledge search intensity				
1, 2a, 2b	Alliance knowledge search intensity	Dependent variable	The number of partners' patents cited by the focal firm in the lagged three-year window following an observation year	Vasudeva and Anand (2011); Schildt et al, 2012
1, 2a, 2b	Innovation performance below aspirations	Independent variable	It is equal to 0 if the firm's innovation performance is higher than its aspiration level and equal to the difference (attainment discrepancy) between its innovation performance and the aspiration level if the innovation performance is lower than the aspiration Innovation performance is the ratio of the focal firm's number of patent and its total R&D expenditure of a certain year Two types of aspiration: Historical aspiration level is a mixture of the focal firm's past-period historical aspiration level and its past performance Social aspiration of year *t* was measured as the average innovation performance of all the companies in the sample in year *t*	Greve, (2003); Gaba and Bhattacharya, (2012)
2a, 2b	Knowledge stock size	Moderator	The sum of the number of patents that were granted to the focal firm in the previous three years	George, Kotha. and Zheng (2008)

Hypothesis	Variable name	Role in the hypothesis	Measurement	Reference
1, 2a, 2b	R&D intensity	Control variables	The ratio of a firm's R&D spending and its sales	Cohen and Levinthal (1990)
	Financial slack resource		Current assets divided by current liabilities	Chen (2008)
	Innovation performance above aspirations		They are defined symmetrically as the innovation performance below historical and social aspiration	Gaba and Bhattacharya, (2012)
	Total number of citation		Total number of citation the focal firm made from year *t+1* to *t+3*	Vasudeva and Anand (2011)
	Alliance knowledge quality		The number of patents received by partners in the observation year	
	Alliance technological distance		The technological distance between a focal firm (all patents received by the focal firm in year *t*) and its alliance network (all patents received by the focal firm's partners in year *t*)	Jeffe (1986); Vasudeva and Anand (2011)
	Tie strength		The number of partners in the focal firm's alliance network and the number of JVs in the alliance network	Oxley (1997)
	Repeated partners		The average score of a firm's number of prior ties with its partners in each year	Hoang and Rothaermel, (2005)
	The portion of cross-border alliance		The portion of cross-border alliance in total alliance relationships	
	Partner dissimilarity		The portion of partner firms which share the same four-digit SIC code which the focal firm	Lavie (2007)
	Inverse Mills ratio		Correct the selection-bias of alliance formation	Heckman (1979)
	Year dummy		Year dummies	

Empirical model 2: searched alliance knowledge, alliance network and firm innovation				
Hypothesis	**Variable name**	**Role in the hypothesis**	**Measurement**	**Reference**
3, 4, 5, 6	Focal firm innovation (patent)	Dependent variable	Number of patent received by the focal firm from year *t+3* to *t+5*	Sampson (2007)
3, 4, 5, 6	Focal firm innovation (NDA)	Dependent variable	the number of NDA received by the focal firm from year *t+8* to *t+12*	
3, 4, 5, 6	Technological distance between the focal firm and searched alliance knowledge	Independent variable	The technological distance between the patents that are received by the focal firm in year *t* and all the partners' patents that are cited by the focal firm from year *t* to year *t+3*	Jaffe (1986)
4	Technological distance between the focal firm and total alliance knowledge	Independent variable	The technological distance between a focal firm (all patents received by the focal firm in year *t*) and its alliance network (all patents received by the focal firm's partners in year *t*)	
5	Repeated partners	Moderator	The average score of a firm's number of prior ties with its partners in each year	
6	Tie strength	Moderator	The number of partners in the focal firm's alliance network and the number of JVs in the alliance network	

Hypothesis	Variable name	Role in the hypothesis	Measurement	Reference
3, 4, 5, 6	Firm size	Control variables	Log of sales	Srivastava and Gnyawali (2011)
	R&D intensity		The ratio of a firm's R&D spending and its sales	
	Financial slack.		Current assets divided by current liabilities	
	Technological diversity of partners		The degree of diversity of partner firm's knoweldge (patent received in the observation year). The degree of diversity was measured using Herfindahl index (based on patent class)	Vasudeva and Anand (2011)
	Portion of R&D alliance		The portion of R&D alliance in total alliance relationships	
	Portion of cross-border alliance		The portion of cross-border alliance in total alliance relationships	
	Partner dissimilarity		The portion of partner firms which share the same four-digit SIC code which the focal firm	
	Year dummy		Year dummies	

5.0. DATA ANALYSIS AND RESULTS

In this chapter, I discuss the data analysis results of the hypotheses described in Chapter 3. As this study consisted of two empirical models with different dependent variables, I present the results for each model separately.

5.1 Models of Alliance Knowledge Search Intensity

First, I examine how innovation performance below aspiration levels and the focal firm's knowledge stock size jointly influence the firm's alliance knowledge search intensity.

5.1.1 Descriptive Statistics

Table 5.1 reports the means, standard deviation, and minimum and maximum values of all the variables in the models of alliance knowledge search intensity, and the Pearson correlation among all the variables in the model. The correlation between variables show that a few variables in the model are highly correlated with each other. First of all, although the correlation between innovation performance below social and historical aspirations is weak, innovation performance above social aspiration and innovation performance above historical aspiration are highly correlated (r=0.98). Therefore, following Gaba and Bhattacharya (2012), I tested social and historical aspirations in separated models. In addition, three control variables, total citation, alliance knowledge quality and Inverse Mills ratio have relatively strong correlations with knowledge stock size, the moderator. I therefore dropped these control variables in the robustness check. The correlations among other exploratory variables are not strong. Therefore, multicollinearity problem seems not be a concern of this test.

Table 5.1 Descriptive Statistics and Correlation (Empirical Model 1)

		Mean	Std. Dev.	Min	Max	1	2	3	4	5	6
1	Alliance knowledge search intensity	3.76	19.98	0	209	1					
2	Innov perf below HA	0.1	0.23	0	1.52	-0.02	1				
3	Innov perf below SA	0.11	0.16	0	0.68	0.18*	0.04	1			
4	Knowledge stock size (KSS)	34.33	68.5	0	234	0.48*	-0.01	0.06*	1		
5	R&D intensity	3.34	7.31	0.01	34.25	-0.08*	-0.01	0.01	-0.16*	1	
6	Financial slack	5.33	5.67	0.04	80.1	-0.11*	0	-0.01	-0.17*	0.19*	1
7	Total citation (t+3)	158.44	346.92	0	1208	0.53*	0	0.13*	0.80*	-0.12*	-0.10*
8	Innov perf above HA	0.03	0.14	0	1.33	-0.01	-0.01	-0.04	-0.02	0.02	-0.01
9	Innov perf above SA	0.06	0.32	0	3.89	-0.01	0	-0.06*	0.01	0.02	0
10	Alliance knowledge quality	146.6	437	0	4996	0.53*	-0.01	0.18*	0.53*	-0.11*	-0.09*
11	Portion of cross-border alliance	0.51	0.39	0	1	-0.01	-0.06*	-0.03	0.05	0.01	-0.03
12	Partner dissimilarity	0.45	0.37	0	1	0.01	0.04	0.02	-0.04	-0.09*	-0.01
13	Repeated partners	1.65	1.01	0	5.5	0.03	0.06*	0.03	0.10*	-0.03	0.04
14	Tie strength	0.09	0.22	0	1	0.04	-0.01	0.15*	0.05	-0.05	-0.08*
15	Tech distant	0.03	0.14	0	1.33	-0.24*	0.01	-0.02	-0.44*	0.09*	0
16	Inverse Mills ratio	0.06	0.32	0	3.89	-0.26*	0.11*	0.05	-0.54*	0.59*	0.27*
17	Innov perf below HA * KSS	0.45	0.37	0	1	0.11*	0.14*	-0.01	0.35*	-0.05	-0.01
18	Innov perf below SA * KSS	1.65	1.01	0	5.5	0.46*	-0.02	0.11*	0.09*	-0.01	-0.03
19	Year 1997	0.01	0.08	0	1	0.06*	-0.01	0.29*	-0.03	0.04	0
20	Year 1998	0.06	0.25	0	1	0.07*	0.06*	0.17*	0.07*	0	0.01
21	Year 1999	0.07	0.26	0	1	0.09*	-0.01	0.51*	0.06*	-0.01	0.05
22	Year 2000	0.08	0.27	0	1	0.03	0.10*	0.03	0.04	-0.01	-0.01
23	Year 2001	0.08	0.27	0	1	0.03	0.01	0.02	0.05	-0.02	-0.03
24	Year 2002	0.08	0.28	0	1	0.04	0	0.0101	0.04	-0.01	0.10*
25	Year 2002	0.08	0.28	0	1	0	-0.01	0.035	0.04	0.01	0
26	Year 2003	0.09	0.28	0	1	-0.04	0	-0.12*	0.04	0.02	-0.02

* $p<0.05$

Table 5.1 Descriptive Statistics and Correlation (Empirical Model 1) (con't)

		7	8	9	10	11	12	13	14	15	16
7	Total citation (t+3)	1									
8	Innov perf above HA	-0.01	1								
9	Innov perf above SA	0.03	0.98*	1							
10	Alliance knowledge quality	0.56*	-0.01	0	1						
11	Portion of cross-border alliance	0.02	-0.03	-0.04	0	1					
12	Partner dissimilarity	-0.05	0.04	0.04	-0.01	0.08*	1				
13	Repeated partners	0.08*	0.04	0.05	0.05	0	0.01	1			
14	Tie strength	0.08*	-0.01	-0.01	0.05	0.07*	-0.17*	0.02	1		
15	Tech distant	-0.45*	-0.06*	-0.06*	-0.21*	0	0.09*	-0.07*	-0.01	1	
16	Inverse Mills ratio	-0.35*	0.11*	0.12*	-0.29*	-0.13*	-0.08*	-0.04	-0.02	0.19*	1
17	Innov perf below HA * KSS	0.28*	-0.01	0.03	0.13*	-0.02	-0.05	0.03	0.01	-0.13*	-0.05
18	Innov perf below SA * KSS	0.20*	0.01	-0.01	0.21*	0.02	0.01	-0.05	0	-0.06*	-0.05
19	Year 1997	0.12*	0.04	0.03	0.10*	-0.03	-0.04	-0.07*	0.03	-0.12*	0.12*
20	Year 1998	0.11*	-0.01	-0.01	0.04	-0.03	-0.02	-0.06*	0.03	-0.05	0.16*
21	Year 1999	0.11*	0.11*	0.09*	0.11*	-0.05	0	0.04	0.07*	-0.10*	0
22	Year 2000	0.12*	0	0	0.05	-0.07*	0.01	0.04	0.05	-0.07*	0.01
23	Year 2001	0.09*	0.01	0.01	0.07*	-0.03	0.01	0.04	0.04	-0.07*	-0.01
24	Year 2002	0.08*	-0.01	0	0.05	0	0.01	0.04	0.05	-0.04	-0.01
25	Year 2002	0.04	-0.01	-0.01	0.06*	-0.01	-0.01	0.04	0.01	-0.05*	-0.01
26	Year 2003	-0.02	-0.01	-0.01	-0.02	0.03	0	0.10*	0.02	-0.02	-0.01

* $p<0.05$

Table 5.1 Descriptive Statistics and Correlation (Empirical Model 1) (con't)

		17	18	19	20	21	22	23	24	25	26
17	Innov perf below HA * KSS	1									
18	Innov perf below SA * KSS	-0.01	1								
19	Year 1997	-0.01	-0.03	1							
20	Year 1998	0.22*	0.04	-0.06*	1						
21	Year 1999	0	0.18*	-0.06*	-0.06*	1					
22	Year 2000	0.01	-0.04	-0.07*	-0.07*	-0.07*	1				
23	Year 2001	-0.01	-0.05	-0.07*	-0.07*	-0.07*	-0.08*	1			
24	Year 2002	-0.02	-0.03	-0.07*	-0.07*	-0.07*	-0.08*	-0.08*	1		
25	Year 2002	0	-0.03	-0.07*	-0.07*	-0.08*	-0.08*	-0.08*	-0.08*	1	
26	Year 2003	0.05	-0.07*	-0.07*	-0.07*	-0.08*	-0.08*	-0.08*	-0.08*	-0.1*	1

* p<0.0

I discuss the descriptive statistics of the dependent variable, alliance knowledge search intensity, in detail. I plotted the data and found that distribution of alliance knowledge search intensity has two important features. First, the data are strongly skewed and the variance of alliance knowledge search intensity is four times larger than its mean. Such distribution is displaying clear signs of overdispersion.

Second, I found that there are some extremely large outliers in the dataset. I examined these outliers carefully and found that they represent large firms such as Pfizer and Eli Lilly. Because I do not have a legitimate reason to drop these observations, they were kept in the data analysis. However, to make sure the results will not be primarily driven by these outliers, I winsorized alliance knowledge search intensity to conduct a robustness check. Alliance knowledge search intensity (AKS) was winsorized at the 95 percentile, generating a new variable AKS_W. Then, I correlated AKS_W with other variables in the model. It appears that correlation coefficients with the winsorized variable are similar to the coefficients reported in Table 5.1, implying that the relationships among alliance knowledge search intensity and other variables are not likely to be driven by the outliers.

5.1.2 Statistical Methods

The dependent variable, alliance knowledge search intensity, is a count variable and has a skewed distribution owing to the large number of zeros while also suffering from over dispersion. A negative binomial model was thus specified (Hausman, Hall, and Griliches, 1984). Furthermore, because the data has an autocorrelation problem due to nonindependence, a generalized estimating equation (GEE) approach was used to generate more consistent and robust parameters when is present (Ballinger, 2004; Hardin and Hilbe, 2003). The GEE model was specified a logit link function and an exchangeable correlation matrix and computed robust

errors. The exchangeable correlation matrix controls for firm differences. This method also allows specification of various forms of within-group correlation.

5.1.3 Hypotheses Testing

Table 5.2 introduces the effects of innovation performance below social and historical aspiration levels on alliance knowledge search intensity. Model 0 presented a base model consisting only of the control variables. Model 1 and Model 2 added the main independent variables, innovation performance below historical and social aspiration levels, and their squared terms respectively. The estimates show that innovation performance below both historical and social aspiration have positive effects on alliance knowledge search (for historical aspiration: $p<0.001$; for social aspiration: $p<0.01$). The beta coefficient of the square term of innovation performance below historical aspiration is negative and significant ($p< 0.01$) and the square term of innovation performance below social aspiration is also negative, although not significant in Model 2. Therefore, the result show that innovation performance below aspiration level, especially historical aspiration, has an inverted U-shaped relationship with alliance knowledge search intensity, supporting Hypothesis 1.

Hypothesis 2 predicts that the focal firm's knowledge stock size moderators the relationship between innovation performance below aspiration and alliance knowledge search. I found that the coefficient of the product of innovation performance below aspiration and knowledge stock size is significantly positive (for historical aspiration: $p<0.1$; for social aspiration: positive but insignificant), which indicates that the positive main effect of poor innovation performance on alliance knowledge search is intensified when the focal firm's knowledge stock is large. Therefore, Hypothesis 2a is supported.

The coefficient of the product of the squired innovation performance below aspiration and knowledge stock is significantly negative (for historical aspiration: $p<0.1$; for social aspiration: positive but insignificant), which indicates that the negative effect of poor innovation performance on alliance knowledge search is also intensified when the focal firm's knowledge stock is large. This finding indicates that increasing knowledge stock size would increase, rather than reduce, the negative effect of poor innovation performance on alliance knowledge search. Thus, Hypothesis 2b is not supported.

Following Miller, Stromeyer and Schwieterman (2013), I illustrate results graphically in Figure 5.1 (based on the model using historical aspiration). The figure shows that firms' knowledge stock size enhances both the positive and negative effects of poor innovation performance on alliance knowledge search.

5.1.4 Robustness Checks

I did two additional analyses to check the robustness of the results. First, following the suggestions of Carlson and Wu (2012), I dropped the control variables that were not significant in any models and were highly correlated with other exploratory variables (total citation, alliance knowledge quality, and Inverse Mills ratio). Second, I picked a three-year moving window of cross citation to measure alliance knowledge search intensity in the reported main data analysis. In the robustness checks, I computed alliance knowledge search using five-year window. The results of the robustness checks are reported in Table 5.3 and Table 5.4. The results of the robustness checks are generally consistent with the results reported in Table 5.2.

Table 5.2 GEE Model of Alliance Knowledge Search Intensity (t+3)

	Model0		Model1		Model2		Model3		Model4	
Innov performance below HA			1.60**	(0.51)			1.52**	(0.48)		
Innov performance below HA2			-1.02**	(0.33)			-0.95**	(0.34)		
Innov perf below HA * knowledge stock size							0.00+	(0.00)		
Innov perf below HA2 * KSS							-0.01+	(0.01)		
Innov performance below SA					3.94*	(1.60)			4.10*	(1.65)
Innov performance below SA2					-3.47	(2.62)			-4.31	(2.80)
Innov perf below SA * KSS									-0.00	(0.00)
Innov perf below SA2 * KSS									0.01	(0.01)
Knowledge stock size (KSS)	0.00*	(0.00)	0.00	(0.00)	0.00+	(0.00)	-0.01	(0.01)	0.00*	(0.00)
R&D intensity	-0.02	(0.01)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)
Financial slack	-0.02	(0.01)	-0.03*	(0.01)	-0.02	(0.03)	-0.03*	(0.01)	-0.02	(0.02)
Total citation	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)
Innov performance above HA	-0.00	(0.05)	0.11**	(0.04)			0.13**	(0.04)		
Innov performance above SA					0.18***	(0.05)			0.18***	(0.04)
Alliance knowledge quality	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)
Portion of cross-border alliance	-0.21	(0.31)	-0.26	(0.33)	-0.55	(0.35)	-0.25	(0.34)	-0.58+	(0.34)
Partner dissimilarity	-0.41	(0.31)	-0.47	(0.32)	-0.29	(0.36)	-0.46	(0.31)	-0.29	(0.35)
Portion of R&D alliance	0.07+	(0.04)	0.07+	(0.04)	0.11*	(0.06)	0.06	(0.04)	0.10+	(0.05)
Tie strength	0.42	(0.39)	0.46	(0.39)	0.02	(0.41)	0.44	(0.40)	0.10	(0.41)
Alliance tech distant	-0.90	(0.78)	-1.07	(0.67)	-1.49**	(0.50)	-1.07	(0.70)	-1.43**	(0.48)
Inverse Mills ratio	-0.08	(0.41)	-0.29	(0.42)	-0.17	(0.42)	-0.32	(0.44)	-0.21	(0.42)
Year dummies	Yes		Yes		Yes		Yes		Yes	
Constant	-1.03	(0.76)	-0.77	(0.73)	-0.99	(0.71)	-0.33	(0.82)	-0.93	(0.68)
Observations/ N_g	835/133		835/133		835/133		835/133		835/133	
df_m	18.00		20.00		20.00		22.00		22.00	
chi2	3219.72		3768.70		2169.92		3920.21		2831.06	

Robust standard errors in parentheses; *** p<0.001, ** p<0.01, * p<0.05, +p<0.1; HA= historical aspiration; SA = social aspiration

Figure 5.1 Interaction between Innovation Performance below Historical Aspiration and Knowledge Stock Size

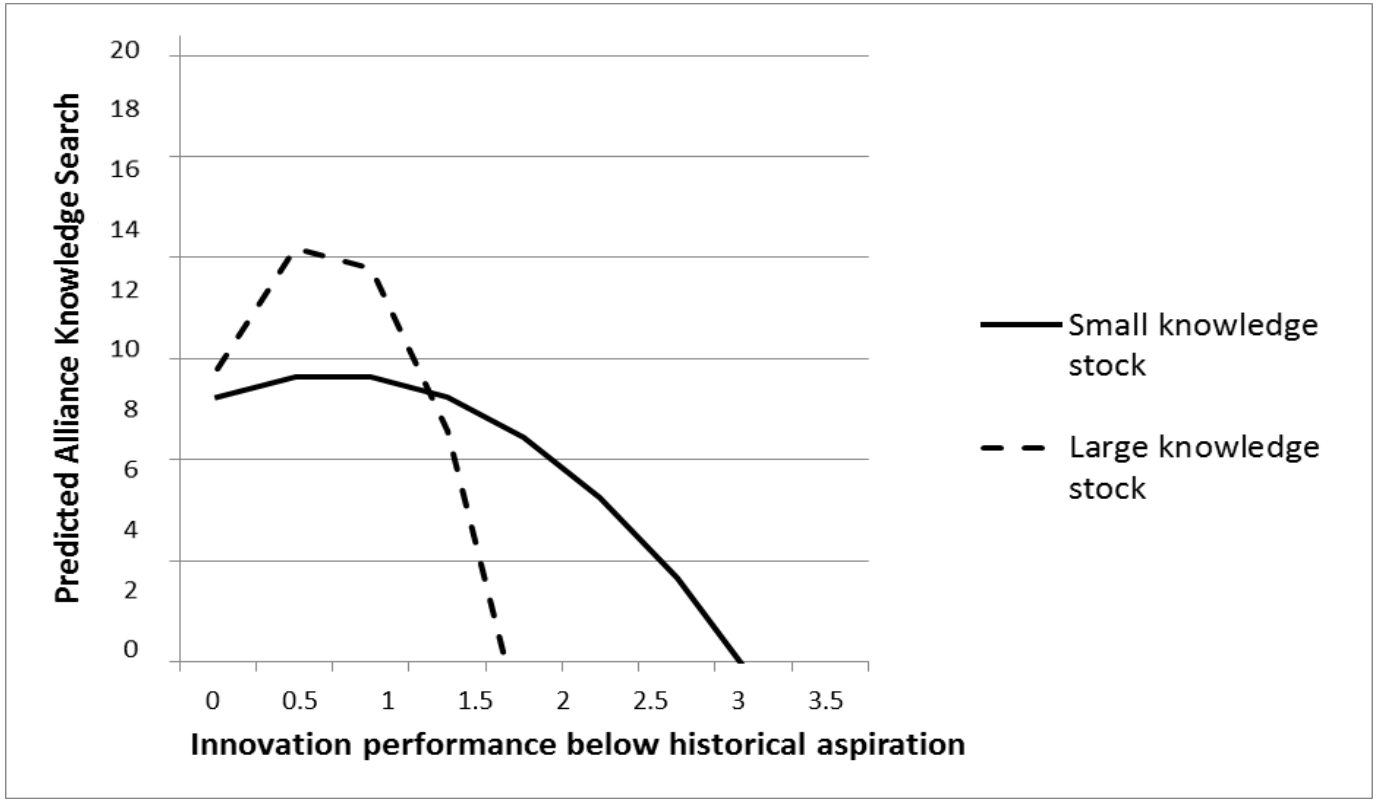


Table 5.3 Robustness Checks: Using selective controls only

	Model5		Model6		Model7		Model8	
Innov performance below HA	0.93	(0.65)			1.17	(0.90)		
Innov performance below HA2	-1.07	(0.69)			-1.47	(1.07)		
Innov perf below HA * KSS					-0.00	(0.00)		
Innov perf below HA2 * KSS					0.00	(0.00)		
Innov performance below SA			1.85	(1.54)			2.64+	(1.53)
Innov performance below SA2			-2.53	(3.17)			-4.50	(3.00)
Innov perf below SA * KSS							-0.01	(0.00)
Innov perf below SA2 * KSS							0.02	(0.01)
Knowledge stock size (KSS)	0.00*	(0.00)	0.00*	(0.00)	0.00	(0.00)	0.00**	(0.00)
Total citation	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)
Alliance knowledge quality	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)
Alliance tech distant	-1.14	(0.70)	-1.06+	(0.64)	-1.19+	(0.69)	-1.02+	(0.58)
Innov performance above HA	0.05	(0.04)			0.05	(0.04)		
Innov performance above SA			0.13**	(0.04)			0.14***	(0.04)
Year dummies	No		No		No		No	
Constant	-1.19**	(0.43)	-1.22**	(0.45)	-1.30**	(0.43)	-1.32**	(0.43)
Observations	886		886		886		886	
N_g	141.00		141.00		141.00		141.00	
df_m	7.00		7.00		10.00		9.00	
chi2	2037.03		1297.83		2530.82		2399.82	

Robust standard errors in parentheses; *** p<0.001, ** p<0.01, * p<0.05, +p<0.1

Table 5.4 Robustness Checks: DV=Alliance knowledge search (t+5)

	Model9		Model10		Model11		Model12	
Innov performance below HA	1.40+	(0.75)			3.56***	(0.91)		
Innov performance below HA2	-1.98+	(1.06)			-3.45**	(1.28)		
Innov perf below HA * KSS					0.00	(0.00)		
Innov perf below HA2 * KSS					0.01	(0.01)		
Innov performance below SA			6.70***	(0.82)			5.10***	(0.87)
Innov performance below SA2			-10.15***	(2.38)			-6.22*	(2.49)
Innov perf below SA * KSS							0.02***	(0.00)
Innov perf below SA2 * KSS							-0.04**	(0.01)
Knowledge stock size (KSS)	0.00	(0.00)	0.00***	(0.00)	0.01	(0.01)	0.00***	(0.00)
R&D intensity	-0.00	(0.00)	0.00	(0.00)	-0.00	(0.00)	0.00	(0.00)
Financial slack	-0.01	(0.01)	0.04**	(0.02)	-0.00	(0.02)	0.03*	(0.02)
Total citation	0.00***	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Innov performance above HA	0.02	(0.05)			0.07	(0.13)		
Innov performance above SA			0.73**	(0.23)			0.70***	(0.21)
Alliance knowledge quality	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)
Portion of cross-border alliance	-0.11	(0.24)	-0.87***	(0.24)	-0.35	(0.23)	-0.81***	(0.24)
Partner dissimilarity	-0.26	(0.24)	1.19***	(0.26)	1.61***	(0.27)	1.16***	(0.26)
Portion of R&D alliance	0.05+	(0.03)	0.49***	(0.10)	0.43***	(0.10)	0.54***	(0.10)
Tie strength	0.86**	(0.29)	0.95*	(0.42)	1.71***	(0.42)	1.03*	(0.42)
Alliance tech distant	-0.90	(0.60)	-4.00***	(0.28)	-4.35***	(0.29)	-3.92***	(0.28)
Inverse Mills ratio	-0.31	(0.27)	-0.48*	(0.22)	-0.60*	(0.23)	-0.47*	(0.22)
Year dummies								
Constant	-0.62	(0.75)	-1.26**	(0.44)	-0.99*	(0.48)	-1.34**	(0.44)
Observations	835		835		835		835	
N_g	133.00		133.00		133.00		133.00	
df_m	20.00		20.00		22.00		22.00	
chi2	4201.53		1019.67		993.40		1011.39	

Robust standard errors in parentheses; *** p<0.001, ** p<0.01, * p<0.05, +p<0.1

5.2 Models of Firm Innovation

Then, I examine how balancing exploration and exploitation in alliance knowledge and alliance network affect firm innovation.

5.2.1 Descriptive Statistics

Table 5.5 reports the means, standard deviation, and minimum and maximum values of all the variables in the models of firm innovation, and the Pearson correlation among all the variables in the model. The correlation table shows that technological diversity of partners and firm size are relatively highly correlated with some other exploratory variables. Thus, I dropped them in the robustness checks. The correlations among the other exploratory variables are not strong. Therefore, multicollinearity problem seems not be a concern of this test.

As I did for alliance knowledge search intensity, I also plotted and checked the distributions of the dependent variables (patent- and NDA-based innovation). Both patent- and NDA-based innovation are count variables. Similar to alliance knowledge search intensity, distributions of both patent- and NDA-based innovation are displaying signs of overdispersion.

5.2.2 Statistical Methods

Since the dependent variables of empirical Model 2, patent- and NDA-based firm innovation, share similar features as alliance knowledge search intensity, the dependent variable of empirical Model 1, I used the same statistical methods (GEE) to test models estimating firm innovation.

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Table 5.5 Descriptive Statistics and Correlation (Empirical Model 2)

		Mean	Std. Dev.	Min	Max	1	2	3	4	5	6
1	Firm innovation (patent)	25.32	110.56	0	1246	1					
2	Firm innovation (NDA)	0.94	2.51	0	24	0.46*	1				
3	Tech distance searched alliance knowledge (SAK)	0.68	0.28	0	1	-0.38*	-0.31*	1			
4	Tech dis SAK * repeated partner	-0.03	0.19	-1.78	1.03	-0.05	-0.12*	0.31*	1		
5	Tech dis SAK * tie strength	0	0.05	-0.68	0.07	-0.13*	-0.05	0.21*	0.11*	1	
6	Total alliance knowledge distance	0.54	0.29	0	1	-0.30*	-0.17*	0.55*	0.11*	0.05	1
7	Tie strength	0.1	0.22	0	1	0.04	0.03	-0.06*	-0.03	-0.05	-0.01
8	Repeated partner	1.63	1	0	5.5	0.02	0.05	-0.09*	0.01	-0.02	-0.07*
9	Technological diversity	0.28	0.29	0	0.9	0.28*	0.24*	-0.50*	-0.15*	-0.15*	-0.52*
10	R&D intensity	3.34	7.31	0.01	34.25	-0.01	-0.01	0.01	0.01	0	0.03
11	Firm size	3.75	3.24	-6.21	11.02	0.30*	0.39*	-0.30*	-0.17*	-0.18*	-0.22*
12	Financial slack	5.25	5.52	0.02	80.1	-0.08*	-0.10*	0.05*	0.05*	0.04	0
13	Portion of cross-border alliance	0.51	0.39	0	1	0.01	0.12*	-0.02	0.02	-0.03	0
14	Partner dissimilarity	0.45	0.37	0	1	-0.01	0.02	0.04	0	0.08*	0.09*
15	Portion of R&D alliance	0.53	0.38	0	1	0.01	0	-0.01	0.02	0.04	-0.11*
16	Year 1996	0.06	0.23	0	1	0.12*	0.03	-0.04*	0.10*	-0.02	-0.12*
17	Year 1997	0.06	0.24	0	1	0.12*	0.04*	-0.02	0.04	-0.01	-0.05
18	Year 1998	0.07	0.25	0	1	0.10*	0.03*	-0.04*	0	0.01	-0.10*
19	Year 1999	0.08	0.26	0	1	0.07*	0.03	-0.03*	0.03	0.02	-0.07*
20	Year 2000	0.08	0.27	0	1	0.01	0.02	-0.02	-0.03	0	-0.07*
21	Year 2001	0.08	0.27	0	1	-0.01	0.02	-0.03	-0.06*	0.02	-0.04
22	Year 2002	0.08	0.27	0	1	-0.04*	0.01	-0.02	-0.04	0.01	-0.05*
23	Year 2003	0.08	0.27	0	1	-0.05*	0.01	-0.01	-0.08*	-0.02	-0.02

* $p<0.05$

Table 5.5 Descriptive Statistics and Correlation (Empirical Model 2) (cont')

		7	8	9	10	11	12	13	14	15	16
7	Tie strength	1									
8	Repeated partner	0.02	1								
9	Technological diversity	0.05	0.06*	1							
10	R&D intensity	-0.04	-0.02	-0.04	1						
11	Firm size	0.02	0.02	0.22*	-0.11*	1					
12	Financial slack	-0.08*	0.04	-0.03	0.01	-0.25*	1				
13	Portion of cross-border alliance	0.07*	0	-0.10*	0.02	0.13*	-0.03	1			
14	Partner dissimilarity	-0.17*	0.01	-0.09*	-0.06*	0.08*	-0.01	0.08*	1		
15	Portion of R&D alliance	0.03	-0.03	0.06*	0	-0.12*	0.13*	-0.12*	-0.07*	1	
16	Year 1996	0.03	-0.07*	0.10*	-0.01	-0.03	0	-0.03	-0.04	0.03	1
17	Year 1997	0.03	-0.06*	0.14*	-0.01	-0.02	0.07*	-0.03	-0.02	0.03	-0.06*
18	Year 1998	0.07*	0.04	0.12*	-0.01	-0.01	0.01	-0.05	0	0.02	-0.06*
19	Year 1999	0.05	0.04	0.09*	-0.01	-0.01	0	-0.07*	0.01	0.02	-0.07*
20	Year 2000	0.04	0.04	0.09*	-0.01	-0.01	-0.01	-0.03	0	0.01	-0.07*
21	Year 2001	0.05	0.04	0.07*	-0.01	0	0.04*	0	0.01	-0.01	-0.07*
22	Year 2002	0.01	0.04	0.05	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.07*
23	Year 2003	0.02	0.10*	-0.02	-0.01	0.01	-0.01	0.03	0	0	-0.07*

		17	18	19	20	21	22	23
17	Year 1997	1						
18	Year 1998	-0.06*	1					
19	Year 1999	-0.07*	-0.07*	1				
20	Year 2000	-0.07*	-0.07*	-0.08*	1			
21	Year 2001	-0.07*	-0.07*	-0.08*	-0.08*	1		
22	Year 2002	-0.07*	-0.07*	-0.08*	-0.08*	-0.08*	1	
23	Year 2003	-0.08*	-0.08*	-0.08*	-0.09*	-0.09*	-0.09*	1

* $p<0.05$

5.2.3 Hypotheses Testing

Table 5.6 and Table 5.7 report the effects of alliance knowledge and alliance network on firm innovation. The results in Table 5.6 are based on models estimating patent-based innovation performance. The results in Table 5.7 are based on models estimating NDA-based innovation performance.

Model 13 and Model 17 present the base models consisting only of the control variables. Then, the independent variable, technological distance of searched alliance knowledge, was included. Hypothesis 3 predicts a U-shaped relationship between technological distance of searched alliance knowledge and firm innovation. Results show that searching distant alliance knowledge has a negative effect on firm innovation (patent-based innovation/Model 14: $p<0.01$; NDA-based innovation/Model 18: $p<0.01$). In Model 15 and Model 19, I added the squared term of technological distance of search alliance knowledge, and it is not significant in both models. Thus, Hypothesis 3 is not supported since the data analysis results indicate that the relationship between technological distance of searched alliance knowledge and firm innovation is negative and linear.

Hypothesis 4 predicts that searched alliance knowledge has a stronger impact on firm innovation than total alliance knowledge. Results (Model 14 and Model 18) provide support for this hypothesis. The coefficient for technological distance of searched alliance knowledge is roughly 50 percent greater than the coefficient associated with technological distance of total alliance knowledge (Model 14: 1.14 *vs*. 0.56). In models estimating NDA-based innovation (Model 18), the coefficient for technological distance of total alliance knowledge is not significant when technological distance of searched alliance knowledge is included in the model.

Hypothesis 5 postulates that the repeated partners moderate the effects of technological distance of searched alliance knowledge on firm innovation such that searching distant alliance knowledge from repeated partners brings more innovation-related benefits to the focal firm. I tested this hypothesis in Model 16 (patent-based innovation) and Model 18 (NDA-based innovation). The result show that having repeated partners has a positive moderating effect on the relationship between technological distance of searched alliance knowledge and patent-based innovation (Model 16, $p<0.05$). The moderating effect is not significant in models estimating NDA-based innovation. Then, I plotted the interaction effect in Figure 5.2, based on the models estimating patent-based innovation. As Figure 5.2 depicts, technological distance of searched alliance knowledge is negatively related with firm innovation at low value of repeated partnerships but is positively related with firm innovation at high value of repeated partnerships. The result shows that, when the focal firm has greater repeated partners, leveraging explorative alliance knowledge contributes more to firm innovation, which is consistent with the theoretical arguments. Thus, Hypothesis 5 is supported, at least for patent-based innovation.

Finally, I tested Hypothesis 6 in Model 16 (patent-based innovation) and Model 20 (NDA-based innovation). Hypothesis 6 proposes that tie strength positively moderates the relationship between technological distance of searched alliance knowledge and firm innovation. However, I found that tie strength has a negative, rather than positive, moderating effect on the relationship between technological distance of searched alliance knowledge and firm innovation, especially in models estimating patent-based innovation. Therefore, Hypothesis 6 is not supported by the data analysis.

5.2.4 Robustness Checks

I did two additional analyses to check the robustness of the results, and report key findings in Table 5.8. First, following Carlson and Wu (2012), I dropped control variables that do not have a significant effect on innovation in any model. I also dropped control variables that are highly correlated with other exploratory variables. Second, I used different year-windows to measure patent-based innovation performance and NDA-based innovation performance. I measured patent-based innovation as the number of patent received by the focal firm from year $t+1$ to $t+3$, and measured NDA-based innovation as the number of NDA received by the focal firm from year $t+6$ to $t+10$. The results of the robustness checks are generally consistent with the results reported in Table 5.8.

Table 5.6 GEE Model of Firm Innovation (Patent-Based)

	Model 13		Model 14		Model 15		Model 16	
Tech distance of searched alliance knowledge (TDSAK)			-1.14**	(0.36)	-8.68	(5.79)	-1.11***	(0.33)
TDSAK ^{2}					-10.92	(7.78)		
TDSAK * repeated partner							0.49*	(0.21)
TDSAK * tie strength							-2.10*	(1.01)
Total alliance knowledge distance	-1.25***	(0.35)	-0.56*	(0.22)	-0.31	(0.51)	-0.51*	(0.23)
Repeated partner	0.11	(0.08)	0.04	(0.04)	-0.01	(0.05)	0.04	(0.03)
Tie strength	-0.73	(0.62)	-0.84*	(0.42)	-1.13*	(0.44)	-1.42***	(0.41)
Technological diversity of partners	1.38**	(0.52)	0.87*	(0.37)	0.89+	(0.51)	0.83*	(0.40)
R&D intensity	0.00	(0.00)	-0.00	(0.00)	0.00***	(0.00)	0.00	(0.00)
Firm size	0.34***	(0.08)	0.26***	(0.07)	0.23**	(0.08)	0.27***	(0.06)
Financial slack	-0.01	(0.02)	-0.02	(0.02)	-0.02	(0.02)	-0.02	(0.02)
Portion of cross-border alliance	0.07	(0.46)	-0.15	(0.31)	-0.02	(0.32)	-0.29	(0.26)
Partner dissimilarity	-1.20**	(0.37)	-0.99**	(0.30)	-1.02***	(0.20)	-0.90***	(0.26)
Portion of R&D alliance	-0.30	(0.37)	-0.22	(0.24)	-0.36	(0.25)	-0.21	(0.21)
Year dummies	Yes		Yes		Yes		Yes	
Constant	-2.45+	(1.30)	-0.73	(1.18)	5.53	(4.30)	-0.65	(1.03)
Observations	910		910		910		910	
N(#of firm)	137		137		137		137	
df_m	18.00		19.00		20.00		21.00	
chi2	700.54		445.31		531.82		509.30	

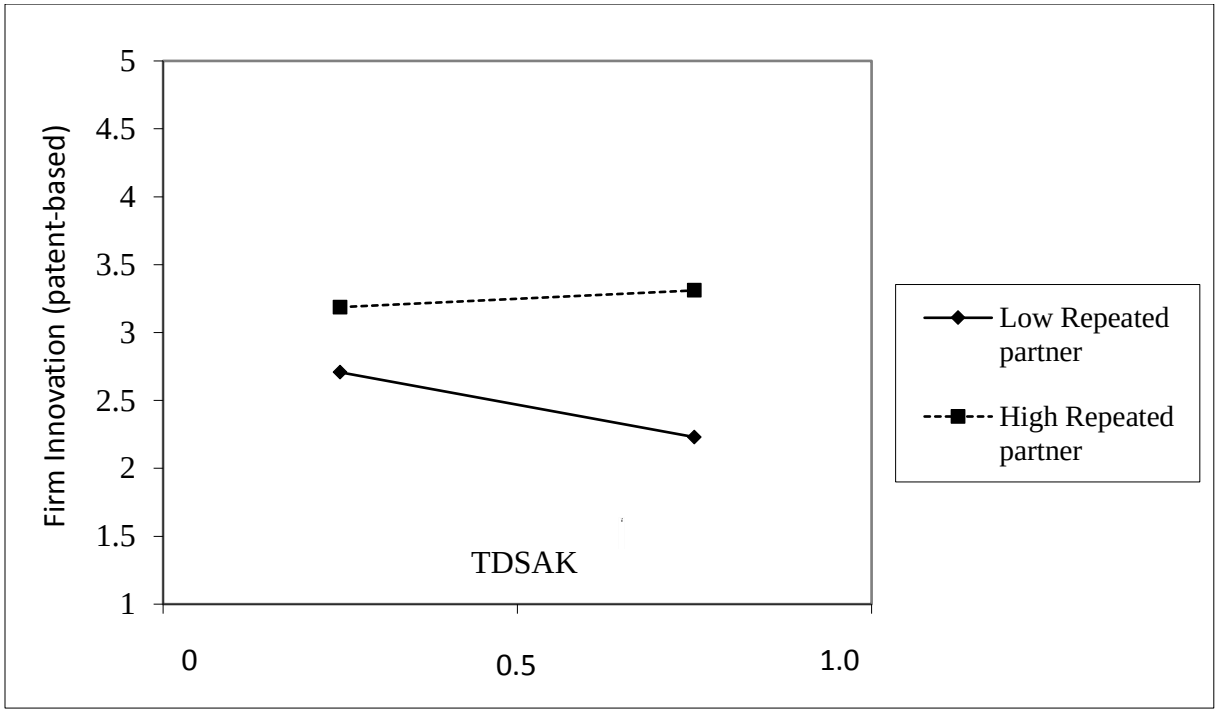
Robust standard errors in parentheses;
*** p<0.001, ** p<0.01, * p<0.05, +p<0.1

Table 5.7 GEE Models of Firm Innovation (NDA-Based)

	Model 17		Model 18		Model 19		Model 20	
Tech distance of searched alliance knowledge (TDSAK)			-1.43**	(0.53)	-1.67	(2.30)	-1.40**	(0.51)
TDSAK ^{2}					-0.37	(3.06)		
TDSAK * repeated partner							0.16	(0.18)
TDSAK * tie strength							0.65	(1.71)
Total alliance knowledge distance	-0.21	(0.54)	0.24	(0.60)	0.24	(0.60)	0.25	(0.59)
Repeated partner	-1.53*	(0.66)	-1.68*	(0.80)	-1.68*	(0.80)	-1.62+	(0.87)
Tie strength	0.18***	(0.05)	0.13**	(0.05)	0.13**	(0.05)	0.12*	(0.05)
Technological diversity of partners	1.44*	(0.72)	0.76	(0.48)	0.76	(0.47)	0.78	(0.48)
R&D intensity	-0.17+	(0.10)	-0.16+	(0.09)	-0.16+	(0.09)	-0.16+	(0.09)
Financial slack	-0.10*	(0.04)	-0.07*	(0.03)	-0.07*	(0.03)	-0.07*	(0.03)
Portion of cross-border alliance	0.79	(0.54)	0.80	(0.52)	0.80	(0.52)	0.82	(0.52)
Partner dissimilarity	-0.01	(0.32)	0.05	(0.33)	0.05	(0.34)	0.03	(0.34)
Portion of R&D alliance	0.29	(0.29)	0.32	(0.28)	0.31	(0.28)	0.32	(0.28)
Year dummies	Yes		Yes		Yes		Yes	
Constant	-0.89	(0.69)	-0.11	(0.54)	0.09	(1.65)	-0.13	(0.55)
Observations	890		890		890		890	
N(#of firm)	127		127		127		127	
df_m	17.00		18.00		19.00		20.00	
chi2	119.88		102.62		116.45		109.07	

Robust standard errors in parentheses;
*** p<0.001, ** p<0.01, * p<0.05, +p<0.1

Figure 5.2 Interaction between Technological Distance of Searched Alliance Knowledge and Repeated Partners



Note:

TDSAK = Technological distance of searched alliance knowledge.

Table 5.8 Robustness Check

	Selective control variables				Use different year-windows for DVs			
	Patent-based		NDA-based		Patent-based		NDA-based	
	Model 21		Model 22		Model 23		Model 24	
TDSAK	-6.08***	(0.41)	-1.43*	(0.58)	-0.99**	(0.33)	-0.99**	(0.33)
TDSAK * repeated partner	2.13***	(0.19)	-0.06	(0.18)	0.56	(0.46)	0.56	(0.46)
TDSAK * tie strength	-5.60***	(1.52)	0.10	(1.69)	-1.32	(1.25)	-1.32	(1.25)
Total alliance knowledge distance	-0.93*	(0.37)	0.21	(0.71)	-0.50+	(0.30)	-0.50+	(0.30)
Tie strength	-0.66	(0.49)	-1.56+	(0.90)	-0.76*	(0.30)	-0.76*	(0.30)
Repeated partner	0.05	(0.05)	0.13**	(0.05)	-0.02	(0.03)	-0.02	(0.03)
Technological diversity of partners	0.83*	(0.32)	0.74	(0.48)	0.43+	(0.26)	0.43+	(0.26)
R&D intensity	-0.00	(0.00)	-0.15	(0.10)	-0.00***	(0.00)	-0.00***	(0.00)
Financial slack	-0.10**	(0.04)	-0.08*	(0.04)	-0.01***	(0.00)	-0.01***	(0.00)
Portion of cross-border alliance					0.21	(0.21)	0.21	(0.21)
Partner dissimilarity					0.62***	(0.15)	0.62***	(0.15)
Portion of R&D alliance					0.28+	(0.16)	0.28+	(0.16)
Year dummies	Yes		Yes		Yes		Yes	
Constant	4.25***	(0.31)	0.65+	(0.38)	1.44***	(0.31)	1.44***	(0.31)
Observations	910		910		910		910	
N(#of firm)	137		137		137		137	
df_m	17.00		17.00		20.00		20.00	
chi2	11350.79		125.95		1191.27		1191.27	

Robust standard errors in parentheses;
*** p<0.001, ** p<0.01, * p<0.05, +p<0.1

5.3 Summary of Hypotheses Testing

The purpose of the data analysis is to empirically examine the research questions presented at the beginning of this study. The results empirically answered the research questions and provided support to most of the hypotheses. Some findings are unexpected and interesting, and I will discuss these findings in the next chapter.

Table 5.9 Summary of Hypotheses and Test Results

#	Hypothesis statement	Test Results
What motivates firms to search technological knowledge from alliance partners?		
1	Innovation performance below aspiration levels has an inverted U-shaped relationship with the alliance knowledge search intensity.	**Significance**: Statistically significant **Direction**: As predicted (∩) **Decision**: Hypothesis is supported
2	Focal firm's size of knowledge stock moderates the inverted U-shaped relationship between innovation performance below aspiration levels and alliance knowledge search in such a fashion that increasing knowledge stock size will:	
2a	(a) increase the slope of the positive effect of innovation performance below aspiration	**Significance**: the interaction term (IV × Moderator) is statistically significant **Direction**: As predicted (+) **Decision**: Hypothesis is supported
2b	(b) reduce the negative effect of innovation performance below aspiration.	**Significance**: the interaction term (IV^2 × Moderator) is statistically significant **Direction**: Opposite to predicted direction (-) **Decision**: Hypothesis is not supported

#	Hypothesis statement	Test Results
How firms generate innovations from searched alliance knowledge?		
3	The technological distance between the focal firm's knowledge base and its searched alliance knowledge has a U-shaped relationship with the firm's innovation performance.	**Significance**: the square term is not significant **Direction**: Linear (-) **Decision**: Hypothesis is not supported
4	The relationship between the technological distance between the focal firm's knowledge base and its total alliance knowledge and firm innovation is weaker than the relationship predicted in H3.	**Comparison**: the coefficient for technological distance of searched alliance knowledge is greater than the coefficient associated with technological distance of total alliance knowledge **Decision**: Hypothesis is supported
5	Repeated partnerships positively moderates the relationship between searching distant knowledge and firm innovation.	**Significance**: Statistically significant **Direction**: As predicted (+) **Decision**: Hypothesis is supported (for patent-based innovation)
6	Tie strength positively moderates the relationship between searching distant knowledge and firm innovation.	**Significance**: Statistically significant **Direction**: Opposite to predicted direction (-) **Decision**: Hypothesis is not supported

6.0 DISCUSSSION AND IMPLICATIONS

In this dissertation, I examined two research questions: 1) what motivates a firm search technological knowledge from alliance partners? And, 2) how does configurations of alliance knowledge and alliance network affect firm innovation? Answering these questions contributes to the literature in three different ways. First, lack of motivation is viewed as a key barrier to alliance knowledge leveraging (Simonin, 2004; Tsang, 2002), because it would lead to underinvestment in alliance knowledge leveraging capabilities. However, little is known about what motivates alliance knowledge search. This study fills this research gap and examines innovation performance feedback as a motivational antecedent of alliance knowledge search. Second, alliance knowledge generates various innovation-related benefits to the leveraging firms (Tsai, 2009). Both configurations of alliance knowledge (Ahuja, 2000; Vasudeva and Anand, 2011) and configurations of alliance network (Dyer and Singh, 1998; Uzzi, 1997) provide unique explanations about the heterogeneous outcome of alliance knowledge leveraging. Examining the interaction between alliance knowledge and alliance network will enable scholars to gain new insights about such heterogeneity. Finally, my literature review shows that there are many contradictions in alliance knowledge search motivation (e.g., Ben-Oz and Greve, 2015; Tyler and Caner, 2015), alliance knowledge (e.g., Phelps, 2010; Sampson, 2007), as well as in alliance network (e.g., Rowley Behrens and Krackhardt, 2000). Taking opposite propositions into consideration and examining alliance knowledge leveraging from a more integrative perspective helps researchers to develop a “holistic” understanding of these two seemingly opposite events, and to therefore, posit reasons for inconsistencies in the current literature.

I developed specific hypotheses to examine the research questions and tested these arguments and related hypotheses using longitudinal data from the U.S. biopharmaceutical

industry. I argue that allocating managerial attention to local domains and distant domains plays a key role in the motivation for alliance knowledge leveraging (Laursen, 2012). On the one hand, firms are motivated to leverage alliance knowledge, because it is helpful to them in exploring distant technological domains (Rosenkopf and Almeida, 2003) and in generating novel and high-impact innovations (Phelps, 2010; Sampson, 2007). On the other hand, alliance knowledge often involves a high degree of knowledge uncertainty (Simonin, 1999; van Wijk et al., 2008) and thereby, increases the likelihood of knowledge leakage (Kale et al., 2000; Li et al., 2012). These concerns can suppress distant attention and make the firm focus on local solutions; effectively reducing alliance knowledge search motivation.

I argue that this tension further increases for a firm that is facing innovation performance below aspiration: poor innovation performance increases the need for more distant knowledge to improve its innovation performance (Ben-Oz and Greve, 2015; Tyler and Caner, 2015); at the same time, it prompts local attention, because poor performers tend to worry about undertaking nonlocal and risk solutions which would further erode the firm's performance (Glibert, 2005). As local attention is likely to overpower distant attention when performance is very low (March and Shapira, 1992), I hypothesized that innovation performance below aspiration has an inverted U-shaped relationship with alliance knowledge search intensity.

Furthermore, I argue that the focal firm's knowledge stock size has a positive moderating effect on the relationship between poor innovation performance and alliance knowledge search intensity for two reasons. First, firms with large knowledge stock could be more capable of generating value from distant alliance knowledge (Volberda et al., 2010). When the firm has more confidence that it will benefit from searching distant knowledge domains, it will be more motivated to conduct alliance knowledge searches in the presence of poor innovation

performance. Second, for a firm with poor innovation performance that has a rather small knowledge stock, further knowledge loss could appear devastating; but, if the same firm has a large knowledge stock, the latter conditions would provide the buffer (Audia and Greve, 2006) against knowledge loss. The buffering effect, thus, reduces the negative impacts of poor innovation performance on alliance knowledge search.

As for the configurations of alliance knowledge and alliance network, I discuss explorative and exploitative activities in both of these domains. Since both exploration and exploitation are important for firm innovation (Katila and Ahuja, 2002; March, 1991), firms need to strike a balance between these two entities in alliance knowledge leveraging (Rothaermel and Deeds, 2004). However, because embracing opposite elements creates tensions, establishing the balance in the configuration of searched alliance knowledge could be highly costly. Therefore, I propose that firms can balance exploration and exploitation across domains (Lavie and Rosenkopf, 2006): they can leverage explorative knowledge through an alliance network that has exploitative features, such as repeated partners (Uzzi, 1997) and strong ties (Sampson, 2007).

6.1 Summary and Discussion of Findings

To answer the two research questions, I tested six hypotheses in this study. The key findings based on the data analysis results are summarized as follows.

6.1.1 Innovation Performance below Aspiration and Alliance Knowledge Search

Hypothesis 1 of this study suggests that innovation performance below (both historical and social) aspiration levels has an inverted U-shaped relationship with alliance knowledge search intensity. The results of data analysis provide a reasonably strong foundation to support this hypothesis. The results show that the relationship between innovation performance below

aspiration and alliance knowledge search intensity is curvilinear: when performance is not far from the aspiration level, poor innovation performance motivates greater alliance knowledge search potential; but, when performance declines further, poor innovation performance would eventually hinder the search.

6.1.2 Moderating Effect of Knowledge Stock Size

Hypothesis 2 predicts that knowledge stock size has a moderating effect upon the relationship between innovation performance below aspiration, and alliance knowledge search in such a fashion that increasing knowledge stock size will: (a) increase the slope of the positive effect of innovation performance below aspiration, and (b) reduce the negative effect of innovation performance below aspiration. I found that large knowledge stock size does intensify the positive effects of both innovation performance below historical and social aspiration levels on alliance knowledge search intensity, which means firms with large knowledge stock are more likely to have distant attention when their innovation performance falls below the aspiration level. This finding supports the idea that firms with strong knowledge appropriation capability are more likely to develop distant attention, and to conduct greater alliance knowledge search in the presence of poor innovation performance (Hypothesis 2a).

However, the interaction between the square term of innovation performance below aspiration and knowledge stock size has a negative impact on alliance knowledge search, especially when the performance is below historical aspiration. This finding is opposite to what is proposed in Hypothesis 2b, since the finding indicates that when innovation performance becomes is very low, firms with large knowledge stock may search less, rather than more, alliance knowledge than firms with small knowledge stock. Thus, the buffering effect argument (Audia and Greve, 2006) is not supported in this study. One possible explanation is that,

although large knowledge stock may buffer poor innovation performance, it may increase the focal firm's performance expectation and thereby intensifies the worry about poor innovation performance. For example, previous studies show that large firms has strong pressures to meet expectations of multiple stakeholders (Short and Palmer, 2003) and therefore, they care more about poor performance relative to aspiration levels. Such pressures would make the firm view poor innovation performance as a crisis, and accordingly enhance, rather than reduce, local attention. This phenomenon may explain why firms with large knowledge stocks do not search for more alliance knowledge when innovation performance is very low.

6.1.3 Exploration and Exploitation in Alliance Knowledge

Next, I examined how the configuration of searched alliance knowledge impacts firm innovation. I propose that because embracing exploration and exploitation at the same time could generate managerial tensions and costs, mixing explorative and exploitive alliance knowledge leads to minimum innovation-related benefits. Based on this logic, I predicted a U-shaped relationship between technological distance of searched alliance knowledge and firm innovation. However, I found a linear negative relationship between technological distance of searched alliance knowledge and firm innovation. The results indicate that exploration alone does not contribute to firm innovation, regardless the degree of exploration is high or low. One explanation is that, as mentioned, integrating explorative alliance knowledge is costly, and increasing exploration generates knowledge integration and appropriation costs overweighting the benefits of accessing novel knowledge. Therefore, firms may fail to conduct exploration if they do not have a strong knowledge-appropriation capability. In this regard, although the hypothesized curvilinear relationship was not supported by the data, the results provide some indirect evidence that both exploration and exploitation are important for innovation.

6.1.4 Comparison between Searched Alliance Knowledge and Total Alliance Knowledge

My data analysis supports the idea that searched alliance knowledge has a stronger impact on firm innovation than total alliance knowledge. This finding implies that future studies may consider the difference between total alliance knowledge and searched alliance knowledge. Differentiating total and searched alliance knowledge may help future studies to re-investigate some inconsistent findings in the current knowledge-related alliance literature. For example, while some studies show that accessing more alliance knowledge has a positive effect on firm innovation (Ahuja, 2000), other studies found a none-effect (Love and Roper, 2001). One possibility is that when using total alliance knowledge to compute the independent variables, the noise in the measurement undermines the real effects. In that case, replicating some studies using searched alliance knowledge may generate new insights on how alliance knowledge leveraging influences innovation.

6.1.5 Balancing Exploration and Exploitation across Domains

I tested how balancing exploration and exploitation across alliance knowledge and alliance network influences firm innovation. The cross-domain balance idea is partially supported, because I only found the interactions between distant searched knowledge and repeated partners to be positive and significant. It is interesting, therefore, to investigate why strong ties do not have a positively moderating effect on the relationship between technological distance of searched alliance knowledge and firm innovation. One explanation is that, contrary to the proposed theoretical argument, strong ties may not encourage alliance knowledge leveraging. The alliance literature indicated that forming such strong ties as joint ventures, aligns partners' incentives (Santoro and McGill, 2005). However, the incentive-aligning mechanism may lead to knowledge specialization, instead of knowledge acquisition (Grant and Baden-Fuller, 2004).

Thus, strong ties may actually hinder alliance knowledge search motivation. Continuing with this argument, it is interesting to note that tie strength does not have a significant impact on alliance knowledge search intensity (see results reported in Table 5.3 and 5.4). Other studies using alliance knowledge search intensity also have generated similar results (Schildt et al., 2012; Vasudeva and Anand, 2011).

Despite the fact that I did not find support for the moderating effect of tie strength, the results do show that firms benefit more from leveraging the distant alliance knowledge gained from repeated partnerships. Thus, the overall idea of cross-domain balance is still supported by the data analysis.

6.2 Theoretical Contributions

This study makes theoretical contributions to the literature in three significantly content areas: alliance knowledge leveraging; aspiration; and the balance of exploration and exploitation.

6.2.1 Contributions to the Literature on Alliance Knowledge Leveraging

Broadly speaking, this study contributes to the alliance knowledge leveraging literature by developing an integrative framework, which helps researchers to recognize and resolve the inconsistent findings in the previous literature. Scholars more and more emphasize that research need to pay attention to the inconsistent propositions and findings in prior works (Poole and van de Van, 1989). To understand these inconsistencies, prior studies propose that researchers need to develop a “paradox” mindset (Poole and van de Van, 1989; Smith and Lewis, 2011). According to Smith and Lewis (2011), a paradox occurs when there are “contradictory yet interrelated elements that exist simultaneously and persist over time” (p382). Literature on organizational paradox suggests the importance of examining the interrelationship between

opposite elements in a contradiction, rather than examining each one separately (Cameron and Quinn, 1988; Chen, 2008; Poole and van de Ven, 1989; Smith and Lewis, 2011). In this paper, I apply the "paradox" perspective and build an integrative framework that examines the opposite propositions in alliance knowledge leveraging simultaneously. By doing so, this study enables researchers to develop a more holistic and comprehensive view of alliance knowledge leveraging.

Moreover, this study examines three pairs of opposite propositions in detail. First, I develop theoretical propositions about the tension between distant and local attention, and subsequently examine how they would influence alliance knowledge search motivation. Prior studies have found that firms tend to be motivated to search external knowledge when experiencing poor performance (Ben-Oz and Greve, 2015; Tyler and Caner, 2015). However, employing a more integrative view, researchers might discover the opposite argument; *i.e.,* that poor performance leads to local attention (Gaba and Bhattacharya, 2012; Gilbert, 2005; Staw et al., 1981), which indicates poor performance can demotivate alliance knowledge search. The opposite argument implies that the relationship between poor performance and alliance knowledge leveraging might be more sophisticated than a linear relationship proposed in previous studies (Ben-Oz and Greve, 2015; Tyler and Caner, 2015). My study could help researchers to perceive this inconsistency in alliance knowledge leveraging and push us to think about the opposite propositions holistically, as well as to explore the relationship between such propositions.

Second, the integrative framework of this paper also helps us to have a better understanding of the balance between exploration and exploitation, which is a classical paradox in organization research (Smith and Lewis, 2011), in the context of alliance knowledge

leveraging. I will discuss the implications of balancing exploration and exploitation in alliance knowledge and alliance network later in section 6.2.3.

Another important theoretical contribution of this study lies in introducing poor innovation performance as a motivational antecedent of alliance knowledge search. The knowledge-related alliance literature has detailed a variety of factors that either enable or hinder the alliance knowledge search: most previous studies examine alliance knowledge search from an absorptive capacity perspective (Mowery et al., 1996; Schildt et al., 2012; Vasudeva and Anand, 2011). This perspective assumes that a firm searches for knowledge from its alliance partners when it has sufficient general or partner-specific absorptive capacity. However, developing absorptive capacity is costly (Cohen and Levinthal, 1990), and therefore, firms are not equally willing to make efforts in building that capacity. In fact, some firms underinvest in alliance knowledge search, even when they have rich alliance knowledge resources (Srivastava and Gnyawali, 2011). Therefore, identifying the motivational antecedent of alliance knowledge search is an essential step toward a better understanding of how and why firms differ in utilizing alliance knowledge. The findings of this study imply poor innovation performance is a double-edged sword which motives alliance knowledge search only for firms with specific conditions (e.g., performance is not far from aspiration levels; the firm has a large knowledge stock).

Finally, this study contributes to the alliance knowledge leveraging literature by examining alliance knowledge and alliance network in a more integrated manner. One type of knowledge-related alliance literature is consistent with the resource-based view and focuses primarily on the resource (knowledge) that the partners can provide, which argues that some firms benefit more from alliance knowledge leveraging than other firms because they access more knowledge in general, or are able to obtain more valuable knowledge (Ahuja, 2000;

Eisenhardt and Schoonhoven, 1996; Powell et al., 1996; Vasudeva and Anand, 2011). Another content area that the literature focused upon was the heterogeneous outcome of alliance knowledge leveraging, from a knowledge appropriation perspective (Dyer and Singh, 1998; Hoang and Rothaermel, 2005; Lane et al., 2001; Uzzi, 1997). These studies focus on how alliance network is constructed and how the construction of alliance network influences the social capital and partner-specific absorptive capacity among network participants and accordingly, influences the participant's ability to appropriate knowledge from other firms in the network. More studies are beginning to take an integrative approach that takes both alliance knowledge, and alliance network into consideration (e.g., Gilsing et al., 2008; Phelps, 2010; Sampson, 2007). This study indicates that considering such a level of integration is very meaningful and provides important implications for understanding the innovation-related outcomes of alliance knowledge leveraging.

6.2.2 Contributions to the Aspiration Literature

This study also makes an important contribution to the aspiration literature by integrating competing behavioral perspectives regarding the effects of poor performance relative to aspiration on an organizational search. A dominate view in the behavioral strategy literature is that performance below aspiration motives distant attention (Baum and Dahlin, 2007; Ben-Oz and Greve, 2015; Tyler and Caner, 2015). However, a competing perspective is that performance below aspiration triggers local attention (Audia and Greve, 2006; Staw et al., 1981). I propose that poor performance triggers both distant and local attentions. I tested this proposition in a unique context of alliance knowledge search, where knowledge is distant to the focal firm, and risk is associated with the search in a simultaneous manner. The findings of this study imply a curvilinear effect, a finding rare in prior aspiration studies; and therefore, clearly supports the

idea that distant and local attention in alliance knowledge search are actually interrelated and co-exist. Thus, this study provides a nuanced explanation of how firms behave in response to poor performance that is relative to aspiration. I also found that buffering effect (Audia and Greve, 2006) does not work in the context of alliance knowledge leveraging, and future studies can explore this issue further.

6.2.3 Contributions to the Exploration-Exploitation Literature

This study also leads to new insights on the balance between exploration and exploitation in alliance knowledge leveraging. Prior studies on exploration and exploitation suggest multiple approaches of balancing exploration and exploitation (Junni et al., 2013); but, many of these approaches are ineffective, since they generate significant managerial costs (O'Reilly and Tushman, 2013). Being consistent with some recent studies (Lavie et al., 2011; Lin et al., 2007), the results of this study provide some indirect evidences of the existence of such costs.

To investigate how firms can establish the balance, I tested cross-domain balancing hypotheses (Lavie and Rosenkopf, 2006; Lavie et al., 2011). Different from many approaches which require the firm to achieve a balance in one network primitive, cross-domain balancing helps the managers to avoid the difficulties of embracing opposite elements in one domain, and therefore, relieves the tension that managers may generally face in establishing the balance between exploration and exploitation. In addition, cross-domain balancing strategy encourages us to develop a more holistic view of alliance knowledge leveraging, recognizing the interaction between different domains of knowledge-related alliances (e.g., knowledge, node, tie, etc). Since this approach is proposed recently, only a few studies have tested this idea (see Lavie et al., 2010). By examining the cross-domain balancing hypotheses, this study leads to a better

understanding on how the cross-domain balancing approach helps firms to generate more innovation-related benefits from alliance knowledge leveraging.

In addition, this study also provides some insights about the concept of learning traps in knowledge search. Prior studies have suggested that repeated partnerships could make firms myopic and also that, firms get novel knowledge from new partnerships (Dhanarag and Parkhe, 2006). Thus, these studies imply that repeated partnerships could lead to a learning trap. The findings of this study show that repeated partnerships are very important, when the focal firm attempts to acquire new knowledge.

6.3 Limitations and Future Directions

Some important limitations of this study also illustrate a few other directions for future research. First, I wish to acknowledge the problems associated with the usage of citation data in measuring alliance knowledge search. One key problem with the citation data is that many citations are added by the patent examiners, not the patent holder (Alcácer and Gittelman, 2006). Researchers also suggest that citation data reflects the flow of codified knowledge, but often fail to capture the flow of tacit knowledge and know-how (Roach and Cohen, 2013). Future studies could develop new measures of inter-firm knowledge flows, using such alternative data sources as scientific publications or surveys. Similarly, using patent and NDA data to measure innovation is also imperfect, because many innovation may not be patented or commercialized in the market. Therefore, alternative measures of innovation are also needed.

Second, while I examined innovation performance below aspiration as a motivator for alliance knowledge search, such motivation can be predicted by many other factors. Future studies could extend this theoretical model and discuss other behavioral antecedents of alliance

knowledge search, such as slack resources (Chen, 2008), cognitive schema (Zahra and George, 2002), and performance above aspiration levels (Greve, 2003).

Third, while this study appears to suggest that firms may always be better off, if they can search explorative knowledge from repeated partnerships, this conclusion may not be hold up, if we take the effect of time into consideration. Having repeated partnerships would enhance the focal firm's knowledge appropriation capability, but may have a long-term negative impact upon the generation of truly new knowledge, because having too many repeated partners can potentially create alliance network inertia (Collinson and Wilson. 2006). Thus, future research can take the effect of time into consideration and examine the long-term impact of cross-domain balancing on firm innovation.

Fourth, in the literature review, I discussed the fact that the alliance network has three primitives: node, tie, and network structure (Ahuja et al., 2012). In this study, I have discussed exploration and exploitation, in terms of node and tie. Future studies can consider the network structure as an additional dimension that is needed to examine the balance between exploration and exploitation.

Finally, this study is based on a single-industry analysis. However, the importance of innovation performance varies in different industries. Firms in other industries may also demonstrate different patterns in alliance knowledge leveraging. Therefore, future research could focus on testing the theoretical framework in other industries as well.

6.4 Managerial Contributions

The findings of this study also have managerial implications. First, results suggest that senior managers should carefully monitor alliance knowledge search when innovation

performance decreases below aspiration. The findings based on data from biopharmaceutical firms demonstrate a challenge of alliance knowledge search for firms with poor innovation performance: while these firms may need to leverage more value from alliance knowledge, they could also lack motivation to conduct alliance knowledge search. This challenge of alliance knowledge leveraging could become more serious when performance is very low, or when the firm has a small knowledge stock. Managers need to understand this challenge and weigh the costs and benefits of alliance knowledge leveraging more carefully when the firm faces this dilemma.

Second, I hope that this study sensitizes managers to the fact that establishing a balance between exploration and exploitation, and achieving this balance across domains, is crucial to innovation performance. To design an alliance network, and regulate alliance knowledge leveraging, managers need to consider the multiple implications of alliance knowledge, alliance network, and the interaction between these two events. High volumes of knowledge exploration in the alliance network might be useful, if the firm develops technique for managing such a network. This study suggests the importance of searching distant knowledge from repeated partnerships. I believe that the findings of this study provide a useful guide to managers in evaluating how their choices about partner selection will affect the innovation benefits that are derived from alliance knowledge leveraging.

Finally, this study indicates that managers need to deal with many paradoxical issues in alliance knowledge leveraging. Resolving these issues is challenging, since it is difficult for the managers to embrace opposite concerns simultaneously. In order to manage the paradoxical tension more effectively, therefore; specific capabilities need to be developed, and decision makers need to learn how to make good decisions in the face of a paradoxical situation.

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APPENDIX A: Literature Review on Alliance Knowledge Leveraging (AKL) Motivation

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Tyler and Steensma (1995) SMJ	How executives actually weigh and integrate the available information during their evaluation of technological collaborations	A survey of top executives having graduated from either a large Midwestern university or a small prestigious engineering school	Firm	Information processing as an antecedent of knowledge alliance formation	• Top executives are found to incorporate information associated with several prominent theories in the strategy literature (e.g., normative strategy, transaction cost economics, options theory • Executive cognitive limitations were found to influence the evaluations
Baum and Dahlin (2007) Org Sci	Understand how organizational learning is conditioned performance feedback	U.S. Class 1 freight railroads' accident costs from 1975 to 2001	Firm	Performance feedback as an antecedent of AKL	• Performance near aspirations fosters local search and exploitive learning, while performance away from aspirations stimulates distant search and exploration,
Srivastava and Gnyawali (2011) AMJ	Examine the paradox of capabilities: how competency traps and the tension between value creation and value protection hinder strong firms from benefiting from knowledge-related alliance networks	Longitudinal (1986–2000) data from publicly traded firms in the U.S. semiconductor industry	Firm/ Alliance network	Competency traps and AKL	• The quality and diversity of portfolio technological resources contribute to breakthrough innovation • There is positive synergy between portfolio and internal resources for such firms • Technologically strong firms, however, benefit from the quality of their portfolio resources when they overcome some of their competency traps

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Ben-Oz and Greve, (2015) JOM	Systematically distinguishing between short- and long-term performance goals and their impact on organizational change, as well as the environmental contingency of dynamism	Israel VC funds firms and their invested early-stage firms	Firm	Performance feedback as an antecedent of AKL	• When organizations' performance relative to aspirations decreases, organizations increase their absorptive capacity. • Long-term performance has greater effect on potential absorptive capacity, while short-term performance has greater effect on realized absorptive capacity. • Environmental dynamism positively interacts with performance feedback in its impact on potential absorptive capacity

APPENDIX B: Literature Review on the Alliance Knowledge Configuration

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Lane and Lubatkin (1998) SMJ	Reconceptualize the firm-level construct absorptive capacity as a learning dyad-level construct, relative absorptive capacity	Pharmaceutical–biotechnology R&D alliances	Dyadic alliance	The antecedents of AKL	• The similarity of the partners' basic knowledge, lower management formalization, research centralization, compensation practices, and research communities were positively related to inter-organizational learning
Simonin (1999) SMJ	The role played by the 'causally ambiguous' nature of knowledge in the process of knowledge transfer between strategic alliance partners	A cross-sectional sample of 147 multinationals	Dyadic alliance	The antecedents of AKL	• Knowledge ambiguity fully mediates the effects of tacitness, prior experience, complexity, cultural distance, and organizational distance on knowledge transfer
Rosenkopf and Nerkar (2001), SMJ	Introduce a typology of exploration that recognizes firms' tendencies toward local search as well as their attempts to integrate knowledge from distant domains.	Patent data in optical disk industry	Firm	The exploration-exploitation balance in AKL	• Exploration that does not span organizational boundaries consistently generates lower impact on subsequent technological evolution • The impact of exploration on subsequent technological evolution within the domain is highest when the exploration spans organizational boundaries but not technological boundaries • The impact of exploration on subsequent technological development beyond the optical disk domain is greatest when exploration spans both organizational and technological boundaries •

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Rosenkopf and Almeida (2003) Manage Sci	How can firms reach beyond their existing contexts in their search for new knowledge?	Patent citation patterns in the semiconductor industry	Firm	Access new knowledge form AKL	• Knowledge is geographic and technological localized • Formation of alliances and mobility of active inventors facilitate interfirm knowledge flows across contexts •
Rothaermel and Deeds (2004) SMJ	To link the exploration–exploitation framework of organizational learning to a technology venture's strategic alliances	325 biotechnology firms	Firm/ Alliance network	The exploration-exploitation balance in AKL	• A product development path beginning with exploration alliances predicting products in development, which in turn predict exploitation alliances • The integrated product development path is moderated negatively by firm size •
Laursen and Salter (2006) SMJ	Investigate the influence of search strategies for external knowledge.	U.K. innovation survey	Firm	The exploration-exploitation balance in AKL	• Searching widely and deeply is curvilinearly (taking an inverted U-shape) related to performance.
Nooteboom et al (2007) Res Policy	Test the relation between cognitive distance and innovation performance of firms engaged in technology-based alliances	116 companies in the chemicals, automotive and pharmaceutical industries	Firm/ Alliance network	The exploration-exploitation balance in AKL	• Cognitive distance has an inverted U-shaped effect on innovation performance • The positive effect for firms is much higher when engaging in more radical, exploratory alliances than in more exploitative alliances • The effect of cumulative R&D turns out to be mixed. It increases absorptive capacity but also reduces the effect of cognitive distance on novelty value

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Im and Rai (2008) Manage Sci	Examine how exploration and exploitation impact the performance of long-term inter-firm relationship Understand the organization designs that facilitate both exploration and exploitation	Data was collected from the managers of the customer firm and the vendor firm in logistics industry	Dyadic alliance	The exploration-exploitation balance in AKL	• The authors found that both exploratory and exploitative knowledge sharing lead to relationship performance gains, that such sharing is enabled by the ambidextrous management of the relationship, and that such sharing is facilitated by ontological commitment
Becerra, et al (2008) JMS	Investigate the extent to which the perceptions of trustworthiness and the willingness to take risk determine the transfer of knowledge between alliance partners and their ultimate impact on alliance success	Survey data from 155 firms from a variety of industries in Norway	Dyadic alliance	The antecedents of AKL	• Explicit knowledge is closely associated with the firm's willingness to take risk • Tacit knowledge is intimately related to high trustworthiness
Sammarra and Biggiero (2008) JMS	To what extent different types of knowledge are exchanged and combined by collaborating firms to foster innovation	A field research in the aerospace industrial cluster of Rome	Firm	The content of transferred knowledge	• In most collaborative relationships, partners exchange technological knowledge together with market and managerial knowledge

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Bierly, et al., (2009) JMS	To improve our understanding of the external knowledge application process for both exploratory and exploitative innovations	Survey firms in industries that frequently work with university research centres (URCs)	Firm	The antecedents of AKL	• Technological relatedness is negatively associated with the application of external knowledge to explorative innovations; • The tacitness of the knowledge transferred that experience is a stronger predictor when the knowledge is more explicit; • Technological capability is a stronger predictor when the knowledge is more tacit
Luo and Deng (2009) JMS	Develop our understanding of the effects of partner similarity on innovation	176 biotechnology firms between 1988 and 1999	Alliance network	The exploration-exploitation balance in AKL	• Similar partners in a focal firm's alliance portfolio contribute to the firm's innovation up to a threshold, beyond which additional similar partners can lead to a decrease in innovation because of the trade-offs embedded in collaboration between similar partners
Rothaermel and Alexandre (2009) Org Sci	To extend the ambidexterity construct more broadly to describe a firm's ability to simultaneously balance different activities in a trade-off situation	Multi-industry sample of U.S. manufacturing companies	Alliance network	The exploration-exploitation balance in AKL	• The relationship between technology sourcing mix and firm performance is an inverted U-shape • Higher levels of absorptive capacity allow a firm to more fully capture the benefits resulting from ambidexterity in technology sourcing

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Vasudeva and Anand (2011) AMJ	How firms facing technological discontinuities utilize knowledge from alliance portfolios	Firms engaged in fuel cell technology development	Firm/ Alliance network	Balancing knowledge diversity and novelty in AKL	• A moderate burden on firms' latitudinal absorptive capacity, corresponding to medium diversity in their portfolios, contributes to optimal knowledge utilization • Simultaneously increasing the demand on firms' longitudinal absorptive capacity affects this relationship negatively
Yang, Zheng and Zhao (2013) SMJ	To understand how do small firms manage their alliance strategies with large firms, this study compares the relative impacts of exploration and exploitation alliances with large firms on small firms' valuation	U.S. biopharmaceutical industry	Alliances/ Firm	The exploration-exploitation balance in AKL	• Exploitation alliances with large firms will on average generate higher values for small firms than exploration alliances with large firms due to a heightened risk of appropriation in exploration alliances • Small firms will increase their valuations from exploration alliances with large firms if they can manage their alliances with large firms via proper alliance governance,

APPENDIX C: Literature Review on the Alliance Network Configurations

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Tie					
Inkpen and Dinur (1998) Org Sci	What is the knowledge management process of international joint venture?	Theoretical work	Alliance	The management of AKL	• Identified four key knowledge management processes—technology sharing, alliance-parent interaction, personnel transfers, and strategic integration • Although all of the knowledge management processes are potentially effective, the different processes involve different types of knowledge and different organizational levels
Inkpen (2000) JMS	Explore the conditions under which firms exploit JV learning opportunities through the acquisition of knowledge	Theoretical paper	Dyadic alliance	The management of AKL	Two firm specific learning-based concepts are developed: alliance knowledge accessibility and knowledge acquisition effectiveness
Grant and Baden-Fuller (2004) JMS	Develop a knowledge accessing theory of strategic alliance	Theoretical work	Alliance	Different AKL strategies	• The primary advantage of alliances over both firms and markets is in accessing rather than acquiring knowledge • Alliance contribute to the efficiency in the application of knowledge; first, by improving the efficiency with which knowledge is integrated into the production of complex goods and services, and second, by increasing the efficiency with which knowledge is utilized

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Fey and Birkinshaw (2005) JOM	How the choice of governance mode for external R&D, along with openness to new ideas and codifiability of knowledge, affects R&D performance	R&D activities of 107 large firms based in the United Kingdom and Sweden	Firm	The management of AKL	Superior R&D performance is viewed as arising through • the choice of approaches used by the firm to access knowledge from outside (university partnering, alliance partnering, and contracting) • the knowledge context of the firm (its openness to new ideas and the codifiability of its knowledge assets) • the interactions between these two sets of factors •
Gomes-Casseres, et al (2006) JFE	Explore the role of interfirm alliances as a mechanism for sharing technological knowledge	Multiple industries	Dyadic alliance/ firm	The governance modes of AKL	• Knowledge flows between alliance partners will be greater than flows between pairs of nonallied firms, and less than flows between units within single firms • Technological, geographic, and business similarities between partners are positively related to knowledge sharing •
Capaldo (2007) SMJ	Investigate why and how strong dyadic interfirm ties and two alternative network architectures (a 'strong ties network' and a 'dual network') impact the innovative capability of the lead firm in an alliance network	Case study of three sample furnishings manufacturers managed their large networks of dyadic joint-design alliances over an investigation period of more than 30 years	Alliance network	The exploration-exploitation balance in AKL	• To gain competitive advantages, firms need to develop ability to integrate a large periphery of heterogeneous weak ties and a core of strong ties is a distinctive lead firm's relational capability

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Node					
Hoang and Rothaermel (2005) AMJ	Link the performance of collaborative R&D projects in the pharmaceutical industry to firms' general and partner-specific R&D alliance experience	Alliances between pharmaceutical companies and their biotechnology partners	Dyadic alliance/ firm	The management of AKL/AKL experience	• General alliance experience of the biotechnology partners, but not of the pharmaceutical firms, positively affected joint project performance • Partner-specific experience had a negative, marginally significant effect on joint project performance
Lin et al (2007) Manage Sci	Engage in inductive case-based theory development to advance research on the evolution of alliance portfolios	Data from five U.S. industries spanning eight years/ simulation	Firm/ Alliance network	The exploration-exploitation balance in AKL	• Although an ambidextrous formation of alliances benefits large firms, a focused formation of either exploratory or exploitative alliances benefits small firms • In an uncertain environment an ambidextrous formation enhances firm performance but so does a focused formation in a stable environment • Firm's centrality and structural hole positions in network relations can moderate the relationships between alliance formation choices and firm performance
Li, et al (2008) AMJ	Develop a theory of how partner selection can help the firm control the threat of knowledge leakage and retain their core proprietary assets	R&D alliances among firms in high-technology industries	Dyadic alliance	The match between AKL process and innovation outcome	• The more radical an alliance's innovation goals, the more likely it is that partners are friends rather than strangers • Strangers are preferred to acquaintances

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Lavie, et al (2011) Org Sci	Develop the theory of domain separation	Alliances formed by U.S. software firms. The U.S. software industry	Firm/ Alliance network	The exploration-exploitation balance in AKL	• Firms do not typically benefit from balancing exploration and exploitation within the function domain and structure domain. • Firms that balance exploration and exploitation across domains. • Increases in firm size that exacerbate resource allocation trade-offs and routine rigidity reinforce the benefits of balance across domains and the costs of balance within domains
Al-Laham, et al (2011) ICC	How managing the dynamic balance that a firm must undertake between applying knowledge stocks and accessing knowledge flows may determine innovativeness	The complete US biotechnology population of 857 firms founded during the period 1973–1999	Firm	The effect of time on AKL	• Frequent engagement with new alliance partners results in a decreased impact of alliance capital on innovative success • A failure to refresh human capital can offset the positive impact of high levels of human capital stocks
Frankort, et al (2012) ICC	Linking research on parallel search and joint R&D to contribute a portfolio perspective to the study of knowledge flows within interfirm R&D partnerships	Firms engaged in R&D partnerships relating to information technology between 1975 and 1999	Firm/ alliance network	The exploration-exploitation balance in AKL	• The size of a firm's R&D partnership portfolio and its share of novel partners both have an inverted U-shaped effect on the inflow of technological knowledge from the firm's R&D partners • These direct effects vary as a function of the level of technological uncertainty within the portfolio

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Network structure					
Ahuja (2000) ASQ	Assess the effects of a firm's network of relations on innovation	A longitudinal study of firms in the international chemicals industry	Alliance network	Structural holes and AKL	• Direct and indirect ties both have a positive impact on innovation but that the impact of indirect ties is moderated by the number of a firm's direct ties • Structural holes are proposed to have both positive and negative influences on subsequent innovation
Schilling and Phelps (2007) Manage Sci	Examine how structure of alliance networks influences their potential for knowledge creation	Longitudinal data of the patent performance of 1,106 firms in 11 industry-level alliance networks	Firm/ Alliance network	Optimal network structure for AKL	• Firms embedded in alliance networks that exhibit both high clustering and high reach (short average path lengths to a wide range of firms) will have greater innovative output than firms in networks that do not exhibit these characteristics
Vanhaverbeke et al (2009) JMS	How two types of redundancy in a focal firm's ego network affect its ability to create new technologies in its technology core areas (exploitation) and/or non-core areas (exploration)	Companies in the chemicals, automotive, and pharmaceutical industries	Alliance network	Network redundancy and AKL	• There are two types of redundancy: ego redundancy (these alliances connect two partners or groups of partners of the focal firm that were otherwise not linked); component density (these alliances between partners do not increase the redundancy in ego's total network, but increase the redundancy within a separate group of partners) • Egonet redundancy has a linear effect on the creation of core technology, and an inverted U-shape effect on non-core technology • Component density has a curvilinear effect on the creation of core technology but has no effect on the development of non-core technology

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Operti and Carnabuci (2011) JOM	How learning from partner firms' public knowledge influence the innovation performance of the focal firm?	Panel of semiconductor firms between 1976 and 2002	Alliance network/ firm	Network structure and spillover knoweldge	• Firms' innovative performance tends to be higher when their spillover network is either munificent or rich in structural holes • The extent to which firms benefit from their spillover network hinges on specific intra-organizational factors—their scientific intensity and degree of downstream integration
Vasudeva, Zaheer, and Hernandez (2013) Org Sci	How national institutions affect the extent to which specific network positions influence innovation?	A longitudinal study of cross-border fuel cell technology alliance networks involving 109 firms	Firm	Integrating institution theory with AKL	• Firm spanning structural holes obtains the greatest innovation benefits when the firm (the broker) or its alliance partners are based in highly corporatist countries, or under certain combinations of broker and partner corporatism
Multiple network primitives					
Mowery, et al (1996) SMJ	Empirical assessment of knowledge transfer in alliance	Citation patterns in a firm's patent portfolio	Dyadic alliance	The governance model of AKL/AKL capability	• Equity arrangements promote greater knowledge transfer • 'Absorptive capacity' (similarity) helps explain the extent of technological capability transfer • The capabilities of partner firms become more divergent in a substantial subset of alliances
Lavie and Rosenkopf (2006) AMJ	Offer theory and evidence that demonstrate why and how firms balance these tendencies over time and across domains	Alliances formed by U.S. software firms. The U.S. software industry	Firm/ Alliance network	Separating exploration and exploitation in different network domains	• Firms balance their tendencies to explore and exploit over time and across domains

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Sampson (2007) AMJ	Examine the impact of partner technological diversity and alliance organizational form on firm innovative performance	463 R&D alliances in the telecommunications equipment industry	Alliance network	Optimized network configuration for AKL	• Alliances contribute far more to firm innovation when technological diversity is moderate, rather than low or high • Hierarchical organization, such as an equity joint venture, improves firm benefits from alliances with high levels of technological diversity
van Wijk, et al (2008) JMS	Use meta-analytic techniques to examine how knowledge, organization and network level antecedents differentially impact organizational knowledge transfer	Meta-analysis	Firm/ Dyadic alliance/ Alliance network	Antecedents and outcomes of AKL	• Causal ambiguity of knowledge hinders its subsequent transfer • Size positively relates to transfer of organizational knowledge • Each of the three dimensions of social capital – structural, relational and cognitive capital – appears to be related to organizational knowledge transfer, albeit to varying degrees • Knowledge transfer increases both performance and innovativeness
Tiwana (2008) SMJ	Examines the underexplored tensions and complementarities between bridging ties and strong ties in innovation-seeking alliances	42 innovation-seeking project alliances involving a major American services conglomerate and its alliance	Project	Optimized network configuration for AKL	• Strong ties complement bridging ties in enhancing alliance ambidexterity at the project level
Gilsing et al (2008) Res Policy	Analyze the role of an alliance network in terms of the technological distance between partners, a firm's network position (centrality) and total network density	Technology-based alliance networks in the pharmaceutical, chemical and automotive industries	Alliance network	The exploration-exploitation balance in AKL	• Successful exploration requires a delicate balance between exploration (creativity and novelty) and efficient of knowledge absorption • Exploration success also depends on the other two dimensions of embeddedness namely technological distance and network density

Author(s)	Research questions/objectives	Research setting/data	Unit of analysis	The role of AKL	Key Findings
Nielsen and Nielsen (2009) JMS	Propose and test an integrated framework in which knowledge tacitness and trust act as mediating mechanisms in the relationship between partner characteristics and alliance outcomes	Danish firms engaged in alliances with partner firms located in foreign countries	Dyadic alliance	Antecedents of AKL	• While knowledge tacitness can inhibit learning it may simultaneously enhance innovative outcomes in alliances • Trust not only directly facilitates learning but also conditions the effect of knowledge tacitness on innovative outcomes
Phelps (2010) AMJ	Examines the influence of the structure and composition of a firm's alliance network on its exploratory innovation	77 telecommunications equipment manufacturers	Alliance network	Optimized network configuration for AKL	• The technological diversity of a firm's alliance partners increases its exploratory innovation • Network density among a firm's alliance partners strengthens the influence of diversity
Schildt, et al (2012) SMJ	How determinants of absorptive capacity influence learning in alliances over time	Longitudinal patent cross-citation data	Dyadic alliance	Antecedents of AKL/AKL capability	• Technological similarity only modestly increases learning in the initial stages of a relationship, but moderate levels substantially increase knowledge flows later in the alliance • High technological diversity is related to higher initial learning rates, but the effects diminish over time • R&D intensity is negatively related to initial learning rates but has a considerable positive effect later in the relationship

APPENDIX D: Expanded Analysis

I conducted an expanded analysis (Carlson and Kunkel, 2015) to examine the capacity of the new theoretically variables of my study. The expanded analysis regroups variables and adopts an ordinary least squares multiple regression (OLS). Following Carlson and Kunkel (2015), I organized the variables in the regression into three categories: theory-derived independent variables identified in previous studies (category 1), theory-derived independent variables which are the focus of the current study (category 2), and variables which may be associated with the dependent variable, but for which a direct explanation for the association is not plain (category 3). Four models including different independent variables were created: Model 1 includes all category 1 variables, Model 2 includes all category 2 variables, Model 3 includes all category 1 and category 2 variables, and Model 4 is the full model including all category 1, 2 and 3 variables. Because the multiple correlation (R) of an OLS regression can be interpreted as the coefficient of determination assessing variance in the dependent variable accounted for by the model, "comparing R for Model 3 to the R for Model 1 offers a non-traditional view of the incremental contribution of a study's focal variables beyond that accounted for by theoretically meaningful variables identified in previous research" (Carlson and Kunkel, 2015, p13).

I reported the results of expanded analysis for models of alliance knowledge search intensity in Table D.1, and reported the results of expanded analysis for models of firm innovation in Table D.2. As shown in both tables, R values of Model 3 is larger than the R values of Model 1, indicating that the theory-derived independent variables of the current study are meaningful.

Table D.1 Expanded Analysis of Analysis of Alliance Knowledge Search Intensity (Empirical Model 1)

	Model 1		Model 2		Model 3			Model 4 (Full model)	
R&D intensity	0.01	(0.01)			0.00	(0.01)		0.00	(0.01)
Financial slack	-0.18+	(0.10)			-0.11	(0.10)		-0.13	(0.10)
Innov performance above HA	-0.11	(0.37)			-0.14	(0.35)		-0.23	(0.35)
Alliance knowledge quality	0.02***	(0.00)			0.01***	(0.00)		0.01***	(0.00)
Portion of cross-border alliance	-1.72	(1.40)			-1.56	(1.35)		-1.46	(1.36)
Partner dissimilarity	2.10	(1.47)			2.50+	(1.43)		2.49+	(1.43)
Portion of R&D alliance	-0.09	(0.53)			-0.26	(0.52)		-0.14	(0.52)
Tie strength	1.60	(2.42)			1.09	(2.41)		0.79	(2.45)
Alliance tech distant	-9.01***	(1.92)			-5.32**	(1.96)		-5.32**	(2.02)
Inverse Mills ratio	-3.55**	(1.16)			0.40	(1.25)		0.50	(1.25)
Innov performance below HA			-0.58	(0.48)	-0.15	(0.93)		-0.26	(0.93)
Knowledge stock size			0.07	(0.00)	0.04***	(0.00)		0.04***	(0.00)
Innov perf below HA * knowledge stock size			-0.07	0.03	0.00	(0.00)		0.00	(0.00)
Innov perf below HA2 * knowledge stock size			0.02	0.03	-0.04	(0.04)		-0.04	(0.04)
Year dummies								Yes	
Constant	10.36***	(2.24)	-0.04	(0.56)	2.36	(2.38)	(0.84)	2.52	(2.42)
R	0.56		0.51		0.59			0.6	
R square	0.32		0.27		0.35			0.36	
Observations	1064		1017		986			986	
ll	-4530.56		-4310.79		-4134.86			-4129.67	
df_m	10.00		2.00		14.00			20.00	

Standard errors in parentheses

Table D.2 Expanded Analysis of Analysis of Firm Innovation (Empirical Model 2)

	Model 1		Model 2		Model 3		Model 4 (full model)	
Technological diversity of partners	50.94***	(12.81)			17.05		-8.82	(12.75)
R&D intensity	0.07*	(0.04)			0.05		0.06+	(0.03)
Firm size	8.55***	(1.08)			4.87***		6.67***	(1.09)
Financial slack	-0.96+	(0.58)			-0.85		-0.83	(0.55)
Portion of cross-border alliance	-4.56	(8.15)			-7.95		-2.08	(7.58)
Partner dissimilarity	2.02	(8.39)			6.40		2.60	(7.88)
Portion of R&D alliance	5.03	(8.36)			5.11		5.84	(7.70)
TDSAK			-197.9***	(11.2)	-154.58***		-141.46***	(14.56)
TDSAK * repeated partner			63.9***	(16.4)	67.15***		40.93*	(16.37)
TDSAK * tie strength			-106.0+	(62.3)	-80.45		-90.71	(61.84)
Tie strength			6.72	(12.7)	8.78		-8.07	(13.31)
Repeated partner			-3.02	(2.85)	-2.71		-0.52	(2.88)
Year dummies							Yes	
Constant	20.20	(13.82)	164.6***	(9.95)	123.94***	(2.35)	88.77***	(17.49)
Observations	1085		1124		1085		1085	
R	0.41		0.48		0.51		0.56	
R square	0.17		0.23		0.26		0.31	
ll	-6537.43		-6712.34		-6481.60		-6437.93	
df_m	8.00		5.00		13.00		21.00	

Standard errors in parentheses
="+ p<0.10; * p<0.05; ** p<0.01; *** p<0.001"