Ph. D. Dissertation in Public Administration

Research on the mechanisms of knowledge-based innovation

- Focusing on the endogenous and exogenous factors -

지식기반 혁신의 메커니즘에 대한 연구
: 내생 및 외생적 변수들을 중심으로

February 2018

Graduate School of Seoul National University

Technology Management, Economics, and Policy Program

Chigu Kim

Abstract

Research on the mechanisms of knowledge-based innovation

- Focusing on the endogenous and exogenous factors -

Chigu Kim
Technology Management, Economy, and Policy Program
The Graduate School
Seoul National University

Over the last 20 decades, knowledge has emerged as a key factor in ensuring that firms stay competitive and can realize financial and innovative growth. Many firms have achieved this by relying on external knowledge and on technologies beyond internal R&D as an innovative strategy because the increasing technology obsolescence and technological uncertainty has increased the importance of securing valuable external knowledge. With the concept of open innovation spreading, research on firm's internal innovation strategy based on external knowledge has emerged in the knowledge management field. Recently, the increased importance of knowledge-based innovation resulted in more research focusing on this issue. In particular, within the research focusing on knowledge-based innovation, increasing attention is placed investigating the effects of external knowledge sources on the performance of firms. However, previous

literature has left gaps in the understanding of the mechanisms of knowledge-based innovation. While prior literature focused on the effects of external knowledge sources, most research treated the mechanisms of knowledge-based innovation as a given fact and did not investigate possible determinants. Recent research investigated the mechanisms of knowledge-based innovation using only endogenous or exogenous factors, and so far no studies have performed a comprehensive investigation it in the context of various perspectives. This dissertation aims at increasing the understanding of the mechanisms of knowledge-based innovation by investigating two key questions: "What are determinants of external knowledge search strategy?" and "Which factors moderate the relationship between unrelated technological diversification and innovation performance?".

Specifically, Chapter 3 investigates the factors that determine the firm's external knowledge search strategy. Considering that the external knowledge search strategy is affected by both internal and external forces, Chapter 3 examines the effects of both endogenous and exogenous factors. As an endogenous factor, Chapter 3 focuses on the potential absorptive capacity, i.e., the firm's ability related to the identification and acquisition of external knowledge sources. In addition, previous literature has linked external knowledge search strategy and the appropriability regime, which is known as an exogenous factor related to flows and volumes of external knowledge sources. The hypotheses of Chapter 3 are tested on a panel dataset containing patent and financial information of 170 international firms from various industries. The findings of Chapter 3 reveal that a firm's potential absorptive capacity has a curvilinear relationship with

external knowledge search strategy. It also finds that the appropriability regime partially moderates the relationship between potential absorptive capacity and external knowledge search strategy. These results highlight the role of the endogenous and exogenous factors in determining the firm's use of external knowledge in the innovation process.

Chapter 4 focuses on the endogenous and exogenous factors that can moderate the relationship between unrelated technological diversification and innovation performance. In particular, among the factors discussed in the prior literature, Chapter 4 investigates organizational slack, technological capability, and technological turbulence, which are related to the firm's innovative activities and the nature of knowledge. The hypotheses of Chapter 4 are tested on a cross-sectional dataset comprised of 251 sample firms from various industries. Unrelated technological diversification is found to have a curvilinear relationship with the firm's innovation performance. Through an analysis of the available data, Chapter 4 shows that organizational slack partially positively moderates the relationship between unrelated technological diversification and the firm's innovation performance. However, technological capability and technological turbulence negatively moderate this relationship. These findings suggest that the maximum level of unrelated technological diversification which contributes to the firm's innovation performance is limited. Firms, however, can take advantage of higher levels of organizational slack and lower both technological capability and technological turbulence in order to maximize their innovation performance.

Overall, this dissertation aims at increasing the understanding of the mechanisms of

knowledge-based innovation. First, by examining the mechanism of knowledge-based innovation, this dissertation expands the innovation management perspective. This thesis investigates the characteristics of the mechanisms of knowledge-based innovation not just through a singular perspective which is often done in individual research focusing on external knowledge search strategy and unrelated technological diversification. Rather, it identifies and comprehensive analyzes both endogenous and exogenous factors. Second, based on the recognition of the effects of the endogenous and exogenous factors on the external knowledge search strategy, this dissertation recommends considering the internal levels of the firm's knowledge base and the volume and flows of external knowledge sources for appropriate searching of external knowledge. Third, this dissertation confirms that the interaction between endogenous and exogenous factors within unrelated technological diversification influences the firm's innovation performance. Based on these findings, the dissertation proposes that firms need to take into account their endogenous and exogenous factors related to innovation activities as important contingent factors with respect to the research of unrelated technological diversification and development of innovation strategy.

Keywords: Knowledge-based innovation, external knowledge search, unrelated technological diversification, innovation performance, knowledge-based view, innovation mechanism

Student Number: 2011-30302

Contents

List of Tables

List of Figures

Chapter 1. Introduction

1.1 Backgrounds

In the last 20 decades, the recognition of the importance of knowledge sources is an important phenomenon in firms dealing with the innovation process (Rigby & Zook, 2002). Specifically, the concept of the knowledge-based economy (Grant, 1996) highlights that knowledge sources, rather than traditional production factors, are key factors for the firm's financial and innovative growth. In order to sustain a competitive advantage, firms are more strongly dependent on the production, distribution, and use of knowledge sources than ever before. Figure 1 shows that the total high-technology exports of OECD member countries have more than doubled since the year 1999.

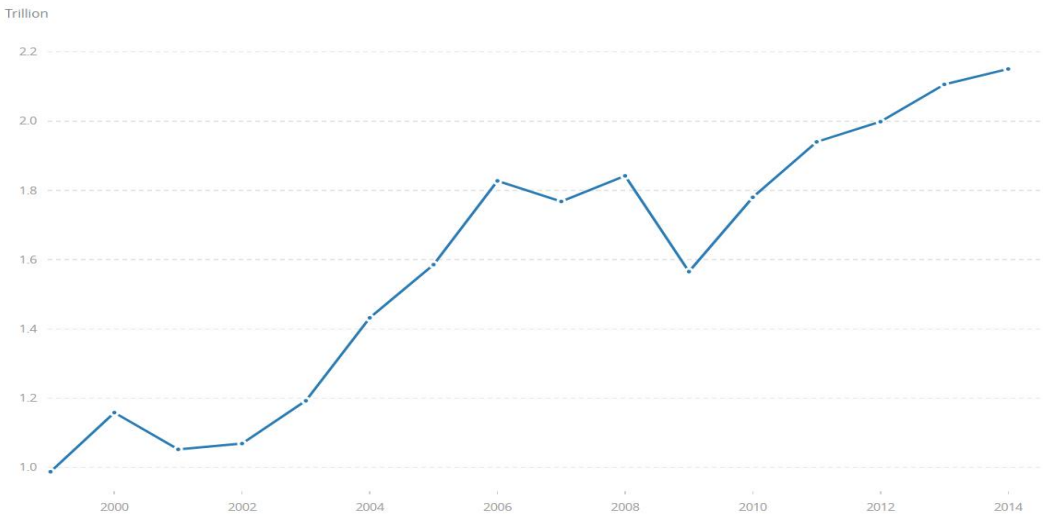

Figure 1. Total OECD high-technology exports (Current US$, 1999-2014)

Source: The World Bank

Valuable knowledge is described as one of the most strategically important assets of the firm and the foundational element of the firm's intangible resources and capabilities (Grant, 1996; Liebeskind, 1996). In addition, the prior research argues that the firm's valuable knowledge is essential for determining its competitive advantage, financial growth, and innovation performance (Conner & Prahalad, 1996; Carayannopoulos & Auster, 2010). Specifically, the recently increasingly adopted concept of open innovation (Chesbrough, 2003) stresses the role of valuable external knowledge sources in enabling firms to leverage a competitive advantage through combination and recombination with the internal knowledge base (Chesbrough, 2006). Accordingly, firms are increasingly more likely to form a strategic alliance or to conduct M&A to obtain the valuable external knowledge sources required for innovation success (Doz & Hamel, 1997; Sivadas & Dwyer, 2000; Khamseh et al., 2017). Figure 2 presents the annual number and value of M&A transactions.

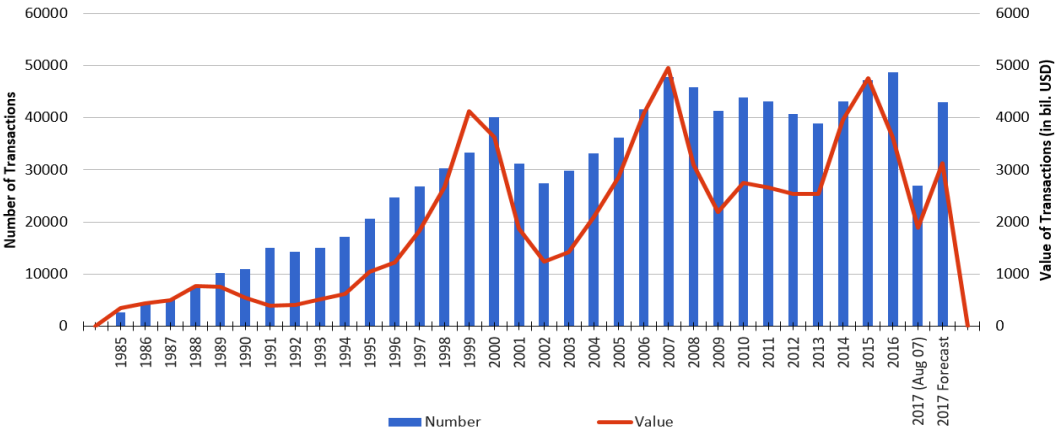

Figure 2. The annual number and value of M&A transactions worldwide (1985-2017)

Source: Thomson Financial, Institute of Mergers, Acquisitions and Alliances (IMAA)

Recently, scholars in knowledge management have highlighted several important aspects of external knowledge sourcing for knowledge-based innovation (Van Wijk et al., 2008; Monteiro et al., 2017). First, external knowledge sourcing enriches the firm's prior knowledge base by adding novel, distinctive variations, thus offering a wider range of choices to solve problems (March, 1991; Monteiro et al., 2017). Second, external knowledge sourcing boosts firm's innovation processes through combinatory and problematic search (Katila & Ahuja, 2002; Nelson & Winter, 1982). Third, based on the innovation perspective, external knowledge sourcing provides opportunities for novel actions, and the process of constructing novel actions often entails finding new combinations and the recombination of disparate ideas (Hargadon & Fanelli, 2002).

This dissertation investigates the mechanisms of knowledge-based innovation which are currently attracting increasing attention from both academics and practitioners. Specifically, this dissertation focuses on the roles of endogenous and exogenous factors related to innovation activities during knowledge-based innovation. Prior research on knowledge-based innovation has the limitation of examining the roles of openness and the effects of external knowledge search on firm's performance using a single perspective. Because the mechanisms of knowledge-based innovation are complex, they should be investigated using not only diverse perspectives but also through a framework covering both internal and external factors to fill the gaps in the existing. Consequently, this dissertation aims to add to the existing research on the mechanisms of knowledge-based innovation by providing the required systematic and holistic investigation into the

mechanisms of knowledge-based innovation.

1.2 Research purpose

Understanding the increasing significance of technology and innovation management, this dissertation focuses on the mechanisms of knowledge-based innovation such as external knowledge search strategy and technological diversification. External knowledge search strategy and technological diversification are major tools used by firms to improve and foster innovation performance through acquiring valuable knowledge from external actors. Especially in the knowledge-based economy, which is characterized by fast-changing technological fashion and valuable knowledge as the new source of the production function, firms are paying more attention to the mechanisms of knowledge-based innovation. However, as the studies on the underlying mechanisms of knowledge-based innovation are relatively sparse compared to the studies on the effects of external knowledge sources on the firm's innovation performance in general, many questions on the characteristics of endogenous and exogenous factors related to innovation activities as well as their impact on knowledge-based innovation remain unanswered.

The aim of this dissertation is to fill the theoretical and empirical gaps in the understanding of knowledge-based innovation. Adopting the knowledge-based view and resource-based view, this dissertation investigates the direct and indirect effects of contextual and contingent factors. It aims at increasing the understanding of determinants

in terms of firm's external knowledge search strategy through investigating how both endogenous and exogenous factors shape the external knowledge search strategy of the firm. It also aims at investigating the effects of different endogenous and exogenous factors on the relationship between unrelated technological diversification and the firm's innovation performance. Overall, the findings of this dissertation increase the academic understanding of the mechanism of knowledge-based innovation as well as provide important managerial implications for increasing the benefits obtained from knowledge-based innovation.

1.3 Research outline

This dissertation consists of three different parts: the literature review, two empirical studies on the mechanisms of knowledge-based innovation, specifically endogenous and exogenous factors, and conclusive remarks of this thesis as well as limitations and recommendations for future research.

Chapter 2 provides the review of the key literature. First, this chapter presents the extant approach related to the mechanism of knowledge-based innovation, i.e., external knowledge search and technological diversification, and how it relates to the approach of this thesis. Moreover, Chapter 2 provides a review of the endogenous and exogenous factors that have been identified by prior studies on knowledge-based innovation and highlights the importance of contextual and contingent roles.

The two different empirical studies are covered in Chapters 3 and 4. Figure 3 presents the overview of the two components related to the mechanisms of knowledge-based innovation and provides the comprehensive view that corresponds to the two different empirical studies of this dissertation.

Chapter 3 investigates the determinants of external knowledge search strategy. Prior studies on the relationship between absorptive capacity and external knowledge search focused on the moderating roles of absorptive capacity in achieving innovation performance. When innovative firms build up their innovation and financial performance, they try to find and acquire valuable knowledge sources from external actors. According to the concepts of Zahra & George (2002), potential absorptive capacity enables firms to identify and absorb the external knowledge sources. However, prior literature has not investigated the contextual roles of potential absorptive capacity on the external knowledge search strategy. Chapter 3 examines the effect of potential absorptive capacity on external knowledge search strategy. Following the prior literature, Chapter 3 examines how a firm's potential absorptive capacity affects its external knowledge search strategy. In addition, Chapter 3 argues that the appropriability regime, as institutional legal protection, affects the flows of external knowledge and the collaboration with external actors. Consequently, the study investigates how the appropriability regime moderates the relationship between potential absorptive capacity and external knowledge search strategy. Chapter 3 finds empirical evidence for the curvilinear relationship between potential absorptive capacity and external knowledge search strategy. It also tests and confirms a

positive moderating effect of the appropriability regime on the relationship between potential absorptive capacity and external knowledge search strategy.

Focusing on answering the question "How can the contingent factors of the firm influence the technological diversification and innovation performance?" Chapter 4 investigates both endogenous and exogenous moderating factors related to the firm's innovation activities and potential. Starting with the base hypothesis on the curvilinear relationship between unrelated technological diversification and the firm's innovation performance, Chapter 4 examines the moderating effects of organizational slack, technological capability, and technological turbulence. Chapter 4 finds that unrelated technological diversification has a curvilinear relationship with the firm's innovation performance. In addition, Chapter 4 finds that organizational slack has a positive moderating effect on this relationship. However, technological capability and technological turbulence were found to have negative moderating effects.

Finally, Chapter 5 provides a summary of the findings of the two different empirical studies and concludes with a discussion of the theoretical and managerial implications. Chapter 5 also discusses the limitations of this dissertation and provides an outlook for future research.

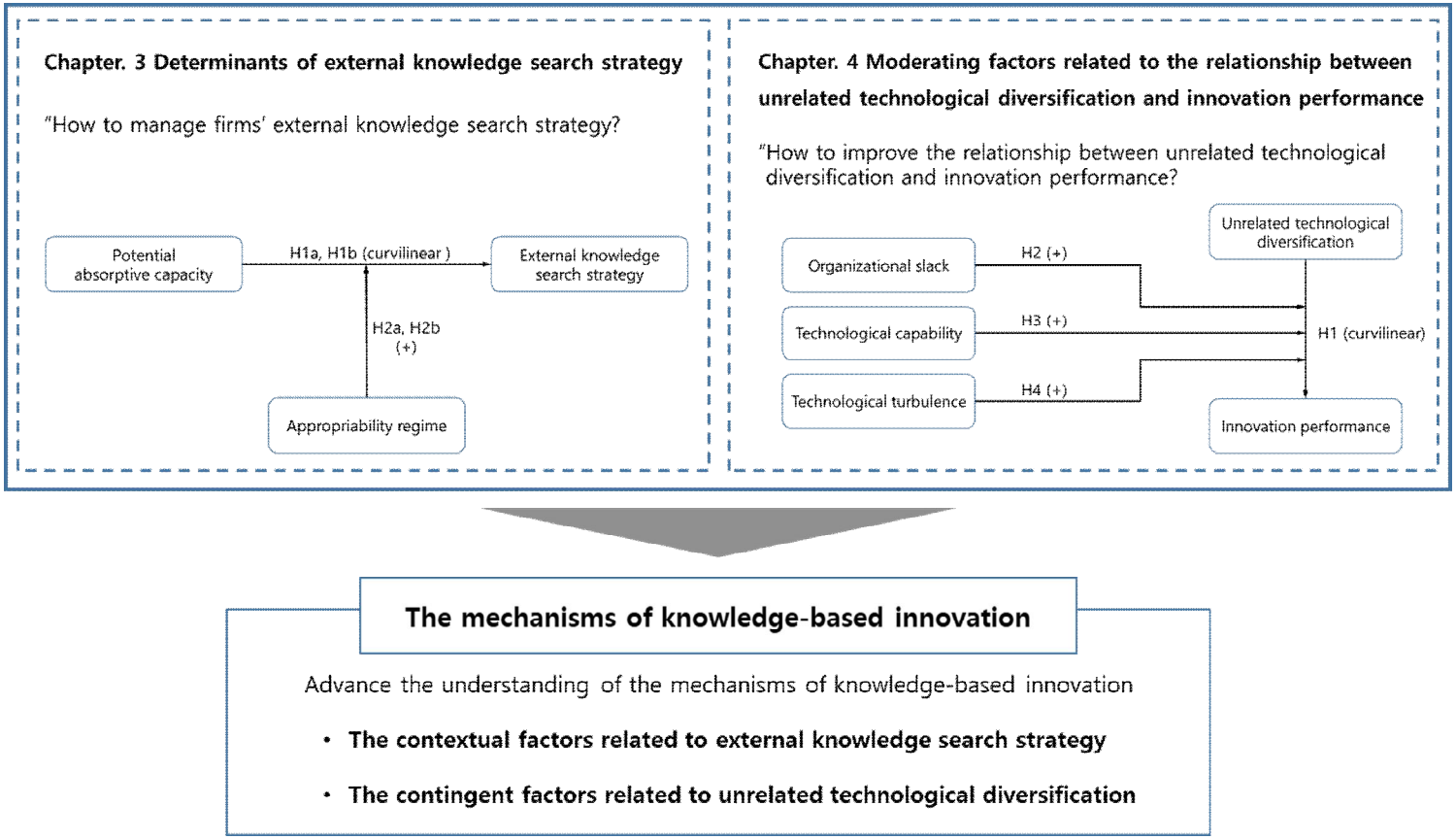

Figure 3. Overview of this dissertation

Chapter 2. Literature review

2.1 Innovation process through external knowledge search

2.1.1 External knowledge search strategy

Especially in times when open innovation is becoming more important, firms need to develop search strategies for gaining access to new and innovative ideas and technologies (Laursen & Salter, 2006). Firms' search strategies strengthen their knowledge pool, enhance recombinatory search, and help add complementary assets (Cohen et al., 2002). Specifically, the search strategy for external knowledge provides an umbrella that integrates a broad range of already existing innovative activities and redefines the organizational boundary between firms and the innovative environment (Cruz-González et al., 2015). Thus, firms need an external knowledge search strategy that provides direction and priorities of valuable knowledge and information inside and outside the organizational boundaries (Laursen & Salter, 2006; Grimpe & Sofka, 2009).

Laursen & Salter (2006) built on the concepts of external search breadth and depth as the components of a firm's external knowledge search strategy. The external search breadth is defined as the number of external sources or search channels that firms rely on in their innovative activities. The external search depth, on the other hand, is defined as the extent to which firms draw from the different external sources or search channels

(Laursen & Salter, 2006). However, this literature focused on diversity and intensity of not the external knowledge itself, but of the external actors or search channels.

Based on the organizational learning perspective, March (1991) suggest that explorativeness includes search activities captured by distal search, variation, risk-taking, experimentation, flexibility, and discovery, whereas exploitativeness signifies search activities related to refinement, trade-off choice, production, efficiency, selection, and implementation (Lee et al., 2014). Accordingly, in the pursuit of explorative knowledge search (explorativeness), firms make an effort to find valuable knowledge and create new technology. However, exploitative knowledge search (exploitativeness) demands more efforts in refining or extending the firm's prior knowledge base (March, 1991).

Katila & Ahuja (2002) have developed a similar approach to examine how firms search or solve problems by adopting the internal learning perspective through extending the ambidexterity concepts of March (1991). They argue that firms can vary in their degree of exploration of external knowledge and reuse of their internal knowledge, just as they can vary in their exploration of new knowledge (Katila & Ahuja, 2002). The former is search depth, which is defined as "how deeply a firm reuses its existing knowledge". The latter is search scope, which is defined as "how widely a firm explores new knowledge" (Katila & Ahuja, 2002: 1183). Thus, based on a learning perspective, search scope fits with the idea of explorative knowledge search and search depth is closer related to exploitative knowledge search (Cruz-González et al., 2015).

Recently, based on heterogeneity, complexity and distinct uses of knowledge,

Santiago and Alcorta (2012) developed explorative and exploitative knowledge search concepts (March, 1991). They suggest that exploration refers to the search for new knowledge and the use of unfamiliar technologies, whereas exploitation refers to the use and refinement of existing knowledge, technologies, and products (Santiago & Alcota, 2012). Thus, knowledge exploration refers to the distant search for new and unfamiliar knowledge. By contrast, knowledge exploitation refers to the local search for familiar, mature, current or proximate knowledge (Santiago & Alcota, 2012). More recently, Tippmann et al. (2014) find that explorative search is related to a wider search for knowledge in distant domains to generate new combinations, whereas exploitative search is related to a narrow search for knowledge in similar domains to draw on familiar and accumulated knowledge. Accordingly, this dissertation focuses on the application dimensions of external knowledge sources on the firm's search activities. In other words, the external knowledge search strategy of the firm should not only encompass the exploratory search perspective but also the exploitative search perspective.

2.1.2 Potential absorptive capacity (PACAP)

Absorptive capacity is the firm's capability to learn from external knowledge sources through the processes of knowledge identification, assimilation, and exploitation (Cohen & Levinthal, 1989). Cohen & Levinthal (1990) reconceptualized the concept of absorptive capacity as the firm's ability to recognize the value of new information,

assimilate it, and apply it to commercial ends. Absorptive capacity is not only related to R&D activities, but also to the diversity or breadth of the organization's knowledge base, its prior learning experience, a shared language, the existence of cross-functional interfaces, and the mental models and problem-solving capacity of the organization's members. Kim (1998) suggests that absorptive capacity is the learning capability and problem-solving ability that enables a firm to assimilate knowledge and create new knowledge through integrating external knowledge and the internal knowledge base. Christensen et al. (2005) understand absorptive capacity as the firm's competence to access, absorb and integrate external ideas, science and other kinds of knowledge inputs for innovation. Focusing on the process of external knowledge inputs, Lane et al. (2006) suggest absorptive capacity as the firm's ability to utilize external knowledge through the sequential processes of exploratory, transformative, and exploitative learning.

Zahra & George (2002) redefined absorptive capacity as a set of organizational routines and processes, by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability. They categorized absorptive capacity into four dimensions in terms of knowledge flow: acquisition, assimilation, transformation, and exploitation (Zahra & George, 2002). Especially, they suggest two distinct constructs of absorptive capacity: potential absorptive capacity (PACAP) and realized absorptive capacity (RACAP). PACAP captures knowledge acquisition and assimilation, i.e., the firm's capacity to identify and acquire externally generated knowledge (Gebauer et al., 2012; Leal-Rodríguez et al., 2014). RACAP reflects

knowledge transformation and exploitation, i.e., the firm's ability to leverage absorbed external knowledge and transform it into innovation performance (Fosfuri & Tribó, 2008). Whereas RACAP enhances the combination of relevant knowledge sources and increases the firm's responsiveness to internal changes, PACAP helps firms to align between external knowledge sources and the internal knowledge base and enhances the firm's responsiveness to external changes (Ben-Menahem et al., 2013). According to the process-based notion of Lane et al. (2006), PACAP and RACAP are not substitutes but form a complementary relationship. Both of them are needed to actually benefit from the external knowledge. For establishing innovation performance, external knowledge is linked to the firm's internal systems and prior knowledge base through the ability to identify and acquire it (Zahra & George, 2002). Especially, PACAP becomes increasingly important in the era of the knowledge-based economy (Grant, 1996; Dean & Kretschmer, 2007) to help reconfigure the external knowledge base and deploy competitive capabilities for the development of new products and processes (Zahra & George, 2002; Todorova & Durisin, 2007). In addition, PACAP can be constituted by firm's prior complementary knowledge and information assets through M&A and alliances (Zahra & George, 2002; Makri et al., 2010).

In particular, Lichtenthaler & Lichtenthaler (2009) suggest knowledge management capacity as a firm's capability of reconfiguring and realigning internal and external knowledge in the open innovation process. They also argue that external knowledge exploration refers to acquiring knowledge from external sources (Lane et al., 2006), and

define PACAP as a firm's ability to explore external knowledge (Lichtenthaler & Lichtenthaler, 2009). Therefore, PACAP is one of the drivers of a firm's external knowledge search strategy to acquire and assimilate external knowledge during the innovation process.

2.1.3 Appropriability regime

Appropriability regime refers to the extent to which firms protect the benefits of their new knowledge and innovative products/processes from external actors by institutional and industry dynamics (Teece, 1986; Cohen & Levinthal, 1990; Willman, 1992; Zahra & George, 2002; Hurmelinna-Laukkanen & Puumalainen, 2007). In general, the appropriability regime can be divided into the legal appropriability regime of the industry (e.g. patents, trademarks, and copyright protection) and the strategic appropriability regime of the firm (e.g. secrecy, lead-time, complexity, first mover advantage, and lock-in) (Amara et al., 2008; Hurmelinna-Laukkanen et al., 2008).

A strong legal appropriability regime increases the firm's reputation for new product development, its negotiation capabilities with external actors, and the firm's accessibility to external knowledge (Cohen et al., 2002; Blind et al., 2006). A strong strategic appropriability regime also enhances internal new product development through the learning effect (Hirshmann, 1964). Thus, a legal appropriability regime can protect valuable knowledge sources from external actors, whereas a strategic appropriability

regime can protect internally developed knowledge through innovative products and processes (Xu et al., 2012). Based on the contingency theory (Hambrick, 1983), firms' external knowledge search strategy will change under different external appropriation environments. To explore external environment (as an institutional systematic mechanism) related knowledge flows, I focus on the legal appropriability regime, i.e., the knowledge appropriation mechanism of the industry, as an exogenous factor which affects the relationship between the external knowledge search strategy and PACAP (Teece, 1986). Thus, the appropriability regime in the context of this research is the legal appropriability regime.

With respect to the characters of the appropriability regime, Teece (1986) suggests two dimensions: the nature of the technology and the efficacy of the legal mechanisms of protection. The nature of the technology can be either explicit or tacit (Teece 1986). Explicit knowledge can be codified and thus transferred easily to the external environment (Liebeskind, 1996), whereas tacit knowledge is often embedded in routines and is difficult to imitate (Hurmelinna-Laukkanen & Puumalainen, 2007). With respect to the efficacy of the legal mechanisms of protection, when knowledge is difficult to imitate and can be legally protected, the appropriability regime can be defined as strong. However, if knowledge can easily be imitated and is difficult to protect, the appropriability regime is defined as weak (Teece, 1986; Hurmelinna-Laukkanen & Puumalainen, 2007). Teece et al. (1997) suggest that also intermediate appropriability regimes exist. Specifically, under a strong appropriability regime, firms tend to convert

new developed products and processes into patents and increase the claims of their patents to extend the protection areas (Escribano et al., 2009). Theoretically, these patents are useful tools for protecting the financial returns arising from innovation (Teece, 1986) and constitute a firm's sustainable competitive advantage (Escribano et al., 2009). Also, firm's patents send positive signals to potential collaborators, increase bargaining power, prevent unwanted knowledge transfer, and enhance first-mover advantage (Hurmelinna-Laukkanen & Puumalainen, 2007). However, under a weak appropriability regime, firms select secrecy as the preferred strategy for protecting their products and processes innovations (Cohen et al., 2000). Because of registration costs and the paradox of disclosure (Arrow, 1962), it is difficult to extend the knowledge flows between innovating firms and external actors. Thus, firms are likely to sustain competitive advantage differences by hampering knowledge spillovers (Zahra & George, 2002).

2.2 Innovation process through technological diversification

2.2.1 Technological diversification

Technological diversification refers to the extent of diversification of a firm's own technological base in the knowledge-intensive system and of the principles underlying the nature of products and their production process (Huang & Chen, 2010; Granstrand & Oskarsson, 1994). Technological diversification has been discussed as an important factor leading to firms' innovative and financial performance through realizing economies of

scale and scope (Chiu et al., 2008). Technological diversification is derived from the knowledge breadth, knowledge distance, and knowledge network of the firm (Christensen & Montgomery, 1981).

Because of several characteristics of technological diversification, firms, especially those within knowledge-intensive or high technology industries, tend to be highly diversified. First, firms can benefit from introducing a wide range of new technology into their core knowledge base (Granstrand, 1998) and exploiting the economies of scope in R&D (Panzar & Willig, 1981). The combination of different technologies helps firms to improve their innovation performance and develop new product and processes. According to the resource-based view of the firm (Penrose, 1959; Montgomery, 1994), technological knowledge and know-how through R&D alliances and cooperative projects (Besanko et al., 2010) accelerate the extension of focal firms' product and business areas, which allows the focal firms to create additional market value and improve their financial outcomes (Robins & Wiersema, 1995). Second, technological diversification allows firms to reduce the lock-in effect (Granstrand, 1998; Suzuki & Kodama, 2004) and to enhance their technological competence (Cantwell & Piscitello, 2000) and adaptability to radical technological environments (Kim et al., 2016). For example, Suzuki & Kodama (2004) suggest that technological diversification allows firms to prevent competency traps through generating new technological trajectories and renovating firms' prior technological trajectories. In addition, expanding the firm's technological scope through technological diversification enables firms to develop firm-specific core technology or

R&D productivity (Henderson & Cockburn, 1996), and to create various technological options for responding to the fast-changing technological environment (Kim et al., 2016). Third, firms engaging in technological diversification can accelerate the search for complementarities to their own knowledge base (Granstrand et al., 1997) and novel opportunities to develop new solutions into products and processes through cross-fertilization between different technological areas (Kim & Kogut, 1996).

2.2.2 The influence of organizational slack

Several prior studies suggest that organizational slack is one of the important contextual factors in terms of the resource-based view of the firm (Geiger & Cashen, 2002) and behavioral theory of the firm (Cyert & March, 1963). Geiger & Cashen defined organizational slack as "the resources in or available to an organization that is in excess of the minimum necessary to produce a given level of organizational output" (2002: p.69). In addition, George suggests that "slack is potentially utilizable resources that can be diverted or redeployed for the achievement of organizational goals" (2005: p.661). Meanwhile, Cyert & March defined organizational slack as "the disparity between the resources available to the organization and the payments required maintaining the coalition" (1963: p.36). Recently, De Carolis et al. (2009) argue that organizational slack is the firm's internal resources that can provide the flexibility to create new resources and find new opportunities or strengthen and extend existing resources for firm's innovative

performance. Based on the above arguments, I define organizational slack as the cushion of the firm-specific resources that allows firms to adapt successfully to internal pressures for adjustment or to external pressures for change in technologies, markets, and policy (Bourgeois, 1981; Lawson, 2001; Huang & Chen, 2010).

According to prior studies, there are multiple components of organizational slack (Bourgeois, 1981; Bourgeois & Singh, 1983; Singh, 1986; Geiger & Cashen, 2002; Voss et al., 2008). Bourgeois (1981) categorized organizational slack as available, recoverable, and potential slack. Singh (1986) categorized organizational slack as absorbed and unabsorbed slack in terms of redeployment. Geiger & Cashen (2002) categorized organizational slack as internal and external slack. Recently, Voss et al. (2008) categorized organizational slack as financial, customer relational, human resource, and operational slack in terms of resource rarity and resource absorption.

Concerning the relationship between organizational slack and firm's innovation, varying arguments have been presented on the benefits of organizational slack (Bourgeois, 1981; Singh, 1986; Geiger & Cashen, 2002; Voss et al., 2008). First, organizational slack buffers the technical core of the organization from environmental uncertainty and provide actual or potential resources that allow for new scientific research and experimentation (Tan & Peng, 2003). Second, organizational slack can be a facilitator of strategic behavior that allows the firm to create new products/processes and enter new markets, and protect from the potential depletion of firm's core resources if firm's investment to diverse technologies fails (Bourgeois, 1981; Thompson, 1967; O'Brien, 2003). Third,

organizational slack can be most likely used as the cushion against internal and external pressures and can become buffers for conflict resolution and downside risk (Tan & Peng, 2003; Lee, 2015).

2.2.3 The influence of technological capability

Technological capability refers to a firm's internally generated skills, knowledge, and technologies in order to perform any relevant technical function or volume activity and to manage change in the technologies used by the firm (Teece et al., 1997; Voudouris et al., 2012). Based on the Resource-based view of the firm, technological capability comprises technological knowledge, trade secrets, know-how, and skills generated by research & development and other technology-specific intellectual property or patents protected by law (Bell & Pavitt, 1995; Dollinger, 1995; Hsieh & Tsai, 2007). The accumulation of internally generated skill and stock of knowledge depends upon the firms' cumulative efforts and investments in both production activities and organizational learning (Dahlman et al., 1987).

Bell & Pavitt (1993) classify technological capability as routine and innovative. The former is related to the resources needed to efficiently produce goods or services, and the latter is related to the resources needed to generate and manage technological changes (Reichert et al., 2011). Based on the analysis of three dimensions (investment, production, and linkages within the economy), Lall (1992) suggests three levels of technological

capability: basic, intermediate, and advanced. In addition, with respect to the innovative potential of a business, technological capability involves the following activities: “a) the search for viable alternative technologies; b) selecting the most appropriate technologies; c) dominating the technology; d) adapting the technology to suit the specific production conditions; e) development of technology by small innovations; f) institutionalized search for the most important innovations by the research and development and; g) conducting basic research” (Reichert et al., 2011; p.16).

With respect to firm’s innovative activities, technological capability enables firms to create new and expand existing technological knowledge, and builds the ability to identify, assimilate, and exploit effectively the external technological knowledge (Cohen & Levithal, 1990). For example, firms with high level of technological capabilities tend to be more innovative and superior performing (McEvily et al., 2004). Facing a rapidly changing market and technology environment, technological capabilities allow firms to secure greater efficiency gains through pioneering process innovations (Teece et al., 1997) and achieve higher differentiation through product developments (Tzokas et al., 2015; Teece & Pisano, 1994; Verona, 1999). Accordingly, technological capabilities are the set of skills for building and leveraging competitive advantage (Zahra et al., 2007). In addition, technological capabilities are the stock of knowledge that depends upon firms’ cumulative efforts and investments in both production activities and initiatives toward innovation (Dahlman et al., 1987).

2.2.4 The influence of technological turbulence

Environmental dynamism refers to the extent to which the rate of change or unpredictable change in firms' environment (Dess & Beard, 1984) and can be regarded as external volatility, uncertainty, instability, and unpredictability (Eroglu & Hofer, 2014). Environmental dynamism with respect to external uncertainty composes market turbulence and technological turbulence (Jaworski & Kohli, 1993). While market turbulence refers to "changes in the composition of customers and their preference" (Slater & Narver, 1994, p.51), technological turbulence refers to "the degree to which technology changes over time within the industry and the degree to which such changes affect the industry" (Chatterjee, 2004, p.718). This dissertation focuses on technological turbulence as a contingency factor to examine the moderation effects on the relationship between unrelated diversification and firms' innovative performance.

Prior studies emphasize the contingency roles of technological turbulence in terms of external knowledge and innovative performance. Based on the survey data of Taiwanese high tech manufacturing firms, Hung & Chou (2013) investigate whether technological turbulence moderates the relationship between open innovation (external knowledge acquisition and exploitation) and firm performance. They find that technological turbulence only positively moderates the relationship between external knowledge acquisition and firm performance, but not external knowledge exploitation (Hung & Chou, 2013). In addition, Cruz-González et al. (2015) explore the moderating role of

technological turbulence in terms of the relationship between external knowledge search strategy and firm performance using the survey data of high-technology manufacturing Spanish firms. Specifically, they find the effect of open search strategies on perceived firm performance is contingent with technological turbulence in a reverse manner (Cruz-González et al., 2015).

Under relatively stable technological turbulence, the value of a firm's internal resources, knowledge, and competencies is sustainable, so firms are more likely to benefit from exploiting and improving their current knowledge base (Cruz-González et al., 2015). Hence, firms operating in this context not only try to enhance their core competencies but also do not need to strive for a diversified technological portfolio (Lin & Chang, 2015). On the other hand, under high technological turbulence, a firm's prior knowledge and capabilities are easy to become obsolete, so firms need to reconfigure their current knowledge base and explore external knowledge sources to develop new competencies (Escribano et al., 2009). In other words, while stable technological turbulence allows firms to enhance their core capabilities (Cruz-González et al., 2015; Leonard-Barton, 1992), high technological turbulence allows firms to grasp new opportunities in markets to grow (Wiklund & Shepherd, 2005). Accordingly, firms facing high technological turbulence are more likely to search more widely beyond the local knowledge domain and explore new knowledge sectors in order to reconfigure their current knowledge assets and to develop innovative products and processes that depart from existing technologies and markets (Rosenkopf & Nerkar, 2001).

Chapter 3. The contextual factors related to external knowledge search strategy

3.1 Introduction

In the knowledge-based economy (Grant, 1996; Dean & Kretschmer, 2007), knowledge, rather than traditional production factors such as land, labor, and capital, is critical for the firm's sustainable success and survival in high- or medium-high technology industrial domains (Grimpe & Sofka, 2009; Martín-de-Castro et al., 2011). Valuable knowledge is the most important asset of firms for creating and achieving competitive advantage (Liebeskind, 1996). In addition, valuable knowledge allows the firm to deploy internal resources to efficiently cope with technological and environmental change, and to create platforms on which the firm can develop new product and process (Ndofor & Levitas, 2004). Specifically, the recent trend towards open innovation (Chesbrough, 2003) has emphasized the importance of valuable external knowledge in enabling firms to achieve sustainable competitive advantage and improve innovative performance (Chesbrough, 2006). According to the knowledge-based view (Grant, 1996), firms tend to find valuable external knowledge and integrate it with their internally developed knowledge to reduce the time and cost of new product development (Chesbrough, 2003). Thus, it is important for firms to have an appropriate search strategy for obtaining valuable knowledge from external actors such as a university, institutes,

supplier, or customers.

According to the external knowledge search perspective, firms decide on an appropriate search strategy to create new products and processes internally through identifying and acquiring external valuable knowledge (Chen & Lin, 2004; Laursen, 2012). Generally speaking, external knowledge search strategies encompass both knowledge search breadth, i.e., how widely firms acquire external knowledge from knowledge sources or search channels, and knowledge search depth, i.e., how deeply firms draw from the different knowledge sources or search channels (Katila & Ahuja, 2002; Laursen & Salter, 2006; Chen et al., 2011). In other words, in terms of external knowledge search strategies, prior studies largely focus on knowledge sources (Katila & Ahuja, 2002) and search channels (Laursen & Salter, 2006). Besides, a number of prior studies treated firm's search strategy as the independent variable and examined its impact on the firm's innovative performance (Laursen & Salter, 2006; Huizingh, 2011; Ferreras-Méndez et al., 2015). However, although external knowledge search strategies are important for a firm's innovative performance, little is known about the endogenous and exogenous factors influencing external knowledge search strategies.

Recently, some studies from the field of knowledge management have suggested, theoretically or empirically, factors related to external knowledge search strategies: absorptive capacity (Grimpe & Sofka, 2009), the availability of technology opportunities (Cohen & Levinthal, 1990), the type of innovation output that the firm seeks to achieve (Köhler et al., 2012), the diversity of knowledge provided by external sources (Olsen et

al., 2017), the communication and coordination process (Knudsen & Srikanth, 2014), and the appropriability strategy of the firm (Laursen & Salter, 2014). From the knowledge-based view of the firm (Grant, 1996), a firm's internal ability to identify and acquire valuable knowledge relates to its external knowledge search strategies (Zahra & George, 2002). This view implies that the firms' internal ability, based on its own knowledge stock might directly affect its external knowledge search strategies. Moreover, according to contingency theory (Hambrick, 1983), firms tend to determine external knowledge search strategies based on the external knowledge environment. In other words, external environments related to knowledge flows may indirectly affect the decision on the firm's external knowledge search strategies. Recently, studies have investigated endogenous and exogenous factors of firms' external knowledge search strategies (Drechsler & Natter, 2012; Laursen & Salter, 2014). However, there is a lack of research simultaneously addressing the direct or indirect effects of both endogenous and exogenous factors on the firm's external knowledge search strategies.

In search activities related to the innovation process, firms require absorptive capacity (Cohen & Levinthal, 1990) in terms of their internal capabilities to identify and acquire the knowledge from external sources (Grimpe & Sofka, 2009). Absorptive capacity refers to the ability to learn from valuable knowledge, assimilate it, and exploit it to commercial ends (Cohen & Levinthal, 1990). Absorptive capacity can be divided into two dimensions: potential absorptive capacity (PACAP) and realized absorptive capacity (RACAP) (Zahra & George 2002). Whereas PACAP relates to knowledge acquisition and

assimilation, RACAP relates to knowledge transformation and exploitation (Zahra & George, 2002). Accordingly, I suggest that PACAP is one of the factors in firms' search decisions by enabling firms to identify and recognize valuable knowledge (Todorova & Durisin, 2007).

In terms of exogenous factors, in order to protect the firm's sustainable competitive advantage (Arora et al., 2001) and appropriate the returns from new innovation, industry-level institutional systematic mechanisms are critical. In this paper, I refer to these institutional systematic mechanisms as the appropriability regime (Teece, 1986). Cohen & Levinthal (1990) define appropriability conditions as the extent to which firms capture the financial benefits of their innovation process. In general, the appropriability regime is the ability of different stakeholders to retain for themselves the financial benefits that arise through the willingness to use various knowledge sources (Willman, 1992; Atkins, 1998; Laursen & Salter, 2014). Specifically, Teece (1986) and Teece et al. (1997) suggest that the appropriability regime not only has three levels (strong, intermediate, and weak) but is also the environmental factor that governs a firm's ability to capture the financial benefits from innovative products and processes. Accordingly, I propose that the appropriability regime is one of the factors that affect the firm's search process during the creation of innovation.

Based on the above literature, it is important that firms should consider the nature of the external knowledge and environment, such as institutional systemic mechanisms, related to knowledge appropriation before knowledge searching. First, firms identify the

nature of the external knowledge based on their internal knowledge stock and then acquire it. Second, the environment related to knowledge appropriation allows firms to transfer knowledge and to gain financial returns within their industry domain. Thus, I explore two factors related to knowledge search strategies: potential absorptive capacity as an endogenous factor and appropriability regime as an exogenous factor related to the external knowledge search process.

To extend and complement prior literature, this research investigates how PACAP affects the choice of the firm with respect to the use of knowledge in its innovation process. First, I investigate the relationship between the firm's external knowledge search strategy and PACAP. I propose that the level of the firm's PACAP affects its external knowledge search strategy. I argue that PACAP and the firm's external knowledge search strategy theoretically go hand-in-hand, but that high levels of PACAP are associated with a decreasing use of new knowledge in the innovation process. Second, I analyze whether the appropriability regime moderates the relationship between PACAP and the firm's external knowledge search strategy. I propose that the appropriability regime, as an important external factor, moderates the relationship between PACAP and the firm's external knowledge search strategy.

This study makes a number of contributions to the literature on the impact of major knowledge-related factors on firms' external knowledge search strategy. First, I extend the investigation of the role played by absorptive capacity in external knowledge search strategy. While previous research has focused on the moderating or mediating effects of

absorptive capacity on the relationship between external knowledge flows and innovative performance (Fosfuri & Tribó, 2008; Hurmelinna-Laukkanen et al., 2012; Yu, 2013; Leal-Rodríguez et al., 2014; Ferreras-Méndez et al., 2015), I link PACAP, the factor which is most related to identifying and assimilating knowledge (Zahra & George, 2002), to the firm's external knowledge search strategy in terms of organizational learning. Second, I explore the effects of the appropriability regime on external knowledge search strategy and the use of knowledge in innovation. While some researchers have suggested the role of the appropriability regime as an activation trigger (Cohen & Levinthal, 1990; Todorova & Durisin, 2007), others have suggested that the appropriability regime moderates the relationship between RACAP and innovation performance (Zahra & George, 2002). I highlight that the strength of the appropriability regime affects the relationship between PACAP and the firm's external knowledge search strategy. Accordingly, my results show that external knowledge search strategy and the level of the firm's PACAP are very closely connected (Laursen & Salter, 2014). Also, my results lead to the suggestion for managers to select an appropriate external knowledge search strategy based on the level of the appropriability regime affecting the external knowledge environment of the firm.

This study is structured as follows. Section 3.2 provides the set of hypotheses driving my analysis. Section 3.3 provides information on the design of the empirical study and describes the data used for the analysis as well as the definitions of the variables. Section 3.4 describes the results of the econometric analysis. Based on these results, I discuss these findings in Section 3.5.

3.2 Research hypotheses

3.2.1 PACAP and external knowledge search strategy

Internal or external knowledge is important for firms to achieve innovative performance in the open innovation system (Chesbrough, 2003). In particular, external knowledge has become more significant in the shift towards an open innovation system and has become more readily available as information and communication technologies improved (Grimpe & Sofka, 2009). Accordingly, firms should develop internal capabilities to assimilate external knowledge into their internal knowledge bases through acquiring valuable external knowledge from external actors. Zahra & George (2002) define these core capabilities of the firm as potential absorptive capacity (PACAP).

Based on the above literature review, PACAP, as one of the two faces of absorptive capacity in terms of a byproduct of R&D, is thought to be used for the pursuit of two distinctive external knowledge strategies: external knowledge search breadth and external knowledge search depth. The former aims at advancing basic science and finding new technology while the latter is directed toward realizing and refining the commercial application of the firm's prior knowledge base (Garcia et al., 2003). Specifically, engaging in knowledge search strategies for external knowledge breadth not only allows firms to obtain financial returns and innovative performances but it also affects organizational structure, development routines, and resource endowments (Laursen & Salter, 2006).

PACAP plays several important roles related to firms' search strategies for external knowledge. First, for firms in pursuit of external knowledge search breadth, PACAP acts as a technological gatekeeper of external knowledge acquired through alliances and M&As (Allen, 1977). I assume that PACAP allows firms to recognize the nature of their own knowledge assets. Through an assessment of their own knowledge assets, firms can identify the lacking knowledge that would be required to cope with emerging technologies and will be able to take advantage of the pool of technological opportunities (Nieto & Quevedo, 2005). To sustain a competitive advantage, firms are more likely to acquire complementary knowledge of external actors as well as to invest in their internal R&D (Laursen & Salter, 2006). According to the resource-based perspective (Wernerfelt, 1984), firms with a high-level of PACAP may identify and acquire broader knowledge resources to gain economies of scope in external knowledge assets (MacDonald, 1985; Rodríguez-Duarte et al., 2007). Based on the notion of Zahra & George (2002), Enkel & Heil (2014: 245) argue that "potential absorptive capacity precludes firms from becoming locked into a specific area of expertise and running the risk of failing to seek out alternative technologies by providing them with the strategic flexibility to adapt to various industry contexts". Furthermore, the prior literature indicates that the attention of innovative firms related to new business and market opportunities play important roles in external knowledge searching (Volberda et al., 2010; Salter et al., 2014). To inspire new business concepts and products/processes, firms are likely to alert to new technological opportunities (Salter et al., 2014). Driven by curiosity and various interests, firms extend

their search strategy to a broad range of external knowledge sources to break the conventional logic of their industry and organization (Kaish & Gilad, 1991). Thus, the higher the PACAP, the greater the ability to identify which external actors are specialized in the technological areas required to solve the organizational problems. Therefore, if PACAP is high, it is possible to expand into various technological fields, and firms will actively accept the knowledge of broader technical fields.

Second, for firms in pursuit of external knowledge search depth, PACAP serves as a knowledge platform using similar cognitive structure, common skills, and shared languages (Lazaric et al., 2008; Ferreras-Méndez et al., 2015). This knowledge platform is useful for developing deep connections between external actors to transfer information and knowledge and increase external knowledge search depth (Laursen & Salter, 2006). Especially, when the knowledge of the donor firm is tacit, firms need to establish a deep connection with external actors to facilitate the knowledge transfer and the combination with the firm's prior knowledge base through an external knowledge searching depth process (Chen et al., 2011). For example, Jensen et al. (2007) find that tacit knowledge and know-how is transferred through closer interaction with external actors outside the organizations. In addition, based on the arguments of Kim & Kogut (1996), the knowledge platform is useful for establishing knowledge-relatedness, one of the key elements in affecting the knowledge transfer of firms. Knowledge is more likely to be transferred between firms with similar skills and backgrounds. When the knowledge-relatedness between individual firms is high, the knowledge transfer is accelerated by

adaptive and local search with respect to the technological trajectory (Nelson and Winter, 1977, 1982; Dosi, 1982). Lane & Lubakin (1998) examined whether similarities in organizational practices and in knowledge influence the external knowledge search using R&D alliance data and suggest that knowledge-relatedness facilitates knowledge identification and absorption. Todorova & Durisin (2007) also suggest that PACAP serves the firm's cognitive schemas and allows firms to create patterns of interaction and fosters mutual understanding between collaborators (Chen et al., 2013; Ferreras-Méndez et al., 2015). Thus, the higher PACAP, the more the search activities that are related to partner firms in the same technological sector are strengthened to solidify the firms' established technological sector. Accordingly, increasing the level of PACAP allows firms to increase their exploitative search activities. Consequently, these activities lead to a deeper understanding of the existing technology fields.

Although an emphasis on PACAP can be linked to the firm's effective external knowledge searching, I posit that the positive effect of PACAP on external knowledge search strategy may decline after it reaches a certain point for two key reasons: First, firms that have a high level of PACAP are more likely to get stuck in the "trade-off to be made between the opportunity of novelty value and the risk of misunderstanding" (Nooteboom et al., 2007: p.1030). Theoretically, PACAP enables firms to identify and acquire external knowledge sources through collaborations such as M&A and alliances (Zahra & George, 2002). Meanwhile, as a firm's PACAP increases, the firm might expand its cognitive distance further afield to find novel knowledge (Wales et al., 2013). In other

words, for firms with high levels of PACAP, cognitive distance allows finding external technological opportunities for combination and recombination of complementary resources using novel knowledge (Nooteboom et al., 2007). However, beyond a certain point, the cognitive distance becomes large enough to preclude a sufficient search strategy for external knowledge sources. For example, Nooteboom et al. (2007) find that while absorptive capacity increases the level of novel value, excessive absorptive capacity reduces the effect of cognitive distance on novelty. They suggest that moderate levels of distance allow firms to search efficiently for external knowledge sources which have novel value, but are not so distant as to preclude mutual understanding (Nooteboom et al., 2007). Accordingly, high levels of PACAP are likely to restrict the efficiency of the firm's external knowledge search strategy.

Second, bounded rationality (Simon, 1947) related to knowledge overload is likely to hamper the efficiency of the external knowledge search strategy. Based on the law of diminishing marginal returns (Karr-Wisniewski & Lu, 2010), I suggest that knowledge overload is a condition that occurs at the level at which a marginal addition of new or complementary technological knowledge reaches the level of diminishing marginal returns. According to the notion of Zahra & George (2002), the firm's level of PACAP is determined by the level of its exposure to complementary knowledge from external actors. Thus, a high level of firm's PACAP is characterized by a knowledge overload within the firm. Simon (2008: p.893) defined bounded rationality as "designate rational choice that takes into account the cognitive limitations of the decision-maker limitations of both

knowledge and computational capacity". In an internal knowledge overload situations, bounded rationality is likely to prevail. In other words, firms with a high level of PACAP tend to search external knowledge at a satisficing level rather than at the optimal level (Simon, 1947). Thus, this knowledge overload situation results in firms decreasing the decision-making for external knowledge searching (O'Reilly, 1980; Karr-Wisniewski & Lu, 2010). Recently, based on a meta-analysis in terms of information overload like knowledge overload, Eppler & Mengis (2004) find a potential negative effect of information overload on the firm's external search strategy. Accordingly, a high level of PACAP is likely to decline the efficiency of the firm's external knowledge search strategy.

In summary, prior research has provided a reason to expect that the firm's PACAP, one of the firm's endogenous factor, is linked closely to the firm's external knowledge search strategy. The positive role of PACAP in strengthening the firm's ability to identify and recognize external valuable knowledge widely increases the level of knowledge transfer among industries or sectors. This allows the firm to incorporate knowledge from a broad range of fields in its innovation process. However, increasing the level of PACAP beyond a certain point will weaken the relationship between PACAP and the search strategy breadth for external knowledge. Thus, I propose the following hypothesis:

Hypothesis 1a. A firm's potential absorptive capacity will show a curvilinear relationship with its external knowledge search breadth.

Similar to the logic described above, I also hypothesize an effect of PACAP on the firm's external knowledge search depth. Firms with a low level of PACAP find it difficult to identify and recognize the most promising external knowledge and cannot choose a technology field deeply. With increasing levels of PACAP, the improved ability to connect and interact with external actors allows the firms to concentrate on the most suitable and promising knowledge. At the same time, increasing PACAP also increases the effects of negative influences of cognitive distance and bounded rationality. Together, this positive and negative effects on external knowledge search depth lead to the following hypothesis:

Hypothesis 1b. A firm's potential absorptive capacity will show a curvilinear relationship with its external knowledge search depth.

3.2.2 External knowledge search strategies, PACAP, and appropriability regime

Before identifying and assimilating external knowledge through the innovation process, firms must carefully evaluate the efficacy and efficiency of the appropriability regime in their industry (Teece, 1986; Drechsler & Natter, 2012). The efficacy of the appropriability regime depends on the strength of institutional protection mechanisms such as legal protection for patents (Teece, 1986). In addition, the efficiency of the appropriability regime depends on the nature of firms' knowledge (e.g. explicit and tacit)

(Frishammar et al., 2015). In particular, prior research suggests that a high perceived degree of effectiveness (efficacy and efficiency) of the appropriability regime actively influences the relationship between PACAP and external knowledge search strategies (Drechsler & Natter, 2012). Acquiring knowledge from external firms usually involves explicit contracts and patents, which give stronger opportunities for technology exploration (West & Bogers, 2014). Performing an analysis on a sample of start-up ventures, Dushnitsky & Shaver (2009) find that the effectiveness of external knowledge acquisition through contracts and patents is associated with the strength of the appropriability regime. They also suggest that the strength of the appropriability regime as an environmental factor (Teece, 1986) is related to the nature of absorptive capacity such as knowledge-relatedness.

The appropriability regime as an environmental factor plays several roles in the relationship between PACAP and external knowledge search strategy. First, the appropriability regime is related to the flows and pools of external knowledge that can be efficiently used by focal firms. Under a strong appropriability regime, firms tend to not only patent their valuable knowledge and information actively (Escribano et al., 2009) but also increase their patent's claims to protect potential revenue streams arising out of their product and process innovation (Xu et al., 2012). These patents contribute to generating comprehensive and accessible external knowledge sources of valuable scientific and technologic information (Granstrand, 1999). Accordingly, in a strong appropriability regime, the amount and quality of external knowledge sources flow that focal firms can

use is greater in knowledge market environments. Thus, firm's patenting aims at extending the pool of explicit knowledge transfer through knowledge licensing within the industry (Granstrand, 1999). Additionally, a firm's increasing propensity to patent its innovations result in an increased diversity of explicit knowledge and technology opportunities.

Second, the appropriability regime is related to firm's decision on conducting collaboration with external actors for identification and acquisition of external knowledge sources. For instance, transaction cost theory suggests that appropriability problem can be hampered the efficient market for technology (Arrow, 1962; Williamson, 1985; Kim, 2009). Following Arrow's description (1962), the appropriability problem refers to the possibility to use the external knowledge without paying for it. Because of this appropriability concerns, a firm will be reluctant to grant access their own core technology. Thus, in a weak appropriability regime, the collaboration for accessing external knowledge is curtailed. By contrast, a strong appropriability regime can be considered as the remedy for the appropriability problem in the market for technology (Cohen et al., 2002; Kim, 2009). According to transaction cost theory (Williamson, 1985), a strong appropriability regime reduces the risk of unintended knowledge spillover, uncertainties about the future value creation and capture, and transaction costs involved in knowledge transfer through collaboration (Baughn et al., 1997; Ritala & Hurmelinna-Laukkanen, 2013; Kim, 2009). Accordingly, the strength of the appropriability regime would affect the firm's decisions related to external knowledge identification and

acquisition.

At each level of PACAP, firms operating under a stronger appropriability regime will search for external knowledge with a broader and deeper scope, taking advantage of the increasingly diverse knowledge and opportunities offered by their increased patenting activities. In other words, an increasing strength of the appropriability regime shifts the curve depicting the relationship between PACAP and external knowledge search breadth and depth upwards. This leads to the following hypothesis:

Hypothesis 2a. The strength of the appropriability regime positively moderates the curvilinear relationship between potential absorptive capacity and external knowledge search breadth.

Hypothesis 2b. The strength of the appropriability regime positively moderates the curvilinear relationship between potential absorptive capacity and external knowledge search depth.

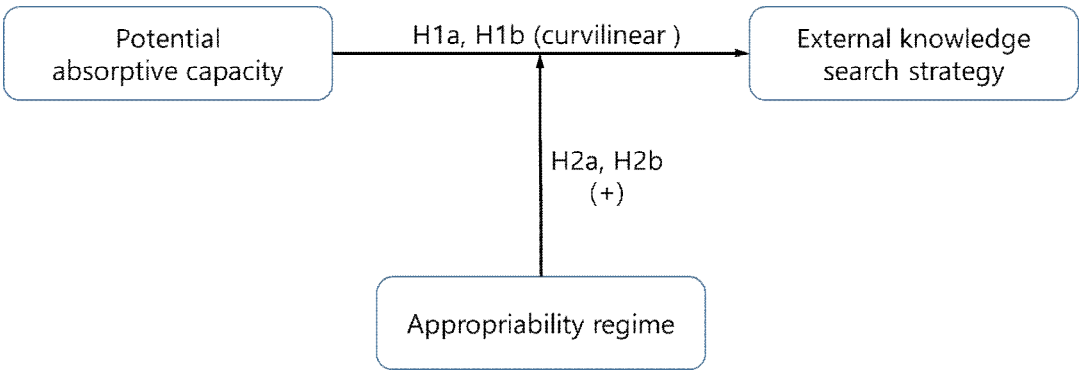

Figure 4. Conceptual model for Chapter 3

3.3 Methods

3.3.1 Data

For the empirical analysis, a panel dataset containing patent and financial information of 170 international firms from various industries and covering the time period from 2005 to 2009 was compiled. Such a panel dataset is suitable to address the dynamic effects of the searching strategic changes. To prevent a potential bias problem, sample firms were chosen from 78 different industries based on the Standard Industrial Classification (SIC) 4-digit code. This research defines the innovation-related search activities of the sample firms using data on granted US patents. As a mean of protecting intellectual properties, patents are widely used in studies analyzing the innovative performances of firms. Additionally, US patents provide detailed information in the form of patent classes that allow researchers to identify links between patents and technological fields (Trajtenberg et al., 1997). Considering the time lag between the R&D activities and the time a patent is actually granted, I based the analysis on the application year of the patent. I collected information on the 61,888 patents which were applied for from 2005 to 2009 and which were ultimately granted to the firms in my sample. I also retrieved information on the 280,031 patents which were granted to 3,744 external partners of the sample firms. The data was obtained from the patent databases provided by the United States Patent and Trademark Office (USPTO). For measuring financial indexes such as the firms' R&D intensity and total sales, I used the Compustat database provided by Standard & Poors

and the Datastream database provided by Thomson Reuters. Furthermore, I gathered information on the M&A and alliance deals of the sample firms during the past seven years from the Securities Data Company (SDC) Platinum database provided by Thomson Reuters. A total of 4,010 M&A deals and 509 alliance deals were used to calculate the sample firms' external knowledge sourcing activities.

3.3.2 Variables

3.3.2.1 Dependent variables

External search is inherently linked with the search for and use of new technological knowledge as well as technological fields from outside the organization. Accessing ideas and knowledge of new technological fields from the external partners could be considered as an exploring activity to enlarge the firm's technological boundaries. In contrast, searching external partner's knowledge in technological fields in which the firm possesses prior experience is closer to exploiting activity aiming at understanding knowledge in-depth. In other words, the firm's intentions for its external knowledge search strategies through external partners could be reflected in how many external partners have similar knowledge compared to the focal firm. If the external partners have little common knowledge with the focal firm, it could be argued that the focal firm's external knowledge search strategies are designed to source knowledge to broaden its technological boundaries. Therefore, to identify the breadth and depth of external

knowledge search, I compared the patents of the focal firms and of their external knowledge sources such as alliance partners and organizations acquired by the focal firms. At first, I retrieved the USPC main class of the external partners' granted patents before the alliance or M&A deal event occurred. I then identified the number of the external partner's patents that were not classified into the USPC main classes where patents were also granted to the focal firms. Finally, I calculated the external knowledge search breadth through the total number of patents classified into new technological fields to the focal firms and granted to external partners until one year prior to the deal event year. I only considered the deal events occurring in the two years after the specific year (t ~ t+2) to measure the firm's strategic response to the PACAP and the appropriability regime. Another aspect of firm's external searching activity is the degree of knowledge exploitation from already familiar technological fields during the R&D process. The level of knowledge overlap between focal firms and their external partners is related to the focal firms' strategic intentions of in-depth understanding of the particular technologic fields. To calculate to what extent firms focus on specific technologies, I measured the total number of partner firm's patents which were classified into the technologic fields where the focal firms registered the most patents. Then, I divided them by the total number of the focal firm's patents. In doing so, I calculated the external knowledge search depth. Finally, I used the log scale to normalize both dependent variables.

3.3.2.2 Independent variables

3.3.2.2.1 Potential absorptive capacity (PACAP)

According to Zahra & George (2002), firm's exposure to knowledge from external sources, including acquisitions and inter-organizational relationships such as alliances and joint ventures, would influence strategic decision making as well as the development of future capabilities. Identifying and acquiring knowledge from different external sources significantly influences the constitution of the subsequent acquisition and assimilation capabilities (Zahra & George, 2002). In this sense, Zahra & George (2002) concluded that the firm's level of PACAP is determined by the level of its exposure to complementary knowledge from external sources. By adopting the concepts of Zahra & George (2002), I measured the firm's PACAP through the level of exposure to complementary knowledge. First, I identified the patents granted to the sample firms' and their external sources which have entered contracts with sample firms or were acquired by the sample firms in the time period of year t-3 to year t-1. Specifically, I considered patents that were applied for until year t-1 and were ultimately granted to the firms. I then classified the patent classes into 36 technological subcategories (Hall et al., 2001) to compare the knowledge overlap between the sample firms and their external sources. Last, I calculated each firm's PACAP using the following formula, which was suggested by Makri et al. (2010) and is used to measure technological complementarity between organizations.

$$\textbf{Potential Absorptive Capacity (PACAP)} = \frac{Number\ of\ Patent\ with\ Overlapping\ Subcategories}{Total\ Number\ of\ Patents\ (Focal\ Firms\ and\ their\ External\ Sources)} - \frac{Number\ of\ Patent\ with\ Overlapping\ All\ Patent\ Classes}{Total\ Number\ of\ Patents\ (Focal\ Firms\ and\ their\ External\ Sources)} \times \frac{Total\ Number\ of\ Focal\ Firm's\ Patents\ in\ Common\ Subcategories}{Total\ Number\ of\ Patents\ (Focal\ Firm)}$$

…Eq. (3-1)

3.3.2.2.2 Appropriability regime

Firms in an industry are facing the same environment to protect their innovation outcomes (Hurmelinna-Laukkanen & Puumalainen 2007). The different tendency for protecting R&D outcomes in each industry leads to firms pursuing legal protection of their innovations to different degrees (Amara et al. 2008). Firms within an industry which more heavily focuses on the protection of their intellectual property rights, will apply for more patents (Teece 1986). This research uses the efforts of firms to protect their innovation through patents as an indicator for the strength of the appropriability regime they operate in. Recently, Kim & Vonortas (2006) defined patent-intensity as a proxy of the strength of the intellectual property protection. Following the study of Kim & Vonortas (2006), I calculated appropriability regime using the patent-intensity of the industry. Thus, I counted the number of patents granted to the focal firm in the year 2009. Then, I divided this number by the R&D expenditures of the industry of firm i in the year 2007.

3.3.2.3 Control variables

3.3.2.3.1 Firm size

The size of a firm can affect the level of its innovation activities such as the level of sourcing external knowledge. For example, small ventures in high-tech industries usually aim at explorative innovation while incumbent large firm focuses on their core activities for exploitative R&D projects. Therefore, I controlled for different firm sizes using the total sales of the sample firms in the year t. The variable was log-transformed.

3.3.2.3.2 R&D intensity

As external knowledge is considered to be a key factor of open innovation, R&D investments facilitate not only learning by doing but also allow to hire external specialists for internalizing and understanding external knowledge which results in enhancing the firm's internal knowledge bases (Cohen & Levinthal, 1990; George et al., 2001). Additionally, the expenditures related to R&D activities reflect reproducing existing knowledge as well as acquiring new knowledge to deal with changes in the external environment. Therefore, I controlled for the firm's R&D activities through the R&D intensity variable, which is defined as R&D expenses over sales in year t.

3.3.2.3.3 Current R&D capacity

Not only the past successful innovation experiences but also the current abilities of the firm's R&D could affect the external knowledge search strategies. To control for the effects of the firms' most recent R&D activities on the level of external knowledge searching activities via external partners, I included this control variable defined as the number of each firm's patent applications in the year t-1.

3.3.2.3.4 Past innovation experiences

The experience of successfully conducting R&D projects allows firms to understand the most efficient way of pursuing R&D and aids the knowledge searching process. Consequently, such experiences enhance firm's development capabilities and increase the possibility of discovering the necessary knowledge from the firm's external partners. Therefore, this research included the firm's innovation experience, defined as the total number of granted patents for each firm until the t-1 year, as a control variable.

3.3.2.3.5 Technological diversity

Some firms narrowly focus on particular technological fields while other firms are involved in a broad range of technologies. From the view of organizational inertia, a firm's tendency of either focusing on few particular technologies or breaking into various

technological fields would influence the firm's further external knowledge search strategies. To control for each firm's technological diversity, I identified the firm's patents which were granted until year t-1 and calculated the diversity index based on the following equation:

$$\text{Technological diversity} = \sum_{i}^{k} f_i * \ln(1/f_i) \quad \text{Eq. (3-2)}$$

where f_i represents the proportion of patent in the ith patent class and k represents the entire number of patent classes.

3.3.2.3.6 M&A, Alliance experiences

As technology becomes more complex, firms tend to adopt open innovation strategies, i.e., sourcing external knowledge rather than conducting the entire R&D internally, to increase the efficiency of their R&D processes (Chesbrough, 2003). Especially alliances and M&A deals are considered as effective means of sourcing codified as well as tacit knowledge. Because alliance and M&A deal frequently occur when firms are entering new technologic fields, I controlled for these activities that influence the firms' external knowledge search strategies. I defined the two experience variables as the number of alliance and M&A deals of each firm during the five years before the year t.

3.3.2.3.7 Sectoral dummy

To control for any differences between the various industries sectors comprising my data sample, this research included sectoral dummy variables in my regression model. Seven dummy variables were coded based on the first digit of the SIC codes of the sample firms.

3.3.3 Empirical model specification

For the tests of my suggested hypotheses, I used panel regression analysis. To begin with, I conducted a Hausman test to determine whether the fixed-effect or the random-effect model is more suitable for my analysis. The results of the Hausman test suggest that the random-effect model is appropriate. Therefore, I employed a random-effect generalized least square (GLS) regression analysis for the analysis of dependent variables, external knowledge search breadth and depth.

3.4 Results

Before testing my hypotheses, I prepared the descriptive statistics and analyzed the correlations between the variables in Table 1. Table 1 shows that the relationship between external knowledge search breadth and external knowledge search depth seems to be correlated, but is actually insignificant. I found a correlation between firm size and the firm's current R&D capacity, past innovation experience and technological diversity. This can be explained by the ability of larger firms to invest more resources into their R&D processes.

Tables 3 and 4 show the results of the empirical testing of the suggested hypotheses. The dependent variables in Model 1 to Model 5 are external knowledge search breadth in Table 3 and external knowledge search depth in Table 4. Among these models, Model 1 is the base model and contains only the control variables, and Model 5 is the full model that contains the entire variables including the interaction terms. Model 5 in Table 3 shows that the current R&D capacity has a significant negative relationship and past innovation experience a significant positive relationship with the firm's external knowledge search breadth. These results indicate that an enhanced current R&D capacity discourages the firm to search more broadly for external knowledge, i.e., the larger the current R&D capacity, the better it is to understand external knowledge from various fields. Meanwhile, a firm's past innovation experience has a positive impact on external knowledge search breadth. In other words, the scope of the external knowledge search by a firm could be

positively affected by past experiences while being negatively affected by current capacity. Additionally, I conducted a Variance Inflation Factor (VIF) test to address possibilities of multicollinearity between the independent and control variables. The results of the VIF test are shown in Table 2. The mean value of the VIFs is 2.01 and the maximum value is 3.62, indicating that no problems with multicollinearity exist in my dataset.

Table 1. Descriptive statistics and pairwise correlations

	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11
1. External knowledge search breadth[1]	2.22	2.69	0	10.04	1										
2. External knowledge search depth[1]	2.16	2.62	0	10.38	.694	1									
3. PACAP	0	1	-1.02	3.83	.136**	.100**	1								
4. Appropriability regime	0	1	-4.79	5.34	-.009	-.132**	.011	1							
5. Firm size[1]	7.62	1.97	.91	12.45	.096**	.339*	.093**	-.294*	1						
6. R&D intensity	.16	.34	.001	4.72	.029	-.012	-.025	-.021	-.397	1					
7. Current R&D capacity	3.23	1.46	0	6.91	.027	.288*	.026	-.081**	.522*	-.081	1				
8. Past innovation experience	5.91	1.48	2.20	9.48	-.038	.372*	-.081**	-.254**	.657*	-.168	.742**	1			
9. Technological diversity	2.53	.86	0.46	4.66	.023	.295*	.070**	-.202	.579**	-.282	.322*	.627	1		
10. M&A experience	8.60	9.01	0	60	.119	.230*	.124*	-.078*	.525	-.166*	.257	.308*	.303**	1	
11. Alliance experience	1.19	2.67	0	21	.078**	.185	.030**	-.188**	.280*	.174*	.235	.219	.005	.098**	1

Note: n=170. [1]Transposed to log scale. Sectoral dummy variables were excluded. ***p<0.01;**p<0.05; *p<0.1;

Table 2. Results of the Variance Inflation Factor (VIF) test

Variable	VIF	1/VIF
PACAP	1.08	0.9218
Appropriability regime	2.72	0.3671
Firm size	2.49	0.4017
R&D intensity	1.15	0.8694
Current R&D capacity	3.62	0.2763
Past innovation experience	2.45	0.4089
Technological diversity	1.86	0.5376
M&A experience	1.51	0.6607
Alliance experience	1.21	0.8288
Mean	2.01	0.5858

Table 3. Results for the random-effect of generalized least square regression model

Dependent variable (External knowledge search breadth)	Model 1	Model 2	Model 3	Model 4	Model 5
Control Variables					
Firm size	.037 (.122)	.020 (.121)	.015 (.121)	.036 (.122)	.024 (.120)
R&D intensity	-0.011 (.075)	-.0224 (.075)	-.0368 (.075)	-.0101 (.075)	-.0316 (.074)
Current R&D capacity	.0015 (.0012)	.0012 (.0012)	.0011 (.0012)	-.0016 (.0018)	-.0031* (.0018)
Past innovation experience	.00009 (.0001)	.0001 (.0001)	.0001 (.0001)	.0001 (.0001)	.0002** (.0001)
Technological diversity	-.1930 (.269)	-.2542 (.268)	-.2741 (.267)	-.2016 (.269)	-.3273 (.266)
M&A experience	-.0055 (.0190)	-.0108 (.0189)	-.0162 (.0190)	-.0072 (.0190)	-.0193 (.0189)
Alliance experience	.0033 (.0504)	.0061 (.0500)	.0032 (.0499)	-.0024 (.0504)	-.0072 (.0497)
Sectoral dummy			*Included*		
_Cons	.918 (1.748)	.6971 (1.732)	.6316 (1.731)	1.136 (1.751)	1.165 (1.725)
Independent Variables					
PACAP		1.7788** (.548)	5.799*** (1.486)		4.247** (1.665)
$PACAP^2$			-7.008** (2.408)		-4.8980* (2.696)
Appropriability regime (AR)				.5039** (.2232)	.1641 (.2756)
PACAP × AR					4.4801** (2.106)
$PACAP^2$ × AR					-6.744* (3.823)
Observations	850	850	850	850	850
Adjusted R-square	.044	.060	.067	.039	.074
Number of firms	170	170	170	170	170

Note: Standard errors in parentheses. ***p<0.001; **p<0.05; *p<0.1;

Table 4. Results for the random-effect of generalized least square regression model

Dependent variable (External knowledge search depth)	Model 1	Model 2	Model 3	Model 4	Model 5
Control Variables					
Firm size	-.0065 (.026)	-.0080 (.026)	-.0085 (.026)	-.0065 (.026)	-.0090 (.027)
R&D intensity	-.0048 (.017)	-.0058 (.017)	-.0080 (.017)	-.0047 (.017)	-.0082 (.017)
Current R&D capacity	-.00003 (.0002)	-.00005 (.0002)	-.000008 (.0002)	-.00002 (.0004)	-.00009 (.0004)
Past innovation experience	-.000004 (.00002)	.0000007 (.00002)	.000003 (.00002)	-.000004 (.00002)	.000003 (.00002)
Technological diversity	-.0265 (.0582)	-.0327 (.0584)	-.0358 (.0585)	-.0265 (.0583)	-.0337 (.0590)
M&A experience	-.0018 (.0043)	-.0023 (.0043)	-.0031 (.0043)	-.0018 (.0043)	-.0031 (.0044)
Alliance experience	.0076 (.0112)	.0079 (.0112)	.0075 (.0113)	.0076 (.0113)	.0076 (.0113)
Sectoral dummy			*Included*		
_Cons	.1454 (.3746)	.1237 (.3752)	.1130 (.3760)	.1449 (.3759)	.0978 (.3802)
Independent Variables					
PACAP		.1710 (.1283)	.7633** (.3494)		.8629** (.3945)
$PACAP^2$			-1.037* (.5696)		-1.143* (.6420)
Appropriability regime (AR)				-.0013 (.0504)	.0301 (.0640)
PACAP × AR					-.2150 (.5000)
$PACAP^2$ × AR					.2477 (.9108)
Observations	850	850	850	850	850
Adjusted R-square	.011	.014	.016	.011	.016
Number of firms	170	170	170	170	170

Note: Standard errors in parentheses. ***p<0.001; **p<0.05; *p<0.1;

To test the curvilinear relationship between PACAP and external knowledge search breadth, I included only the first order term of PACAP in Model 2 and included both the first order and the second order (square) term of PACAP in Model 3. Model 2, Model 3 and Model 5 in Table 3 show that the first order term of PACAP is positively significant. Moreover, the results of Model 3 and Model 5 indicate that the square term of PACAP was negatively significant (-7.008 and -4.8980, respectively) with the firm's external knowledge search breadth. Additionally, Figure 5 displays the curvilinear relationship between PACAP and external knowledge search breadth. The empirical results provide support for Hypothesis 1a of this research. Increasing the level of PACAP in firms causes facilitation of external knowledge search breadth. Beyond a certain level of PACAP, however, an excessive level of PACAP hampers the increase of external knowledge search breadth.

Likewise, Model 2, Model 3 and Model 5 in Table 4 indicate that the first order term of PACAP was positively significant. Model 3 and Model 5 confirm that the square term of the PACAP was negatively significant (-1.037 and -1.143, respectively) with the level of external knowledge search depth. The resulting curvilinear relationship is plotted in Figure 6. The empirical results provide support for my Hypothesis H1a and H1b. Increasing the level of PACAP causes facilitation of both external knowledge search breadth and external knowledge search depth. Beyond a certain level of PACAP, however, an excessive level of PACAP hampers the increase of both external knowledge search breadth and external knowledge search depth.

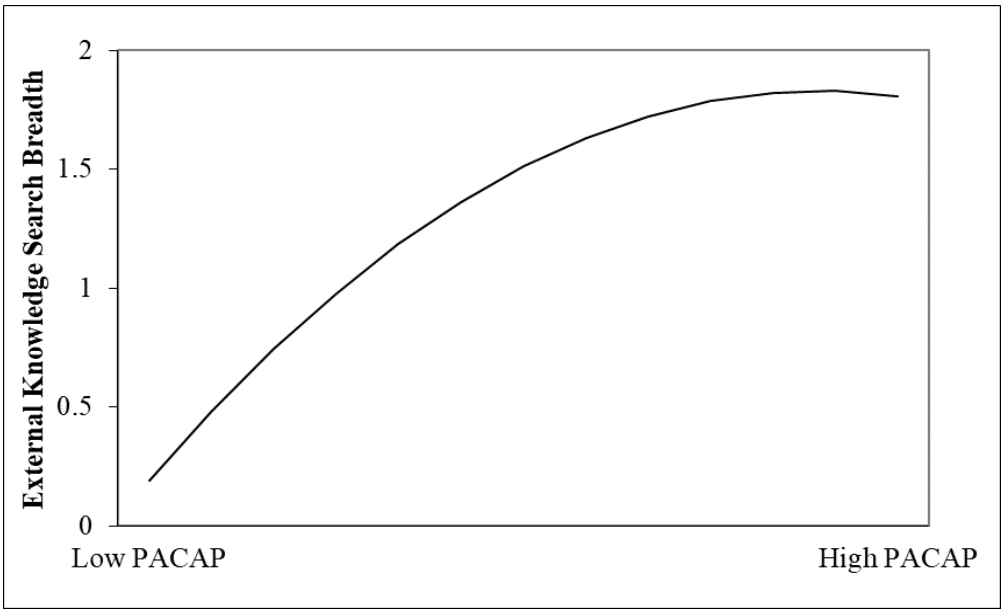

Figure 5. The relationship between PACAP and external knowledge search breadth.

Low and high are one standard deviation below/above the mean value

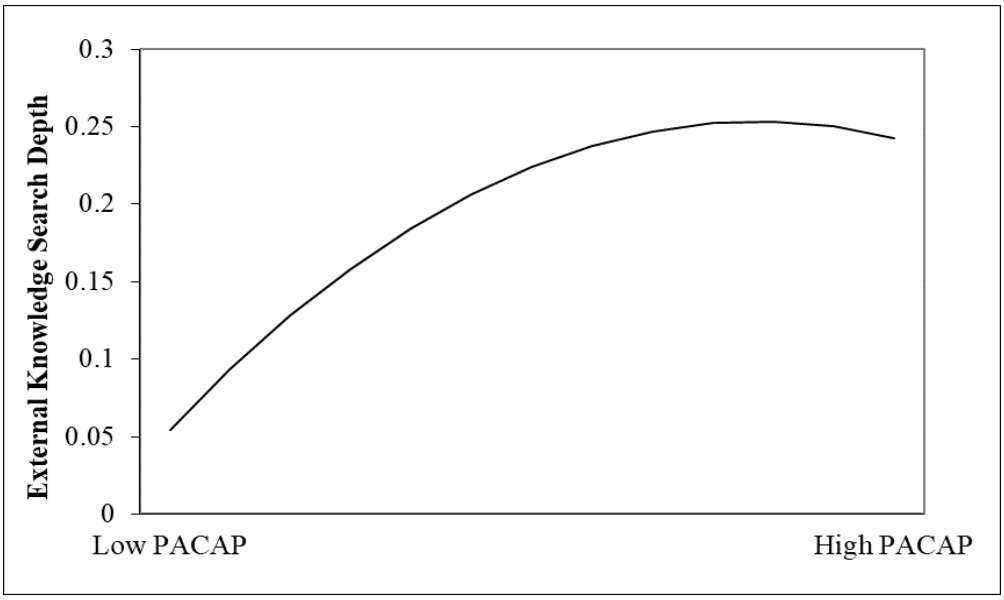

Figure 6. The relationship between PACAP and external knowledge search depth.

Low and high are one standard deviation below/above the mean value

Next, I included the interaction terms of both first order and square term of PACAP and appropriability regime in my models. The quadratic main effect (X) and the linear moderation effect (Z) can be expressed using the following formula:

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 Z + +\beta_4 XZ + \beta_5 X^2 Z + \epsilon \quad \text{Eq. (3-3)}$$

Prior to testing the moderating effect of the appropriability regime proposed in Hypothesis 2a and 2b, I conducted F-test between the complete model and a model without the XZ and X^2Z terms to test whether the appropriability regime moderates the relationship between PACAP and external knowledge search breadth and depth (Dawson, 2014). Based on the tests of coefficients β_4 and β_5, I confirmed that the moderation effect of the appropriability regime on the relationship between PACAP and external knowledge search breadth is statistically significant (p-value<0.001).

Model 5 in Table 3 indicates that the coefficient of the square term of PACAP is negatively significant (-7.008) while the moderating coefficient affecting the square term of PACAP is negatively significant (-6.744). This shows that the curvilinear relationship between PACAP and external knowledge search breadth is steepened with an increase in the strength of the appropriability regime (Aiken & West, 1991; Haans et al., 2016). Figure 7 shows that in accordance with the level of the appropriability regime, the relationship between PACAP and external knowledge search breadth exhibits an inverted U-shape. As the level of appropriability regime increases, the relationship curve is pushed upwards and steepened through the moderation effect. This shows that the relationship

between PACAP and external knowledge search breadth is positively moderated (steepened) through a moderation effect of the appropriability regime. This supports Hypothesis 2a of this study. However, Model 5 in Table 4 indicates that the square term of PACAP is negative and significant (-1.143) while the interaction term between the square term of PACAP and appropriability regime is not statistically significant (0.2477). These results indicate that my suggested Hypothesis 2b is not supported.

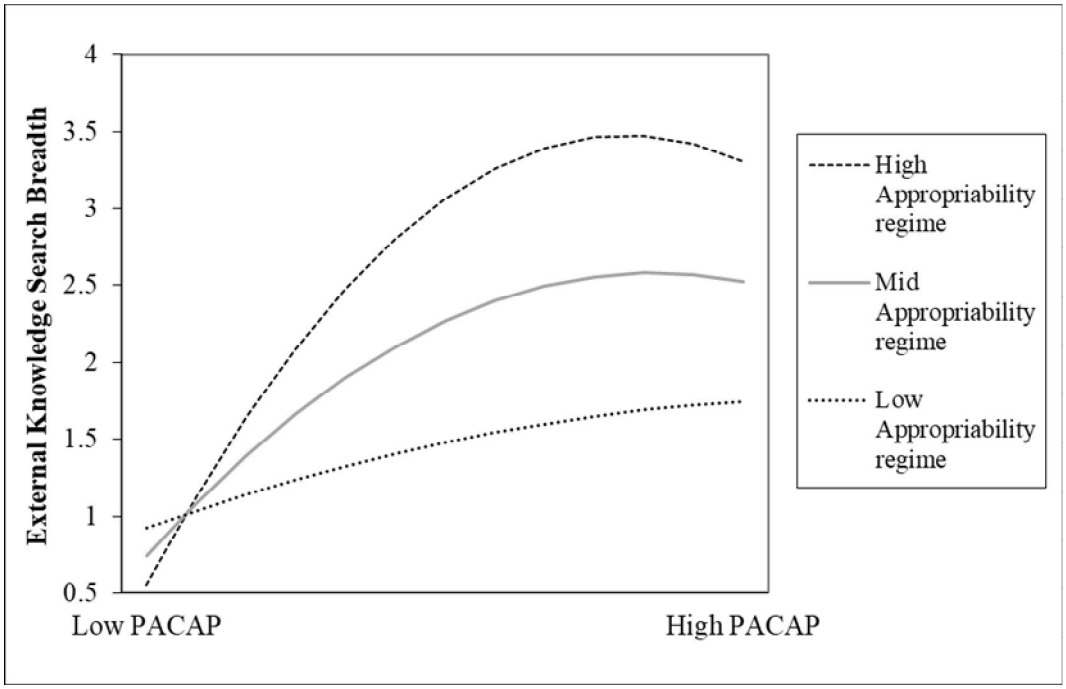

Figure 7. The moderation effect of appropriability regime on the relationship between PACAP and external knowledge search breadth. Low and high are one standard deviation below/above the mean value (mid)

3.5 Discussion

The purpose of this study is to uncover the relationship between a firm's level of PACAP and its search strategy for external knowledge during the innovation process. In addition, I confirmed the moderating effects of the appropriability regime, one of the major factors in planning and executing search activities for external knowledge sourcing, on the relationship between PACAP and external knowledge search strategy.

The results of this study advance the prior theoretical literature, especially literature on the endogenous and exogenous factors related to external knowledge search strategy, in several ways. First, these results show that PACAP has a curvilinear relationship with external knowledge search breadth and depth. This implies that there are positive returns to PACAP, but beyond a certain level, it becomes detrimental to external knowledge search breadth. These findings support the theoretical propositions from prior literature that high level of PACAP in external knowledge searching activities may be associated with the trade-off to be made between cognitive distance and bounded rationality (Nooteboom et al., 2007; Simon, 2008) for identifying and acquiring external knowledge, thereby diminishing external knowledge search breadth. On the one hand, PACAP allows firms to have the cognitive capability to assess the firm's own knowledge assets, and the incentive to search broader and deeper knowledge resources in terms of economies of scope and scale (Rodríguez-Duarte et al., 2007). On the other hand, high levels of PACAP increase the cognitive distance for external knowledge search breadth and depth. This

might increase the novelty of broader knowledge resources, but it also reduces the benefits of mutual understanding (Nooteboom et al., 2007; Wales et al., 2013). In addition, for firms with limited time and attention, bounded rationality allows arriving at restricted satisfactory searching rather than ones that are wider to all others in every dimension (March and Simon, 1958; Haas, 2006). In other words, based on the bounded rationality perspective (Simon, 1997), high levels of PACAP are more likely to decrease the efficiency of decision-making for the external knowledge breadth and depth. Accordingly, these results show that PACAP is directly linked to a firm's external knowledge search breadth and depth, and accelerates the firm's absorption of external knowledge through the innovation process. These results further show that a high level of PACAP reduces this acceleration of firms' absorption in terms of external knowledge search breadth and depth. In conclusion, these results confirm PACAP as one of the major factors that heavily influence firm's search activities for external knowledge sources.

Second, these results on the moderating effect of the appropriability regime have been partially supported. The strength of the appropriability regime positively moderates the relationship between PACAP and external knowledge search breadth. This finding supports the theoretical proposition of prior literature that the strength of the appropriability regime enhances not only the external knowledge flows of firms by increasing patenting and patent's claims (Escribano et al., 2009; Xu et al., 2012) but also the collaboration for searching external knowledge sources (Ritala & Hurmelinna-Laukkanen, 2013; Kim, 2009). In order words, this seems to indicate that the search for

various knowledge sources increases as the environment in which a firm operates can better secure an appropriation of the innovation outcomes. This is because a strong appropriability regime not only decreases fear about the imitative behaviors of external competitors (Teece, 2002) but also creates confidence in the possibility of building an external environment where firms can be assured to be rewarded for their innovative activities (Chesbrough, 2006). Accordingly, the tendency of search activities for external knowledge breadth increases with an increase in the firm's PACAP and is further increased by a strengthened appropriability regime. This result confirms the appropriability regime as one of the major factors that affect search activities for external knowledge sources depending on the level of a firm's PACAP. On the other hand, my results provide no support for a moderation effect of the appropriability regime on the relationship between PACAP and external knowledge search depth. Knowledge identification and absorption through a deep connection with external actors are not significantly associated with the strength of the appropriability regime of the industry. In summary, while the tendency of search activities for external knowledge breadth increases with an increase in the firm's PACAP and is further increased by a strengthened appropriability regime, the search activities for external knowledge depth showed no such effects. This result partially confirms the appropriability regime as one of the major factors that affect search activities for external knowledge sources depending on the level of a firm's PACAP.

Chapter 4. The contingent factors related to unrelated technological diversification

4.1 Introduction

Technology as a valuable resource has received increasing attention from studies in strategic management and the knowledge-based innovation sector, especially with the emergence of the concept of the knowledge-based economy. Consequently, innovative firms and industries have started to recognize the importance of a technological diversification strategy through searching and achieving new technologies as an important driving force for sustaining competitive advantage and realizing organizational growth (Granstrand, 1998; Suzuki & Kodama, 2004; Garcia-Vega, 2006; Chen et al., 2013; Kim et al., 2016).

In terms of a boundary spanning perspective of the firm's prior knowledge base, technological diversification can be distinguished into related and unrelated diversification. According to the notion of Kim et al. (2016), related technological diversification refers to extending the firm's technological boundaries around adjacent technological fields, whereas unrelated technological diversification refers to allocating technological resources across a wide range of technological fields. In order to cope with the accelerating technology obsolescence and fragmented market needs, shortening of product life cycles, and the need to overcome the capital market failure (Teece, 1982), it

is necessary for firms to adopt unrelated technological diversification. This is accomplished through expanding the numbers of technology options and integrating different kinds of knowledge (Subramaniam & Youndt, 2005; Lin & Chang, 2015; Andrés et al., 2017). Ng (2007) argues that because of path-dependence and the narrow scope of Penrose's logic of synergies, related technological diversification does not fully consider or control for these situations (Palich et al., 2000; Teece, 1982). Thus, the merits of unrelated technological diversification may play more important roles in achieving firm's innovation performance, especially in the knowledge-based economy. In addition, the relationship between unrelated technological diversification and the firm's innovation performance is an issue of considerable interest to managers and academics within the fields of knowledge management and operational strategy (Nyaingirl & Ogollah, 2015).

Despite the prevalence of studies about the effect of overall technological diversification on firms' performance, a universally accepted theory and explanation of the benefits of unrelated technological diversification has not been developed (Leontiades, 1980; Peng et al., 2005; Dhir & Dhir, 2015). Generally, based on Penrose's (1959) resource-based approach, scholars in knowledge management literature tend to accept that related technological diversification is the dominant mode of organizational expansion and generates superior performance than unrelated technological diversification (Montgomery & Wernerfelt, 1988; Palich et al., 2000; Teece et al., 1994). In addition, some scholars have suggested that due to biases in data (Villalonga, 2004), methodological issues (Campa & Kedia, 2002), and exclusion of moderating factors

(Andrés et al., 2017), the theory and mechanisms of unrelated technological diversification have not been well established.

This study aims to contribute to the knowledge management literature by addressing the lacuna on this issue. First, I investigate the relationship between unrelated technological diversification and the firm's innovation performance. Prior studies generally examined the effects of overall technological diversification on the financial-based performance or on firm grow (Chiu et al., 2008; Huang & Chen, 2010; Chen et al., 2013; Lin & Chang, 2015). Recently, Kim et al. (2016) examine the differential effects of related and unrelated technological diversification on firm growth. However, they did not specifically focus on the nature of unrelated technological diversification but decomposed the overall technological diversification. Thus, in order to better reflect the nature and roles of unrelated technological diversification, I investigate whether unrelated technological diversification is beneficial to the firm's innovation performance. Second, I focus my attention on the moderating effects of endogenous and exogenous factors on this relationship at the firm level. Prior studies suggest that unrelated technological diversification is the process of combination and recombination between the firm's prior technology base and external technology within different fields (Huang & Chen, 2010; Chen & Lin, 2013; Kim et al., 2016; Lin & Chang, 2015). Thus, it is helpful to use endogenous and exogenous factors related to technology flow and convergence to investigate the relationship between unrelated technological diversification and innovation performance. Accordingly, in order to obtain a clearer picture of this

relationship, I examine how organizational slack and technological capability as endogenous factors, and technological turbulence as an exogenous factor moderate the relationship between unrelated technological diversification and the firm's innovation performance.

This study makes a number of contributions to the related literature. First, unlike prior studies that focused on the effects of overall technological diversification, I investigate the effects of unrelated technological diversification on firms' innovation performance. This approach extends prior research on technological diversification and helps to fill a gap in knowledge management literature. Second, I include three endogenous and exogenous factors, i.e., organizational slack, technological capability, and technological turbulence. Based on the resource-based view and a contingency approach, this study addresses the appropriate strategic fit to enhance the firm's innovation performance through unrelated technological diversification. Third, in order to focus on the nature of technology, I adopt patent data to measure the dependent and independent variables.

The remainder of this study is organized as follows: In Chapter 4.2, I address the theoretical background and research hypotheses on unrelated technological diversification, organizational slack, technological capability, and technological turbulence. Chapter 4.3 describes the methodology, data set, and variables of this study. Chapter 4.4 presents the empirical results. Chapter 4.5 provides a discussion of the findings.

4.2 Research hypotheses

4.2.1 Unrelated technological diversification and innovation performance

There are two dimensions related to technological diversification: related technological diversification and unrelated technological diversification. While related technological diversification refers to the firm's diversification into adjacent technological fields, unrelated technological diversification refers to firm's diversification into a wide range of technological fields through introducing new technologies in order to improve products or services (Kim et al., 2016). Related technological diversification helps firms achieve economies of scope and production cost savings (Jones & Hill, 1988; Teece, 1982) and allows firms to gain benefits through transaction cost efficiency and prior existing knowledge networks (Hoskisson & Hitt, 1990). It also offers additional benefits from the development and exploitation of core skills of prior adjacent markets (Bettis, 1981). Unrelated technological diversification allows firms to gain benefits from arbitrage opportunities in incomplete markets through the efficiencies of internal capital markets (Ng, 2007). It also lowers the probability of bankruptcy risk of the firm in terms of the employment risk of managers because of imperfectly correlated cash flows of different industries and management entrenchment (Montgomery, 1994; Shleifer & Vishny, 1989). Moreover, unrelated technological diversification helps firms to increase the opportunities for gaining market power through expansion options (Miller, 1973;

Vassolo et al., 2004).

According to the knowledge-based view of the firm (Grant, 1996), unrelated technological diversification is suggested to be beneficial for improving firms' innovation performance. First, unrelated technological diversification increases firms' potential for cross-fertilization between the new technologies and the existing core technologies in order to yield new inventions, new functionalities, and increased product/process performance (Granstrand, 1998; Suzuki & Kodama, 2004). Second, unrelated technological diversification allows firms to alleviate the problem of diminishing marginal returns to R&D investment into existing core technological areas through the allocation of the firms' resources across a wide range of various technological fields (Kim et al., 2016). Third, acquiring diverse external technology resources into the core technological fields, unrelated technological diversification allows firms to not only increase their core-technology competence (Kim et al., 2016) and sustainable competitive advantage but also to enter new industries in order to enlarge the range of applications and increase the revenues derived from the new external technology (Rodríguez-Duarte et al., 2007).

However, excessive unrelated technological diversification would hamper the firm's innovative performance from the perspectives of coordination, communication, and integration costs. First, excessive diversification into unrelated technology fields can be frustrating due to the difficulties associated with coordination of firms' core technology trajectory and communication with experts (Granstrand, 1998; Chen & Yu, 2012; Leten et

al., 2007). Second, by spreading firms' restricted internal resources too thinly across remote technology fields, excessive unrelated technological diversification makes it more difficult for firms to achieve and sustain core technology competence and competitive advantage (Kim et al., 2016). Third, a larger amount of integration costs arises, in particular when firms try to excessively diversify into unrelated technological fields with the novel, emerging technologies that might conflict with the firms' core technology trajectory (Granstrand, 1998; Leten et al., 2007). This leads to the following hypothesis:

Hypothesis 1. The unrelated technological diversification of a firm has a curvilinear relationship with innovation performance.

4.2.2 The moderating roles of organizational slack

In Hypothesis 1, I suggest that there is a curvilinear relationship between unrelated technological diversification and the firm's innovation performance. However, this relationship can be influenced by specific endogenous factors of the firm, e.g., organizational slack. Organizational slack is the cushion of firm-specific resources that allows firms to adapt successfully to internal pressures for adjustment or to external pressures for changes in technologies, markets and policy (Bourgeois, 1981; Lawson, 2001; Huang & Chen, 2010).

Previous studies related to organizational innovation have long supported the notion

that organizational slack allows firms to grow endogenously and achieve innovation performance (Penrose, 1959; Bourgeois, 1981; Singh, 1986; Nohria & Gulati, 1996; Lawson, 2001; Geiger & Cashen, 2002; Voss et al., 2008). First, organizational slack can be used as a cushion against internal and external pressures, and can become a buffer for conflict resolution and downside risk (Tan & Peng, 2003; Lee, 2015). For example, organizational slack buffers the coordination and integration costs of external different technological knowledge across disciplinary frontiers by resolving organizational goal conflicts and reducing internal resources competition among the firm's innovation projects (Tan & Peng, 2003). Through this buffering, organizational slack helps the experts focus their attention on the scientific research and industrial development (Huang & Chen, 2010). Accordingly, organizational slack can strengthen the benefits of economies of scope and knowledge cross-fertilization and lessens the coordination, integration, and communications costs related to technological diversification.

Second, organizational slack can be a facilitator of strategic behavior that allows the firm to create new products and processes and enter new markets, and protect it from the potential depletion of the firm's core resources if the investments into new technologies fail (Bourgeois, 1981; Thompson, 1967; O'Brien, 2003). For example, organizational slack enables managers to establish new strategies to initiate and execute new technology development projects for introducing new products and entering new markets (Thompson, 1967; Nohria & Gulati, 1996; Huang & Chen, 2010). While higher organizational slack is often associated with increased product exploration entailing unpredictable investments

and uncertain short-term returns, low levels of organizational slack may be seen as insufficient for successful product exploration (Voss et al., 2008). In addition, a high level of organizational slack often leads to firms investing their resources in dubious projects, such as pet research experiments, industrial development projects, and unrelated technological acquisitions (Nohria & Gularti, 1996). This leads to the following hypothesis:

Hypothesis 2. Organizational slack positively moderates the relationship between unrelated technological diversification and firm's innovation performance.

4.2.3 The moderating role of technological capability

Technological capability refers to a firm's internally generated skills, knowledge, and technologies which are necessary to perform any relevant technical function or volume activity and to manage change in the technologies used by the firm (Teece et al., 1997; Voudouris et al., 2012). Based on the resource-based view of the firm, technological capability comprises technological knowledge, trade secrets, know-how, and skills generated by R&D as well as other technology-specific intellectual property or patents protected by law (Bell & Pavitt, 1995; Dollinger, 1995; Hsieh & Tsai, 2007). The accumulation of internally generated skills and knowledge stocks depends upon the firms' cumulative efforts and investments in both production activities and organizational

learning (Dahlman et al., 1987).

Firms' technological capability has increasingly been recognized as extremely important strategic resources, enabling them to respond to dynamic market needs and rapid technological change with respect to the development of new products and process (Tzokas et al., 2015; Kim, 2000). For example, technological capability enables firms to promote organizational learning through new external knowledge searching and generate new product/process developments (Cohen & Levinthal, 1990). In addition, technological capability not only fosters new product and process creativity (Zhou & Wu, 2010) but also stimulates the firm's innovation performance (Moorman & Slotegraaf, 1999).

Specifically, prior studies suggest that technological capability plays important roles in the relationship between unrelated diversification and firms' innovation performance. First, technological capability increases the firms' skills and abilities to deploy and utilize various internal resources. This helps firms diversify their own knowledge base into a wide range of technological fields sharing no physical elements or knowledge (Kim et al., 2016). In other words, superior technological capability enables firms to increase their ability to recognize, appraise and assimilate new technologies (Cohen & Levinthal, 1990). Consequently, they are more likely to be receptive to new external technologies (Berkhout et al., 2010) and to successfully accomplish any process of technological change (Voudouris et al., 2012). Second, technological capability increases the firms' abilities to develop new products and use new technological processes in response to current and expected future sudden technological change (Ince et al., 2016). It also allows

firms to achieve greater efficiency for innovative performance through process innovations or the redesigning of products (Tsai, 2004). Indeed, superior technological capacity accelerates the pace of new product and process developments because firms with superior technological capacity need a less adaptive and more innovative orientation (McDonough & Barczak, 1992). In summary, superior technological capability enables firms to engage with an unrelated technological portfolio and more easily generate innovation performance from it. This leads to the following hypothesis:

Hypothesis 3. Technological capability positively moderates the relationship between unrelated technological diversification and the firm's innovation performance.

4.2.4 The moderating role of technological turbulence

Although extending the technology portfolio is critical to the firms' innovation process in general, it becomes even more important in the context of rapidly changing technological environments (Lin & Chang, 2015). When innovative firms face the environmental uncertainty caused by technological turbulence, they need to reconfigure their technological base in order to sustain competitive advantages (Danneels, 2008). For example, according to prior studies, technological turbulence make firms' technological competencies become obsolete because the different levels of technological turbulence are applied in different contexts (Lin & Chang, 2015). Accordingly, technological

turbulence is recognized as an important contingent factor in defining the boundary conditions that either intensify or reduce the potential influence of firm-specific technological competencies (Wang & Chen, 2010).

On one hand, in the context of a relatively low technological turbulence, firms have a strong emphasis on exploiting knowledge and technologies that are more closely related, i.e., they less tend to perform unrelated technological diversification (Van den Bosch et al., 1999; Escribano et al., 2009). For example, Van den Bosch et al. (1999) argue that a relatively low technological turbulence leads to firms more focusing on the efficiency of knowledge and technologies and this efficiency focus will result in path dependencies related to the firm's current accumulated knowledge and technologies. Thus, firms are less likely to develop sensitivity to emerging new technological opportunities (Van den Bosch et al., 1999). On the other hand, in the context of a high technological turbulence, firms tend to be more active in the exploration of new knowledge and technologies, i.e., performing unrelated technological diversification, in order to reconfigure their knowledge repository and build new technological competencies (Gilsing et al., 2014; Hung & Chou, 2013). High technological turbulence leads to firms more focusing on the scope and flexibility of knowledge and technologies (Van den Bosch et al., 1999). I suggest that this focusing of scope and flexibility allows firms to have an unrelated diversified technological portfolio. Specifically, in a high technological turbulence environment, firms can better take advantage of the cross-fertilization effects through an unrelated technological diversification (Suzuki & Kodama, 2004) and avoid the risk of

core rigidities (Lin & Chang, 2015; Leonard-Barton, 1992). Accordingly, high technological turbulence is more likely to lead to beneficial effects of firms' unrelated technological portfolios. This leads to the following hypothesis:

Hypothesis 4. Technological turbulence positively moderates the relationship between unrelated technological diversification and the firm's innovation performance.

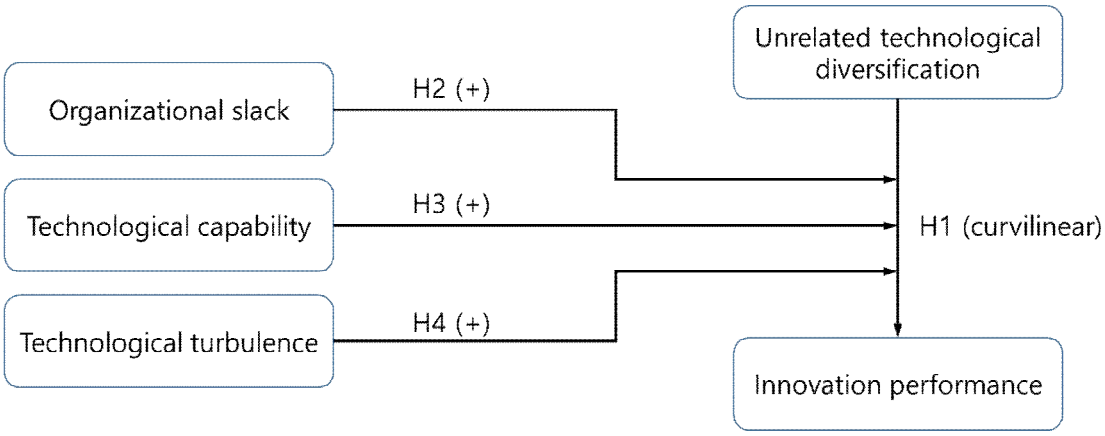

Figure 8. Conceptual model for Chapter 4

4.3 Methods

4.3.1 Data

For the empirical tests, I have compiled a cross-sectional dataset with 2007 as the base year that contains patents and financial information of 251 sample firms. Based on the Standard Industrial Classification (SIC) 4-digit code, these firms operate in 94 different industries. The sample firms' financial and corporate information, such as data on sales, current assets, current liabilities, and R&D expenses, were collected from the Compustat database of Standard & Poors and the Datastream database of Thomson Reuters. In the next step, I collected patent information from the United States Patent and Trademark Office (USPTO) for assessing the knowledge-based variables of the analysis. The USPTO patent database contains information on the focal firms' efforts to develop new products and processes and information on how often the patents of the focal firms were cited by other patents. The number of granted patents and the number of citations received to serve as the basis for calculating the dependent and independent variables, as well as some of the moderating variables of this study. In addition, in order to control for the M&A and alliance experiences of the sample firms, I collected information on M&A and alliances deals concluded by the focal firms in the three years preceding the focal year from the Securities Data Company (SDC) Platinum database of Thomson Reuters. The final sample consists of 251 sample firms from 94 industries and 16,626 granted patents.

4.3.2 Dependent variable

With respect to quantitative aspects of innovation performance, previous studies used the number of patents granted in a focal year (Penner-Hahn & Shaver, 2005; McGill & Santoro, 2009; Srivastava et al., 2015). As patents provide meaningful information about the scope, effectiveness, and future value of firms' R&D (Hirschey et al., 1999), and confer certain intellectual property rights, patents possess an external validity and economic profit potential (Srivastava et al., 2015). Thus, also in this analysis, patents are used as a means to capture innovation output. In line with prior research, I consider the typical R&D time lag to be 1.5 years and the patent application periods to be 1.5 years (Hausman et al., 1984). Consequently, with the focal year of this study being 2007, innovation performance is defined as the total number of patents that were granted to the sample firms in 2010.

4.3.3 Independent variables

4.3.3.1 Unrelated technological diversification

The main independent variable of this study is unrelated technological diversification, i.e., diversification into technological fields which share no knowledge (Kim et al., 2016). With respect to diversification measurements, prior studies used two approaches: the Herfindahl index (Jacquemin & Berry, 1979) and the entropy index (Palepu, 1985). In

comparison with the Herfindahl index, the entropy index is objective, continuous, and decomposable (Park & Jang, 2013). In addition, the entropy index has been used in prior studies as a measurement of diversification for numerous aspects of firms' strategy such as technology (Granstrand & Oskarsson, 1994; Miller et al., 2007; Kim et al., 2016), product (Varadarajan, 1986; Galan & Sanchez, 2006), market (Chatterjee & Wernerfelt, 1991), and business (Robins & Wiersema, 1995, 2003; Ramaswamy et al., 2017). Specifically, the entropy index can be divided into related and unrelated diversification. Accordingly, I choose the entropy index to measure unrelated technological diversification.

Following the diversification measurement used in Kim et al. (2016), I measure the unrelated technological diversification (UTD) of the firm as follows:

$$UTD = \sum_{k=1}^{n} PS_{ikt} ln(\frac{1}{PS_{ikt}}) \quad \text{Eq. (4-1)}$$

Where PS_{ikt} is firm i's patent share for patent class k at time t (i.e., $PS_{ikt}=P_{ikt}/P_{it}$), P_{ikt} denotes the number of firms i's patent granted in patent class k at time t, and P_{it} denotes the total number of a patent granted by firm i at time t. The equation reflects the degree of unrelated technological diversification which is measured for 361 technological categories defined by patent main-classes.

4.3.3.2 Organizational slack

Organizational slack is related to the short-term available resources of the firm. Based on prior studies (Hao & Jaffe, 1993; Geiger & Cashen, 2002; Geiger & Makri, 2006, Singh, 1986; Herold et al., 2006), I use the "current ratio" as a measurement of organizational slack. The current ratio is defined as total current assets divided by total current liabilities (Marlin & Geiger, 2015). Current assets are assets that can be changed into cash or quickly used in the business, while current liabilities are defined as the financial obligations that firms have to settle within one year (Herold et al., 2006). I use 2007 financial data of the sample firms for the measurement of the current ratio.

4.3.3.3 Technological capability

Technological capability is defined as the firm's internal skills, knowledge, and information related to effectively performing transformation and exploitation for the firms' innovation processes (Teece et al., 1997). Prior studies suggest the use of patent data to measure the technological capabilities of the firm because patents reflect important information about the firms' innovative activities and allow to trace their technological level (Duysters & Hagedoorn, 2000; Griliches, 1990). Based on Martínez-Noya & García-Canal's study (2011), I employ the number of patents that have been granted to each focal firm during the 2007-2009 period as an indicator of the firm's technological capability.

4.3.3.4 Technological turbulence

Technological turbulence refers to the extent of technological changes within the industry and the extent to which these changes affect the firms operating in the industry (Chatterjee, 2004). Following prior studies (Dess & Beard, 1984; Keats & Hitt, 1988; Kor et al., 2004; Sharfman & Dean, 1991; Wang & Chen, 2010), I use the number of patents issued in each technology class (3-digit). Specifically, I regressed the number of patents issued annually for the five years preceding the focal year on the year variable. Next, I obtained the standard error of the regression coefficient, and then divided it by the mean number of patents in the specific technology class to produce a standardized index of technological turbulence.

4.3.4 Control variables

The analysis includes a number of control variables to represent firm- and industry-specific characteristics that could influence the relationship between a firm's unrelated technological diversification and its innovative performance. First, in order to control for the effect of R&D on innovative performance, I include the firm's R&D intensity, measured as the ratio of R&D expenses to sales in 2007. Second, I control for the size of the focal firm, as larger firms are typically able to utilize more resources in their innovation processes. I measure the size of the focal firms as each focal firm's annual sales in 2007 is averaged and is represented in logarithmic form. Third, in order to control

for the influence of the firm's innovation impact on the innovation performance, I include the average number of the forward citations received by the firm's recent patents. I measure the average number of forward citation received by the 2007-2009 patents within 4 years from their grant year. Fourth, I control for the firms' innovative activities, so I include the total number of patents granted to the focal firms. I measure the total number of patents during 1969-2006 periods. This variable is transformed into natural log form. Fifth, I control for external knowledge search activities, specifically, the firms' M&A and alliances deals. I measure two variables as the number of M&A and alliances deals of each firm during the 2004-2006 periods. Finally, eight industry sectoral dummy variables are included to control for the differences between the various industry sectors found in my data sample and are coded based on the first digit of the SIC code of the sample firms.

4.3.5 Empirical model specification

The dependent variable of this study, the firms' innovation performance, is based on the number of granted patents, a discrete integer variable. Table 5 shows that its standard deviation (266.1972) is greater than its mean value (66.2390). Thus, the dependent variable is a case of over-dispersed count data. Consequently, I employ negative binomial regression (NBR) instead of Poisson regression for my empirical analysis (Song & Shin, 2008).

Table 5. Descriptive statistics and pairwise correlations

	Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1	R&D intensity	.2119	.9030	1										
2	Firm size	7.0915	2.2419	-.3297***	1									
3	Innovation impact	3.1577	4.7049	-.0052	-.0822	1								
4	Firm' innovative activities	4.1258	2.4355	-.0307	.4671***	-.0208	1							
5	M&A experiences	3.5816	5.7463	-.0873	.4031***	.0023	.2589***	1						
6	Alliance experiences	2.5378	7.1213	.0236	.2573***	.0308	.2749***	.5162***	1					
7	Unrelated technological diversification	1.4760	.9668	-.1018	.4472***	-.0282	.6371***	.3286***	.2964***	1				
8	Organizational slack (current ratio)	2.9983	3.1026	.2078***	-.4604***	.0794	-.2245***	-.2082***	-.0719	-.1760**	1			
9	Technological capability	153.992	633.5526	-.0256	.2808***	.0159	.3634***	.4291***	.8208***	.3684***	-.0771	1		
10	Technological turbulence	.0047	.0165	-.0400	.3217***	.0102	.4002***	.4237***	.7902***	.4264***	-.1113*	.8969***	1	
11	Innovation performance	66.2390	266.1972	-.0284	.2939***	.0271	.3435***	.4402***	.8372***	.3719***	-.0808	.9790***	.9186***	1

***p<0.001; **p<0.05; *p<0.1

Table 6. Results of the Variance Inflation Factor (VIF) test

Variable	VIF	1/VIF
Unrelated technological diversification	1.89	0.5277
Organizational slack	1.29	0.7734
Technological capability	6.22	0.1607
Technological turbulence	5.75	0.1737
R&D intensity	1.17	0.8526
Firm size	1.92	0.5215
Innovation impact	1.01	0.9855
Firm's innovation activities	1.91	0.5227
M&A experience	1.56	0.6418
Alliance experience	3.67	0.2723
Mean	2.64	0.5431

Table 7. Results of the negative binomial regression for Innovation performance

Dependent variable (Innovation performance)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Control variables							
R&D intensity	0.2847 (0.1777)	0.2232* (0.1260)	0.2824** (0.1174)	0.3301** (0.1289)	0.2584** (0.0788)	0.1911* (0.1031)	0.0803 (0.0890)
Firm size	0.4406*** (0.0560)	0.2856*** (0.0535)	0.3417*** (0.0514)	0.4456*** (0.0583)	0.2082*** (0.0401)	0.1653** (0.0531)	0.1094** (0.0473)
Innovation impact	0.0101 (0.0254)	0.0401 (0.0255)	0.0344 (0.0232)	0.0364 (0.0246)	0.0326** (0.0140)	0.0290 (0.0185)	0.0247* (0.0148)
Firm' innovative activities	0.1731*** (0.0365)	0.0489 (0.0359)	0.0627* (0.0367)	0.0671* (0.0403)	0.0257 (0.0303)	0.0889** (0.0374)	0.0444 (0.0325)
M&A experiences	0.0022 (0.0210)	-0.0065 (0.0176)	-0.0043 (0.0171)	-0.0075 (0.0182)	0.0147 (0.0093)	-0.0037 (0.0150)	0.0054 (0.0129)
Alliance experiences	0.0777** (0.0287)	0.0487** (0.0207)	0.0559** (0.0205)	0.0605** (0.0223)	-0.0236 (0.0101)	0.0465** (0.0200)	0.0201 (0.0181)
Sectoral dummy				Included			
_Cons	7.0254*** (0.7883)	2.1370** (0.7207)	-4.438*** (0.8625)	-1.2996 (0.8580)	-3.290*** (0.6892)	-3.3159*** (0.8326)	1.1217 (2.3433)
Independent variables							
Unrelated technological diversification		1.1674*** (0.1349)	2.1776*** (0.2771)	2.2167*** (0.4312)	2.1204*** (0.2491)	1.7585*** (0.3191)	0.8099** (0.3863)
Unrelated technological diversification^2			-0.315*** (0.0745)	-0.2823** (0.1164)	-0.2389** (0.0703)	-0.2121** (0.1013)	0.0878 (0.1182)
Organizational slack				0.0192 (0.0902)			0.0121** (0.0045)
Unrelated technological diversification x Organizational slack				0.1676 (0.1242)			-0.0060* (0.0032)
Unrelated technological diversification^2 x Organizational slack				-0.0741* (0.0390)			0.0007 (0.0005)
Technological capability					0.0286*** (0.0031)		-0.0879 (0.0717)
Unrelated technological diversification x Technological capability					-0.016*** (0.0018)		0.1592 (0.1015)
Unrelated technological diversification^2 x Technological capability					0.0025*** (0.0002)		-0.0421 (0.0328)
Technological turbulence						639.6262*** (131.3342)	263.4395** (120.1318)
Unrelated technological diversification x Technological turbulence						-350.115*** (82.3278)	-145.0703 (88.9359)
Unrelated technological diversification^2 x Technological turbulence						49.1460*** (12.8833)	19.7008 (15.4279)
Observations	251	251	251	251	251	251	251
Log-likelihood	-949.450	-911.232	-893.396	-900.825	-870.762	-864.4348	-854.1802
Chi square	227.00***	303.44***	339.11***	324.26***	384.38***	397.04***	417.55***

*p<0.10, **p<0.05, ***p<0.001

4.4 Results

Table 5 shows a descriptive statistics and pairwise correlations of independent and control variables used in this research. I found the correlation between technological capability and innovation performance as well as technological turbulence and innovation performance. It can also be shown that the highest levels of correlation between alliance experiences and innovation performance. Firms that have a larger knowledge stock and alliance experiences produce more patents. In addition, I test the possibilities of multicollinearity of my dataset, including independent and control variables and using a Variance Inflation Factor (VIF). Table 6 shows the results of VIF test. The mean value of the VIFs is 2.64 and the maximum value is 6.22, indicating that no problems with multicollinearity exist in a dataset of this study.

Table 7 presents the results of the negative binomial regression analyses for the firms' innovation performance. Model 1 contains only the control variables. Model 2 indicates that the coefficient of unrelated technological diversification is positive and significant ($\beta = 1.1674$; $p<0.001$). However, a number of prior studies suggested that excessive unrelated technological diversification would hamper the firm's innovation performance from the perspectives of coordination, communication, and integration costs (Granstrand, 1998; Chen & Yu, 2012; Leten et al., 2007; Kim et al., 2016). Thus, in order to investigate the effects of excessive unrelated technological diversification on the firm's innovation performance, I additionally included the quadratic term of unrelated technological

diversification. According to the results of Model 3 (β = -0.315; $p<0.001$), excessive levels of unrelated technological diversification weaken the effect on the firm's innovation performance. In addition, Figure 9 displays the curvilinear relationship between unrelated technological diversification and firm's innovation performance. Accordingly, Hypothesis 1 is supported.

Hypothesis 2 predicted a positive moderating effect of organizational slack on the relationship between unrelated technological diversification and innovation performance. As shown in Model 4, the coefficient of the interaction term between unrelated technological diversification and organizational slack is positive and insignificant (β = 0.1676). Model 4 reveals that the coefficient of the interaction term between unrelated diversification-squared and organizational slack is negative and significant (β = -0.0741; $p<0.1$). Figure 10 shows that in accordance with the level of organizational slack, the relationship between unrelated technological diversification and firm's innovation performance is steepened (Aiken & West, 1991; Hanns et al., 2016). However, beyond a certain level of PACAP, superior organizational slack hamper the relationship between unrelated technological diversification and firm's innovation performance. Thus, these results partially support Hypothesis 2.

Hypothesis 3 predicted a positive moderating effect of technological capability. Model 5 indicates that the interaction term of unrelated technological diversification and technological capability is negative and significant (β = -0.016; $p<0.001$). Model 5 reveals that the coefficient of the interaction term between unrelated technological

diversification-squared and technological capability is positive and significant (β = 0.0025; $p<0.001$). Figure 11 shows that in accordance with the level of technological capability, the relationship between unrelated technological diversification and firm's innovation performance is flattened. Accordingly, the inclusion of the moderating effect of technological capability in Model 5 shows that increasing technological capability decreases the ability of the firm to turn unrelated technological diversification into innovation performance. Thus, Hypothesis 3 is not supported.

Hypothesis 4 predicted a positive moderating effect of technological turbulence. In terms of the interaction term of unrelated technological diversification and technological turbulence, Model 6 indicates that it is negative and significant (β = -350.115; $p<0.001$). Model 6 presents that the coefficient of interaction term between unrelated technological diversification-squared and technological turbulence is positive and significant (β = 49.1460; $p<0.001$). Figure 12 shows the relationship between unrelated technological diversification and firm's innovation performance under different levels of technological turbulence. Accordingly, increasing the firm's unrelated technological diversification is less beneficial for firms operating in an environment of higher technological turbulence. Thus, Hypothesis 4 is not supported.

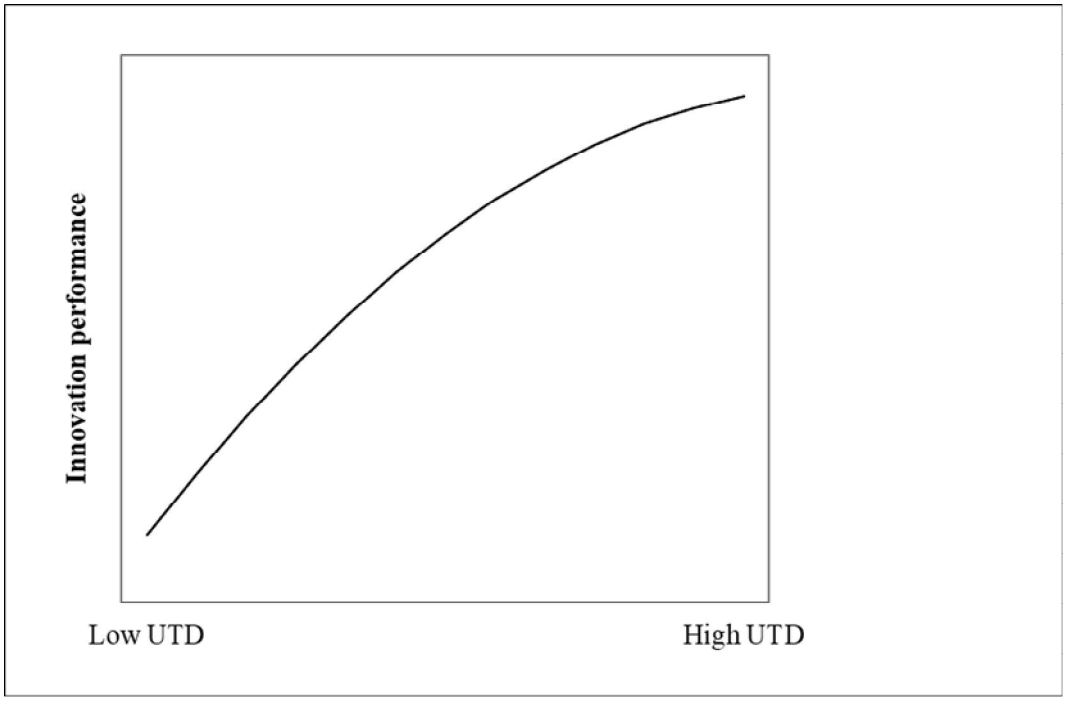

Figure 9. The curvilinear relationship between unrelated technological diversification (UTD) and firm's innovation performance

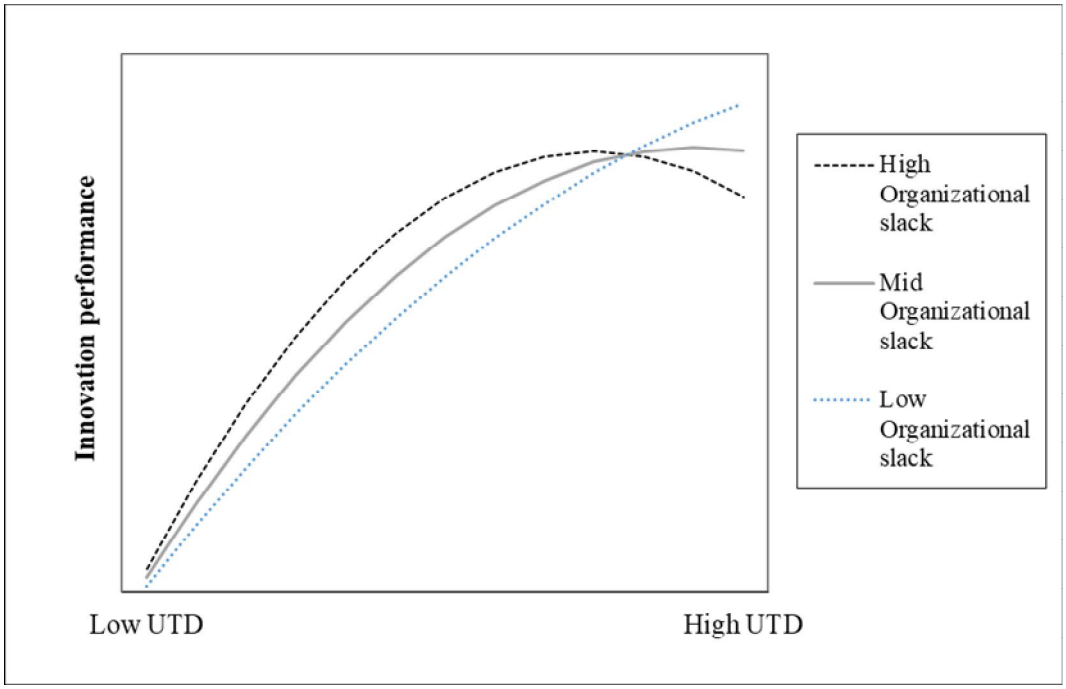

Figure 10. The relationship unrelated technological diversification and firm's innovation performance under different levels of organizational slack

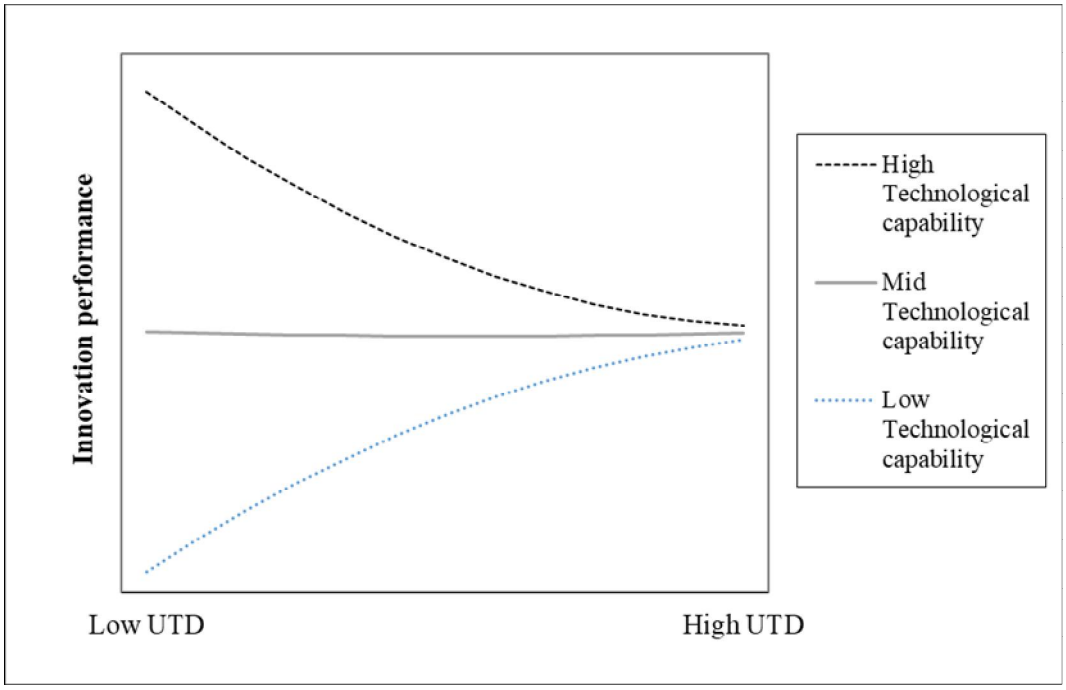

Figure 11. The relationship between unrelated technological diversification and firm's innovation performance under different levels of technological capability

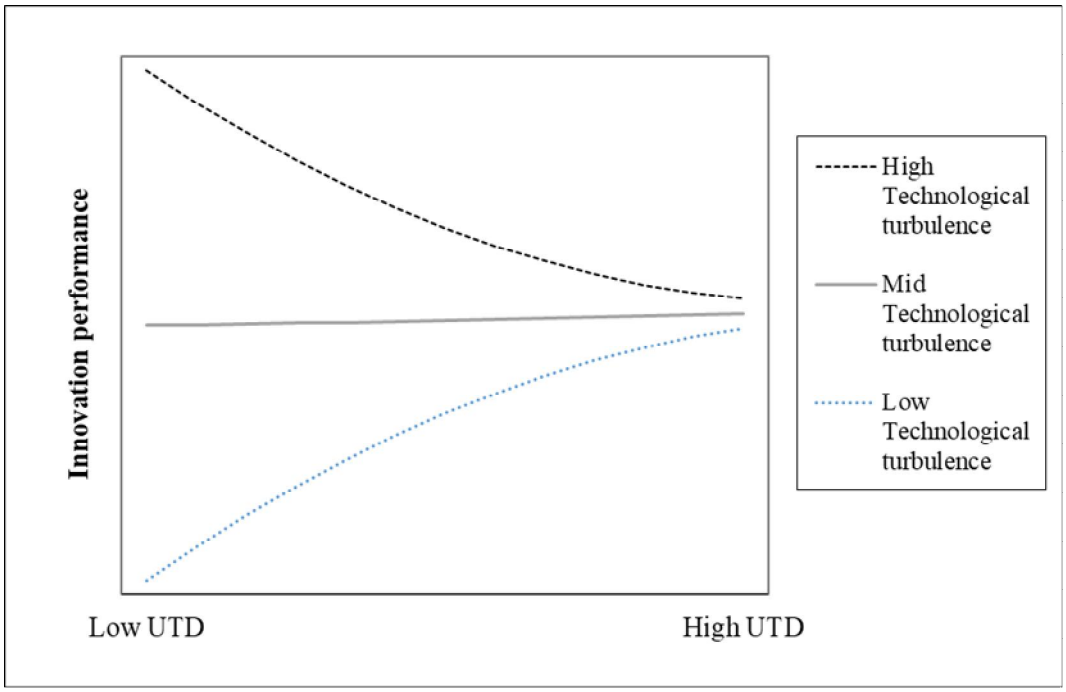

Figure 12. The relationship between unrelated technological diversification and firm's innovation performance under different levels of technological turbulence

4.5 Discussion

This study explores the effect of unrelated technological diversification on the firm's innovation performance. In addition, it examines the moderating roles of organizational slack, technological capability, and technological turbulence on this relationship and finds the following:

First, the results show that unrelated technological diversification of a firm has a positive relationship with its innovation performance. These findings provide evidence for the positive role of unrelated technological diversification in achieving innovation performance. However, through an additional analysis for excessive unrelated technological diversification, I find that beyond a certain level it becomes detrimental to the firm's innovation performance. These results support my theoretical propositions that, in terms of unrelated technological diversification, firms are capable of improving innovation performance through enlarging their technological core competencies through cross-fertilization by technological convergence, whereas excessive unrelated technological diversification may be associated with additional costs related to coordination, internal restricted resources conflict, and integration. These lead to a diminishing positive effect on innovation performance when the unrelated technological diversification reaches high levels.

Second, based on a resource-based view of the firm (Montgomery, 1994), the results of this study show that a focal firm's level of organizational slack has a positive

moderating effect on the relationship between unrelated technological diversification and innovation performance. This finding implies that increasing level of organizational slack allows firms to explore a wide range of technological fields that are not related to firm's prior knowledge base (Bourgeois, 1981). This result also supports the view that organizational slack acts as a buffer for the coordination and integration cost from external technology and internal source competition (Tan & Peng, 2003). In other words, organizational slack allows a firm with a diversified technological portfolio with unrelated technological fields to achieve a higher innovation performance than firms with a lower level of organizational slack. However, beyond a superior level of organizational slack, organizational slack hamper firm's achieving innovation performance because the superior level of organizational slack exacerbates the coordination costs (Tan & Peng, 2003).

Third, in terms of the contingency effect of the firm's technological capability, this result shows that technological capability has a negative moderating effect on the unrelated technological diversification & firm's innovative performance relationship. Contrary to my hypothesis, this finding implies that superior technological capability does not strengthen, but lessens the effects of unrelated technological diversification on the firm's innovation performance. Prior studies pointed out that the accumulation of technological capability not only links the generated technological trajectories and path-dependencies of R&D professionals adjacent to the firm's core technologies (Suzuki & Kodama, 2004) but also generates lock-in effects (Henderson & Clark, 1990) and

competency traps (Levinthal & March, 1993). This result suggests that superior technological capability may play a preventive role in the relationship between unrelated technological diversification and firms' innovative performance.

Fourth, similar to technological capability, this result shows that technological turbulence negatively moderates the relationship between unrelated technological diversification and firm's innovation performance. This result suggests that the increasing technological turbulence may force firms to pay more attention to exploring novel, emerging, and unrelated technologies through firm's integration mechanisms to achieving innovation performance (Tsai et al., 2015). Cruz-González et al. (2015) argue that, in highly technological turbulence contexts, firm's prior knowledge and competence lead to organizational inertia. Thus, I suggest that maintaining strong and frequent interactions with a large number of unrelated technological diversification in high technological turbulence is problematic and exacerbates the costs of unrelated technological diversification (Cruz-González et al., 2015).

Mini case: General Electric (GE)

General Electric is one of the most innovative firms in the world. Over the past few decades, General Electric made hundreds of acquisitions & divestitures and diversified their technologies far beyond its original base. For example, General Electric diversified their technological base from insurance, materials, equipment services, entertainment, and industrial platforms to power, oil and gas, renewable energy, aviation, healthcare, transportation, home and business solutions, and capital.

Additionally, one of General Electric's main strategies is resource allocation to differentiate their technological composition using free cash flow. Their free cash flow was $32.6 billion in 2016. Free cash flow allows General Electric to create technological opportunities and expand in developing markets.

General Electric recorded a revenue of $113.2 billion in 2016; in 1980, the revenue of General Electric was $26.8 billion. In 2015 and 2016, General Electric achieved a 4% revenue growth.

Source:

Inkpen, A. (2014). General Electric's corporate strategy. *Harvard Business Review.* 1-16.

General Electric's 2016 Annual Report

Chapter 5. Conclusive remarks

5.1 Contributions and implications

In conclusion, this current dissertation contributes to a better understanding of the mechanisms related to knowledge-based innovation such as external knowledge searching and technological diversification. Specifically, prior studies suggest that endogenous and exogenous factors of the firm play important roles in knowledge-based innovation (Drechsler & Natter, 2012; Zahra and George, 2002; Teece, 2002; Kim et al., 2016; Lin & Chang, 2015). However, there remained theoretical and empirical gaps in the understanding and explanations of the mechanisms of knowledge-based innovation that this dissertation aimed to address. First, this dissertation investigates determinants of external knowledge search strategy and finds that it is influenced by PACAP as a central determining factor and by the appropriability regime as an activation trigger during external knowledge search activities. Second, this dissertation investigates the effects of unrelated technological diversification on innovation performance. It also examines the moderating roles of contingency factors related to knowledge-based innovation. Overall, the contributions of this dissertation provide both academic values as well as managerial implications for firms trying to achieve benefits and maximizing performance through knowledge-based innovation.

Based on the findings of Chapter 3, this thesis provides several theoretical and

empirical implications. First, prior studies have considered the role of PACAP in moderating innovative performance as a complementary factor (Cohen & Levinthal, 1990; Katila & Ahuja, 2002; Chesbrough et al., 2006; Laursen & Salter, 2006; Escribano et al., 2009) and in enhancing competitive advantage as a transformation factor (Zahra & George, 2002; Todorova & Durisin, 2007; Laursen & Salter, 2014). This thesis proposes that PACAP plays an important role in external knowledge identification and acquisition from external actors for extending Zahra & George's (2002) concept. Consistent with the above proposition, my results call for a contextual perspective of external knowledge search strategy in which the efficacy of PACAP should be considered with a careful reflection of not only on its potential gains but also of its pains.

Second, this study also extends the few empirical studies that investigated the moderation effect of the appropriability regime on the relationship between PACAP and external knowledge search strategy. Theoretically, Todorova & Durisin (2007) suggested that the appropriability regime acts as an activation trigger for external knowledge absorption. Recently, Laursen & Salter (2014) empirically investigated the contextual model of the effect of firms' appropriability strategy on openness. However, they have considered not the appropriability regime of the industry but the appropriability strategy of the firm as an endogenous factor (Laursen & Salter, 2014). To date, no previous empirical study has investigated how the strength of the appropriability regime moderates the relationship between PACAP and external knowledge search strategy at the firm level. This study demonstrates that as the strength of the appropriability regime increases, it acts

as a contextual factor that leads to firms pursuing external knowledge search breadth.

In addition, Chapter 3 suggest the following managerial implications: First, contrary to prior literature about the moderation effects of absorptive capacity for innovative performance (Cohen & Levinthal, 1990; Katila & Ahuja, 2002; Chesbrough et al., 2006; Laursen & Salter, 2006; Escribano et al., 2009), Chapter 3 suggests that PACAP has a curvilinear effect on external knowledge search breadth and depth. In this vein, managers should be cognizant of the potential disadvantages of PACAP, in particular, the costs of excessive levels of PACAP such as the trade-off to be made between cognitive distance and bounded rationality (Nooteboom et al., 2007; Simon, 2008). Thus, for a successful external knowledge search strategy, managers should make a conscious choice to keep a rational level of PACAP, avoiding the associated potential problems.

Second, Chapter 3 suggest that when firms try to explore external knowledge sources, the appropriability regime is an important contingency factor that managers have to consider. Specifically, when engaging in external knowledge search breadth, managers should carefully monitor the strength of the appropriability regime as an institutional systematic mechanism in terms of their industry context in order to make informed decisions concerning the levels of the firm's PACAP. Accordingly, when the strength of the appropriability regime increases from weak to strong, to facilitate external knowledge search breadth, managers need to be concerned with ensuring appropriate process-based reward systems and greater stimulation of risky and innovative behavior in new product and process development (Li et al., 2010).

Chapter 4 investigates the relationship between unrelated technological diversification and innovation performance and considers the moderating effects of endogenous and exogenous factors on this relationship. Based on the findings of Chapter 4, this thesis suggests several managerial implications. First, the findings show that unrelated technological diversification has a positive relationship with the firm's innovation performance. Thus, managers in focal firms need to pay more attention to how an unrelated technological diversification strategy can contribute to improving innovation performance. It can help firms to access emerging new technology and skills, and ultimately lead to a superior innovation performance through reconfiguring the firm's prior technological base. The findings of Chapter 4 also show that high levels of unrelated technological diversification have a negative relationship with innovation performance. Accordingly, beyond a certain level, managers should recognize the potential negative effects of unrelated technological diversification. Thus, managers should not only encourage greater investment and patient support for risky R&D projects but also ensure the establishment of technology processing and integration systems for various technological solutions and projects (Quintana-García & Benavides-Velasco, 2008).

Second, the findings of Chapter 4 suggest that the relationship between unrelated technological diversification and the firm's innovative performance can be positively or negatively moderated in specific contexts. Organizational slack has a positive moderating role, whereas technological capability and technological turbulence have a negative moderating role. Thus, in order to improve the firm's innovation performance, managers

should understand that their unrelated technological diversity strategy should be carefully implemented while considering the levels of organizational slack, technological capability, and technological turbulence.

In terms of theoretical implications, the findings of Chapter 4 also show that in general, an unrelated technological diversification strategy has a positive effect on the firm's innovation performance. However, this effect diminishes with excessive levels of unrelated technological diversification. Specifically, adopting a contingency approach and considering multifaceted factors related to the innovation process, this thesis proposes that different endogenous and exogenous factors have different moderating effects on the relationship between unrelated technological diversification and the firm's innovation performance. Chapter 4 extends the literature on technological diversification strategy and fills the gap in understanding the mechanisms of improving firm's innovation performance through an unrelated technological diversification strategy.

5.2 Limitations and future research

Despite making fruitful contributions and implications to the research on the mechanisms of knowledge-based innovation, this dissertation has several limitations which might be overcome through future research.

Chapter 3, while providing insights into the effects of PACAP and the appropriability regime on firms' external knowledge search strategy, has several limitations. First, I use

patent data to calculate the dependent and independent variables. While patents are generally regarded as a very objective measure, some knowledge of the firm may not be easily codified and not explicitly revealed in the form of patents. Patents also only represent successfully "found" knowledge, which might hide some search activities of the firm which was either prematurely terminated or did not result in patentable innovations (Olsen et al., 2017). Although the findings of Chapter 3 make it clear that the characteristics of the endogenous and exogenous factors related to the external knowledge search strategy do matter, I suggest that the data set of Chapter 3 would be enriched if it could include non-patented knowledge such as tacit knowledge. Several innovation outcomes might not be patented due to strategical considerations (Rosenberg, 1990) or because they were considered to have failed. Accordingly, I believe that future research can address this limitation by collecting data on R&D activities (external knowledge search strategy, PACAP, and appropriability regime) from data sources such as surveys or in-depth interviews and use it to supplement the patent data. Second, I examine the strength of the appropriability regime of the industry using patent claims in firms' patents. Specifically, I calculate the strength of appropriability regime as the average number of patent claims. However, the appropriability regime, in general, is composed of patent, trademark, and copyright protection (Amara et al., 2008; Hurmelinna-Laukkanen et al., 2008). Thus, future research should develop more inclusive measurements with respects to the appropriability regime. Third, I use the number of partner firms' patents within similar categories to calculate the external knowledge search depth of the focal firms.

Although this measure demonstrates the tendency of firms to explore external knowledge deeply, it cannot accurately represent whether focal firms have been searching for external knowledge in similar technological fields. Therefore, future studies should develop measures that allow to more accurately represent the external knowledge search depth.

In Chapter 4, while providing important implications on the effects of unrelated technological diversification on innovation performance, this dissertation has a number of limitations, which I hope can be overcome by future studies in this field. First, I use patents to measure the dependent and independent variables. This is consistent with prior studies in knowledge and innovation management literature but has a number of known limitations (Pavitt, 1985; Kleinknecht et al., 2002). Thus, future studies should strive to include other sources, such as surveys, in-depth interviews, or product-level data to supplement the patent-based indicators. Second, endogenous and exogenous factors of the firm are multifaceted. Due to the main objectives of Chapter 4, I only examined the moderating effect of organizational slack, technological capability, and technological turbulence on the firm's innovation performance. Future studies should consider other endogenous and exogenous factors that may accelerate, hamper or confound the relationship between unrelated technological diversification and innovation performance.

Bibliography

Aiken, L. & West, S. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks: Sage.

Allen, T. (1977). *Managing the flow of technology: technology transfer and the dissemination of technological information within the r and d organization*. Cambridge, Mass.: The MIT Press.

Amara, N, Landry, R. & Traore, N. (2008). Managing the protection of innovations in knowledge-intensive business services. *Research Policy*, 37(9), 1530-1547.

Andrés, P.D., Fuente, G.D.L. & Velasco, P. (2017). Diversification, relatedness and growth options value: Beyond a linear relationship. *Long Range Planning*, In press.

Arora, A., Fosfuri, A. & Gambardella, A. (2001). *Markets for Technology: Economics of Innovation and Corporate Strategy*. The MIT Press, Cambridge, MA.

Arrow, K. (1962). *Economic welfare and the allocation of resources for invention*. In: Arrow, K.J. (Ed.). *The rate and Direction of Inventive Activity*. Princeton University Press, Princeton.

Atkins, M. (1998). The role of appropriability in sustaining competitive advantage-An electronic auction system case study. *The Journal of Strategic Information Systems*, 7(2), 131-152.

Baughn, C.C., Denekamp, J.G., Stevens, J.H. & Osborn, R.N. (1997). Protecting

intellectual capital in international alliances. *Journal of World Business*, 32(2), 103-177.

Bell, M. & Pavitt, K. (1993). Technological accumulation and industrial growth: Contrasts between developed and developing countries. *Industrial and corporate change*, 2(2), 157-209.

Bell, M. & Pavitt, K. (1995). *The development of technological capabilities*, In: Haque, I.U. (Ed), Trade, Technology and International Competitiveness. Economic Development Institute of the World Bank, Washington, 69-100.

Ben-Menahem, S., Kwee, Z., Volberda, H. & Van Den Bosch, F. (2013). Strategic renewal over time: the enabling role of potential absorptive capacity in aligning internal and external rates of change. *Long Range Planning*, 46(3), 216-235.

Berkhout, G., Hartmann, D. & Trott, P. (2010). Connecting technological capabilities with market needs using a cyclic innovation model. *R&D Management*, 40(5), 474-490.

Besanko, D., Doraszelski, U., Kryukov, Y. & Satterthwaite, M. (2010). Learning-by-doing, organizational forgetting, and industry dynamics. *Econometrica*, 78(2), 453-508.

Bettis, R.A. (1981). Performance differences in related and unrelated diversified firms. *Strategic Management Journal*, 2(4), 379-393.

Blind, K., Edler, J., Frietsch, R. & Schmoch, U. (2006). Motivies to patent: empirical evidence from Germany. *Research Policy*, 35(5), 655-672.

Bourgeois, L.J. (1981). On the measurement of organizational slack. *The Academy of*

Management Review, 6(1), 29-39.

Bourgeois, L.J. & Singh, J.V. (1983). Organizational slack and political behavior among top management teams. Academy of Management Proceedings, 43-47.

Campa, J.M. & Kedia, S. (2002). Explaining the diversification discount. *Journal of Finance*, 57(4), 1731-1762.

Cantwell, J. & Piscitello, L. (2000). Accumulating technological competence: Its changing impact on corporate diversification and internalization. *Industrial and Corporate Change*, 9(1), 21-51.

Carayannopoulos, S. & Auster, E. (2010). External knowledge sourcing in biotechnology through acquisition versus alliance: A KBV approach. *Research Policy*, 39(2), 254-267.

Chatterjee, S. (2004). Interfirm alliances in online retailing. *Journal of Business Research*, 57(7), 714-723.

Chatterjee, S. & Wernerfelt, B. (1991). The link between resources and type of diversification: Theory and evidence. *Strategic Management Journal*, 12(1), 33-48.

Chen, C., Chang, M., Tseng, C., Chen, B. & Chang, Y. (2013). Critical human factor evaluation of knowledge sharing intention in Taiwanese enterprises. *Human Factors and Ergonomics in Manufacturing & Service Industries*, 23(2), 95−106.

Chen, J., Chen, Y. & Vanhaverbeke, W. (2011). The influence of scope, depth, and orientation of external technology sources on the innovative performance of

Chinese firms. *Technovation*, 31(8), 362-373.

Chen, J. & Lin, B. (2004). The effects of environment, knowledge attribute, organizational climate, and firm characteristics on knowledge sourcing decisions. *R&D Management*, 34(2), 137-146.

Chen, Y.M. & Huang, Y.F. (2010). Creative workforce density, organizational slack, and innovation performance. *Journal of Business Research*, 63(4), 411-417.

Chen, Y.M., Yang, D.H. & Lin, F.J. (2013). Does technological diversification matter to firm performance? The moderating role of organizational slack. *Journal of Business Research*, 66(10), 1970-1975.

Chen, C.J. & Yu, C.M.J. (2012). Managerial ownership, diversification, and firm performance: Evidence from an emerging market. *International Business Review*, 21(3), 518-534.

Chesbrough, H. (2003). *Open Innovation. The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press, Boston.

Chesbrough, H. (2006). *Open Business Models: How to Thrive in the New Innovation Landscape*. Harvard Business School Press, Boston.

Chesbrough, H., Vanhaverbeke, W. & West, J. (Eds.), (2006). *Open Innovation: Researching a New Paradigm*. Oxford University Press, Oxford.

Chiu, Y.C., Lai, H.C., Lee, T.Y. & Liaw, Y.C. (2008). Technological diversification, complementary assets, and performance. *Technological Forecasting & Social Change*, 75(6), 875-892.

Christensen, H.K. & Montgomery, C.A. (1981). Corporate economic performance: Diversification strategy versus market structure. *Strategic Management Journal*, 2(4), 327-343.

Christensen, J., Olesen, M. & Kjaer, J. (2005). The Industrial Dynamics of Open Innovation: Evidence from the Transformation of Consumer Electronics. *Research Policy*, 34(10), 1553-1549.

Cohen, W., Goto, A., Nagata, A., Nelson, R. & Walsh, J. (2002). R&D spillovers, patents and the incentives to innovate in Japan and the United States. *Research Policy*, 31(8-9), 1349-1367.

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

Cohen, W. & Levinthal, D. (1990). Absorptive capacity: a new perspective of learning and innovation. *Administrative Science Quarterly*, 35(1), 128-152.

Cohen, W., Nelson, R. & Walsh, J. (2000). Protecting their intellectual assets: Appropriability conditions and why US manufacturing firms patent (or not). *NBER Working Paper #7552*. NBER. Cambridge, MA.

Conner, K.R. & Prahalad, C.K. (1996). A resource-based theory of the firm: Knowledge versus opportunism. *Organization Science*. 7(5), 477-501.

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

Cyert, R. & March, J. (1963). *A Behavioral Theory of the Firm*. Prentice-Hall, Englewood Cliffs, NJ.

Dahlman, C.J., Ross-Larson, B. & Westphal, L.E. (1987). Managing technological development: Lessons from the newly industrializing countries. *World Development*, 15(6), 759-775.

Danneels, E. (2008). Organizational antecedents of second-order competences. *Strategic Management Journal*, 29(5), 519-543.

Dawson, J. (2014). Moderation in management research: What, why, when, and how. *Journal of Business and Psychology*, 29(1), 1-19.

De Carolis, D.M., Yang, Y., Deeds, D.L. & Nelling, E. (2009). Weathering the storm: The benefit of resources to high-technology ventures navigating adverse events. *Strategic Entrepreneurship Journal*, 3(2), 147-160.

Dean, A. & Kretschmer, M. (2007). Can Ideas be Capital? Factors of Production in the Postindustrial Economy: A Review and Critique. *Academy of Management Review*, 32(2), 573-594.

Dess, G.G. & Beard, D.W. (1984). Dimensions of organizational task environments. *Administrative Science Quarterly*, 29(1), 52-73.

Dhir, S. & Dhir, S. (2015). Diversification: Literature review and issues. *Strategic Change*, 24(6), 569-588.

Dollinger, M.J. (1995). *Entrepreneurship: Strategies and resources*. Irwin: Boston, MA.

Dosi, G. (1982). Technological paradigms and technological trajectories: A suggested

interpretation of the determinants and directions of technical change. *Research Policy*, 11(3), 147-162.

Doz, Y.L. & Hamel, G. (1997). *The use of alliances in implementing technology strategies*. In M. L. Tushman, & P. Anderson (Eds), Managing strategic innovation and change (pp. 556-580). New York: Oxford University Press.

Drechsler, W. & Natter, M. (2012). Understanding a firm's openness decisions in innovation. *Journal of Business Research*, 65(3), 438-445.

Dushnitsky, G. & Shaver, J. (2009). Limitations to interorganizational knowledge acquisition: The paradox of corporate venture capital. *Strategic Management Journal*, 30(10), 1045-1064.

Duysters, G. & Hagedoorn, J. (2000). Core competencies and company performance in the worldwide computer industry. *Journal of High Technology Management Research*, 11(1), 75-91.

Enkel, E. & Heil, S. (2014). Preparing for distant collaboration: Antecedents to potential absorptive capacity in cross-industry innovation. *Technovation*, 34(4), 242-260.

Eppler, M.J. & Mengis, J, (2004). The concept of information overload: A review of literature from organization science, accounting, marketing, MIS, and related disciplines. *The Information Society*, 20(5), 325-344.

Eroglu, C. & Hofer, C. (2014). The effect of environmental dynamism on returns to inventory leanness. *Journal of Operations Management*, 32(6), 347-356.

Escribano, A., Fosfuri, A. & Tribó, J. (2009). Managing external knowledge flows: The

moderating role of absorptive capacity. *Research Policy*, 38(1), 96-105.

Ferreras-Méndez, J., Newell, S., Fernández-Mesa, A. & Alegre, J. (2015). Depth and breadth of external knowledge search and performance: The mediating role of absorptive capacity. *Industrial Marketing Management*, 47, 86-97.

Fosfuri, A. & Tribó, J. (2008). Exploring the antecedents of potential absorptive capacity and its impact on innovation performance. *Omega*, 36(2), 173-187.

Frishammar, J., Ericsson, K. & and Patel, P. (2015). The dark side of knowledge transfer: Exploring knowledge leakage in joint R&D projects. *Technovation*, 41-42, 75-88.

Galan, J.I. & Sanchez, M.J. (2006). Influence of industry R&D intensity on corporate product diversification: Interaction effect of free cash flow. *Industrial and Corporate Change*, 15(3), 531-547.

Garcia-Vega, M. (2006). Does technological diversification promote innovation?: An empirical analysis for European firms. *Research Policy*, 35(2), 230-246.

Garcia, R., Calantone, R. & Levine, R. (2003). The role of knowledge in resource allocation to exploration versus exploitation in technologically oriented organization. *Decision Sciences*, 34(2), 323-349.

Gebauer, H., Worch, H. & and Truffer, B. (2012). Absorptive capacity, learning processes and combinative capabilities as determinants of strategic innovation. *European Management Journal*, 30(1), 57-73.

Geiger, S.W. & Cashen, L.H. (2002). A multidimensional examination of slack and its impact on innovation. *Journal of Managerial Issues*, 14(1), 68-84.

Geiger, S.W. & Makri, M. (2006). Exploration and exploitation innovation processes: The role of organizational slack in R&D intensive firms. *The Journal of High Technology Management Research*, 17(1), 97-108.

George, G., Zahra, S., Wheatley, K. & Khan, R. (2001). The effects of alliance portfolio characteristics and absorptive capacity on performance: A study of biotechnology firms. *Journal of High Technology Management Research*, 12(2), 205-226.

Gilsing, V., Vanhaverbeke, W. & Pieters, M. (2014). Mind the gap: Balancing alliance network and technology portfolio during periods of technological uncertainty', *Technological Forecasting & Social Change*, 81, 351-362.

Granstrand, O. (1998). Towards a theory of the technology-based firms. *Research Policy*, 27(5), 465-489.

Granstrand, O. (1999). *The economics and management of intellectual property*. Edward Elgar, UK.

Granstrand, O. & Oskarsson, C. (1994). Technology Diversification in "MUL-TECH" Corporations. *IEEE Transactions on Engineering Management*, 41(4), 355-364.

Granstrand, O., Patel, P. & Pavitt, K. (1997). Multi-technology corporations: Why they have "distributed" rather than "distinctive core" competencies. *California Management Review*, 39(4), 8-25.

Grant, R. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17(Issue S2), 109-122.

Griliches, Z. (1990). Patent statistics as economic indicators: A survey. *Journal of*

Economics Literature, 28(4), 1661-1707.

Grimpe, C. & Sofka, W. (2009). Search patterns and absorptive capacity: low- and high-technology sectors in European countries. *Research Policy*, 38(3), 495-506.

Haans R., Pieters, C. & He, Z. (2016). Thinking about U: theorizing and testing U- and inverted U-shaped relationships in strategy research. *Strategic Management Journal*, 37(7), 1177-1195.

Haas, A. (2006). The rationality of law student's career choices. *Richmond Journal of Law and the Public Interest*, 10(1), 54-79.

Hall, B., Jaffe, A. & Trajtenberg, M. (2001). The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools, *CEPR Discussion Papers 3094*, C.E.P.R. Discussion Papers.

Hambrick, D. (1983). High profit strategies in mature capital goods industries: A contingency approach. *Academy of Management*, 26(4), 687-707.

Hao, K.Y. & Jaffe, A.B. (1993). Effect of liquidity on firms' R&D spending. *Economics of Innovation and New Technology*, 2(4), 275-282.

Hargadon, A. & Fanelli, A. (2002). Action and possibility: Reconciling dual perspectives of knowledge in organizations. *Organization Science*, 13(3), 290-302.

Hausman, J., Hall, B.H. & Griliches, Z. (1984). Econometric models for count data with an application to the patents-R&D relationship. *Econometrica*, 52(4), 909-938.

Henderson, R.M. & Clark, K.B. (1990). Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. *Administrative*

Sciences Quarterly, 35(1), 9-30.

Henderson, R. & Cockburn, I. (1996). Scale, scope, and spillovers: The determinants of research productivity in drug discovery. *RAND Journal of Economics*, 27(1), 32-59.

Herold, D.M., Jayaraman, N. & Naryaynaswamy, C.R. (2006). What is the relationship between organizational slack and innovation?' *Journal of Managerial Issues*, 18(3), 372-392.

Hirschey, M., Richardson, V. and Scholz, S. (1999). *Value relevance of nonfinancial information: The case of patent data*. School of Business, University of Kansas, mimeo.

Hirshmann, W. (1964). Profit from the learning curve. *Harvard Business Review*, 42, 116-130.

Hoskisson, R.E. & Hitt, R.A. (1990). Antecedents and performance outcomes of diversification: A review and critique of theoretical perspectives. *Journal of Management*, 16(2), 461-509.

Hsieh, M.H. & Tsai, K.H. (2007). Technological capability, social capital and the launch strategy for innovative products. *Industrial Marketing Management*, 36(4), 493-502.

Huang, Y. & Chen, C. (2010). The impact of technological diversity and organizational slack on innovation. *Technovation*, 30(7-8), 420-428.

Huizingh, E. (2011). Open innovation: State of the art and future perspectives.

Technovation, 31(1), 2-9.

Hung, K.P. & Chou, C. (2013). The impact of open innovation of firm performance: The moderating effects of internal R&D and environmental turbulence. *Technovation*, 33(10-11), 368-380.

Hurmelinna-Laukkanen, P., Olander, H., Blomqvist, K. & Panfilii, V. (2012). Orchestrating R&D networks: Absorptive capacity, network stability, and innovation appropriability. *European Management Journal*, 30(6), 552-563.

Hurmelinna-Laukkanen, P. & Puumalainen, K. (2007). Nature and dynamics of appropriability: Strategies for appropriating returns on innovation. *R&D Management*, 37(2), 95-112.

Hurmelinna-Laukkanen, P., Sainio, L. & Jauhiainen, T. (2008). Appropriability regime for radical and incremental innovations. *R&D Management*, 38(3), 278-289.

Ince, H., Imamoglu, S.Z. & Turkcan, H. (2016). The effect of technological innovation capabilities and absorptive capacity on firm innovativeness: A conceptual framework. *Procedia-Social and Behavioral Sciences*, 235, 764-770.

Jacquemin, A.P. & Berry, C.H. (1979). Entropy measure of diversification and corporate growth. *Journal of Industrial Economics*, 27(4), 359-369.

Jaworski, B.J. & Kohli, A.K. (1993). Market orientation: Antecedents and consequences. *Journal of Marketing*, 57(3), 53-70.

Jensen, M., Johnson, B., Lorenz, E. & and Lundvall, B. (2007). Forms of knowledge and modes of innovation. *Research Policy*, 36(5), 680-693.

Jones, G.R. & Hill, C.W.L. (1988). Transaction cost analysis of strategy of strategy-structure choice. *Strategic Management Journal*, 9(2), 159-172.

Kaish, S. & Gilad, B. (1991). Characteristics of opportunities search of entrepreneurs versus executives: Sources, interests, general alertness. *Journal of Business Venturing*, 6(1), 45-61.

Karr-Wisniewski, P. & Lu, Y. (2010). When more is too much: Operationalizing technology overload and exploring its impact on knowledge worker productivity. *Computers in Human Behavior*, 26(5), 1061-1072.

Katila, R. & Ahuja, G. (2002). Something old, something new: a longitudinal study of search behavior and new product introduction. *Academy of Management Journal*, 45(6), 1183-1194.

Keats, B.W. & Hitt, M.A. (1988). A causal model of linkages among environmental dimensions, macro organizational characteristics, and performance. *Academy of Management Journal*, 31(3), 570-598.

Khamseh, H.M., Jolly, D., & Morel, L. (2017). The effect of learning approaches on the utilization of external knowledge in strategic alliances. *Industrial Marketing Management*, 63, 92-104.

Kim, L. (1998). Crisis construction and organizational learning: Capability building in catching-up at Hyundai Motor. *Organization Science*, 9(4), 506-521.

Kim, L. (2000). The dynamics of technological learning in industrialization. *UNU/INTECH Discussion paper*.

Kim, L. (2009). Choosing between international technology licensing partners: An empirical analysis of U.S. biotechnology firms. *Journal of Engineering and Technology Management*, 26(1-2), 57-72.

Kim, D. & Kogut, B. (1996). Technological platforms and diversification. *Organization Science*, 7(3), 283-301.

Kim, J., Lee, C.Y. & Cho, Y. (2016). Technological diversification, core-technology competence, and firm growth. *Research Policy*, 45(1), 113-124.

Kim, Y. & Vonortas, N. (2006). Determinants of technology licensing: The case of licensors. *Managerial and Decision Economics*, 27(4), 235-249.

Kleinknecht, A., Van Montfort, K. & Brouwer, E. (2002). The non-trivial choice between innovation indicators. *Economics of Innovation and New Technology*, 11(2), 109-121.

Knudsen, T. & Srikanth, K. (2014). Coordinated exploration: Organizing joint search by multiple specialists to overcome mutual confusion and joint myopia. *Administrative Science Quarterly*, 59(3), 409-441.

Köhler, C., Sofka, W. & Grimpe, C. (2012). Selective search, sectoral patterns, and the impact on product innovation performance. *Research Policy*, 41(8), 1344-1356.

Kor, Y.Y., Watson, S. & Mahoney, J.T. (2004). Industry effects on the use of board and institutional investor monitoring and executive incentive compensation. *University of Illinois at Urbana-Champaign Working Paper*.

Lall, S. (1992). Technological capabilities and industrialization. *World Development*,

20(2), 165-186.

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

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

Laursen, K. (2012). Keep searching and you'll find: what do we know about variety creation through firm's search activities for innovation? *Industrial and Corporate Change*, 21(5), 1181-1220.

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

Laursen, K. & Salter, A. (2014). The paradox of openness: Appropriability, external search, and collaboration. *Research Policy*, 43(5), 867-878.

Lawson, M.B. (2001). In praise of slack: Time is of the essence. *Academy of Management Perspectives*, 15(3), 125-135.

Lazaric, N., Lonhi, C. & Thoma, C. (2008). Gatekeepers of knowledge versus platforms of knowledge: From potential to realized absorptive capacity. *Regional Studies*, 42(6), 837-852.

Leal-Rodríguez, A., Roldán, J., Ariza-Montes, J. & Leal-Millán, A. (2014). From potential absorptive capacity to innovation outcomes in project teams: The

conditional mediating role of the realized absorptive capacity in a relational learning context. *International Journal of Project Management*, 32(6), 894-907.

Lee, S. (2015). Slack and innovation: Investigating the relationship in Korea. *Journal of Business Research*, 68(9), 1895-1905.

Lee, C., Wu, H. & Pao, H. (2014). How does R&D intensity influence firm explorativeness? Evidence of R&D active firms in four advanced countries. *Technovation*, 34(10), 582-593.

Leonard-Barton, D. (1992). Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal*, 13, 111-125.

Leontiades, M. (1980). *Strategies for diversification and change*, Little, Brown: Boston, MA.

Leten, B., Belderbos, R. & Von Looy, B. (2007). Technological diversification, coherence, and performance of firms. *Journal of Product Innovation Management*, 24(6), 567-579.

Levinthal, D.A. & March, J.G. (1993). The myopia of learning. *Strategic Management Journal*, 14, 95-112.

Li, C., Chu, C. & Lin, C. (2010). The contingent value of exploratory and exploitative learning for new product development performance. *Industrial Marketing Management*, 39(7), 1186-1197.

Lichtenthaler, U. & Lichtenthaler, E. (2009). A capability-based framework for open innovation: Complementing absorptive capacity. *Journal of Management Studies*,

46(8), 1315-1338.

Liebeskind, J. (1996). Knowledge, strategy, and the theory of the firm. *Strategic Management Journal*, 17(Issue S2), 93-107.

Lin, C. & Chang, C.-C. (2015). The effect of technological diversification on organizational performance: An empirical study of S&P 500 manufacturing firms. *Technological Forecasting & Social Change*, 90(Part B), 575-586.

MacDonald, J. (1985). R&D and the directions of diversification. *The Review of Economics and Statistics*, 67(4), 583–590.

Makri, M., Hitt, M. & Lane, P. (2010). Complementary technologies, knowledge relatedness, and invention outcomes in high technology mergers and acquisitions. *Strategic Management Journal*, 31(6), 602-628.

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

March, J. & Simon, H.A. (1958). *Organizations*. New York: John Wiley.

Marlin, D. & Geiger, S.W. (2015). A reexamination of the organizational slack and innovation relationship. *Journal of Business Research*, 68(12), 2683-2690.

Martínez-Noya, A. & García-Canal, E. (2011). Technological capabilities and the decision to outsource/outsource offshore R&D services. *International Business Review*, 20(3), 264-277.

Martín-de-Castro, G., Delgado-Verde, M., López-Sáez, P. & Navas-López, J. (2011). Towards 'An Intellectual Capital-Based View of the Firm': Origins and Nature.

Journal of Business Ethics, 98(4), 649-662.

McDonough III, E.F. & Barczak, G. (1992). The effects of cognitive problem-solving orientation and technological familiarity on faster new product development. *Journal of Product Innovation Management*, 9(1), 44-52.

McEvily, S.K., Eisenhardt, K.M. & Prescott, J.E. (2004). The global acquisition, leverage, and protection of technological competencies. *Strategic Management Journal*, 25(8/9), 713-722.

McGill, J.P. & Santoro, M.D. (2009). Alliance portfolio and patent output: The case of biotechnology alliances. *IEEE Transactions on Engineering Management*, 56(3), 388-401.

Miller, D.J. (2006). Technological diversification, related diversification, and firm performance. *Strategic Management Journal*, 27(7), 601-619.

Miller, R.A. (1973). Concentration and marginal concentration, advertising and diversity: Three issues in structure performance tests. *Industrial Organization Review*, 1(1), 15-24.

Miller, D.J., Fern, M.J. & Cardinal, L.B. (2007). The use of knowledge for technological innovation within diversified firms. *Academy Management of Journal*, 50(2), 308-326.

Monteiro, F., Mol, M., & Birkinshaw, J. (2017). Ready to be open? Explaining the firm the firm level barriers to benefiting from openness to external knowledge. *Long Range Planning*, 50(2), 282-295.

Montgomery, C.A. (1994). Corporate diversification. *Journal of Economic Perspective*, 8(3), 163-178.

Montgomery, C.A. & Wernerfelt, B. (1988). Diversification, Ricardian rents, and Tobin's q. *RAND Journal of Economics*, 19(4), 623-632.

Moorman, C. & Slotegraaf, R.J. (1999). The contingency value of complementary capabilities in product development. *Journal of Marketing Research*, 36(2), 239-257.

Nelson, R. & Winter, S. (1977). In search of useful theory of innovation. *Research Policy*, 6(1), 36-76.

Nelson, R. & Winter, S. (1982). *An evolutionary theory of economic change*. Cambridge, Mass: Harvard University Press.

Ndofor, H. & Levitas, E. (2004). Signaling the strategic value of knowledge. *Journal of Management*, 30(5), 685-702.

Ng, D.W. (2007). A modern resource based approach to unrelated diversification. *Journal of Management Studies*, 44(8), 1481-1502.

Nieto, M. & Quevedo, P. (2005). Absorptive capacity, technological opportunity, knowledge spillovers, and innovative effort. *Technovation*, 25(10), 1141-1157.

Nohria, N. & Gulati, R. (1996). Is slack good or bad for innovation? *Academy of Management Journal*, 39(5), 1245-1264.

Nooteboom, B., Haverbeke, W., Duysters, G., Gilsing, V. & van den Oord, A. (2007). Optimal cognitive distance and absorptive capacity. *Research Policy*, 36(7),

1016-1034.

Nyaingirl, S. & Ogollah, K. (2015). Influence of unrelated diversification strategy components on corporate performance: Case of Sameer group in Kenya. *Journal of Business and Management*, 17(4), 78-83.

O'Brien, J.P. (2003). The capital structure implications of pursuing a strategy of innovation. *Strategic Management Journal*, 24(5), 415-431.

Olsen, A., Sofka, W. & Grimpe, C. (2017). Solving environmental problems: knowledge and coordination in collaborative search. *Long Range Planning*, In press.

O'Reilly, C. (1980). Individuals and information overload in organizations: Is more necessarily better? *Academy of Management Journal*, 23(4), 684–696.

Palich, L.E., Cardinal, L.B. & Miller, C.C. (2000). Curvilinearity in the diversification-performance linkage: An examination of over three decades of research. *Strategic Management Journal*, 21(2), 155-174.

Panzar, J. & Willig, R. (1981). Economies of scope. *The American Economic Review*, 71(2), 268-272.

Palepu, K. (1985). Diversification strategy, profit performance and the entropy measure. *Strategic Management Journal*, 6(3), 239-255.

Park, K. & Jang, S. (2013). Effects of within-industry diversification and related diversification strategies on firm performance. *International Journal of Hospitality Management*, 34, 51-60.

Pavitt, K. (1985). Patent statistics as indicators of innovative activities: Possibilities and

problems. *Scientometrics*, 7(1-2), 77-99.

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

Penrose, E. (1959). *The theory of the growth of the firm*, New York: John Wiley.

Peng, M.W., Lee, S.H. & Wang, D. (2005). What determines the scope of the firm over time? A focus on institutional relatedness. *Academy of Management Review*, 30(3), 622-633.

Quintana-García, C. & Benavides-Velasco, C.A. (2008). Innovative competence, exploration and exploitation: The influence of technological diversification. *Research Policy*, 37(3), 492-507.

Ramaswamy, K., Purkayastha, S. & Petitt, B.S. (2017). How do institutional transitions impact the efficacy of related and unrelated diversification strategies used by business group?' *Journal of Business Research*, 72, 1-13.

Reichert, F., Beltrame, R., Corso, K., Trevisan, M. & Zawislak, P.A. (2011). Technological capability's predictor variables. *Journal of Technology Management & Innovation*, 6(1), 14-25.

Rigby, D. & Zook, C. (2002). Open-market innovation. *Harvard Business Review*, 80(10), 80-89.

Ritala, P. & Hurmelinna-Laukkanen, P. (2013). Incremental and radical innovation in coopetition: The role of absorptive capacity and appropriability. *Journal of*

Production Innovation Management, 30(1), 154-169.

Robins, J.A. & Wiersema, M. (1995). A resource-based approach to the multibusiness firm: Empirical analysis of portfolio interrelationships and corporate financial performance. *Strategic Management Journal*, 16(4), 277-299.

Robins, J.A. & Wiersema, M. (2003). The measurement of corporate portfolio strategy: Analysis of the content validity of related diversification indexes. *Strategic Management Journal*, 24(1), 39-59.

Rodríguez-Duarte, A., Sandulli, F., Minguela-Rata, B. & López-Sánchez, J. (2007). The endogenous relationship between innovation and diversification, and the impact of technological resources on the form of diversification. *Research Policy*, 36(5), 652-664.

Rosenberg, N. (1990). Why do firms do basic research (with their own money)? *Research Policy*, 19(2), 165-174.

Rosenkopf, L. & Nerkar, A. (2001). Beyond local search: Boundary spanning, exploration, and impact in the optical disk industry. *Strategic Management Journal*, 22(4), 287-306.

Salter, A., Criscuolo, P. & Ter Wal, A. (2014). Coping with open innovation: Responding to the challenges of external engagement in R&D. *California Management Review*, 56(2), 77-94.

Santiago, F. & Alcorta, L. (2012). Human resource management for learning through knowledge exploitation and knowledge exploration: Pharmaceuticals in Mexico.

Structural Change and Economics Dynamics, 23(4), 530-546.

Sharfman, M.P. & Dean, J.W. (1991). Conceptualizing and measuring the organizational environment: A multidimensional approach. *Journal of Management*, 17(4), 681-700.

Shleifer, A. & Vishny, R.W. (1989). Management entrenchment: The case of manager-specific investments. *Journal of Financial Economics*, 1989(25), 123-139.

Simon, H. (1947). *Administrative behavior*. New York, NY: Free Press.

Simon, H. (1997). *Models of Bounded Rationality*. Cambridge, Mass: MIT Press.

Simon, H. (2008). *Rationality, bounded*. In S., & L. (Eds.), *The new Palgrave dictionary of economics* (2nd ed.). Hampshire: Palgrave.

Singh, J.V. (1986). Performance, slack, and risk taking in organizational decision making. *Academy of Management Journal*, 29(3), 562-585.

Sivadas, E. & Dwyer, F.R. (2000). An examination of organizational factors influencing new product success in internal and alliance-based processes. *Journal of Marketing*. 64(1), 31-49.

Slater, S.F. & Narver, J.C. (1994). Does competitive environment moderate the market orientation-performance relationship? *Journal of Marketing*, 58(1), 46-55.

Srivastava, M.K., Gnyawali D.R. & Hatfield, D.E. (2015). Behavioral implications of absorptive capacity: The role of technological effort and technological capability in leveraging alliance network technological resources. *Technological Forecasting & Social Change*, 92, 346-358.

Song, J. & Shin, J. (2008). The paradox of technological capabilities: A study of knowledge sourcing from host countries of overseas R&D operations. *Journal of International Business Studies*, 39(2), 291-303.

Subramaniam, M. & Youndt, M.A. (2005). The influence of intellectual capital on the types of innovative capabilities. *Academy of Management Journal*, 48(3), 450-463.

Suzuki, J. & Kodama, F. (2004). Technological diversity of persistent innovators in Japan: Two case studies of large Japanese firms. *Research Policy*, 33(3), 531-549.

Tan, J. & Peng, M.W. (2003). Organizational slack and firm performance during economic transitions: Two studies from an emerging economy. *Strategic Management Journal*, 24(13), 1249-1263.

Teece, D.J. (1982). Towards an economic theory of the multiproduct firm. *Journal of Economic Behavior and Organization*, 3(1), 39-63.

Teece, D. (1986). Profiting from technological innovation: implications for integration collaboration, licensing and public policy. *Research Policy*, 15(6), 285-305.

Teece, D. (2002). *Managing Intellectual Capital*. Oxford University Press, Oxford.

Teece, D.J., Rumelt, R.P., Dosi, G. & Winter, S. (1994). Understanding corporate coherence: Theory and evidence. *Journal of Economic Behavior and Organization*, 23(1), 1-30.

Teece, D.J. & Pisano, G. (1994). The dynamic capabilities of firms: An introduction. *Industrial and Corporate Change*, 3(3), 537-556.

Teece, D., Pisano, G. & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), 509-533.

Thompson, J. (1967). *Organization in Action*. McGrawHill: New York.

Tippmann, E., Scott, P.S. & Mangematin, V. (2014). Stimulating knowledge search routines and architecture competences: the role of organizational context and middle management. *Long Range Planning*, 47(4), 206–223.

Todorova, G. & Durisin, B. (2007). Absorptive capacity: valuing a reconceptualization. *Academy of Management Review*, 32(3), 774-786.

Trajtenberg, M., Henderson, R. & Jaffe, A. (1997). University versus corporate patents: A window on the basicness of invention. *Economics of Innovation and new technology*, 5(1), 19-50.

Tsai, K.H. (2004). The impact of technological capability on firm performance in Taiwan's electronics industry. *Journal of High Technology Management Research*, 15(2), 183-195.

Tsai, K.H., Liao, Y.C. & Hsu, T.T. (2015). Does the use of knowledge integration mechanisms enhance product innovativeness? *Industrial Marketing Management*, 46, 214-223.

Tzokas, N., Kim, Y.A., Akbar, H. & Al-Dajani, H. (2015). Absorptive capacity and performance: The role of customer relationship and technological capabilities in high-tech SMEs. *Industrial Marketing Management*, 47, 134-142.

Van den Bosch, F.A.J., Volberda, H.W. & de Boer, M. (1999). Coevolution of firm

absorptive capacity and knowledge environment: Organizational forms and combinative capabilities. *Organization Science*, 10(5), 551-568.

Van Wijk, R., Jansen, J.J.P. & Lyles, M.A. (2008). Inter-and intra-organizational knowledge transfer: A meta-analytic review and assessment of its antecedents and consequences. *Journal of Management Studies*. 45(4), 830-853.

Varadarajan, P.R. (1986). Product diversity and firm performance: An empirical investigation. *Journal of Marketing*, 50(3), 43-57.

Vassolo, R.S., Anand, J. & Folta, T.B. (2004). Non-additivity in portfolios of exploration activities: A real options-based analysis of equity alliances in biotechnology. *Strategic Management Journal*, 25(11), 1045-1061.

Verona, G.A. (1999). A resource based view of product development. *Academy of Management Review*, 24(1), 132-142.

Villalonga, B. (2004). Diversification discount or premium? New evidence from BITS establishment-level data. *Journal of Finance*, 59(2), 479-506.

Volberda, H., Foss, N. & Lyles, M. (2010). Perspective-Absorbing the concept of absorptive capacity: how to realize its potential in the organization field. *Organization Science*, 21(4), 931-951.

Voudouris, I., Lioukas, S., Iatrelli, M. & Caloghirou, Y. (2012). Effectiveness of technology investment: Impact of internal technological capability, networking and investment's strategic importance. *Technovation*, 32(6), 400-414.

Voss, G.B., Sirdeshmukh, D. & Voss, Z.G. (2008). The effects of slack resources and

environmental threat on product exploration and exploitation. *Academy of Management Journal*, 51(1), 147-164.

Wales, W., Parida, V. & Patel, P. (2013). Too much of a good thing? Absorptive capacity, firm performance, and the moderating role of entrepreneurial orientation. *Strategic Management Journal*, 34(5), 622-633.

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

Wernerfelt, B. (1984). The resource-based view of the firm. *Strategic Management Journal*, 5(2), 171-180.

West, J. & Bogers, M. (2014). Leveraging external sources of innovation: A review of research on open innovation. *Journal of Product Innovation Management*, 31(4), 814-831.

Wiklund, J. & Shepherd, D. (2005). Entrepreneurial orientation and small business performance: A configurational approach. *Journal of Business Venturing*, 20(1), 71-91.

Williamson, O.E. (1985). *The Economic Institutions of Capitalism*. New York: Free Press.

Willman, P. (1992). Playing the Long Game; Reaping the Benefits of Technological change. *Business Strategy Review*, 3(1), 89-98.

Xu, K., Huang, K. & Gao, S. (2012). Technological sourcing, appropriability regimes, and new product development. *Journal of Engineering and Technology*

Management, 29(2), 265-280.

Yu, S. (2013). Social capital, absorptive capability, and firm innovation. *Technological Forecasting & Social Change*, 80(7), 1261-1270.

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

Zahra, S.A., Neubaum, D.O. & Larrañeta, B. (2007). Knowledge sharing and technological capabilities: The moderating role of family involvement. *Journal of Business Research*, 60(10), 1070-1079.

Zhou, K.Z. & Wu, F. (2010). Technological capability, strategic flexibility, and product innovation. *Strategic Management Journal*, 31(5), 547-561.

Abstract (Korean)

최근 20년동안 지식은 기업이 경쟁우위를 지키고 재정적/혁신적 성장을 하기 위한 주요 요소로 부상하였다. 기업은 내부 R&D에서 벗어나 외부 지식을 적극적으로 수용하는 것을 기업의 혁신 전략으로 활용하였는데, 기술의 진부화 및 불확실성의 증가에 대응하기 위해 가치 있는 외부 지식을 확보하는 것에 대한 중요성이 높아졌기 때문이다. 개방형 혁신의 개념이 확산되면서, 가치있는 외부 지식을 바탕으로 한 기업 내부의 혁신 전략에 대한 연구들이 등장하기 시작했다. 최근 지식 경영분야에서의 연구에서 지식기반 혁신이 큰 주목을 받고 있다. 그 중에서도 외부 지식의 기업 성과에 미치는 영향에 대한 부분에 대한 연구가 활발하게 이루어지고 있다. 그러나, 외부 지식 기반 혁신의 메커니즘과 관련된 연구는 충분히 이해되지 못했다. 대부분의 기존 연구에서는 외부 지식이 기업의 성과에 어떤 영향을 주고 있는가에 만 머무르고 있으며, 외부 지식을 바탕으로 한 기업의 혁신 과정의 메커니즘에 대한 연구가 부족한 것이 현실이다. 최근 연구에서 지식기반 혁신의 메커니즘 연구가 내부 또는 외부 인자들을 포함하여 이루어지고 있으나, 다양한 관점과 종합적인 연구로 연결되지는 못하고 있는 실정이다. 본 학위 논문은 지식기반 혁신의 메커니즘의 세부 사항에 대한 이해를 증진시키는 것에 목적을 두고 “외부 지식 탐색 전략을 결정하는 것은 무엇인가?” “비 관련 기술 다각화와 혁신 성과간 관계를 촉진하는 요인은 무엇인가”라는 두 가지 질문을 다룬다.

구체적으로 3장에서는 외부지식 탐색 전략을 결정하는 요인들을 고찰한다. 외부지식 탐색 전략이 내생적 및 외생적 영향을 동시에 받는다는 점을 고려하여 기업 내생적 인자와 기업 외생적 인자를 모두 함께 고려하여 조사하였다. 내생적 요인으로는 외부 지식의 인지와 흡수에 영향을 주는 능력으로 이론적으로 알려져 있는 기업의 잠재적 흡수 역량을 다루었다. 외생적 요인으로는 기존 문헌에서 외부 지식의 흐름과 양에 영향을 주는 것으로 알려져 있는 전유성 체제를 다루었다. 본 연구의 가설은 다양한 산업 군의 170개 기업으로 구성된 패널 데이터 셋을 기반으로 검증하였다. 3장의 결과를 통해, 기업의 잠재적 흡수역량은 외부 지식전략 탐색 전략에 위로 구부러진 곡선적 영향을 주는 것을 확인할 수 있었다. 또한, 부분적으로 전유성 체제는 외부 지식탐색 전략을 촉진하는 것을 확인할 수 있었다. 이러한 결과는 혁신과정에서 기업의 외부지식 사용에 내생적 및 외생적 인자가 주요한 역할을 하고 있음을 확인할 수 있었다.

4장은 비 관련 기술 다각화가 기업의 혁신 성과간 관계에 영향을 미치는 내생적 및 외생적 요인들에 대하여 고찰한다. 특히, 기존 문헌들에서 제시되었던 인자들 중, 혁신 활동들 및 지식의 속성과 관련된 내생적 및 외생적 인자인 조직적 슬랙, 기술적 역량 그리고 기술적 변동성에 대하여 조사하였다. 본 연구의 가설은 다양한 산업 군의 251개 기업으로 구성된 단면 데이터 셋을 기반으로 검증하였다. 기본적으로 비 관련 기술 다각화는 기업의 혁신 성과와 위로 구부러진 곡선적 영향을 주는 것을 확인할 수 있었다. 이러한 가운데 조직적 슬랙과의 상호작용은 비 관련 기술 다각화와 기업의 혁신 성과간 관계를

부분적으로 증진시키는 것을 확인할 수 있었다. 그러나, 기술적 역량과 기술적 변동과의 상호작용은 상기 관계를 저해시키는 것을 확인할 수 있었다. 본 결과는 기업이 조직적 슬랙을 많이 보유하거나 기업적 역량과 기술적 변동성이 낮은 경우에 비 관련 기술다각화로부터 이점을 극대화할 수 있음을 시사한다.

결론적으로, 본 학위 논문은 지식 기반 혁신의 메커니즘에 대한 이해를 증진시키는 것에 그 목적을 둔다. 첫째, 지식 기반 혁신의 메커니즘과 관련된 연구를 진행함으로써 혁신 경영 연구의 관점을 확장시켰다. 지식 탐색전략 및 기술 다각화 등 분야별로 이루어지는 개별 연구들의 단편적인 부분을 벗어나 기업의 내생적 및 외생적 인자들을 통합적으로 분석함으로써 지식 기반 혁신의 메커니즘의 특징을 파악하였다. 두 번째, 본 연구는 외부 지식 탐색 전략에 대한 기업 내부와 외부 요소들의 효과를 확인함으로써 적절한 외부 지식 탐색을 진행하기 위하여 기업 내부의 지식 수준 및 기업 외부의 지식 양과 흐름에 대하여 고려할 것을 권고한다. 세 번째, 본 연구는 새로운 환경에 대처하기 위한 방법으로 기업이 비 관련 기술 다각화를 진행할 때 혁신활동과 관련한 기업 내부 및 외부 요소들과의 적절한 상호작용들이 기업의 혁신 성과 달성에 영향을 주는 것을 확인하였다. 기업이 비 관련 기술 다각화 연구 및 실제 전략 수립에 있어 혁신활동과 관련된 기업 내부 및 외부 요소들은 중요한 요인으로 고려되어야 할 것이다.

주요어 : 지식기반 혁신, 외부지식 탐색, 비 관련 기술 다각화, 혁신 성과, 지식 기반 관점, 혁신 메커니즘
학 번 : 2011-30302