Ph. D. Dissertation in Engineering

Realizing Innovation through Technological M&As

: Target Firm Selection, Post-M&A Inventor Contexts, and the Subsequent Technology Portfolio Renewal

기술혁신형 인수합병을 통한 혁신: 피인수 기업 선정, 인수 후 연구인력의 혁신 환경, 그리고 궁극적 혁신 방향의 변화를 중심으로

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Graduate School of Seoul National University

Technology Management, Economics, and Policy Program

John Seokhyun Han

Abstract

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John Seokhyun Han
Technology Management, Economics, and Policy Program
College of Engineering
Seoul National University

In high-technology industries, which are characterized by short technology life cycles and a dynamic external environment, firms need to keep creating novel innovation in order to sustain their competitive advantage. Within this context, technological Mergers and Acquisitions (M&As) have been highlighted as a prominent external knowledge sourcing strategy for the last decade. Technological M&A has been increasingly used, especially in high-technology industries such as computer software and hardware, machinery, communication equipment, life science, and others.

Technological M&As are characterized by the integration of the knowledge bases of two different firms. Unlike other external knowledge sourcing strategies such as strategic alliances or cross licensing, through technological M&As, the acquirer firm can assimilate

the target firm's bundle of knowledge resources, including human resources and their organizational contexts. With respect to these properties, previous literature on technological M&As investigated two significant factors; 1) the dyadic knowledge base characteristics of the acquirer and the target firm, and 2) the post-M&A integration of the target firm's human resources.

Considering the existing research stream and practical issues of technological M&As, this dissertation focuses on three major building blocks of technological M&As: "Target firm selection based on dyadic knowledge characteristics", "Target firm inventor's post-M&A organizational context", and "Acquirer firms' core technology portfolio changes through technological M&As". The interplay and consideration of these components are important for the success of technological M&As, and each of the components also provides individual strategic implications.

Each building block has significant impacts on the success or failure of technological M&As. First, when selecting a target firm in technological M&As, the acquirer firm should consider the double-edged characteristics of the target firm's high quality knowledge. That is, target firm's high quality knowledge with significant impact is also difficult to transfer without a common knowledge area. Second, when considering the post-M&A integration of the target firm, not only the target firm inventor retention but also their network retention and field retention are important success factors for the knowledge transfer and synergy realization through technological M&As. Third, technological M&A is a prominent strategy for a firm's core technology portfolio change. The target firm inventor retention is

an important strategic factor when conducting technological M&As for core technological portfolio change. The objective of this study is to empirically investigate the impact of primary factors in each of the described processes of technological M&As on the firm's subsequent innovation performance, thereby uncovering the success factors for technological M&As.

Chapter 3 of this dissertation examines the dyadic knowledge base characteristics between the acquirer and the target firm that should be taken into account when selecting target firms in technological M&As. Specifically, the study analyzes the impact of the knowledge overlap between the acquirer and target firm on post-M&A innovation performance. Extending previous studies which merely focused on quantitative characteristics of the acquirer and target firm's knowledge, the study presents a framework for examining the impact of both qualitative and quantitative characteristics of knowledge on two distinguished knowledge areas, i.e., the overlapped and non-overlapped parts of the target firm's knowledge base. The results of the analysis show that the high quality of overlapped knowledge has positive effects on the subsequent innovation performance, while its effects are negative for non-overlapped knowledge quality. The study also shows consistent results with regards to the quantitative side of the knowledge overlap. The results of the study suggest that sufficient knowledge overlap is essential in order to successfully assimilate a target firm's high quality knowledge.

Focusing on the post-M&A integration context of technological M&As, Chapter 4 investigates the effects of the target firm inventors' post-M&A organizational context on

subsequent innovation performance. Extending the previous literature which states the importance of post-M&A key inventor retention in technological M&As, the study focuses on more detailed dimensions of inventor retention. Specifically, the study examines how the retention of the target firm inventor network and the inventors' technological fields affects the post-M&A innovation process. Specifically, the study looks at the effects on both knowledge preservation and synergy realization. The results show that both the target firm's inventor network and the field retention are beneficial for the target firm's knowledge preservation. However, they simultaneously decrease the creativity in the combined entity, decreasing post-M&A synergy realization. The results of this study suggest that the acquirer firms need to leverage the various dimension of target firm inventor retention to efficiently achieve their objective of the technological M&As.

Chapter 5 of this dissertation proposes technological M&A as a firm's core technology portfolio renewal strategy. In order to explore the important factors of firm's core technology portfolio change through technological M&As, the study investigates two significant factors of organizational change based on the evolutionary theory of the firm and the organizational learning theory, i.e., path dependency and the combinative capabilities of the acquirer firm. The study examines the direct effect of each factor on the post-M&A core technology portfolio change. Additionally, the study suggests target firm inventor retention as a strategic factor which can moderate the direct relationships of the path dependency and the combinative capabilities of the acquirer firm with core portfolio change. The results of the analysis indicate that the path dependency of the acquirer firm

impedes the inflow of the target firm's knowledge and causes a Not-Invented-Here (NIH) syndrome, thereby negatively affecting any post-M&A core technology portfolio change. On the other hand, high combinative capabilities of the acquirer firm facilitate small changes using the target firm's knowledge and help to amplify those changes, ultimately generating a positive effect on core technology portfolio change. Further, the target firm inventor retention can serve as a significant moderator, mitigating the negative effect of path dependency. The study contributes to the field of organizational learning by empirically demonstrating that technological M&A yields a significant effect of learning-by-hiring through the absorption of the target firm inventors. The findings of this study present practical implications for firms that are considering technological M&A as a core technological portfolio renewal strategy.

In conclusion, this dissertation focuses on major building blocks of technological M&As that significantly affect the firm's post-M&A innovation performance. Providing both theoretical contributions and practical implications, the dissertation empirically investigates the importance of those procedural building blocks of technological M&As. Even though the number of technological M&As is constantly increasing, most M&A deals fail to learn from the target firm's knowledge resources and realize synergies. This dissertation allows firms to understand the mechanisms of technological M&As in more detail and therefore have a higher potential for realizing creative synergy through technological M&As. Ultimately, the innovation created through technological M&As can enhance firms' dynamic capabilities which allow firms to deal with the fast-changing

environment and enable them to sustain their competitive advantage.

Keywords: Technological M&A, M&A process, Knowledge overlap, Inventor retention, Post-M&A integration, Core technology portfolio renewal

Student Number: 2011-23452

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Chapter 1. Introduction

1.1. Backgrounds

Due to the increasing technological complexity and fast-changing environment, firms in high technology industries are facing immense challenges of breakthrough innovation and corporate change (Ranger-Moore, 1997). The resource constraints of internal R&D induce firms to be heavily specialized and path dependent, thereby hindering breakthrough innovation to overcome the challenges of the modern world (Rigby and Zook, 2002). In this regard, firms are trying to assimilate external knowledge resources to overcome these limitations using external knowledge sourcing strategies such as cross licensing, strategic alliances, or technological M&As (Cassiman and Veugelers, 2006; Kang, Jo, and Kang, 2015). Among the various external knowledge sourcing strategies, technological M&A has become a prominent external knowledge sourcing strategy for firms as it allows to assimilate the target firm's bundle of knowledge resources including inventors and their innovation context (Jo, Park, and Kang, 2016).

Technological M&A refers to an M&A deal in which the objective is to acquire the target firm's knowledge base (Ahuja and Katila, 2001). Traditional M&A studies have presented various motives for conducting M&As such as achieving market power, realizing cost synergies, and eliminating potential rivalry firms. Studies on technological M&A, on

the other hand, highlight motives based on changing conditions and the nature of innovation, such as 1) increasing innovation complexity, 2) shorter industry life cycles, 3) the stylized fact that most breakthrough innovation originates from start-ups (Abernathy and Utterback, 1978; Sears and Hoetker, 2014). As a result, firms widely use technological M&As to supplement their in-house technological development. Those dynamic conditions of modern industries have led to a major rise of technological M&As starting from the late 1990s (Ahuja and Katila, 2001; Cloodt, Hagedoorn, and Van Kranenburg, 2006). As shown in Figure 1-1, the number of M&A transactions in biopharmaceutical industries has been extremely increased from early 2000s. Likewise, technological M&A became an increasingly popular strategy for achieving novel innovation.

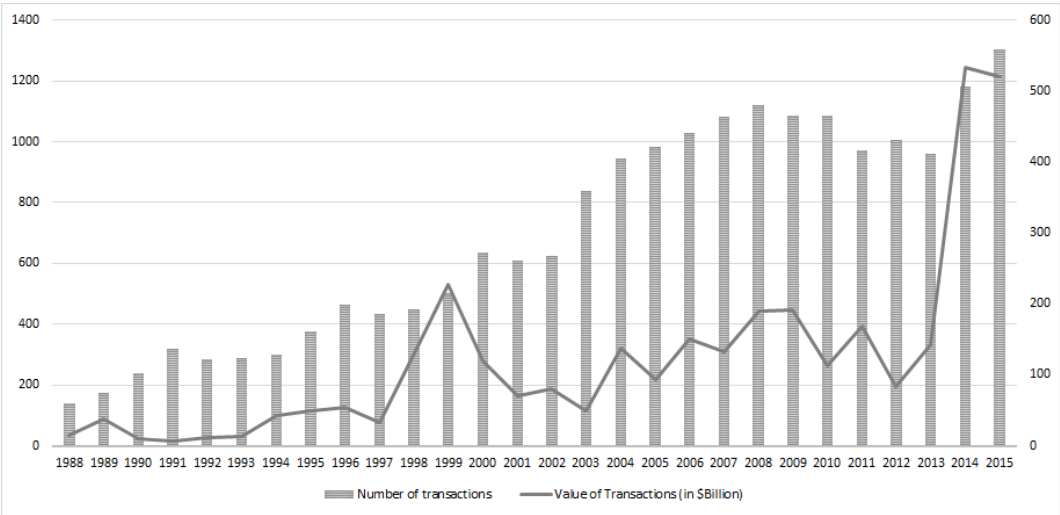

Figure 1-1. Technological M&A deals in biopharmaceutical industry

Prior research has investigated various characteristics of technological M&As and their impacts. Earlier literature focusing on the pre-M&A context examined the dyadic knowledge base characteristics between the acquirer and the target firm in technological M&As (Ahuja and Katila, 2001; Cloodt et al., 2006; Kapoor and Lim, 2007). This stream of research commonly argued that considering the knowledge overlap between the target and the acquirer firm's knowledge bases is important to select an optimal target firm and successfully create novel recombination through technological M&As (Sears and Hoetker, 2014; Sleuwaegen and Valentini, 2006).

Further, previous studies on the post-M&A context of technological M&As focused on the post-M&A integration of the target firm inventors. One of the most distinguishable characteristics of technological M&As is that the acquirer firm can assimilate the target firm's human resources, which are the most important knowledge reservoir of the firm's knowledge base (Argote and Ingram, 2000; Ernst and Vitt, 2000). Therefore, the successful integration of target firm inventors is a compelling issue when considering the post-M&A integration of technological M&As (Paruchuri, Nerkar, and Hambrick, 2006). Consequently, research on the post-M&A context examined the impact of post-M&A inventor retention on subsequent innovation performance (Ranft and Lord, 2000).

A broad range of theoretical lenses has been adopted to identify the key success factors of technological M&As. The theoretical lenses in this research stream are including the resource based view, the knowledge based view, organizational leaning, the theory of absorptive capacity, the evolutionary theory of the firm, and others.

1.2. Research purpose

Recently, the research on technological M&As is trying to extricate the double-edged dilemmas of both pre-M&A knowledge base characteristics and the post-M&A integration of target firm knowledge resources. In the pre-M&A stage, when selecting a target firm with a knowledge overlap, there exists a trade-off relationship between the novelty of the acquired knowledge and the relative absorptive capacity. That is, the larger the knowledge overlap between target firm and acquirer firm, the higher is the relative absorptive capacity between the two knowledge bases. Simultaneously, however, the high knowledge overlap entails high knowledge redundancy, which causes inefficiency of organizational learning. Prior studies have investigated the optimum knowledge overlap between the target and the acquirer firm in technological M&As.

Another paradox exists in the phase of post-M&A knowledge integration. The study of Ranft (2006) acknowledged the issue of target firm knowledge preservation and its trade-off relationship with knowledge integration. The main idea of this paradox is that since valuable knowledge is fragile and difficult to transfer, the target firm's knowledge could be disrupted by the acquirer firm's effort of post-M&A knowledge integration. On the contrary, without any attempt to integrate the target firm's knowledge resources, the synergy realization between the two knowledge bases is not likely to take place (Ernst and Vitt, 2000).

The purpose of the dissertation is as follows: First, the dissertation disentangles the dilemmas in each stage of technological M&As. Providing a more detailed framework for the pre-M&A target selection and the post-M&A knowledge base integration stage, it newly interprets the trade-off relationships in each stage and suggests how to deal with them according to the specific context of technological M&As. Specifically, Chapter 4 of this dissertation deals with the dilemma of knowledge overlap, i.e., the double-edged relationship of absorptive capacity and the knowledge redundancy. In Chapter 5, the dissertation examines the paradox of post-M&A knowledge preservation and synergy realization, especially focusing on the post-M&A target firm inventor's organizational characteristics.

Second, the dissertation provides a comprehensive framework of technological M&A stages to examine the collective impact of each stage on the ultimate success of a firm's technological M&As. Chapter 6 of this dissertation investigates the comprehensive impact of pre-M&A knowledge base characteristics and post-M&A target firm inventor retention. Moreover, extending the previous literature which merely focused on post-M&A innovation performance, Chapter 6 examines the role of technological M&As as a firm's core technology portfolio renewal strategy. It empirically investigates the effects of the essential factors in each stage of technological M&As on firm's innovation outcome to present the anatomy of technological M&As and firm's successful core technology innovation.

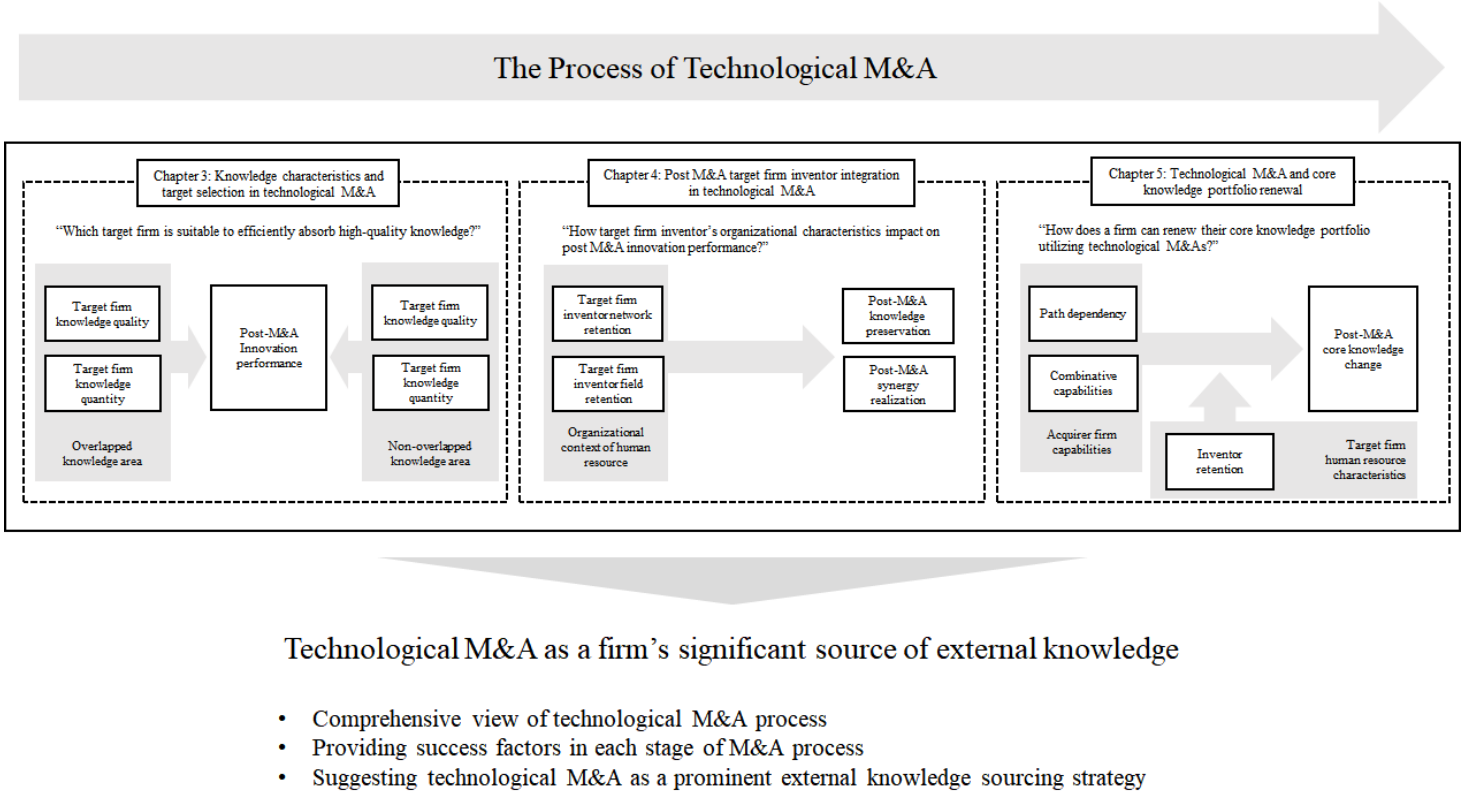

Figure 1-2. Research outline of the dissertation

Table 1-1. Overview of Chapters 3, 4 and 5

	Chapter 3	**Chapter 4**	**Chapter 5**
Purpose	Investigating the effect of knowledge overlap assimilating target firm's high quality knowledge	Illuminating the impact of post-M&A target firm inventor's organizational context	Technological M&A as a core technological portfolio renewal strategy
Focus	Pre-M&A knowledge base characteristics	Post-M&A target firm inventor integration	Measuring overall performance of technological M&As
Industry	Biopharmaceuticals & IT industries	Biopharmaceuticals industry	Biopharmaceuticals industry
Method	Negative binomial regression	Negative binomial regression/ Logit-transformed ordinary least squares regression	Logit-transformed ordinary least squares regression
Implication	In order to assimilate target firm's high quality knowledge, knowledge overlap is required	Not only the retention of target firm key inventors but also their organizational context plays an important role assimilating target firm's knowledge resources	Technological M&A can be considered as a strategy for renewing the firm's core technological portfolio, while the target firm inventor retention is a significant strategic factor.

1.3. Research outline

The main part of the research consists of a literature review, three different empirical studies which cover a distinct stage of technological M&As, and the overall conclusions.

Chapter 2 of this dissertation provides the collective literature review of previous studies. Chapter 2 introduces the previous research stream related to each stage of technological M&As and links it with the central research questions of this dissertation.

Chapters 3, 4 and 5 cover three different empirical studies, each focusing on one of the stages of technological M&As. Figure 1-2 represents the overall research framework of this dissertation based on these empirical studies covering target selection of technological M&As based on dyadic knowledge base characteristics, post-M&A target firm inventor's organizational context, and the overall core technology portfolio renewal through technological M&As. The detailed summary of each chapters are presented in Table 1-1.

Focusing on the pre-M&A knowledge base characteristics of technological M&As, Chapter 3 analyses the effects of the knowledge overlap between acquirer and target firms on the performance of technological M&As. Extending previous research that has focused on the quantitative characteristics of knowledge, Chapter 3 introduces a framework capturing the effects of both the quantity and quality of knowledge in the overlapped and non-overlapped parts of the knowledge base on subsequent innovation performance. Analyzing a data set of 192 technological M&As of 162 high-technology firms from 2001 to 2009, the results show that a high quality of overlapped knowledge has a positive effect

on subsequent innovation performance, while the effect is negative for non-overlapped knowledge quality. In addition, this study investigates the influence of the knowledge quantity on subsequent innovation performance. The implication of this study is that the knowledge overlap in technological M&As is essential for acquiring high-quality knowledge from the target firm and for improving innovation performance.

Chapter 4 of this dissertation discusses post-M&A knowledge base integration focusing on the target firm inventor's post-M&A organizational context. Chapter 4 investigates the impact of the target firm inventor's post-M&A organizational characteristic on firms' subsequent innovation performance. Specifically, extending the previous literature which merely focused on how many of the target firm's inventors were retained after the M&A, Chapter 4 suggests more detailed dimensions of target firm inventor retention, i.e., the target firm inventor network retention and the target firm inventor field retention. The chapter investigates how these factors affect the post-M&A innovation process in terms of knowledge preservation and synergy realization. Using logit transformed ordinary least squares regression and negative binomial regression, 99 M&A deals of 73 firms in the biopharmaceutical industry from 2001 to 2009 were investigated. The key implications of Chapter 4 are that by changing the post-M&A organizational context of the target firm inventors, firms can better leverage their innovation performance and align it with the ultimate goal of the technological M&A.

Highlighting the comprehensive impact of both pre-M&A knowledge base characteristics and post-M&A inventor characteristics, Chapter 5 introduces technology

M&A as a strategy for renewing a firm's core technology portfolio. In high-tech industries, companies are forced to renew their core technological portfolio in order to build up and maintain competitive advantages. While previous research extensively focused on the relationship between technological M&As and post-M&A innovation performance, it overlooked the role of technological M&As as a firm's core technology portfolio change strategy. To bridge this gap, Chapter 5 investigates the key strategic factors for the firm's technological M&A as a core technology portfolio renewal strategy. Based on the theory of organizational learning and evolutionary theory of the firm, Chapter 5 examines the direct effect of path dependency and combinative capabilities as well as the moderating effect of post-M&A target firm inventor retention on post-M&A core technology change. The hypotheses are tested on a dataset of 287 technological M&As conducted by firms in the biopharmaceutical industry from 2001 to 2008. The results show that the path dependency of the acquirer firm hinders the firm's core technological portfolio change. At the same time, the combinative capabilities of the acquirer firm can enhance such a change. The results also confirm that the target firm's inventor retention should be seen as a key success factor for core technology change through technological M&A, as it reduces the negative direct effects of the acquirer firm's path dependency. The findings of this study provide direct implications for managers of firms who consider using technological M&A not simply as a tool for improving the innovation performance of the firm, but as a strategy for renewing the firm's core technological portfolio.

Chapter 6 provides a comprehensive summary of this dissertation. The chapter also

provides a discussion of theoretical contributions as well as some implications for practitioners.

Chapter 2. Literature review

2.1. Technological M&A: previous literatures and the overall research agenda

2.1.1. Definition of technological M&As

The conventional goals of firm's M&As are realizing economies of scale and leveraging slack resources of the current market, such as realizing market power synergies, or expanding the firm's business into new markets. Conventionally, the M&A phenomenon is studied in various research fields including the fields of economics and business studies (Rossi, Yedidia Tarba, and Raviv, 2013). The comprehensive review of Rossi et al. (2013) presents a summary of literature from both streams of research and their implications.

The economic research stream is distinguished into two streams of research: financial economics and industrial organization (Capasso and Meglio, 2005; Rossi et al., 2013). Literature on financial economics, on one hand, has focused on performance analysis, examining the variance between the actual and expected return of M&A events (Bruner, 2002; Rossi, 1999; Rossi et al., 2013). On the other hand, based on the structure-conduct-performance paradigm, the M&A literature following an industrial organization approach constantly argued that the market structure is the key determinant of M&A strategy and consequently affects the post-M&A financial performance (Church and Ware, 2000; Scherer, 1980).

The stream of business studies is also divided into two main fields of research: strategic management and organizational behavior. Scholars of strategic management have studied various significant factors affecting the success and failure of M&As (Anand and Singh, 1997; Capron, Dussauge, and Mitchell, 1998; Chatterjee, 1986; Datta and Grant, 1990; Haleblian and Finkelstein, 1999; Rossi, 1999; Zollo and Singh, 2004). However, due to the heterogeneous characteristics of M&A deals, prior studies could not identify the decisive strategic factors for increasing post-M&A performance. Organizational behavior scholars adopted a more detailed level of analysis and studied the organizational and individual factors which affect M&A success (Larsson, Driver, Holmqvist, and Sweet, 2001). Focusing on the human resource perspective of M&A deals, their studies discovered significant factors which impedes M&A success such as top management turnover (Lubatkin, Schweiger, and Weber, 1999), organizational conflict (Vaara, Sarala, Stahl, and Björkman, 2012), cultural distance (Chakrabarti, Gupta-Mukherjee, and Jayaraman, 2009), and others. The strategic management literature especially focused on the cultural gap between the acquirer and target firm in M&As, arguing that the different culture between the two firms causes a disruption of the target firm's resources and increases post-M&A corporate problems (Sales and Mirvis, 1984; Rossi et al., 2013).

Table 2-1. Conventional M&A literature from various fields

Research Field	Research Subfield	Approach	Key factors
Economic research	**Financial Economics**	Performance analysis	Financial performance
	Industrial Organization	Structure-Conduct-Performance paradigm	Market structure
Business studies	**Strategic Management**	Variance & Process approach	Heterogeneous factors for each studies
	Organizational Behavior	Focusing on the quality of the post-M&A integration process	Cultural difference

Source: Adapted from Rossi et al. (2013)

Likewise, the literature which explains the motivation and impact of conventional M&As shows various approach and results, implying that the heterogeneous characteristics of each M&A deal cause the fragmentation in identifying the success factors of M&As. However, firms in innovative industries encounter a fast-changing environment and highly complex technological standards, which are almost impossible to keep up with when only relying on internal development (Dierickx and Cool, 1989). The high complexity of technology leads to firms' specialization, while at the same time, the rapidly changing environment renders those specializations obsolete. Even though firms are aware of their organizational obsolescence, highly specialized incumbent firms are not able to transform

their core technology due to the path dependent nature of their innovation. Literature confirms this phenomenon by empirically finding that highly novel innovation is more likely to originate from start-ups with high creativity and no path dependency. This context of high-technology industries leads incumbent firms to explore new knowledge by acquiring the knowledge resources of small, technology intensive firms. For this reason, the acquisition of technology intensive firms has become one of the most prominent external knowledge sourcing strategies among the various external knowledge sourcing modes. The study of Ahuja and Katila (2001) has first coined the term technological M&A to define M&As with those distinctive characteristics. Following this foundational study on technological M&As and the subsequent innovation performance, an increasing number of studies has started to examine the impact of technological M&As on firms' innovation.

2.1.2. The research stream of technological M&As

The main motivation of technological M&As is to obtain external knowledge resources by acquiring technology intensive firms which can enhance the acquirer firm's knowledge base (Graebner, Eisenhardt, and Roundy, 2010). Compared to other types of acquisitions which are motivated by achieving economies of scale and scope, learning a target firm's technological inputs is the central issue in technological M&As. Therefore, most prior studies on technological M&As have paid particular attention to the pre/post-M&A knowledge base characteristics of the target and acquired firms and the subsequent

innovation performance (Ahuja and Katila, 2001; Cloodt et al., 2006; Puranam and Srikanth, 2007). Specifically, Meglio (2009) divided the technological M&A literature into three main streams of research: 1) Pre-M&A target selection, 2) Post-M&A integration, and 3) Post-M&A performance.

The research stream of pre-M&A target selection includes literature which examines the impact of various dimensions of target firm characteristics on target firm selection (Benou and Madura, 2005; Chakrabarti, Hauschildt, and Süverkrüp, 1994; Kennedy, Payne, and Whitehead, 2002), dyadic pre-M&A knowledge base characteristics (Ahuja and Katila, 2001; Cloodt et al., 2006; Makri, Hitt, and Lane, 2010), cultural characteristics (Weber and Tarba, 2011), and strategic decision between alliances (Hagedoorn and Duysters, 2002; Meschi, Metais, and Shimizu, 2017). Studies from this research stream have examined the effects of various pre-M&A contexts on target firm selection or post-M&A innovation performance. Unlike general M&A literature on pre-M&A target firm selection, that presented fragmented results due to the heterogeneous and complex motivations of M&A deals, research on pre-M&A characteristics of technological M&As have uncovered various success factors which heavily focus on knowledge characteristics and organizational learning (Meschi et al., 2017; Sears and Hoetker, 2014).

Similarly, the research on post-M&A integration in technological M&As is very likely to focus on knowledge base characteristics and its reservoirs. Within this stream of research, prior research has focused on 1) post-M&A inventor integration based on the theory of organizational learning and knowledge reservoirs (Castro-Casal, Neira-Fontela, and

Álvarez-Pérez, 2013; Ernst and Vitt, 2000; Ernst and Vitt, 2000; Ranft and Lord, 2000), and 2) structural perspectives which particularly focus on the post-M&A integration of R&D units (Puranam, Singh, and Zollo, 2006; Puranam and Srikanth, 2007). They commonly argued that the key success factor for technological M&As is to leverage the factors which mitigate post-M&A knowledge disruption and facilitate post-M&A collaboration activities (Hussinger, 2012; Kapoor and Lim, 2007; Paruchuri and Eisenman, 2012).

The other research focus is on measuring the performance of technological M&As. Even though the performance of technological M&As is heterogeneous (Cloodt et al., 2006; Laamanen and Keil, 2008), the mainstream of such research is commonly arguing that post-M&A innovation performance is the right proxy to measure the success of technological M&As (Ahuja and Katila, 2001; Choi and McNamara, 2017). Therefore, previous research measured post-M&A innovation performance using the firm's granted patents, new product development data, and similar metrics. Table 2-1 presents the research focus and selected works of technological M&A literature.

Table 2-2. The research focus of technological M&A literature

Pre-M&A Target Selection	Post-M&A Integration	Post-M&A Performance
Target characteristics	***Inventor perspectives***	***Financial performance***
Chakrabarti et al. (1994)	Ranft and Lord (2000)	Ragozzino (2006)
Kennedy et al. (2002)	Ranft and Lord (2002)	Laamanen and Keil (2008)
Benou and Madura (2005)	Ernst and Vitt (2000)	
	Graebner (2004)	***Innovation performance: Patenting Performance (organizational level)***
Knowledge base characteristics	Paruchuri et al. (2006)	
Ahuja and Katila (2001)	Kapoor and Lim (2007)	Ahuja and Katila (2001)
Cloodt et al. (2006)	Hussinger (2012)	Cloodt et al. (2006)
Makri et al. (2010)	Castro-Casal et al. (2013)	Puranam and Srikanth (2007)
Colombo and Rabbiosi (2014)	Paruchuri and Eisenman (2012)	Sears and Hoetker (2014)
Sears and Hoetker (2014)		Jo, Park, and Kang (2016).
Jo, Park, and Kang (2016).	***Structural perspectives***	Choi and McNamara (2017)
	Birkinshaw, Bresman, and Håkanson (2000)	
Cultural characteristics	Miller (2004)	***Patenting Performance (Individual level)***
Chakrabarti et al. (2009)	Grimpe (2007)	Kapoor and Lim (2007)
Weber and Tarba (2011)	Puranam et al. (2006)	Paruchuri and Eisenman (2012)
	Puranam and Srikanth (2007)	Hussinger (2012)
Strategic Decision between Alliances	King, Slotegraaf, and Kesner (2008)	
Mitchell and Singh (1992)	Weber and Tarba (2011)	***New product development***
Hagedoorn and Duysters (2002)	Colombo and Rabbiosi (2014)	Grimpe (2007)
Meschi et al. (2017)		Puranam et al. (2006)

Source: Adapted and from Meglio (2009)

2.2. Target firm selection: Knowledge base characteristics and innovation in technological M&As

2.2.1. Knowledge overlap in technological M&As

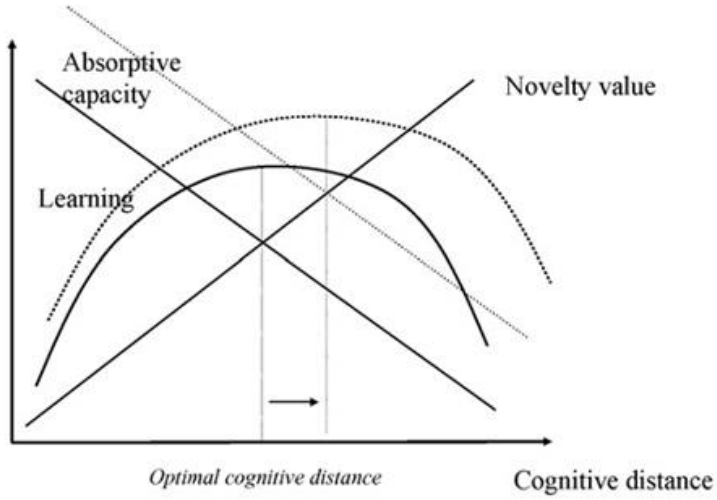

Figure 2-1. The trade-off relationship between absorptive capacity and novelty value

(Source: Nooteboom, Van Haverbeke, Duysters, Gilsing, and Van den Oord, 2007)

Since technological M&A is characterized by the integration of two different knowledge bases, a knowledge overlap between the two firms is often inescapable. Uncovering how the acquirer firm can easily recognize the target firm's knowledge resources and understand the recombination potential between two knowledge bases, scholars have identified the trade-off relationship between knowledge redundancy and the relative absorptive capacity shaped by the knowledge overlap between the acquirer and target firms. As shown in Figure

2-1, the study of Nooteboom et al. (2007) described the trade-off relationship between absorptive capacity and the novelty value of knowledge. That is, the higher the overlapped part of knowledge between two different knowledge bases, the easier is the knowledge transfer between the two entities since there exists a common technological understanding. In contrast, high knowledge overlap causes high knowledge redundancy which decreases the novelty of the acquired knowledge base. Based on this tradeoff, previous research has examined the optimal extent of knowledge overlap in a firm's external knowledge sourcing strategies.

Table 2-3. Knowledge overlap in technological M&As

Study	Type of overlap	Dependent variable
· Ahuja and Katila (2001)	Knowledge relatedness	Post-M&A innovation performance
· Cloodt et al. (2006)	Knowledge relatedness	Post-M&A innovation performance
· Kapoor and Lim (2007)	Knowledge relatedness	Post-M&A inventor productivity
· Cassiman, Colombo, Garrone, and Veugelers (2005)	Knowledge relatedness	Post-M&A innovation performance
· Makri et al. (2010)	Knowledge similarity/complementarity	Post-M&A innovation performance
· Colombo and Rabbiosi,(2014)	Knowledge similarity/complementarity	Post-M&A innovation performance
· Miozzo, DiVito, and Desyllas (2015)	Knowledge similarity/complementarity	Target firm knowledge utilization
· Sears and Hoetker (2014)	Target/ acquirer knowledge overlap (continuous)	Post-M&A innovation performance
· Orsi, Ganzaroli, De Noni, and Marelli (2015)	Knowledge similarity/complementarity	Target firm knowledge utilization

Previous research on technological M&As has identified various effects of knowledge overlap on post-M&A performance (Ahuja and Katila, 2001; Cassiman et al., 2005; Makri et al., 2010; Sears and Hoetker, 2014; Orsi et al., 2015). It has assumed that the overlapped and non-overlapped knowledge are two ends of a continuum and accordingly has measured knowledge overlap using a continuous variable. Overlapped knowledge between two firms reduces non-overlapped knowledge, and vice versa. The basic assumption behind this line of research is that the non-overlapped knowledge part provides novel knowledge to the acquiring firm, but simultaneously leads to integration problems because of the lack of absorptive capacity in the unknown fields (Cloodt et al., 2006). On the other hand, while overlapped knowledge is not accompanied by such integration problems, it does not provide new knowledge that is important for the firm to create novel recombination (Sears and Hoetker, 2014). By analyzing this effect using a single concept, that is, knowledge overlap, previous research has argued that a moderate balance between overlapped and non-overlapped knowledge is most beneficial for post-M&A innovation performance (Ahuja and Katila, 2001; Cloodt et al., 2006). Extending the research on knowledge overlap and post-M&A innovation performance, Kapoor and Lim (2007) explain that a moderate level of knowledge overlap has a positive effect on post-M&A inventor productivity, due to the novelty of the non-overlapped knowledge and the ease of communication that stems from organizational routine similarity. One of the latest studies on knowledge overlap in technological M&As divides the concept of knowledge overlap into target and acquirer overlap and analyzes the effect of each type of overlap on the subsequent performance of

M&As (Sears and Hoetker, 2014). Sears and Hoetker (2014) identify that an increasing knowledge overlap negatively affects post-M&A innovation performance due to firms' inability to benefit from novel ideas and technologies. They also discover that the effect of overlapped knowledge (absorptive capacity) is less significant than the effect of non-overlapped knowledge (novelty of knowledge).

Another stream of research provides a more refined framework for the concept of knowledge overlap: knowledge similarities and complementarities. Makri et al. (2010) first adopted this framework to the literature on technological M&As and found that the knowledge similarity of the target firm is negatively related to post-M&A innovation novelty (Makri et al., 2010). Colombo and Rabbiosi (2014) also distinguish the knowledge base into similar and complementary knowledge and examine the effect of firms' technological knowledge characteristics on post-acquisition innovation performance. More recent studies have adopted this framework and identified how knowledge base similarities and complementarities affect investments in the R&D assets of the target firm and target firm knowledge utilization in technological M&As (Miozzo et al., 2015; Orsi et al., 2015). Despite several minor differences in the results, previous studies have commonly identified the importance of non-overlapped knowledge in organizational learning, thus highlighting the importance of novelty for subsequent innovation performance (Makri et al., 2010; Colombo and Rabbiosi, 2014; Sears and Hoetker, 2014). However, previous studies have focused on the quantitative degree of knowledge overlap and have overlooked the importance of qualitative aspects in facilitating learning within the overlapped parts of the

knowledge base. Chapter 3 of this dissertation introduces these qualitative aspects of knowledge into the theoretical framework of knowledge overlap and examines how quantitative and qualitative characteristics of overlapped knowledge and non-overlapped knowledge affect post-M&A innovation performance. Figure 2-2 depicts the conceptual framework of knowledge overlap in technological M&As.

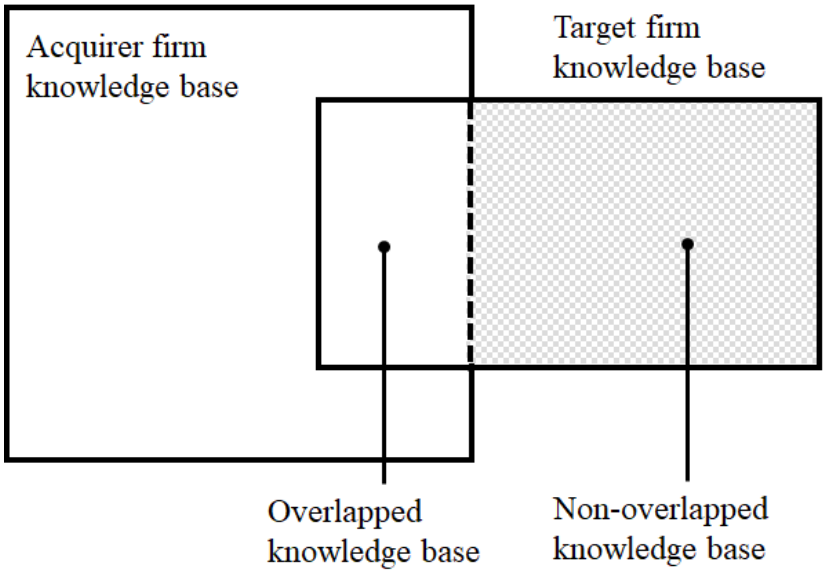

Figure 2-2. Conceptual framework of knowledge overlap in technological M&As

2.3. Post-M&A knowledge base integration

2.3.1. Post-M&A inventor retention in technological M&As

While foundational research on technological M&As has focused on the firms' pre-M&A dyadic knowledge base characteristics as the most significant factor for a successful target selection, another stream of research stressed the context of post-M&A integration (Paruchuri, 2010). Post-M&A integration literature argues that no matter how valuable the target firm's knowledge resources are, the acquirer firm cannot realize synergies without a successful integration of the target firm knowledge resources (Grant, 1996). That is, even the acquirer and the target firm knowledge bases complement each other and have a high potential for synergies, these synergies might not be realized (Ranft and Lord, 2002). Potential value could be realized or destroyed during the phase of post-M&A knowledge base integration (Capron et al., 1998). Therefore, studies on post-M&A integration investigated various factors which significantly affect the post-M&A target firm knowledge integration.

The essence of post-M&A knowledge integration is the integration of the target firm's inventors, since they possess the tacit and valuable knowledge resources (Kapoor and Lim, 2007). According to the Knowledge Based View of the firm, the firm's valuable knowledge resources are embedded in the human resources within the boundary of the firm (Argote and Ingram, 2000). The technological knowledge resources embedded in the target firm inventors are tacit and valuable, but also at the same time they are fragile and difficult to

transfer (Ranft and Lord, 2002). Based on this understanding, a number of previous studies examined how to successfully integrate target firm's inventors in the post-M&A context.

An early stream of such research, which reflects the Knowledge Based View of the firm and emphasized the importance of the target firm inventors as the firm's knowledge reservoir, has merely focused on target firm inventor retention, i.e., how many inventors have been retained after the M&A deal (Ranft and Lord, 2000; Ranft and Lord, 2002; Castro-Casal et al., 2013; Cannella and Hambrick, 1993; Reus and Lamont, 2009; Hwang, Seo, and Song, 2015). Studies have examined the antecedents of target firm inventor retention and its subsequent impact (Hwang et al., 2015). Ranft and Lord (2000) highlighted the significance of post-M&A target firm inventor retention and provided a framework for predicting post-M&A target firm employee retention based on the theory of relative standing and the knowledge based view. The study empirically identified that autonomy, status, and commitment are significant factors for increasing post-M&A inventor retention, while economic incentives do not play a significant role (Ranft and Lord, 2000). Cannella and Hambrick (1993) found that the departure of target firm executives significantly decreases post-M&A performance no matter what the pre-M&A knowledge relatedness is. Extending these empirical findings, other studies identified various factors which affect post-M&A key inventor retention (Ranft and Lord, 2002; Castro-Casal et al., 2013; Butler, Perryman, and Ranft, 2012). The follow-up study of Ranft and Lord (2002), presenting a grounded model for successful post-M&A knowledge integration, argued that the retention of target firm key inventors would preserve the target firm's technologies and

capabilities which are highly complex and tacit, and thereby difficult to imitate otherwise. Castro-Casal et al. (2013) also delineate the factors which have a positive impact on high value human resource retention in technological M&As, such as organizational autonomy, frequent use of rich media, financial incentives, and relative profitability. Likewise, the literature on target firm key inventor retention has commonly argued that the most important factor for technological M&A is the successful post-M&A integration of target firm key inventors.

Besides the literature examining the antecedents and impacts of target firm inventor retention, several studies have specifically focused on post-M&A inventor productivity, conducting their analysis on the inventor level. Paruchuri et al. (2006) focused on the post-M&A productivity of target firm inventors and examined that the acquisition integration causes productivity losses of the target firm inventors. The research examined the characteristics of target firm inventors who undergo a disruption of their technological core and lost productivity through the post-M&A integration process. The study identified factors such as the inventor's relative standing, divergence from acquirer's expertise, and the pre-acquisition social embeddedness (Paruchuri et al., 2006). Further, Kapoor and Lim (2007) identified the impact of dyadic knowledge base characteristics between the acquirer and target firm on post-M&A inventor productivity providing the implication that a greater overlap of routines and a moderate level of skill overlap between the acquirer and target firm's knowledge resources are necessary to achieve high post-M&A inventor productivity. More recent studies incorporated the organizational theory into the post-M&A inventor

productivity literature, and confirmed the positive relationship between the acquirer firm's absorptive capacity and post-M&A target firm inventor productivity (Hussinger, 2012). Further, another recent work applied a social network perspective to post-M&A inventor productivity to provide a more detailed framework of post-M&A inventor productivity by separating the knowledge utilization mechanism into knowledge dissemination and signal interpretation (Paruchuri and Eisenman, 2012). Likewise, using various theoretical lenses, the previous studies of post-M&A inventor productivity provides various significant factors which affects target firm inventor's post-M&A innovation creation.

However, literature on post-M&A inventor retention and their productivity has not yet examined the following contexts: First, previous literature has only focused on the retention and their impact of target firm key inventors. According to the theory of organizational learning and knowledge transfer, the valuable knowledge is complexly embedded in the networks of human resources and other knowledge reservoirs (Argote and Ingram, 2000). Therefore, it is important to examine the transfer of knowledge embedded in the inventor networks as well as the single key individuals. Second, previous literature simply examined post-M&A productivity measures to proxy successful post-M&A inventor integration. To understand the dilemma of knowledge preservation and integration (Puranam and Srikanth, 2007), more detailed measures for the impact of post-M&A inventor retention are required.

Chapter 4 of this dissertation fill these research gaps and examines the effects of various dimension of post-M&A inventor retention, i.e., the post-M&A inventor network retention and the post-M&A inventor field retention on various measures of post-M&A innovation

performance; post-M&A knowledge preservation and the post-M&A synergy realization. Figure 2-3 depicts the acquirer and target firm's inventors and their networks in the process of technological M&As

Table 2-4. Post-M&A inventor retention in technological M&As

Study	Focus	Key factors
Literature on post-M&A target firm inventor retention		
Cannella and Hambrick (1993)	Top management team retention	The impact of executive departures on post-M&A performance
Ranft and Lord (2000)	Key inventor retention	How to retain key employees after the M&A
Ernst and Vitt (2000)	Key inventor retention	Defining factors influencing post-M&A key inventor behaviors
Ranft and Lord (2002)	Key inventor retention	Presenting a grounded model for successful post-M&A knowledge integration
Castro-Casal et al. (2013)	Key inventor retention	Knowledge embeddedness and tacit knowledge transfer by high value human resources
Reus and Lamont (2009)	Key inventor retention	Level of non-location specific knowledge transfer in foreign acquisitions
Hwang et al. (2015)	Inventor retention	The impact of inventor retention on acquirer to target knowledge transfer
Literature on post-M&A target firm inventor productivity		
Paruchuri et al. (2006)	Target firm inventor productivity	Productivity losses caused by post-M&A structural integration
Kapoor and Lim (2007)	Target firm inventor productivity	Knowledge base characteristics and post-M&A inventor productivity

Study	Focus	Key factors
Hussinger (2012)	Target firm inventor productivity	Relationship between the acquirer firm's absorptive capacity and post-M&A target firm inventor productivity
Paruchuri and Eisenman (2012)	Post-M&A inventor productivity	Applied a social network perspectives to post-M&A inventor productivity

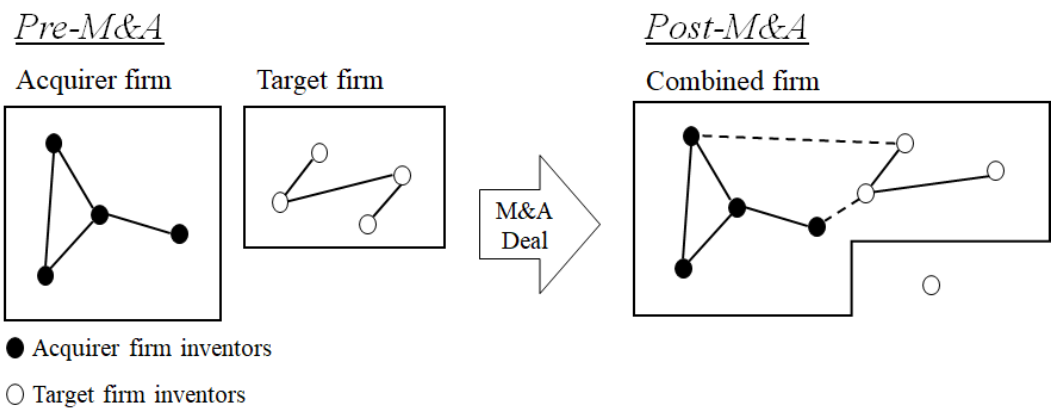

Figure 2-3. Inventor retention in technological M&As

2.4. Measuring the performance of technological M&As: Technological M&A as a core technology portfolio renewal strategy

2.4.1. Performance measures of technological M&As

Measuring post-M&A performance according to its objectives is a significant issue for both academic research and practice. The mainstream of conventional M&A literature has heavily focused on the financial performance to measure the success or failure of M&A strategies. According to Zollo and Meier (2008), about 60% of M&A literature in the field of strategic management and organization studies employed measures related to short term and long term financial performance. Table 2-4 lists the performance indicators of M&As in various fields of research (Meglio and Risberg, 2011).

Table 2-5. Types of M&A performance measures

Performance domain	Measure type	Performance indicators
Financial	Market performance	· Risk (Jensen's Alpha, Beta)
		· Market value(CAR, CAAR, APD, CPD)
	Accounting performance	· Growth (Sales growth)
		· Profitability (Net Income, ROA, ROI)
		· Cash flow
Non-financial	Operational performance	· Productivity increase (Cost synergies)
		· Innovation performance(No. of patents)
		· Marketing performance (Market size)
	Overall performance	· M&A success (Goals achievement)
		· Firm survival (Divestiture)

Source: Adapted from Meglio and Risberg (2011)

However, the phenomenon of technological M&A is heavily biased towards the acquisition of small start-ups rather than large enterprises (Sears and Hoetker, 2014) and thus rarely affects the acquirer firm's immediate financial performance. This enables the research on technological M&As to solely focus on post-M&A innovation performance. Following the foundational study of Ahuja and Katila (2001), the research on technological M&As used the subsequent innovation creation to measure the post-M&A performance (Cloodt et al., 2006; Sears and Hoetker, 2014). Specifically, many studies employed the post-M&A granted patent count to measure the post-M&A innovation performance (Makri et al., 2010).

Extending this research, further studies utilized various measures of subsequent innovation performance such as innovation quality (Valentini, 2012), post-M&A exploration and exploitation (Phene, Tallman, and Almeida, 2012), target firm knowledge utilization (Puranam and Srikanth, 2007; Orsi et al., 2015), post-M&A inventor productivity (Kapoor and Lim, 2007), and others. Valentini (2012) considered both qualitative and quantitative aspects of innovation and investigated the impact of technological M&A on firms' innovation quality and quantity. Phene et al. (2012) adopted a conventional measure of innovation performance often used in strategic management; post-M&A exploration and exploitation, distinguishing the post-M&A innovation in the acquirer firm's core and non-core technological areas. Puranam and Srikanth (2007) divided the utilization of the target firm resources into target firm knowledge utilization and capability leverage, investigating the distinctive impact of post-M&A structural integration on both types of the target firm's post-M&A performance. Studying the various effects of pre-M&A knowledge base characteristics, one of the more recent studies also considered the post-M&A target firm knowledge utilization, focusing on the acquirer firm's exploitation of the target firm knowledge (Orsi et al., 2015). Kapoor and Lim (2007) extended the study of Ahuja and Katila (2001) and investigated the impact of knowledge base characteristics on post-M&A inventor productivity. The measure of post-M&A inventor productivity has been widely used in literature dealing with post-M&A integration, which is investigating the various contextual factors such as the relative status of inventors and the inventors' social network perspectives (Hussinger, 2012; Paruchuri, 2010).

Despite previous studies exploring various measures of post-M&A innovation performance in technological M&As, the mechanism of the firm's core technological portfolio changes through technological M&As has not yet been uncovered. Given that technological M&As are one of the most prominent external knowledge sourcing strategies for firm wanting to assimilate external knowledge and change their core technology portfolio (Phene et al., 2012), previous studies are limited in measuring the fragmentary aspects of innovation performance. The study of Jain (2016) has identified the mechanism of the firm's core technology portfolio change through hiring inventors with distant knowledge and found a significant relationship between the hiring and core technology change of the firm. In this vein, technological M&As could affect the acquirer firm more significantly since they allow to assimilate the bundle of target firm inventors and their entire organizational context (Jo et al., 2016). To address this gap, Chapter 5 of this dissertation investigates firm's core technology portfolio renewal through a technological M&A strategy.

2.4.2. Core technological portfolio renewal and technological M&As

High technology industries are characterized by increased technological complexity, short technology life cycles, and a generally fast changing technological environment (Dierickx and Cool, 1989). Firms facing high technological complexity need to specialize

their core technology through accumulative learning as they keep developing their own innovation process (Sørensen and Stuart, 2000). The specialization narrows down their boundary of core technology and increases the depth of the firm's knowledge base. At the same time, the fast changing technological environment makes their specialized core technology become obsolete more rapidly (Jain, 2016; Ranger-Moore, 1997). That is, firms willing to survive in high tech industries need to renew their core technology portfolio according to the dynamic environment. The change of a firm's core technology portfolio is realized through the firm's access to distant knowledge and absorbing this knowledge through accumulated procedures of organizational learning (Phene et al., 2012). Previous literature confirms that hiring inventors with new-to-the-firm knowledge is one major strategy which stimulates a firm's core technology portfolio change (Jain, 2016). Following the basic finding that organizational human resource turnover raises the superiority of the organizational knowledge level (March, 1991), Song, Almeida, and Wu (2003) developed the framework of "learning by hiring" as a strategy for overcoming a firm's technology portfolio obsolescence. More recent literature adopted this framework and investigated the effect of learning by hiring on various dimensions of firm performance and organizational change (Palomeras and Melero, 2010; Parrotta and Pozzoli, 2012; Tzabbar, Silverman, and Aharonson, 2015). Likewise, prior literature consistently focused on the strategies of firm's core technology portfolio change in high technology industries.

Amongst other external knowledge sourcing strategies, technological M&As are widely recognized as a strategy for firm's core knowledge change. Literature on strategic

management and innovation measured M&A activities as the firm's core knowledge change (Hayward and Hambrick, 1997; Kim, Haleblian, and Finkelstein, 2011; Shin, Han, Marhold, and Kang, 2017). Higgins and Rodriguez (2006) argued that M&A is the most prominent strategy for a firm's strategic change in accordance with the fast changing external environment. Other research also considered the M&A activities as a proxy of firms' strategic change (Hayward and Hambrick, 1997; Kim et al., 2011). The underlying assumption is that firms conducting M&A activities must have a willingness to change their knowledge portfolio (Shin et al., 2017). However, even though much of prior research considered M&A as a firm's core knowledge change strategy, they have not investigated the detailed mechanisms of the firm's core knowledge change through M&A activities. Furthermore, adopting technological perspectives, literature on technological M&A has not investigated technological M&A as a firm's core technology portfolio change strategy. Recalling that technological M&A is the external knowledge sourcing strategy that allows firms to acquire the target firm's bundle of knowledge resources, the strategy could be distinctly utilized as a tool for firm's core technology portfolio renewal (Jo et al., 2016).

For a successful core technology portfolio renewal through external knowledge sourcing strategies, the acquired knowledge should be effectively transferred and amplified throughout the entire organization (Jain, 2016). The first step of a core technology portfolio renewal mechanism is the small initial change engendered by external knowledge. The small initial change of the firm caused by transferred new-to-the-firm knowledge could be the primary source of core technology portfolio change. For this to take place, the firm's

path dependency needs to be disrupted. The path dependency of the firm is formed through repeated innovation patterns and cumulatively formed organizational routines (Tripsas, 1997). The path dependency of the firm entails the Not-Invented-Here (NIH) syndrome limiting both new-to-the-firm knowledge transfer and small initial change caused by them (Hussinger and Wastyn, 2016).

As the second step, the small initial change should be amplified throughout the entire organization (Jain, 2016; Sydow, Schreyögg, and Koch, 2009). The small initial change is not enough to change the firm's core technology portfolio, but has to be amplified over the entire organization (Simon, 1991). The frequent knowledge exchange mechanism is the key to amplify those small changes at this stage (Björkdahl, 2009; March, 1991). Therefore, combinative capabilities which are formulated by efficient knowledge exchange mechanisms of the firm facilitate the amplification of the small initial change (Gebauer, Worch, and Truffer, 2012). Likewise, by adopting the framework of the firm's core technology portfolio renewal mechanism (Jain, 2016), there are two significant intra-organizational characteristics of firm's core technology portfolio renewal: path dependency of the firm and combinative capabilities.

Chapter 3. Knowledge base characteristics and target selection in technological M&A[1]

3.1. Introduction

Most of the foundational research on technological M&As has focused on the relationship between the knowledge characteristics of the acquirer and target firms and post-acquisition performance (Ahuja and Katila, 2001; Hagedoorn and Duysters, 2002; Cloodt et al., 2006; Kapoor and Lim, 2007; King et al., 2008; Sears and Hoetker, 2014; Orsi et al., 2015). Because technological M&As are characterized by the integration of the knowledge bases of two different firms, the knowledge overlap of the firms is a useful concept in studying post-acquisition knowledge integration (Sears and Hoetker, 2014). Accordingly, previous studies have investigated the effects of knowledge overlap, specifically the effects of overlapped knowledge and non-overlapped knowledge, on various dimensions of post-M&A performance, such as inventor productivity (Kapoor and Lim, 2007), post-M&A innovation performance (Cloodt et al., 2006; Makri et al., 2010; Sears and Hoetker, 2014), knowledge utilization of the target firm's knowledge base (Orsi et al., 2015), and investment in the target firm's R&D assets (Miozzo et al., 2015). To investigate these impacts of knowledge overlap in technological M&As, the theoretical framework has been continuously adapted and refined, e.g., dividing the knowledge base of the target firm into

[1] An earlier version of this chapter has been accepted for publication in *Journal of Management and Organization*.

knowledge similarities and complementarities (Makri et al., 2010). Recent studies have utilized the framework of Makri et al. (2010) to investigate the impact of the target firm's overlapped and non-overlapped knowledge on firm performance (Colombo and Rabbiosi, 2014; Miozzo et al., 2015).

However, previous studies on knowledge overlap in technological M&As have merely focused on the quantitative characteristics of the knowledge base. Specifically, Ahuja and Katila (2001) pay attention to the quantity of knowledge when investigating the effects of knowledge base overlap on subsequent innovation performance. In addition, the previous literature has defined knowledge overlap as the amount of overlapped knowledge without considering qualitative characteristics (Kapoor and Lim, 2007; Makri et al., 2010). Phene et al. (2012) focus on the amount of both common and unique knowledge of the acquirer and target firms. Sears and Hoetker (2014) extend the concept of knowledge overlap into target overlap and acquirer overlap but consider only the qualitative measures of knowledge overlap, i.e., the amount of overlapped knowledge between the acquirer firm and the target firm prior to the M&A.

When analyzing the knowledge base of firms participating in technological M&As, it is important also to consider qualitative aspects of the knowledge, as quantity by itself does not accurately reflect innovation capabilities (Chen and Chang, 2010). Yang, Wei, and Chiang (2014) develop qualitative indicators to be used in technological M&As. Furthermore, arguing that identifying the quality of knowledge is an important factor for the successful knowledge transfer of firms, Yoo (2014) redefines the substructures of

perceived knowledge quality (PKQ) and their effects on knowledge transfer. While there is an increasing understanding of the need to consider the quality of the knowledge base when using external knowledge-sourcing strategies such as technological M&As, previous research has fallen short of empirically testing the effects of qualitative knowledge characteristics on post-M&A performance.

To address this research gap, this study investigates the effects of the target firm's knowledge-quality characteristics on the subsequent innovation performance of technological M&As. In line with previous research, the study divides the knowledge base of the firm into an overlapped part and a non-overlapped part. Subsequently, for each part, this paper investigates the influence of the target firm's knowledge quality on post-M&A innovation performance. The analysis reveals that a high quality of overlapped knowledge has a positive effect, while the effect of non-overlapped knowledge quality is negative. In addition, this research hypothesizes and confirms the effects of knowledge quantity on subsequent innovation performance.

This study makes several contributions to the research on knowledge management and technological M&As: First, by revealing the double-sided characteristics of high-quality knowledge, this research extends the theory of the knowledge-based view in the field of knowledge management. That is, the study highlights that high-quality knowledge is not always beneficial for a firm's subsequent innovation performance. Second, by extending previous studies that have investigated the relationship between quantitative knowledge base characteristics and subsequent innovation performance in technological M&As, this

study highlights the effects of knowledge quality on post-M&A innovation performance. Third, while most previous empirical studies have focused on the quantitative characteristics of knowledge when investigating knowledge overlap and innovation performance in technological M&As, this research investigates the relationship between the quality of knowledge and post-M&A innovation performance. Additionally, the research model of this study provides an integrative framework of overlapped/non-overlapped knowledge and its qualitative and quantitative characteristics. This allows a more detailed analysis of the target firm's knowledge base characteristics that increase the success of technological M&As.

This paper is structured as follows: The first section reviews the relevant literature, linking it to the hypotheses on the effects of knowledge quality and quantity. The next section provides the specifications of the research data and methods used to empirically test the hypotheses. Using a negative binomial regression model, this research tests the hypotheses using data on 192 technological M&A deals conducted by 162 firms in high-technology industries. After presenting the results, the study concludes with a discussion of the findings and an outlook for future studies.

3.2. Research hypotheses

3.2.1. The link between knowledge quality and innovation performance

According to the theory of organizational learning, knowledge transfer and knowledge creation are the most important processes that allow a firm to turn its acquired external knowledge into a competitive advantage (Argote and Ingram, 2000). Consequently, for technological M&As, whose motivation is to acquire new knowledge and to create new innovation, knowledge transfer and creation represent significant success factors.

High-quality knowledge is tacit, complex, and highly asset specific (Kogut and Zander, 1992; Argote and Ingram, 2000). Previous literature on knowledge transfer has argued that the higher the quality of the knowledge, the more complexly it is embedded within a firm's knowledge reservoirs, i.e., people, tasks, tools, and their networks (Argote and Ingram, 2000; Argote and Miron-Spektor, 2011). This complexity of high-quality knowledge is the source of its inimitability and asset specificity (Kogut and Zander, 1993; Castro-Casal et al., 2013). In addition, the ambiguity caused by the tacitness of the knowledge components makes knowledge transfer difficult, especially when there is no overlapped routine compatible with both actors of learning (Uygur, 2013). Furthermore, because high-quality knowledge is formed by the process of "learning by doing" inside an organization, the key for its creation is the accumulation of experience and knowledge (Nonaka, Takeuchi, and

Umemoto, 1996). Therefore, it is hard to expect perfect learning of high-quality knowledge merely through the transfer of simple knowledge components (Song et al., 2003; Song, Almeida, & Wu, 2003; Oğuz and Şengün, 2011).

However, the existence of overlapped knowledge between the acquirer firm and the target firm can facilitate the transfer of high-quality knowledge. A knowledge overlap indicates common processes and routines shared by the acquirer firm and the target firm (Lane and Lubatkin, 1998). Cohen and Levinthal (1990) suggest that a knowledge overlap between actors provides common technologies, a similar cognitive base, and shared technological languages. The presence of those components results in a high level of absorptive capacity of the acquirer firm and thus yields a better understanding of the target firm's high-quality knowledge, which improves the knowledge transfer (Phene et al., 2012).

High-quality knowledge, often referred to as cutting-edge or state-of-the-art knowledge in the technological field, is beneficial to the process of knowledge creation. When the acquirer firm already possesses some knowledge in a specific field, advanced knowledge is essential to improve it. Previous literature on technological M&As has highlighted the importance of the non-overlapped and novel knowledge of the target firm (Cloodt et al., 2006; Sears and Hoetker, 2014). However, the contributions of the overlapped knowledge need to be considered as well. Although overlapped knowledge may contain redundant technological solutions, processes and routines might vary due to the different environments in which they were created (Cantwell, 1994). High-quality knowledge is specialized and has a strong originality and impact (Trajtenberg, 1990). It is usually

comprised of more efficient routines and allows a wider range of usage than low-quality knowledge (Cho and Pucik, 2005). Therefore, high-quality overlapped knowledge provides the acquirer firm with new technologies, which allow it to further develop and improve the processes, routines, and usage of its existing knowledge. This leads to the following hypothesis:

Hypothesis 3-1*: In technological M&As, the higher the quality of the overlapped knowledge, the higher the post-M&A innovation performance.*

When the high-quality knowledge is non-overlapped, the acquirer firm will attempt to integrate the knowledge, bearing the inefficiencies resulting from the lack of absorptive capacity. Additionally, the features of high-quality knowledge, such as asset specificity, tacitness, and complexity, make the knowledge transfer more difficult (Spender, 1989; Jasimuddin, Klein, and Connell, 2005; Cloodt et al., 2006). Knowledge from non-overlapping technological fields differs in its processes and routines, which makes it harder for the acquirer firm to transfer and integrate it (Kogut and Zander, 1992). As a result, the target firm's high-quality non-overlapped knowledge incurs high integration costs due to the inefficiency of the knowledge transfer. This causes the acquirer firm to waste research and development resources, which otherwise would have been used to enhance the core competencies of the firm, thus negatively affecting innovation (Jiang, Tan, and Thursby,

2011). Moreover, the time spent transferring the acquired non-overlapped high-quality knowledge will prevent the timely creation of new knowledge from the transferred resources (Koput, 1997). That is, high-quality non-overlapped knowledge has a negative effect by increasing not only the cost but also the time required for the knowledge transfer.

Despite the high costs, non-overlapped high-quality knowledge that is successfully transferred possesses great combinative potential and will positively influence knowledge creation. The combinative potential and application capabilities of the target firm's high-quality knowledge in fields that are new to the acquirer firm are greater than those of the firm's low-quality knowledge. However, the positive effects of the combinative potential of high-quality knowledge are limited by the lack of the acquirer firm's absorptive capacity. Without any knowledge overlap, the acquirer firm finds it hard to recognize and understand novel recombinations of the high-quality knowledge. This further impedes the creation of new innovation (Lane and Lubatkin, 1998; Phene et al., 2012). Therefore, as the quality of the non-overlapped knowledge increases, the negative effects from the increasing integration cost prevail over the positive effects from the increasing combinative potential. Moreover, high-quality knowledge from non-overlapped fields can negatively affect the creation of innovation due to attention allocation problems (Koput, 1997). Jiang et al. (2011) note that continuous attempts to create innovation in areas without prior background knowledge can negatively affect knowledge creation. This could weaken the firm's core competence through cannibalizing the resources used in current core activities. In other words, high-quality non-overlapped knowledge leads firms to wrongly allocate attention

and resources and thus has a negative effect on their core competencies and knowledge creation.

In summary, while high-quality non-overlapped knowledge possesses great combinative potential, it actually leads to negative effects due to high integration costs and firms' problematic allocation of their limited resources. Therefore, this study hypothesizes that the quality of non-overlapped knowledge has negative effects on the subsequent innovation performance:

Hypothesis 3-2*: In technological M&As, the higher the quality of the non-overlapped knowledge, the lower the post-M&A innovation performance.*

3.2.2. The link between knowledge quantity and innovation performance

Transferring overlapped knowledge is much easier because acquirer firms already possess related absorptive capacity (Ahuja and Katila, 2001; Makri et al., 2010; Orsi et al., 2015). The knowledge overlap with the target firm facilitates knowledge transfer by allowing the sharing of common technological knowledge and know-how (Kogut and Zander, 1993; Lane and Lubatkin, 1998). According to Phene et al. (2012), the knowledge overlap between the acquirer firm and the target firm enables engineers to share a common mindset, to bring about similarity in organizational systems and processes and to facilitate the

absorption of knowledge. Consequently, even if the amount of knowledge that the acquirer firm needs to integrate increases, efficient knowledge transfer is possible as long as the acquirer firm possesses sufficient absorptive capacity as a result of overlapping knowledge with the target firm (Kang et al., 2015).

An increase in overlapped knowledge quantity through technological M&As can also positively influence the process of knowledge creation. As the quantity of overlapped knowledge absorbed by the acquirer firm increases, a recombination of different knowledge and technologies can strengthen the existing core competencies of the firm (Nonaka et al., 1996). The increased quantity of overlapped knowledge leads to an active exchange and new combinations with existing knowledge, positively affecting the firm's exploitation of its existent knowledge base (Makri et al., 2010).

However, excessive amounts of overlapped knowledge can also negatively affect a firm's knowledge creation. First, a strong increase in the amount of overlapped knowledge raises the probability of knowledge redundancy and reduces the opportunities for learning. High knowledge redundancy decreases the potential for novel recombination, resulting in a negative influence on the creation of new innovations (Ahuja and Katila, 2001; Sears and Hoetker, 2014). Sears and Hoetker (2014) also suggest that a larger amount of overlap between the firms' knowledge bases increases the redundancy of the firms' resources, ultimately fostering the risk of conflict among members and resulting in organizational disruption. In other words, while an increase in the amount of overlapped knowledge helps a firm's exploitation and improves its subsequent innovation performance, an excessive

amount of overlap increases redundancy, causes organizational disruption, and ultimately negatively influences subsequent innovation performance. This leads to the following hypothesis:

Hypothesis 3-3*: In technological M&As, an inverted U-shaped relationship exists between the quantity of overlapped knowledge and the post-M&A innovation performance.*

In areas where knowledge does not overlap, it requires more time and resources to absorb knowledge due to the acquirer firm's lack of absorptive capacity (Lane and Lubatkin, 1998). When firms with insufficient absorptive capacity face the inflow of an excessive quantity of non-overlapped knowledge, the resulting information overload impedes the process of learning from knowledge transfer (Ahuja and Lampert, 2001; Phene, Fladmoe-Lindquist, and Marsh, 2006). The acquirer firm's information overload intensifies its confusion regarding which knowledge should be chosen to efficiently create innovation. The overload also makes it more difficult to timely absorb and integrate the information by delaying the transfer process (Koput, 1997; Hagedoorn and Duysters, 2002). An excessive quantity of non-overlapped knowledge causes high integration costs and inefficiencies in the knowledge transfer through technological M&As (Ahuja and Katila, 2001; Sears and Hoetker, 2014).

On the other hand, an increase in the quantity of non-overlapped knowledge that is successfully transferred through technological M&As can positively influence the

knowledge-creation process. A larger quantity of the absorbed non-overlapped knowledge results in more recombinations that enable firms to diversify into new technological fields (Larsson and Finkelstein, 1999; Karim and Mitchell, 2000; Graebner et al., 2010). The recombination of a firm's non-overlapped knowledge and the existing fields creates more valuable inventions (Yayavaram and Chen, 2015). The non-overlapped parts of the target firm's knowledge base serve as a toolbox for the acquirer firm to explore new fields. This includes the acquisition, transfer and use of new knowledge, processes, and routines that were not part of the acquirer firm's pre-M&A knowledge base (Ahuja and Lampert, 2001). In other words, as increasing amounts of non-redundant knowledge are transferred to the acquirer firm, the potential for recombination and the possibility to enter a new technological field increases and improves the firm's innovation output (Phene et al., 2012).

However, information overload as a result of an excessive amount of non-overlapped knowledge negatively affects the process of knowledge creation as well as the process of knowledge transfer. First, it disrupts existing innovation activities and complicates the process of knowledge creation by incurring costs and delays, which ultimately negatively influence the acquirer firm's subsequent innovation performance (Chakrabarti et al., 1994; Capron and Mitchell, 2004; Cloodt et al., 2006). When the acquirer firm absorbs too much non-redundant knowledge, its attention to developing specific technology is distracted, which can inhibit the creation of new innovation (Koput, 1997).

In summary, a large quantity of non-overlapped knowledge increases the number of possibilities for the novel recombination of knowledge, contributing to the firm's

explorative innovation. However, when the quantity exceeds a certain level, the acquirer firm suffers from high integration costs due to an insufficient absorptive capacity and delayed knowledge transfer. Moreover, excessive quantities of non-overlapped knowledge can disrupt a firm's existing innovative activity. This leads to the following hypothesis:

Hypothesis 3-4: *In technological M&As, an inverted U-shaped relationship exists between the quantity of non-overlapped knowledge and the post-M&A innovation performance.*

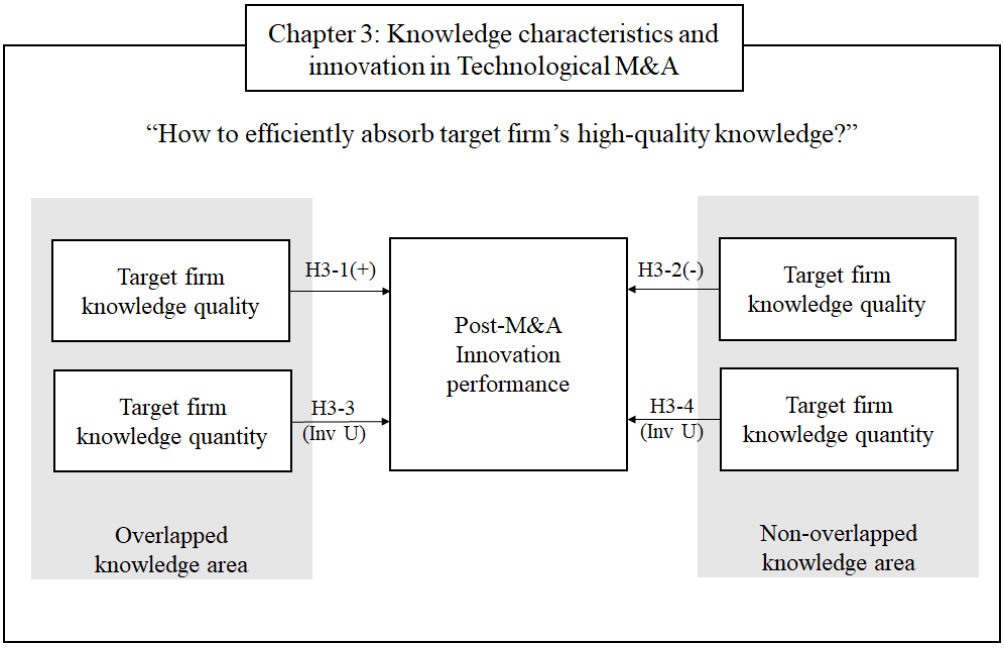

Figure 3-1. Conceptual model for Chapter 3

3.3. Methods

3.3.1. Data

The hypotheses are tested using a dataset of technological M&As conducted in high-tech industries from 2001 to 2009. Technological M&As, i.e., M&As with the main motivation of acquiring the target firm's knowledge base, have been a popular strategy for external technology sourcing since the early 2000s (Sleuwaegen and Valentini, 2006; Alexandridis, Mavrovitis, and Travlos, 2012). The upper bound of 2009 provides enough time to observe post-acquisition patenting activity. Information on high-tech industry M&A deals that were conducted in the timeframe of the study was collected from the Thomson Reuters SDC Platinum database. M&A deals that involved firms repurchasing their remaining assets and cases of acquisition of remaining interest were excluded. Additional financial information on the firms was acquired from Datastream. Information regarding the patents granted to the firms was collected through the United States Patent and Trademark Office (USPTO) database. The United States has recorded the highest number of patent litigations in the global technology market. Thus, both US and foreign firms usually apply for US patents to protect their innovation from patent infringement (Albert, Avery, Narin, and McAllister, 1991). In addition, previous research has found that US patents are a good proxy for the study of the innovation of foreign firms (Dosi, Pavitt, and Soete, 1990). Therefore, by using USPTO data, this research does not suffer from differences in the patent application

systems in various countries. Following the method of Ahuja and Katila (2001), only M&A deals in which the target firm had applied for at least one patent in the five years prior to the M&A deal are considered technological M&As. The final dataset consists of 192 technological M&A deals conducted by 162 acquirer firms. The M&A samples are divided into six sub-categories that fall within the IT and bio-pharmaceutical industries: communications equipment, computer and office equipment, drugs, electronic and electrical equipment measuring, medical photo equipment, and telecommunications. These six sub-categories represent industries that have a strong propensity to conduct technological M&As to acquire new technologies. In the sample, electronic and electrical equipment account for 26% of the M&A deals, followed by drugs with 20%, measuring, medical, and photo equipment with 19%, computer and office equipment with 12%, telecommunications with 11.5%, and communications and equipment with 11%. The 192 M&A cases include deals conducted by major firms such as Johnson & Johnson, GlaxoSmithKline, Oracle, SAP, Acer, and Hewlett Packard. Looking at the national origin of the firms in the sample, the U.S has the highest share with 56%, followed by Europe with 21% and then Asia with 19%. M&A deals of firms from other regions account for only 5% of the total technological M&A deals.

3.3.2. Variables

3.3.2.1 Dependent variable

Subsequent innovation performance

This study utilizes patent data to measure the post-M&A innovation performance of acquirer firms. The patenting activity of a firm can be used to approximate its technological characteristics and innovation performance (Hagedoorn and Schakenraad, 1994; Ahuja, 2000; Rothaermel and Alexandre, 2009; Yoon, Lee, and Song, 2015). Previous research on technological M&As has used patent count to measure the subsequent innovation performance of the acquirer firm (Ahuja and Katila, 2001; Puranam and Srikanth, 2007; Jo et al., 2016). In this research, patent count is employed as a lagged measure for firms' post-M&A innovation performance. This study assumes a lag of one year after the M&A deal to account for the time it takes from the transfer of the knowledge to its use in a new patent (Makri et al., 2010). Previous studies have shown that the value of technological inventions, especially in high-tech industries, depreciates rapidly (Park, Shin, and Park, 2006; Van de Vrande, Vanhaverbeke, and Duysters, 2009). Thus, it is difficult to assume that patents created more than 5 years after an M&A deal have originated from the knowledge that was transferred as part of the acquisition. Accounting for both the lag in using newly transferred knowledge as well as the depreciation of knowledge, the present research defines subsequent innovation performance as the number of granted patents of the acquirer firm that were applied for between one and five years after the M&A deal year (Bettis and

Mahajan, 1985; Ahuja and Lampert, 2001; Harrison, Hitt, Hoskisson, and Ireland, 2001; Jiang et al., 2011).

3.3.2.2 Independent variables

Overlapped knowledge quality and non-overlapped knowledge quality

Measuring the quality of overlapped and non-overlapped knowledge requires two key steps: The first step is to classify the knowledge base as overlapped and non-overlapped, while the second step is to measure the qualitative characteristics of each part of knowledge.

The classification of a patent according to the United States Patent Classification represents the technological characteristics of the patent, which implies that patents with similar technologies are classified within the same class, showing the overlap of the knowledge (Sampson, 2007; Makri et al., 2010; Jo et al., 2016). The opposite also holds true, i.e., when two patents belong to the same patent class, it is implied that they are developed in the same technological field (Sampson, 2007). Therefore, for patents in the same class, the knowledge embedded in the inventions can be considered to be overlapped (Makri et al., 2010). More recent research presumes that two different patents in the same patent class are created using common knowledge, representing the overlapped part of knowledge between the knowledge bases of firms. Furthermore, recent research uses patent class data to measure knowledge similarities and overlap (Diestre and Rajagopalan, 2012; Frankort, 2016). Following these studies, I also employ the USPC system to classify the

knowledge overlap. Thus, patents of acquirer and target firms within the same class are categorized as overlapped, while the ones in different classes are categorized as non-overlapped (Carayannopoulos and Auster, 2010; Lin, Wu, Chang, Wang, and Lee, 2012).

The quality of each of the overlapped and non-overlapped parts is calculated using the impact of the patents. Previous innovation-related research has used the impact of patents to represent knowledge quality (Kim, Song, and Nerkar, 2012; Valentini, 2012). According to Trajtenberg (1990), the impact of a patent refers to the total number of its forward citations. In the present research, overlapped knowledge quality and non-overlapped knowledge quality are each calculated as the average impact of all the target firm's patents in the overlapped and non-overlapped patent classes, respectively.

$$Knowledge\ \ quality = \sum_{j=1}^{n} \frac{P_i}{n}\ \ (Where\ \ P_i\ \ indicates\ \ the\ \ number\ \ of\ \ foward\ \ citation\ \ of\ \ patent\ \ i\ \ received)$$

Overlapped knowledge quantity and non-overlapped knowledge quantity

The definition of overlapped knowledge quantity and non-overlapped knowledge quantity follows the approach described above. The variable overlapped knowledge quantity is measured as the number of patents in the overlapped parts of the target firm's knowledge base. Consequently, the variable non-overlapped knowledge quantity is measured as the number of patents in the non-overlapped parts of the target firm's knowledge base.

3.3.2.3 Control variables

This research adopts a number of control variables to allow uncovering the effects contributed to the independent variables. Because not all granted patents in the observation period can be directly linked to the performance of technological M&As, following previous research, this study controls for a number of possible additional effects on the post-M&A innovation performance of the acquiring firm (Ahuja and Katila, 2001; Hagedoorn and Duysters, 2002; Chen and Chang, 2010). First, the technical and financial characteristics and capabilities of the acquiring firm that may influence post-M&A innovation performance are controlled using the *acquirer size* and *acquirer R&D capability* variables (Phene and Almeida, 2008). The size of the acquirer firm is calculated as the log value of the average revenue of the three years prior to the M&A deal. The R&D capability of the acquirer firm is measured as the 3-year averaged value of R&D intensity, i.e., R&D expenditure divided by total sales of the firm. The R&D intensity of a firm implies the firm's level of effort for innovation and direct input of innovation, thereby affecting post-innovation performance (Hagedoorn and Duysters, 2002). Additionally, the larger the knowledge base of the firm is, the more possibilities of novel recombination exist (Ahuja and Katila, 2001). The influence of the acquirer firm's knowledge base, i.e., the patents owned by the acquirer firm, is controlled using the total number of patents granted to the firm prior to the M&A deal. In addition to the quantity of the knowledge stock, the quality of the acquirer firm's knowledge base also affects the firm's innovation performance because possessing high-quality knowledge provides more applicable choices for

subsequent recombination (Trajtenberg, 1990). Thus, the study also controls for the quality of the firm's existing knowledge stock by using the average impact of the acquirer firm's knowledge base prior to the M&A deal. A number of dummy variables are introduced to capture cross-border M&As, the deal year and the country of the acquirer firm.

3.3.3. Model

The dependent variable of this study, subsequent innovation performance, is a non-negative count variable. In such cases, Poisson regression is a common choice of methodology. However, according to the descriptive statistics presented in Table 3-1, the dependent variable shows over-dispersion, which violates the basic assumption of the Poisson regression model. Thus, the present research uses a negative binomial model (Hausman, Hall, and Griliches, 1984).

3.4. Results

3.4.1. Descriptive statistics

Table 3-1. shows the summary statistics and the correlations among the variables used in the research. The correlations among the variables are generally low. In addition, the study carries out a variance inflation factor (VIF) test to increase the validity of the analysis and rule out a multicollinearity problem caused by the high correlation between variables. All VIF values are lower than 3, which verifies that there is no multicollinearity problem among the variables (Myers, 1990).

Table 3-1. Descriptive statistics and correlations among the variables

Variables	1	2	3	4	5	6	7	8	9	Mean	Std. Dev
Subsequent innovation performance	1.00									91.35	212.22
Overlapped knowledge quality	0.44	1.00								4.99	5.97
Non-overlapped knowledge quality	-0.11	-0.09	1.00							6.27	18.29
Overlapped knowledge quantity	0.20	0.19	-0.13	1.00						14.39	20.84
Non-overlapped knowledge quantity	-0.07	-0.13	-0.02	-0.03	1.00					13.26	62.87
Acquirer size	0.31	0.07	-0.14	0.16	0.19	1.00				5.91	1.13
Acquirer R&D capability	-0.07	-0.09	-0.03	0.07	-0.04	-0.42	1.00			0.27	0.62
Acquirer knowledge base	0.37	0.19	-0.08	0.26	-0.05	0.36	-0.07	1.00		638.40	2437.98
Acquirer technology quality	0.16	0.41	-0.01	0.05	-0.12	-0.02	-0.01	0.14	1.00	12.75	15.88

3.4.2. Negative binomial regression results

Table 3-2 describes the results of the negative binomial regression. Model 1 analyses the influence of the control variables on the dependent variable. Only acquirer size is found to have a consistently significant effect. Models 2 to 4 introduce the independent variables, while Model 5 is the full model that includes all the control and independent variables as well as their square terms.

According to the results of Table 3-2, overlapped knowledge quality shows a positive and significant ($p < 0.01$) result from Model 2 to Model 5. Thus, Hypothesis 3-1, which states that the target firm's high quality of the overlapped knowledge has a positive influence on post-M&A innovation performance, is confirmed. Hypothesis 3-2 states that as the quality of the target firm's non-overlapped knowledge increases, the subsequent innovation performance of the acquirer firm is negatively affected. Non-overlapped knowledge quality shows negative results of $p < 0.01$ significance in Model 3 and $p < 0.05$ significance in Models 4 and 5. Thus, Hypothesis 3-2 is also supported.

To verify the curvilinear relationship stated in Hypothesis 3-3, both overlapped knowledge quantity and its squared term are included in Models 4 and 5. As a result, the first-order overlapped knowledge quantity variable shows a positive significance of $p < 0.01$ in both models. At the same time, the squared term of the overlapped knowledge quantity variable (overlapped knowledge quantity squared) shows a negative significance of $p < 0.01$ in Model 4 and $p < 0.05$ in Model 5. Thus, the overlapped knowledge quantity

between the acquirer and target firms exhibits an inverted U-shaped relationship, verifying Hypothesis 3-3.

Hypothesis 3-4 suggests a similar inverted U-shaped relationship also for non-overlapped knowledge quantity. In Model 5, however, both non-overlapped knowledge quantity and its square term (non-overlapped knowledge quantity squared) show no significance according to the p value. Thus, Hypothesis 3-4 is not supported. In summary, Hypotheses 3-1, 3-2 and 3-3 are strongly supported, while Hypothesis 3-4 is not supported by any statistically significant result and cannot be verified.

As stated in Table 3-2, some independent variables are highly significant, but the associated coefficients have a seemingly small numeric value. However, one needs to recall that the employed negative binomial regression is a nonlinear regression with the equation of $\ln y = \beta_0 + \beta_2 x_2 + ... + \beta_p x_p$. Therefore, the actual proportion of variance for each independent variable takes the exponential form of the coefficient. Thus, in this study, the actual proportion of variance for the dependent variable is sufficiently large to show a meaningful impact of the chosen variables on the post-M&A performance of the firms.

Table 3-2. Negative binomial regression results for subsequent innovation performance

Dependent variable **(Subsequent innovation performance)**	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	Coefficient (S.E.)	**Coefficient (S.E.)**	**Coefficient (S.E.)**	**Coefficient (S.E.)**	**Coefficient (S.E.)**
Control variables					
Acquirer size	0.95**	0.89**	0.84**	0.74**	0.78**
	(0.17)	(0.15)	(0.15)	(0.14)	(0.14)
Acquirer R&D capability	0.45	0.59†	0.51†	0.14	0.17
	(0.32)	(0.30)	(0.29)	(0.23)	(0.23)
Acquirer knowledge base	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Acquirer technology quality	0.03†	0.02	0.02†	0.03*	0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Independent variables					
Overlapped knowledge quality		0.13**	0.12**	0.10**	0.10**
		(0.03)	(0.03)	(0.02)	(0.02)
Non-overlapped knowledge quality			-0.02**	-0.02*	-0.02*
			(0.01)	(0.01)	(0.01)
Overlapped knowledge quantity				0.07**	0.06**
				(0.02)	(0.02)
Overlapped knowledge quantity squared				-0.0006**	-0.0006*
				(0.0002)	(0.0002)
Non-overlapped knowledge quantity					0.00
					(0.01)
Non-overlapped knowledge quantity squared					0.00
					(0.00)
Log likelihood	-878.12	-863.89	-860.48	-849.60	-847.96
Pseudo R^2	0.03	0.05	0.05	0.06	0.07
LR Chi^2	59.22	87.67	94.48	116.25	119.53
Regression p-value	0.00	0.00	0.00	0.00	0.00

Notes: †p < 0.10; *p < 0.05; **p < 0.01

N=192 (Control dummy variables are included)

3.4.3. Robustness test

In addition to the impact of the patent, prior research has used other methods to measure the quality of a patent. In particular, originality and generality are other exemplary variables representing the quality of patents (Trajtenberg, 1990). To show whether the choice of measurement influences the results, the analysis is repeated using originality and generality as the measures for knowledge quality.

The generality of a patent refers to its use in various fields. According to Trajtenberg (1990), patents with a high generality are actively used not only in the technological field to which they belong but also in wider range of fields. The generality of a patent is calculated as 1 minus the Herfindahl index, measuring the concentration of citations received from patents in different patent classes (Valentini, 2012).

$$Patent\ \ Generality = 1 - \sum_{j=1}^{n} s_{ij}^2\ (s_{ij}\ \ indicates\ \ the\ \ percentage\ \ of\ \ citations\ \ received\ \ by$$

$$patent\ \ i\ \ that\ \ belongs\ \ to\ \ patent\ \ class\ \ j, out\ \ of\ \ n\ \ patent\ \ classes$$

The originality of a patent is an index used to determine how creative a new patent is compared to previous ones. According to the originality index, a patent's quality increases as the underlining patents become more diverse (Rosenkopf and Nerkar, 2001). Because these patents are based on diverse ideas and technologies, they are considered more innovative than other patents that are based on only one field (Trajtenberg, Henderson, and Jaffe, 1997; Valentini, 2012). The originality of a patent is calculated similarly to its generality, using a Herfindahl index-based measure of the backward citations of the patent.

$$Patent\ \ Originality = 1 - \sum_{j=1}^{n} t_{ij}^{2}\ (\ t_{ij}\ \ indicates\ \ the\ \ percentage\ \ of\ \ citations\ \ received\ \ by$$

$$patent\ \ i\ \ that\ \ belongs\ \ to\ \ patent\ \ class\ \ j, out\ \ of\ \ n\ \ patent\ \ classes.)$$

The two indexes are applied to measure the quality of the patents and used to verify Hypotheses 3-1 and 3-2 of the present research. The results from this analysis are identical to the results presented in Table 3-2, which further validates the robustness of this study. The results of the additional tests are displayed in Table 3-3 and Table 3-4 of the Appendix.

Table 3-3. Robustness test results: knowledge generality

Dependent variable **Subsequent innovation performance**	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	Coefficient (S.E.)	**Coefficient (S.E.)**	**Coefficient (S.E.)**	**Coefficient (S.E.)**	**Coefficient (S.E.)**
Control variables					
Acquirer size	0.84**	0.91**	0.80**	0.77**	0.77**
	(0.16)	(0.15)	(0.14)	(0.14)	(0.15)
Acquirer R&D capability	0.05	0.25	0.13	0.02	0.02
	(0.26)	(0.25)	(0.24)	(0.22)	(0.22)
Acquirer knowledge base	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Acquirer technology quality	3.73**	2.59**	2.34**	1.93**	1.97**
	(0.63)	(0.61)	(0.60)	(0.57)	(0.58)
Independent variables					
Overlapped knowledge quality		3.35**	3.25**	2.63**	2.69**
		(0.76)	(0.71)	(0.62)	(0.62)
Non-overlapped knowledge quality			-1.86**	-1.67**	-1.73**
			(0.55)	(0.53)	(0.54)
Overlapped knowledge quantity				0.06**	0.06**
				(0.02)	(0.02)
Overlapped knowledge quantity squared				-0.0006**	-0.0007**
				(0.0002)	(0.0002)
Non-overlapped knowledge quantity					0.01
					(0.01)
Non-overlapped knowledge quantity squared					0.00
					(0.00)
Log likelihood	-866.59	-856.80	-851.72	-845.04	-843.35
Pseudo R^2	0.05	0.06	0.06	0.07	0.07
LR Chi^2	82.27	101.86	112.01	125.37	128.76
Regression p-value	0.00	0.00	0.00	0.00	0.00

Notes: †p < 0.10; *p < 0.05; **p < 0.01

N=192 (Control dummy variables are included)

Table 3-4. Robustness test results: knowledge originality

Dependent variable Subsequent innovation performance	Model 1	Model 2	Model 3	Model 4	Model 5
	Coefficient (S.E.)	Coefficient (S.E.)	Coefficient (S.E.)	Coefficient (S.E.)	Coefficient (S.E.)
Control variables					
Acquirer size	0.92**	0.98**	0.94**	0.87**	0.87**
	(0.15)	(0.14)	(0.14)	(0.14)	(0.15)
Acquirer R&D capability	0.26	0.21	0.14	0.00	0.01
	(0.29)	(0.26)	(0.25)	(0.24)	(0.24)
Acquirer knowledge base	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Acquirer technology quality	3.88**	2.94**	2.78**	2.69**	2.75**
	(0.71)	(0.70)	(0.69)	(2.65)	(0.66)
Independent variables					
Overlapped knowledge quality		2.69**	2.55**	1.51**	1.53**
		(0.57)	(0.57)	(0.57)	(0.56)
Non-overlapped knowledge quality			-1.07*	-1.29**	-1.36**
			(0.45)	(0.43)	(0.44)
Overlapped knowledge quantity				0.06**	0.06**
				(0.02)	(0.02)
Overlapped knowledge quantity squared				-0.0007**	-0.0007**
				(0.0002)	(0.0002)
Non-overlapped knowledge quantity					0.01
					(0.01)
Non-overlapped knowledge quantity squared					0.00
					(0.00)
Log likelihood	-867.83	-857.72	-855.00	-848.50	-846.98
Pseudo R^2	0.04	0.06	0.06	0.07	0.07
LR Chi^2	79.79	100.02	105.46	118.46	121.49
Regression p-value	0.00	0.00	0.00	0.00	0.00

Notes: †p < 0.10; *p < 0.05; **p < 0.01

N=192 (Control dummy variables are included)

3.5. Discussions

3.5.1. Conclusions and discussion

This research analyses the effects of knowledge overlap's quantitative and qualitative characteristics on the subsequent innovation performance in technological M&As. Specifically, the study divides the target firm's knowledge base into overlapped and non-overlapped parts and examines the effects of each part's characteristics on subsequent innovation performance. The results indicate that a higher quality of the overlapped knowledge positively affects post-M&A innovation performance. On the contrary, a higher quality of the non-overlapped knowledge causes high integration costs due to a lack of absorptive capacity and negatively affects the post-M&A innovation performance. This study verifies these effects by analysing the post-M&A innovation performance of 162 high-tech firms engaged in 192 technological M&A deals.

By considering the qualitative characteristics of knowledge, this research is able to make a number of contributions to the research on knowledge management and technological M&As: First, by uncovering the double-sided characteristics of high-quality knowledge, this research provides a more profound understanding of the knowledge-based view (KBV) in the field of knowledge management. According to the KBV, a firm's competitive advantage arises from the acquisition of difficult-to-imitate and highly asset-specific knowledge (Grant, 1996). Therefore, previous literature on KBV has extensively stressed the need for firms to transfer or create valuable knowledge (Kogut and Zander,

1992; Tsai, 2001). It also argues that identifying and acquiring high-quality knowledge is important for a firm to sustain a competitive advantage (Nonaka and Toyama, 2002). However, this research explains that while the transferred knowledge can positively impact the mechanism of knowledge creation, the tacit nature of high-quality knowledge makes the transfer of such knowledge costly and inefficient.

Also, this research provides an empirical study on the effects of the qualitative characteristics of knowledge. While the importance of the quality of knowledge has been continuously emphasized in the literature on organizational learning and strategic management, most empirical studies on technological M&As have solely focused on the quantitative characteristics of knowledge when investigating the effects of the knowledge base on post-M&A innovation performance. Until now, researchers have only considered knowledge quality as an output measure of a firm's post-M&A performance and focused on how to measure the quality of a target firm's knowledge (e.g., Valentini, 2012; Yang et al., 2014). To my knowledge, this research is the first attempt to fill this research gap and to clarify the effects of the quality of knowledge on the post-acquisition performance of technological M&As.

Besides the contributions to knowledge management studies, this research also contributes to the strategic management literature on technological M&As. Extending previous studies that have addressed the knowledge overlap between acquirer and target firms in technological M&As, this research finds a more complex relationship between the knowledge overlap and the subsequent innovation performance in technological M&As.

The stream of recent research focusing on knowledge overlap suggests a negative effect of overlapped knowledge on subsequent performance and highlights the importance of acquiring new knowledge with no overlap (Cloodt et al., 2006; Colombo and Rabbiosi, 2014; Sears and Hoetker, 2014). However, by extending the point of view and also considering the qualitative characteristics of the knowledge, this research shows a positive impact of knowledge overlap on subsequent innovation performance. Along the same line, by showing that higher quality of knowledge in non-overlapped fields negatively influences post-M&A performance, this research complements the results of previous studies. I show that in the context of M&A deals that result in the acquisition of high-quality knowledge, the overlapped knowledge plays a more significant role than the non-overlapped knowledge.

In addition to the various contributions stemming from the consideration of quality-related characteristics of knowledge, this study provides a comprehensive framework for studying the effects of the knowledge base of the acquirer and target firms in technological M&As. This study assumes that the overlapped and non-overlapped parts of the knowledge base have distinctive characteristics, and it conducts an analysis of the qualitative/quantitative characteristics for each part of the knowledge. This approach allows a more systemic view when analysing the knowledge base of firms in technological M&As and will contribute to future research in this field.

Chapter 4. Post-M&A target firm inventor integration in technological M&A

4.1. Introduction

In high-tech industries, technological M&A is a significant source of technological inputs for realizing open innovation (Ahuja and Katila, 2001; Chesbrough, 2003; Hagedoorn and Duysters, 2002; Leonard-Barton, 1995; Puranam and Srikanth, 2007). The motivation of a technological M&A is to acquire the target firm's knowledge resources (Cloodt et al., 2006), which are embedded in the knowledge reservoir of the organization (Argote and Miron-Spektor, 2011).

Under the basic assumption that human resources are one of the most important knowledge reservoirs of the firm, previous research on technological M&As has focused on post-M&A target firm inventor retention (Hussinger, 2012; Ranft, 2006). This stream of research has considered the retention of the target firm's key inventors as a significant success factor for technological M&As (Paruchuri et al., 2006). However, besides the member-focused view of previous literature on post-M&A inventor retention, their organizational context should also be taken into consideration (Autio, Kenney, Mustar, Siegel, and Wright, 2014). Because once the target firm's inventors are retained, it becomes important to consider who they work with, and what role they perform in the post-M&A merged entity.

For a successful external knowledge sourcing through technological M&A, the firm should understand the paradox between post-M&A knowledge preservation and synergy realization (Puranam and Srikanth, 2007; Ranft and Lord, 2002). That is, the acquirer firm's knowledge integration efforts simultaneously disrupt the target firm's knowledge reservoirs (Ranft and Lord, 2002; Risberg, 2001). This relationship has continuously been identified in the literature on technological M&A which has shown that the target firm inventors are being disrupted by the acquirer firm's knowledge integration efforts (Graebner, 2004; Paruchuri et al., 2006; Puranam and Srikanth, 2007; Schweizer, 2005). However, previous research has not yet determined which organizational contexts can leverage the paradox between post-M&A knowledge preservation and synergy realization.

To fill this research gap, this research investigates the impact of the target firm inventors' organizational characteristics on firms' open innovation performance through technological M&As. Specifically, the study investigates two dimension of inventor retention, i.e., target firm inventor network retention (who do they work with), and target firm inventor field retention (in what field do they work after the M&A). This study develops theoretical arguments that those organizational contexts have different impacts on each side of open innovation, i.e., knowledge preservation and synergy realization. Through empirical tests employing a dataset comprised of technological M&A deals conducted in the biopharmaceutical industries from 2001 to 2009, this research finds positive effects of inventor network and field retention on post-M&A knowledge preservation, while, at the same time, they negatively affect post-M&A synergy realization.

The results support the hypotheses that retaining the organizational context of the target firm helps to preserve the target firm's knowledge by preventing organizational disruption among the target firm inventors. However, by decreasing the organizational creativity, the retention of those organizational contexts actually hinders post-M&A knowledge integration and synergy realization. The study contributes to the literature on technological M&As and strategic management by providing a more profound explanation of post-M&A knowledge preservation and synergy realization. Further, by investigating the impact of diverse contexts of post-M&A inventor retention, the research also contributes to the field of organizational learning. The results of this study provide the practical implications that in order to successfully conduct technological M&As, managers should pay close attention to the post-M&A knowledge configuration taking into account the target firm's inventors and their contextual factors.

4.2. Research hypotheses

4.2.1. Technological M&A dilemma: The trade-off relationship between knowledge preservation and synergy realization

Previous literature on technological M&A focuses on what kind of knowledge the firm should acquire in order to create synergy through the target firm's knowledge resources (Ahuja and Katila, 2001; Cloodt et al., 2006; Makri et al., 2010; Orsi et al., 2015). The foundational research on technological M&As, Ahuja and Katila (2001) found that knowledge relatedness is a determining factor for post-M&A innovation performance in technological acquisitions. Makri et al. (2010) provided the concepts of knowledge complementarity and similarity, a more refined framework for analyzing the dyadic perspective of the knowledge bases between target and acquirer firm. Likewise, the research on technological M&A mainly investigated the impact of the firms' dyadic knowledge base characteristics on post-M&A innovation performance (Cloodt et al., 2006; Sears and Hoetker, 2014). Based on the theories of absorptive capacity and organizational learning, previous literature commonly argued that it is important to acquire target firm knowledge which is complementary to the acquirer firm's knowledge base (Makri et al., 2010; Sears and Hoetker, 2014).

However, acquiring a target firm possessing a valuable and complementary knowledge base does not guarantee that the knowledge can be successfully transferred and integrated into the combined entity (Larsson and Finkelstein, 1999; Ranft and Lord, 2000). Based on

the knowledge-based view (KBV) of the firm, the study of Ranft (2006) pointed out the issue of target firm knowledge preservation and its trade-off relationship with knowledge integration. The main theme of this research is that since valuable and tacit knowledge is fragile and difficult to transfer (Barney, 1991; Carayannis, Popescu, Sipp, and Stewart, 2006; Spender, 1994), the target firm's knowledge can be damaged during the post-M&A knowledge integration process. The acquirer firm's attempts to integrate the target firm's knowledge base may change the existing organizational context and routines, thereby disrupting the target firm's inventors and other knowledge components of the firm (Paruchuri et al., 2006). On the other hand, if the acquirer firm does not try to integrate the target firm's knowledge and decides to preserve it, knowledge sharing and synergy realization between the two knowledge bases are not likely to take place (Ernst and Vitt, 2000).

Prior studies suggest the retention of the target firm's key employees as one way to manage post-M&A target firm knowledge preservation (Hussinger, 2012; Paruchuri et al., 2006; Ranft and Lord, 2002). The knowledge-based view of the firm implies that human resources are the most significant knowledge reservoir, and have a direct impact on the target firm knowledge preservation in technological M&As. Ranft (2006) empirically verified that key employee retention is a success factor for the post-M&A target firm knowledge transfer, supporting organizational knowledge preservation. Castro-Casal et al. (2013) also suggests that the target firm's rarest and most valuable knowledge can be preserved through the retention of high-value inventors in technological M&As. Other

studies further uncovered the factors which prevent a disruption of the target firm inventors (Cannella and Hambrick, 1993; Castro-Casal et al., 2013; Hussinger, 2012; Sears and Hoetker, 2014). They suggest that in order to retain the target firm inventors and successfully transfer the target firm's knowledge, the acquirer firm should establish sufficient absorptive capacity which allows it to understand the target firm's technological language, foster rich communication channels between the two entities that can prevent a disruption of inventors, and more (Castro-Casal et al., 2013; Ranft, 2006). Though some literature recognized the issue of the knowledge preservation vs. integration dilemma and provides the solution of key inventor retention, they have overlooked that the retention of target firm inventors will preserve knowledge but simultaneously have a different impact on post-M&A knowledge sharing and synergy realization. Further, literatures until now merely investigated the quantitative aspects of inventor retention, i.e., how many key inventors are retained after the M&A.

This study analyzes the impact of various dimensions of inventor retention on those two key processes of technological M&As, knowledge preservation and synergy realization. Extending the member-focused view and bridging the gap between inventor retention and the theory of organizational learning, the paper investigates the impact of various retention-related factors on post-M&A target firm knowledge preservation and synergy realization.

4.2.2. Target firm inventor retention and target firm knowledge preservation in technological M&As

According to the theory of organizational learning and the knowledge-based view, organizational knowledge is complexly embedded in the knowledge reservoir, i.e., member, task, tools, and their networks (Argote and Ingram, 2000). Among those knowledge components, inventors and their networks are the most significant knowledge reservoirs of the firm since valuable knowledge tends to be more complexly embedded among individuals (Argote and Miron-Spektor, 2011). When inventors of an organization repeatedly conduct their R&D projects, they form distinctive inventor networks which formulates organizational routines and processes (Kogut and Zander, 1992; Paruchuri and Awate, 2016). The knowledge accumulated in those inventor networks is mostly tacit knowledge, which is hard to imitate or transfer (Kogut and Zander, 1992). The individuals of an organization share their routines, norms, practices, decision making processes, and problem solving mechanisms through interpersonal networks (Haspeslagh and Jemison, 1991). Further, as technological solutions of research become more complex, they become heavily embedded in the network (Carnabuci and Operti, 2013). As a result, the true nature of organizational knowledge is not embedded in individuals, but rather resides in their networks. This knowledge, which is embedded in the inventor network, is the most valuable knowledge that should be transferred to the acquirer firm through technological M&A.

The research fields in which the target firm inventors specialized in before the M&A

should also be retained in order to achieve a high level of knowledge preservation. The target firm inventor field retention implies that the knowledge embedded in tasks and member-task networks can be preserved. An inventor's specialized knowledge is formulated through the accumulation of field-specific experiences, i.e., experience from successively performed tasks (Cohen and Levinthal, 1990; Toh, 2014). Those task experiences provide inventors with the process of learning by doing, which can be the source of tacit knowledge of individuals (Argote and Miron-Spektor, 2011; Eckardt, Skaggs, and Youndt, 2014; Schilling, Vidal, Ployhart, and Marangoni, 2003). However, the formulated context-specific knowledge which is retained in the task can be damaged if inventors leave their field of expertise and start to work in new field (Jones, 2009).

In summary, the post-M&A retention of the inventor networks and the inventors' original research field would help the target firm's knowledge preservation. Retaining these significant knowledge reservoirs will maximize the target firm's knowledge preservation.

Hypothesis 4-1a*: The retention of the target firm inventor network after a technological M&A has a positive impact on post-M&A target firm knowledge preservation*

Hypothesis 4-1b*: The retention of the target firm inventor research fields after a technological M&A has a positive impact on post-M&A knowledge preservation*

4.2.3. Target firm inventor retention and post-M&A synergy realization

Despite its positive effect on knowledge preservation, inventor network retention may hinder post-M&A synergy realization. To achieve post-M&A synergy realization through technological M&As, the knowledge resources of the acquirer and target firm should be integrated and recombined (Ahuja and Katila, 2001; Larsson and Finkelstein, 1999). However, even though the retained routines and processes embedded in the target firm inventor network would provide the tacit know-how and problem solving skills (Argote and Ren, 2012), they will only help the target firm inventor's exploitative activities, not the collaborative exploration between acquirer and the target firm for the following reasons:

First, the organizational inertia of the target firm inventors would also be retained as the inventor network is retained in the combined entity. The knowledge in the network such as "how to work together" or "who knows what" make people comfortable with reusing existing ties for successive projects (Argote and Miron-Spektor, 2011; Dai, Roundy, Chok, Ding, and Byun, 2016). The target firm inventors would fall into a competency trap, having less motivation to explore the acquirer firm's knowledge assets and pursue integration (March, 1991). As a result of the target firm inventors' organizational inertia and the competency trap, the inventor network retention impedes post-M&A knowledge integration and thereby the synergy realization with the acquirer's knowledge base.

Second, the organizational routines and collective thinking retained in the target firm

inventor network may cause conflicts between the acquirer and target firm inventor groups. One of the main barriers for post-M&A synergy realization is the firm's 'exposure to organizational disruption due to conflict between acquirer and target firm inventors' (Sears and Hoetker, 2014). When two rigid routines face each other, both groups of knowledge workers would compete rather than collaborate (Paruchuri et al., 2006; Puranam et al., 2006). Those conflicts can actually damage organizational creativity by reducing the experimental recombination between the two different knowledge bases (Björkdahl, 2009). Thus, though the inventor network retention supports target firm knowledge preservation, it simultaneously impedes post-M&A synergy realization.

Hypothesis 4-2a. *The retention of the target firm inventor network after a technological M&A has a negative impact on post-M&A synergy realization*

Target firm inventor field retention can also deter post-M&A synergy realization. First, when target firm inventors change their research field after the M&A, inventors from both the target and acquirer firm face increasingly diverse knowledge (Arts and Fleming, 2016). The increased diversity provides more possible recombination sets for a collaboration, which would help the firm to create innovation with a higher novelty (Cohen and Levinthal, 1990; Faems, De Visser, Andries, and Van Looy, 2010; Nieto and Santamaría, 2007). When inventors face a diverse set of knowledge resources, their creativity would be increased by adopting their specialized problem solving skills to new resources (Merton,

1973). In technological M&As, a mixture of knowledge from different specializations would raise the organization's creativity and positively affect post-M&A synergy realization.

Next, to create synergy through novel innovation, the collaborative group of acquirer and target firm inventors should think outside of the existing routines or processes. Inventors retaining the same research field would be bounded to their known solutions and routines (Levinthal and March, 1993). They would become path dependent to their existing problem solving routines (Jain, 2016). Especially when the target firm inventors face fluctuation in the post-M&A environment (Ernst and Vitt, 2000), they would try to collaborate less with the acquirer firm inventors. Inventors who change their research field, on the other hand, would not be limited by such path dependency and are more likely to adopt new perspectives and skills for their projects (Ahuja and Lampert, 2001). Therefore, to achieve a synergy realization of the acquirer firm and the target firm's knowledge base, a change in the research fields of the target firm inventors would be necessary.

Hypothesis 4-2b: *The retention of the target firm inventor research fields after a technological M&A has a negative impact on post-M&A synergy realization.*

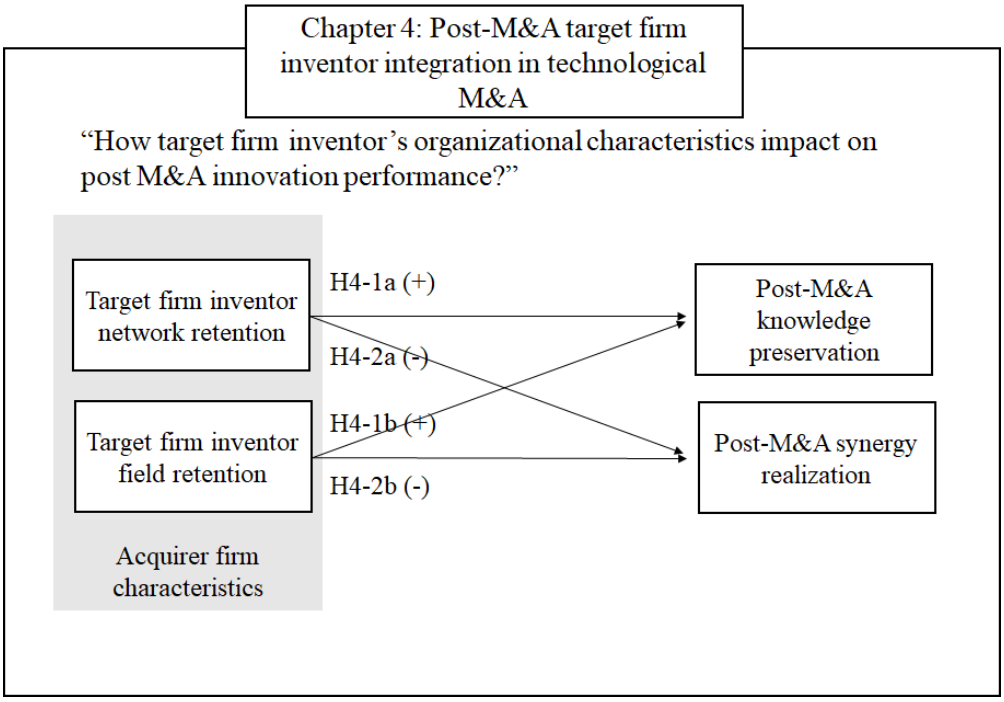

Figure 4-1. Conceptual model for Chapter 4

4.3. Methodology

4.3.1. Data

The hypotheses were tested using a data sample of technological M&A deals conducted by firms in the biopharmaceutical industry. Information on M&A deals conducted between 2001 and 2009 by firms in the biopharmaceutical industry was collected from the Thomson Reuters SDC Platinum database. Only M&A deals in which the acquirer firm acquires other firms were considered, excluding any self-acquisition deals. Information on the patents granted to each of the firms involved in the M&A deals was collected from the United States Patent and Trademark Office (USPTO) database. The patent data is used to track the retention of the target firm inventors (Hussinger, 2012; Marx, Strumsky, and Fleming, 2009). Following prior studies on technological M&A (Ahuja and Katila, 2001), all M&A deals in which the target firm had been granted no patents before the M&A deal were excluded. Financial information for each of the firms was collected from the Datastream database. Since the study focuses on the impacts of the retention of the networks and research fields of the inventors that are retained after the M&A deal, also all M&A deals in which no inventor was retained were excluded. The final data sample includes 99 M&A deals.

4.3.2. Variables

4.3.2.1 Dependent variables

In order to capture the acquirer and the target firm's knowledge base operation during the pre-M&A time period, the patents granted to each firm during the 5 years prior to the M&A deal were investigated (e.g., Ahuja and Katila, 2001). Then, a 2-year time lag was applied after the M&A deal to account for the time it typically takes for applied patent to be granted and the effects of the M&A to become noticeable (Phene et al., 2012; Popp, Juhl, and Johnson, 2004). The post-M&A performance was captured using information on the patents granted during the 5-year period following the above mentioned time lag. In other words, patents granted from 2 years to 6 years after the M&A deal were considered (e.g., Phene et al., 2012). In cases where the target firm continued to exist as a separate entity, any patents granted in the name of the target firm were added to list of patents granted to the acquirer firm.

Post-M&A Target Knowledge Preservation measures the extent to which the target firm's knowledge and expertise are preserved in the process of the M&A and the acquirer firm continues to create innovation within the target firm's pre-M&A knowledge areas after the M&A. Using the target firm's pre-M&A knowledge base, the list of pre-M&A knowledge areas (following the USPTO main-class classification) in which the target firm had been granted at least one patent was compiled. Then, the number of patents granted to the acquirer firm during the post-M&A time period and that fall within the target firm's

pre-M&A knowledge areas were counted.

$$Post\ \ M\&A\ \ Target\ \ Knowledge\ \ Preservation$$

$$= \#\ of\ \ patents\ \ granted\ \ within\ \ the\ \ target\ \ firm's\ \ pre\_M\&A\ \ knowledge\ \ areas_{t+2,t+6}$$

Post-M&A Synergy Realization captures the extent to which the acquirer firm creates innovation through knowledge recombination in a unique way during the post-M&A time period. The study assumes that in order to realize synergy from technological M&As, the innovation resulting from the technological M&As should be created in a way that both firm have not done before (Carayannis and Provance, 2008; Cassiman et al., 2005). Therefore, among the various measures of post-M&A synergy realization, this study measured the novelty of the patented innovations. To this end, this study adopted the measure of originality, which was proposed by Hall, Jaffe, and Trajtenberg (2001). When an innovation is based on diverse knowledge areas, i.e., a patent is drawing on prior patents from diverse knowledge areas (as indicated through patent main-classes), the innovation is considered to be developed through a unique or novel recombination (Hall et al., 2001; Valentini, 2012). The originality values of each patent granted to the acquirer firm during the post-M&A time period were calculated and averaged to obtain a firm-level measure.

$$Post\ \ M\&A\ \ Synergy\ \ Realization$$

$$= \frac{\sum_1^i \left(1 - \ \sum_j^{n_i} {s_{ij}}^2\right)_{t+2,t+6}}{\#\ of\ \ patents\ \ granted\ \ to\ \ the\ \ acquirer\ \ firm_{t+2,t+6}}$$

where s_{ij} represent the ratio of the number of patent *i*'s backward citations which belong to USPTO main-class *j* to patent *i*'s entire number of backward citation, and n_i denotes the number of USPTO main-classes that the patent *i* cites.

4.3.2.2 Independent variables

Similar to prior studies using patent data to capture each inventor's collaboration network and active research fields (e.g., Hussinger, 2012; Paruchuri, 2010), the study uses patent information to define these characteristics and then capture whether the inventors' networks and research fields have been retained in the process of the M&A.

Network Retention captures the degree to which the pre-M&A target inventors' linkages with their fellow co-inventors are retained in the process of the M&A. Following prior studies on inventor collaboration networks (Paruchuri and Eisenman, 2012), co-invention linkages are considered to be formed between pairs of inventors that are listed as inventors on the same patent. In order to construct the variable, first, the number of the target firm's co-invention linkages during the pre-M&A time period was determined. Then the number of co-invention linkages that are retained in the process of M&A was counted by searching

for the same linkages in the patents granted during the post-M&A time period. Then, the number of retained co-invention linkages during the post-M&A time period was divided by the total number of co-invention linkages during the pre-M&A time period.

$$Network\ \ Retention = \frac{\#\ of\ \ retained\ \ co\_invention\ \ linkages_{t+2,t+6}}{\#\ of\ \ co\_invention\ \ linkages_{t-5,t-1}}$$

Field Retention measures the degree to which the pre-M&A target inventors' research fields are retained in the process of the M&A. First, a list of each target inventor's pre-M&A knowledge areas, i.e., the USPTO main classes of the granted patents which include the target inventor during the pre-M&A time period was created. Then, it was examined whether each of the target inventors continued to create innovation within these pre-M&A knowledge areas during the post-M&A time period. Finally, the number of retained inventor-field pairs was divided by the total number of pre-M&A target inventor-field pairs.

$$Field\ \ Retention = \frac{\#\ of\ \ retained\ \ inventor\ \ and\ \ field\ \ pairs}{\#\ of\ \ pre\_M\&A\ \ target\ \ inventor\ \ and\ \ field\ \ pairs}$$

4.3.2.3 Control variables

In order to control for the impact of other factors that may significantly affect the dependent variables, the study included several control variables. Control variables for the absolute size of the acquirer firm's knowledge base (*Absolute Size of Knowledge Base*), the relative

size of the acquirer firm and the target firm's knowledge bases (*Relative Size of Knowledge Base*), the knowledge diversity of the acquirer firm (*Acquirer Knowledge Diversity*), the knowledge base similarity between the acquirer firm and the target firm (*Knowledge Similarity*), the acquirer firm size (*Acquirer Firm Size*) and the R&D intensity of the acquirer firm (*R&D Intensity*) were included (Ahuja and Katila, 2001; Makri et al., 2010; Phene et al., 2012). Moreover, possible influences stemming from the acquirer firm's nationality, cross border acquisitions, technological sectors, the deal year and post-M&A inventor collaboration between the acquirer and target inventor were also controlled by including the corresponding dummy variables.

4.3.3. Model

The two dependent variables are of different types. The dependent variable *Post-M&A Target Knowledge Preservation* takes the form of a non-negative integer value, however, its standard deviation and mean values are very different. Therefore, negative binomial regression was employed rather than Poisson regression. The other dependent variable, *Post-M&A Synergy Realization*, is a continuous variable whose values range between 0 and 1. In order to prevent the results of the regression from falling outside this range, logit transformation was performed. As a logit transformation cannot be applied on values that are exactly 0 or 1, the variable has been first transformed using the following equation (Smithson and Verkuilen, 2006; Warton and Hui, 2011):

$$Post\ \ M\&A\ \ Synergy\ \ Realization^{\prime} = \frac{[Post\ \ M\&A\ \ Synergy\ \ Realization\ \ \times (N-1) + \frac{1}{2}]}{N}$$

Subsequently, an ordinary least squares regression was employed to analyze the logit-transformed dependent variable *Post-M&A Synergy Realization*.

4.4. Results

4.4.1. Descriptive statistics

The descriptive statistics and the correlation between variables are presented in Table 4-1. None of the correlation values exceeds the 0.70 threshold (Cohen, Cohen, West, and Aiken, 2003) and the variance inflation factor (VIF) values (shown in each model of Table 4-2 and Table 4-3) fall under 3.0 (Myers, 1990), implying that no problems related to multicollinearity exist in the analysis.

Table 4-1. Descriptive statistics and correlations among the variables

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
Post-M&A Target Knowledge Preservation	124.22	357.20	1.00									
Post-M&A Synergy Realization	0.45	0.13	-0.14	1.00								
Network Retention	0.14	0.15	0.03	-0.13	1.00							
Field Retention	0.54	0.36	-0.09	-0.15	0.19	1.00						
Absolute Size of Knowledge Base	235.06	462.36	0.69	-0.10	-0.03	-0.09	1.00					
Relative Size of Knowledge Base	1.25	4.48	-0.06	-0.11	-0.06	0.00	-0.11	1.00				
Acquirer Knowledge Diversity	2.85	4.33	0.21	-0.02	-0.12	-0.03	0.50	-0.12	1.00			
Knowledge Similarity	0.38	0.37	0.16	-0.36	-0.10	-0.20	-0.07	0.12	-0.07	1.00		
Acquirer Firm Size	6.58	1.36	0.32	-0.47	-0.01	-0.11	0.36	-0.27	0.22	0.28	1.00	
R&D Intensity	0.65	4.69	-0.04	0.06	-0.05	0.14	-0.06	0.04	-0.04	-0.07	-0.37	1.00

4.4.2. Negative binomial regression results

Table 4-2 presents the results from the negative binomial regression for the dependent variable Post-M&A Target Knowledge Preservation. Model 1 presents the impacts of the control variables on the post-M&A target knowledge preservation. The results show that the control variables Absolute Size of Knowledge base, Knowledge Similarity and Acquirer Firm Size have significant effects on Post-M&A Target Knowledge Preservation. This is consistent with the results found in prior literature (Ahuja and Katila, 2001; Kapoor and Lim, 2007; Makri et al., 2010; Papadakis, 2005). Model 2 shows that Network Retention has a positive and significant ($p<0.05$) effect on Post-M&A Target Knowledge Preservation, thereby supporting Hypothesis 4-1a. Model 3 shows that Field Retention also has a positive and significant ($p<0.01$) effect on the post-M&A target knowledge preservation, thereby supporting Hypothesis 4-1b. Model 4, the full model, further confirms the positive and significant effects of both Network Retention and Field Retention on Post-M&A Target Knowledge Preservation. Therefore, Hypotheses 4-1a and 4-1b are strongly supported. Likewise, the independent variables in this study are highly significant and thereby support the hypotheses, but the coefficients of each variable present a small numeric value. However, the employed negative binomial regression is a nonlinear regression containing the natural logarithm. That is, the actual explanatory power of those variables on the dependent variable is larger than it might appear at first look and is significant enough.

Table 4-2. Negative binomial regression results for post-M&A target knowledge preservation

Negative Binomial Regression **Target Knowledge Preservation**	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Independent Variables				
Network Retention		2.033**		1.595**
		(0.818)		(0.802)
Field Retention			0.972***	0.807**
			(0.354)	(0.360)
Control Variables				
Absolute Size of Knowledge Base	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Relative Size of Knowledge Base	-0.037	-0.031	-0.033	-0.029
	(0.024)	(0.024)	(0.024)	(0.024)
Acquirer Knowledge Diversity	0.025	0.019	0.020	0.017
	(0.036)	(0.035)	(0.035)	(0.034)
Knowledge Similarity	1.260***	1.223***	1.250***	1.219***
	(0.335)	(0.320)	(0.322)	(0.312)
Acquirer Firm Size	0.298*	0.314**	0.275*	0.302**
	(0.155)	(0.146)	(0.148)	(0.142)
R&D Intensity	-0.015	-0.012	-0.025	-0.020
	(0.028)	(0.027)	(0.027)	(0.026)
Constant	-2.269*	-2.920**	-2.628**	-3.121**
	(1.338)	(1.326)	(1.323)	(1.320)
Log likelihood	-496.16	-492.98	-492.63	-490.58
Regression p-value	0.000	0.000	0.000	0.000
LR Chi^2	101.00	107.36	108.06	112.15
Max VIF	2.45	2.46	2.46	2.46
Mean VIF	1.49	1.47	1.47	1.47

Notes: †p < 0.10; *p < 0.05; **p < 0.01

N=99 (Control dummy variables are included)

4.4.3. Logit transformed ordinary least squares regression results

Table 4-3 presents the results of the ordinary least squares regression analysis for the logit transformed dependent variable Post-M&A Synergy Realization. Model 5 shows the effects of the control variables on Post-M&A Synergy Realization. The control variables Relative Size of Knowledge Base, Knowledge Similarity, and Acquirer Firm Size have significant impacts on Post-M&A Synergy Realization. Model 6 shows that Network Retention has a negative and significant ($p<0.05$) effect on Post-M&A Synergy Realization, which supports Hypothesis 4-2a. Model 7 shows that Field Retention also has a negative and significant ($p<0.01$) effect on Post-M&A Synergy Realization, thereby supporting Hypothesis 4-2b. Model 8, the full model, also confirms the negative and significant effects of Network Retention and Field Retention on Post-M&A Synergy Realization. Therefore, Hypotheses 4-2a and 4-2b are strongly supported.

Table 4-3. Ordinary least squares regression results for post-M&A synergy realization

Logit transformed OLS **Synergy Realization**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
Independent Variables				
Network retention		-0.186*		-0.147†
		(0.074)		(0.0746)
Field retention			-0.085**	-0.070*
			(0.032)	(0.032)
Control Variables				
Absolute size of knowledge base	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Relative size of knowledge base	-0.006*	-0.006*	-0.006*	-0.006*
	(0.003)	(0.003)	(0.003)	(0.003)
Acquirer knowledge diversity	0.004	0.004	0.003	0.003
	(0.003)	(0.003)	(0.003)	(0.003)
Knowledge similarity	-0.066†	-0.077*	-0.083*	-0.089**
	(0.034)	(0.033)	(0.034)	(0.033)
Acquirer firm size	-0.043**	-0.043**	-0.042**	-0.042**
	(0.013)	(0.012)	(0.012)	(0.012)
R&D intensity	-0.003	-0.003	-0.002	-0.002
	(0.003)	(0.003)	(0.003)	(0.003)
Constant	0.610**	0.645**	0.640**	0.662**
	(0.141)	(0.138)	(0.137)	(0.135)
R^2	0.381	0.423	0.429	0.454
Max VIF	2.45	2.46	2.46	2.46
Mean VIF	1.49	1.47	1.47	1.47

Notes: †p < 0.10; *p < 0.05; **p < 0.01

N=99 (Control dummy variables are included)

4.5. Discussions

4.5.1. Conclusions and discussion

This study addresses more profound dimension of post-M&A inventor retention: which fields do they work in, and whom do they work with after the technological M&A. Dealing with the conventional trade-off dilemma of technological M&As, the study hypothesizes that, for retained inventors, their network and research field retention support the target firm's knowledge preservation, but will have a negative impact on post-M&A synergy realization. The findings of this research provide several theoretical contributions to different streams of research and also provide practical implications for managers of firms conducting technological M&As.

First, the theoretical model of this study contributes to the fields of organizational learning and knowledge management by examining the impact of various knowledge reservoirs of the organization in technological M&As. According to organizational learning theory, the knowledge of the firm is embedded in the knowledge reservoir which is comprised of members, tasks, tools and their networks (Argote and Ingram, 2000). Especially, a firm's significant knowledge resources are often complexly embedded in its organizational members, member-member networks, and the networks among member and other organizational reservoirs (Argote and Miron-Spektor, 2011). Although previous research has stressed the importance of human resources networks as knowledge reservoirs (Castro-Casal et al., 2013; Puranam et al., 2006), it has not investigated the relationship

between the retention of such knowledge reservoirs and the firm's knowledge transfer and creation. Using the context of technological M&As, this research investigated the impact of the retention of the member-member network and member-task network on post-M&A knowledge preservation and synergy realization, thereby enriching the literature on knowledge reservoirs of the firm.

Second, by exemplifying the trade-off relationship of post-M&A knowledge preservation and synergy realization, the research contributes to the research on technological M&As. Prior literature on M&As has described the dilemma of technological M&As, i.e., the more the acquirer firm tries to integrate the target firm's knowledge resources, the less knowledge can be preserved (Paruchuri et al., 2006; Ranft and Lord, 2000; Ranft, 2006). By looking at the different impact of organizational contexts on both knowledge preservation and synergy realization, the study further increases the understanding of this dilemma and how firms can actively influence knowledge preservation and post-M&A synergy realization.

Third, the empirical findings of this study extend the research on inventor retention in technological M&As by exploring various dimension of post-M&A target firm inventor retention. Previous research on technological M&As has mostly focused on the post-M&A productivity of the target firm inventors, i.e., how much innovation do the target firm inventors create after the M&A (Hussinger, 2012; Kapoor and Lim, 2007). The basic assumption of this literature is that the retention of key employee is beneficial for post-M&A performance, and consequently it is important to keep target firm inventors from

leaving the firm or being disrupted during the M&A (Ernst and Vitt, 2000). However, this research finds that while retaining the target firm inventors and their organizational context may help to preserve their organizational knowledge, it negatively affects the synergy realization of the merged entity by inducing the collision of the rigid routines of both firms and decreasing the organizational creativity of the merged entity. These findings extend the research on inventor retention by questioning whether inventor retention is really always beneficial.

Chapter 5. Technological M&A as a core technology portfolio renewal strategy

5.1. Introduction

In technology intensive industries, firms suffer from technological obsolescence due to the rapidly changing external environment, short technology life cycles and the increasing pressure of competition (Ranger-Moore, 1997). According to the evolutionary theory of the firm, firms in high technology industries tend to be heavily bounded in their prior experiences and routines in order to increase their productivity (Cyert and March, 1963). The result of this accumulated learning formulates the organization's core knowledge specialization (Argote, 2013). However, the increased dynamics of the external environment result in the firm's core knowledge becoming obsolete more easily. In order to preempt this technological obsolescence, firms need to make flexible changes to their core knowledge portfolio, a process often supported by the acquisition of external knowledge. Creating novel knowledge solely relying on internal developments is highly limited since firms tend to exploit their existing resources and capabilities (Hagedoorn and Schakenraad, 1994). Moreover, the repeated internal R&D process reinforces the path dependency of the firm's processes. This leads the firm to fall into a competency trap, which impedes radical change of the firm's knowledge portfolio (Levinthal and March, 1993). On the other hand, external knowledge sourcing provides novel knowledge and

processes to the acquirer firm (Narula, 2001). Recombination between the acquired knowledge and the acquirer firm's existing knowledge in unprecedented ways may result in a breakthrough or high-quality innovation (Kogut and Zander, 1992). This allows the firm to undergo a substantial change within their knowledge base. Therefore, utilizing external knowledge sourcing strategies is crucial for firms to create novel innovation and to achieve a successful knowledge base change (Chiesa, 2001).

For a firm to achieve core knowledge change through external knowledge sourcing strategies, the acquired external knowledge should be effectively transferred and amplified throughout the entire organization (Jain, 2016). According to the evolutionary theory of the firm, one of the largest obstacles for the transfer of external knowledge is the path dependency of the firm (Stuart and Podolny, 1996). Path dependency gives rise to effects hindering knowledge transfer, such as organizational inertia and the Not-invented-here (NIH) syndrome (Hussinger and Wastyn, 2016). These characteristics of an organization result in firms falling into a competency trap and hinder the successful transfer of external knowledge (March, 1991). On the other hand, organizational learning literatures argues that the combinative capabilities of the firm support internal knowledge diffusion, thereby helping to change the knowledge portfolio (Carmeli and Azeroual, 2009). Core knowledge change occurs when the internally accepted knowledge is transferred and amplified throughout the entire organization through knowledge exchange processes (Jain, 2016; Sydow et al., 2009). Therefore, a firm should possess sufficient combinative capabilities in order to assimilate the transferred knowledge and create new innovation through the

recombination of knowledge assets (Koruna, 2004). Together, firms need to both break their own path dependency and have a high level of combinative capabilities in order to successfully change their own core knowledge portfolio utilizing external knowledge sourcing strategies.

Among the various external knowledge sourcing mechanisms, technological M&A is recognized to be one of the most efficient strategies for firms to foster change in their core knowledge portfolio (Hagedoorn and Duysters, 2002; Phene et al., 2012). Unlike other external knowledge sourcing modes such as strategic alliances, technological M&A is a knowledge sourcing strategy that allows for the assimilation of the target firm's entire knowledge reservoir, including people, tasks, tools and internal networks (Argote and Miron-Spektor, 2011; Ranft and Lord, 2002). This allows the acquirer firm to better understand the target firm's core knowledge, including the tacit knowledge which is hard to be transferred using other external knowledge sourcing strategies (Szulanski, 1996). The acquired tacit knowledge improves the organizational learning of the acquirer firm and its ability to create new-to-the-firm knowledge (Kogut and Zander, 1992; Song et al., 2003). Additionally, the knowledge integration process between the acquirer and the target firm disrupts the acquirer firm's existing routines and processes (Sears and Hoetker, 2014). This disruption improves organizational flexibility and hence positively affects core knowledge change.

Previous studies on technological M&A, however, have overlooked the effects of technological M&As on core knowledge change. The mainstream of technological M&A

research investigates the relationship between the firms' knowledge base characteristics and post-M&A innovation performance (Ahuja and Katila, 2001; Cloodt et al., 2006; Sears and Hoetker, 2014). Following Ahuja and Katila (2001), previous research focuses on dyadic perspectives of the acquirer and the target firm's knowledge base characteristics (Makri et al., 2010; Orsi et al., 2015). Since one of the most distinctive characteristics of technological M&As is that the acquirer firm can acquire the target firm's human resources, more recent research investigates the impact of target firm inventor characteristics (Ranft, 2006; Paruchuri et al., 2006; Kapoor and Lim, 2007; Hussinger and Wastyn, 2016). Literature on target firm inventor characteristics mainly argues that target firm inventor retention has a positive impact on target firm knowledge preservation (Castro-Casal et al., 2013) and post-M&A knowledge transfer (Ranft, 2006). On the other hand, some studies on post-M&A integration processes suggest negative effects of the target firm's inventor retention on innovation performance (Hwang et al., 2015), which stems from disruptions occurring in both the acquirer and the target firm inventors' existing routines and productivity (Paruchuri et al., 2006). These prior studies imply that inventor retention through technological M&A fosters significant change in the organization's routines and processes, which results in the firm's core knowledge change. Despite the consistent arguments in previous literature, the impact of inventor retention on the firm's core knowledge portfolio change has yet to be explored.

To address this gap, this research investigates how firms change and renew their core knowledge portfolio through technological M&As. Specifically, based on concepts from

organizational learning and evolutionary theory, the study examines the direct effects of the acquirer firm's path dependency and combinative capabilities on post-M&A core knowledge change. It also suggests that target firm inventor retention can be a significant success factor for firms utilizing technological M&A as a strategy for core knowledge portfolio renewal. This study expects that inventor retention, which is a distinctive characteristic of technological M&As, can disrupt the firm's path dependency and core rigidities, simultaneously enhancing combinative capabilities. Therefore, this study investigates the moderating effect of the inventor retention on both direct effects of path dependency and combinative capabilities of the firm.

The results of this study provide several contributions to the research on strategic management and organizational learning theories. First, by focusing on the impact of technological M&As as a strategy for core knowledge change and by uncovering its key success factors, this research contributes to the literature on technological M&As and strategic management. Second, by highlighting the effect of inventor retention as a significant factor for decreasing the negative effects of the firm's path dependency, this study provides a more profound understanding of the evolutionary theory of the firm. Additionally, the study also contributes to the theory of organizational learning by confirming the "learning-by-hiring" effect of technological M&As. The findings of this study provide direct implications for managers of firms who consider pursuing M&A deals to actively renew the core technological portfolio of their firms.

5.2. Research hypotheses

5.2.1. Firm's path dependency and post-M&A core knowledge change

The path dependency of firm innovation refers to the firm's innovation patterns becoming rigid as a result of the firm's accumulated organizational learning (Sørensen and Stuart, 2000). The accumulated organizational learning forms the innovation routines of the firm, leading the firm to take 'reciprocally triggered sequences of action' (Jain, 2016; Cohen and Bacdayan, 1994). Nelson and Winter (1982) argue that, when a firm persistently creates innovation within certain knowledge areas, the firm builds up routines and beliefs in the knowledge creation process. While this reduces complexity, it further increases the firm's path dependency. Following this mechanism, the firm formulates a particular trajectory for its innovation activity and becomes more path dependent (Tripsas, 1997). In general, path dependency of the firm increases efficiency and immediacy in the decision making processes, facilitating exploitative innovation (Cohen and Levinthal, 1990). However, increasing path dependency of the firm causes groupthink among the organization group members (Janis, 1973) and organization inflexibility (Gersick and Hackman, 1990), which result in creativity loss and rigidity in innovation pattern. Moreover, since the solidified innovation pattern appears repeatedly regardless of the results of the innovation process, highly path dependent firms are more likely to be caught in a competency trap (March,

1991).

Although external knowledge is acquired from outside the firm, path dependency impedes the firm's core knowledge change as the firm continues to focus on its existing knowledge areas and innovation processes. First, firms with a high path dependency try to find solutions for problems only from the knowledge areas and processes they are already familiar with (Helfat, 1994; Stuart and Podolny, 1996). This increases the firm's vulnerability to radical innovation and rapidly changing environments. That is, highly path dependent firms find it difficult to utilize new-to-the-firm knowledge effectively due to an excessive focus on existing and familiar knowledge and resources (Leonard-Barton, 1992). Second, path dependency increases the NIH syndrome of the firm (Katz and Allen, 1982). Individuals in firms with a high path dependency have a strong characteristic of self-enhancement (Bartel, 2001). This characteristic leads to the individuals recognizing the knowledge acquired from external sources as a threat to the existing core knowledge, which is the focus of expertise of the existing knowledge workers, being replaced by the acquired knowledge (Hussinger and Wastyn, 2016). Thus, even if the technological superiority or suitability for problem solving of the external knowledge are indisputable, firm change through acquiring new-to-the-firm external knowledge is hard to be realized in firms with high path dependency as a result of the resistance against the transferred knowledge. For these reasons, high path dependency negatively affects the firm's core knowledge change through external knowledge sourcing.

Technological M&A has a significant impact on the acquirer firm's core knowledge

change. External knowledge sourcing through technological M&As differentiates itself from other external knowledge sourcing modes, such as alliances or licensing, by acquiring the entire knowledge base and inventors of the target firm (Jo et al., 2016). The acquired inventors and knowledge base create innovation through being integrated and recombined with the acquirer firm's existing knowledge base (Ahuja and Katila, 2001). Inventors from the target firm transfer the knowledge of the target firm to the acquirer firm, thereby significantly affecting post-M&A innovation performance (Ranft, 2006). Moreover, they create novel recombination through cooperating with the acquirer firm's existing inventors, which also allows to create innovation within unique knowledge areas (Phene et al., 2012). The new innovation areas that are created through these mechanisms cause a change in the acquirer firm's core knowledge portfolio.

However, although the firm acquires a bundle of knowledge from the target firm through technological M&A, firms with high path dependency experience difficulties in achieving core knowledge change through technological M&A. First, the competency trap, a common problem of path dependent firms, reduces the attention allocated to the transfer of the target firm's knowledge base and impairs the recognition of the value of recombination using the new resources (Kraatz and Zajac, 2001; Koput, 1997). The competency trap of the firm impedes the development within new core knowledge area, thereby negatively influencing possible changes in the acquirer firm's core knowledge portfolio (Liu, 2006). Second, the NIH syndrome of path dependent firms increases the perceived risk of losing status among the knowledge workers of both the acquirer firm and

the target firm (Hussinger and Wastyn, 2016). This perceived risk leads to conflict between the knowledge workers, ultimately hindering collaboration between the knowledge workers of the acquirer and target firm and negatively impacting core knowledge change (Sears and Hoetker, 2014). Therefore, in the context of external knowledge sourcing through technological M&A, the acquirer firm's path dependency negatively affects post-M&A core knowledge change by reducing the flexibility which is required for the acquirer firm to renew and change its core knowledge areas.

Hypothesis 5-1*: The path dependency of the acquirer firm negatively affects post-M&A core knowledge change.*

5.2.2. Firm's combinative capabilities and post-M&A core knowledge change

Firm's combinative capabilities refer to the firm's capabilities to recombine knowledge from different knowledge areas (Kogut and Zander, 1992). To create breakthrough innovations, the firm should be able to develop connections among various knowledge elements and combine them in many different ways, thereby create novel recombination (Carnabuci and Operti, 2013). Therefore, firm's combinative capabilities are key elements of the firm, especially due to the firm's limited set of knowledge and resources (Katila and Ahuja, 2002). The source of combinative capabilities of the firm is the interfirm knowledge

exchange mechanism (Obstfeld, 2005). The fluent knowledge sharing among organizational members enables the diffusion of both the codified and tacit parts of each knowledge element. The shared tacit knowledge plays a significant role as a bridge of different knowledge elements, supporting a more profound knowledge recombination (Leonard and Sensiper, 1998). Therefore, the more knowledge exchange occurs among individuals, the more likely is the firm to have novel recombination (Hargadon and Sutton, 1997; Carnabuci and Operti, 2013). That is, when a firm has a well-established innovation process with knowledge recombination through sharing and coordinating knowledge among the firm's members, the firm has high combinative capabilities (Zollo and Winter, 2002).

Although valuable knowledge is acquired from external sources, the knowledge is not able to have a positive impact on the firm's core knowledge change if the firm lacks combinative capabilities. This is due to the interaction between the firm's combinative capabilities and learning process being an important factor in realizing the firm's core knowledge change through successful external knowledge sourcing (Gebauer et al., 2012). According to Jain (2016), in order to realize core knowledge change of the firm, for the realization of novel recombination, both the in-flow of external knowledge and processes that diffuse the novel recombination throughout the organization are required. Combinative capabilities help to create novel recombination using the acquirer firm's existing knowledge base and the externally sourced knowledge (Koruna, 2004). Also, the capabilities allow the firm to have an active knowledge exchange among its members, and

facilitate diffusing the external knowledge throughout the firm. As a result, the firm's combinative capabilities have a positive impact on the core knowledge change through acquiring external knowledge.

In case of external knowledge sourcing through technological M&A, the acquirer firm's combinative capabilities also play an important role on the firm's core knowledge change. First, when the acquirer firm's combinative capabilities are high, the acquirer firm produces more recombination sets from the target firm's knowledge base that is acquired and integrated through technological M&A (Deng, 2010). Owing to the high combinative capabilities of the acquirer firm, the frequency of knowledge exchange within the firm would increase, which helps small changes occurring throughout the knowledge base by giving incentives to increase the number of possible recombination sets (Björkdahl, 2009). Second, the knowledge spillover, which allows to amplify these small changes throughout the firm, is facilitated as the post-M&A socialization process occurs more actively. In the context of external knowledge sourcing through technological M&A, the acquirer firm's combinative capabilities positively affect the post-M&A core knowledge change.

Hypothesis 5-2*: Combinative capabilities of the acquirer firm positively affect the post-M&A core knowledge change.*

5.2.3. Moderating effect of post-M&A target firm inventor retention

The study suggests inventor retention as an M&A specific factor which significantly moderates the impact of path dependency and combinative capabilities on the core knowledge change of the firm. Prior research mentions that the driving force behind successful core knowledge change is the hiring of new human resources, i.e., learning by hiring, which overcomes the firm's solidified inertia and path dependency and renews the firm's capabilities (Song et al., 2003). Hiring new inventors introduces distant knowledge to the existing organization (March, 1991). The in-flow of new human resource causes a disruption of the acquirer firm's routines and contributes to core knowledge change (Jain, 2016). One of the most distinctive factors of technological M&As compared to other external knowledge sourcing strategies is that the acquirer firm can absorb the target firm's entire knowledge reservoir, i.e., human resources (Ranft, 2006; Argote and Ingram, 2000). In other words, in technological M&A, absorbing the target firm's inventor group leads to learning-by-hiring within the post-M&A combined firm (Castro-Casal et al., 2013). Hiring inventors with the target firm's bundle of knowledge would strengthen the effect of knowledge inflow through technological M&A on the firm's core knowledge change. Since the degree to which the target firm's inventors are retained after a technological M&A would have a significant effect on the firm's core knowledge change, I examine how the target firm's inventor retention moderates the impacts of the acquirer firm's path

dependency and combinative capabilities on the firm's core knowledge change.

The post-M&A target firm's inventor retention positively moderates the impact of path dependency of the acquirer firm on the core knowledge change of the firm. Regardless of the field of knowledge they specialized in, the target firm's inventors, which are absorbed and retained through the technological M&A, disrupt the acquirer firm's groupthink and cohesiveness, which were the main cause of the acquirer firm's path dependence (Jain, 2016). The influx of new inventors from the target firm results in the acquirer firm reorganizing its work groups, and the acquirer firm's existing inventors also experience a disruption of their routine and process due to the new inventors from the target firm (Sears and Hoetker, 2014). The disruption of the habitual and repeated innovation process, which has been formed as a result of the acquirer firm's path dependency, occurs alongside this process, thereby reducing its negative effect on the core knowledge change of the firm. Moreover, face-to-face communication, which would be increased as the inventor retention increases after M&A, may alleviate the perceived risk of the acquirer firm's inventor resulting from the NIH syndrome (Graebner, 2004). The NIH syndrome occurring within a firm with high path dependency is rooted in miscommunication and misunderstanding with respect to new-to-the-firm knowledge (de Pay, 1995). The target firm's inventor retention reduces the perceived risk against new-to-the-firm knowledge by allowing to better understand the tacit knowledge that the target firm's inventors possess (Colombo, Conca, Buongiorno, and Gnan, 2007). Finally, the NIH syndrome would be alleviated since the acquirer firm's attention allocated to understanding and incorporating the target firm's

knowledge base increases as the target firm's inventor retention increases (Koput, 1997). The more inventors with knowledge of the target firm remain in the combined firm, the larger is the probability of the acquired knowledge affecting the firm's core knowledge change as the firm's attention towards new-to-the-firm knowledge areas increases.

Hypothesis 5-3a*: The target firm's inventor retention alleviates the negative impact of the acquirer firm's path dependency on the core knowledge change.*

The impact of the acquirer firm's combinative capabilities on the core knowledge change would be enhanced by the post-M&A target firm's inventor retention. First, tacit knowledge embedded in the target firm's inventors helps to form the possible knowledge recombination set with the acquirer firm's combinative capabilities more efficiently. The target firm's inventors are knowledge reservoir of the target firm, i.e., they possess knowledge that is more valuable and tacit than the explicit knowledge such as patents (Ranft, 2006). The target firm's inventors tacit knowledge includes know-how and who-knows-what with respect to the target firm's innovation (Argote and Ingram, 2000; Argote and Miron-Spektor, 2011). Therefore, the target firm's tacit knowledge, which is retained along with the inventor acquired, provides incentives to create more valuable recombination with the other existing knowledge. The tacit knowledge also acts as bridge between knowledge from two different knowledge areas by increasing the understanding of knowledge areas (Leonard and Sensiper, 1998). Second, retained inventors help the

acquirer firm's recognize which knowledge areas could be developed as core knowledge of the organization by increasing the acquirer firm's comprehension of recombination sets (Ranft and Lord, 2000; Castro-Casal et al., 2013). That is, when both inventor groups from the acquirer firm and the target firm exist in an organization, the impact of combinative capabilities on the firm's core knowledge change would be facilitated by understanding the potential of synergy realization on new knowledge recombination. Last, inventor retention can enhance the acquirer firm's combinative capabilities by boosting knowledge exchange through increasing face-to-face interaction between the acquirer firm and the target firm (Ranft and Lord, 2002). According to Ranft (2006), tacit knowledge of the target firm may be transferred only through face-to-face interaction or learning-by-doing. An increased number of face-to-face interactions through inventor retention would have a positive effect on both recombination formation and diffusion of the small change that resulted from the acquirer firm's combinative capabilities. Thus, the target firm's inventor retention would enhance the impact of the acquirer firm's combinative capabilities on the core knowledge change.

Hypothesis 5-3b: *The target firm's inventor retention positively moderates the impact of the acquirer firm's combinative capabilities on the core knowledge change.*

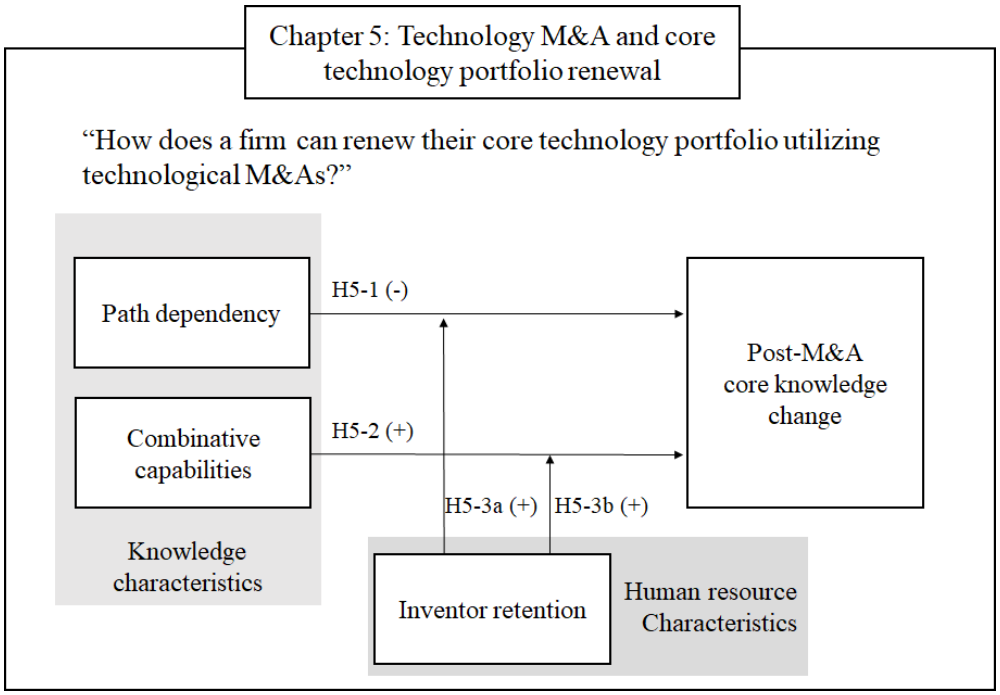

Figure 5-1. Conceptual model for Chapter 5

5.3. Methodology

5.3.1. Data

The hypotheses were examined using a data set of M&A deals conducted by firms in the U.S biopharmaceutical industry. The U.S biopharmaceutical industry provides an ideal setting for this research. First, since it is a technology-intensive industry, a firm's competitive advantage is largely determined by its core knowledge (Bierly and Chakrabarti, 1996; Duysters and Hagedoorn, 2000; Jo et al., 2016). Moreover, firms in this industry are required to wisely manage and change their core knowledge portfolio in order to sustain a competitive advantage (Grant, 1996). Second, firms in biopharmaceutical industry actively apply for patents in order to protect their new inventions (De Carolis, 2003). This allows for the use of patent data to proxy the acquirer and the target firm's knowledge base.

Information on M&A deals in the U.S biopharmaceutical industry was collected from the Thomson Reuters SDC Platinum database. Since firms in the U.S biopharmaceutical industry heavily utilized technological M&As between 2001 and 2008, this research focuses on this time period for its wealth of data. M&A deals in which the acquirer firm repurchased its remaining assets or interests were excluded. Information on patents granted to the firms involved in the M&A deals between 1996 and 2014 was collected from the United States Patent and Trademark Office (USPTO). Following Ahuja and Katila (2001) which first defined technological M&A, deals in which the target firm had no patent

granted before the M&A deal were considered as non-technological M&A and excluded from the data set. Information on the individual inventors of the firms was obtained from dataset of Li et al. (2014). The dataset was supplemented with financial information of each firm, collected from the Datastream database.

The final sample consists of 287 M&A deals conducted by 112 firms. The definition of the biopharmaceutical industry is drawn from the Thompson Reuter's SDC platinum database, which also distinguished several fields within this industry. In the dataset, companies involved with Measuring, medical and photo equipment accounted for the majority of firms (54.0%), followed by firms developing drugs (34.8%), and firms involved with chemicals and allied products (4.2%). In terms of the national origin of firms in the sample, most firms are from the Unites States (87.1%), followed by firms from Europe (10.8%), Asian countries (2.1%).

5.3.2. Variables

5.3.2.1 Dependent variable

This study investigates the acquirer and target firms' patenting activities during the pre- and post- M&As time periods in order to capture the firms' knowledge base operations or routines and the subsequent knowledge base changes (Ahuja and Katila, 2001; Valentini, 2012). Since the dependent variable of the study is the change in core knowledge areas of

the acquirer firm, the study compared the acquirer firm's core knowledge areas during the pre- and post-M&A time period. The acquirer firm's knowledge base before the M&A deal was measured using patents granted to the firm during the 5 years prior to the M&A deal (Cloodt et al., 2006; Makri et al., 2010; Sears and Hoetker, 2014). A 2-year time lag was employed to account for the time it takes for the M&A deal to be completed and effects to be noticeable as well as the time required for applied patents to be granted (Phene et al., 2012). The acquirer firm's patents granted during the 5-year period following the time lag were used to represent the acquirer firm's knowledge base during the post-M&A time period (Ahuja and Katila, 2001; Phene et al., 2012).

A 3% cutoff (Granstrand, Patel, and Pavitt, 1997) is used to distinguish core knowledge areas of the acquirer firm. A knowledge area (following the USPTO 3-digit main-class classification system) is considered to be a core knowledge area if more than 3% of the acquirer firm's entire granted patent during each of the pre- and post-M&A time period falls within its classification, otherwise it is considered as a non-core knowledge area. By comparing the core knowledge areas during the pre- and post-M&A time periods, post-M&A core knowledge areas of the acquirer firm were classified into existing core knowledge areas, i.e., areas classified as core knowledge areas in both the pre- and post-M&A time periods, and new core knowledge areas, i.e., areas only classified as core knowledge area in the post-M&A time period. Patents granted in these two knowledge areas during the post-M&A time period allow to measure the degree to which the acquirer firm has changed its core knowledge areas using the following equation:

$$Core\ change = \frac{\#\ of\ patents\ granted\ in\ new\ core\ knowledge\ areas_{(t+2,t+6)}}{\#\ of\ patents\ granted\ in\ entire\ core\ knowledge\ areas_{(t+2,t+6)}}$$

5.3.2.2 Independent variables

Following prior research, this study measured the acquirer firm's knowledge base operations and organizational R&D characteristics by analyzing the acquirer firm's patent granted before the M&A. Further, citations made in each patent allowed to closely investigate the acquirer firm's patenting routine (Sørensen and Stuart, 2000). The independent variable *Path dependency* was calculated using the self-citation ratio of the acquirer firm. A firm with a high path dependency in its R&D process is more likely to create new innovation drawing on local search, i.e., its prior knowledge or knowledge within the firm boundary, rather than distant search (Song et al., 2003). Thus, a firm's self-citation ratio represents the degree of the firm's path dependency in its R&D process (Rosenkopf and Nerkar, 2001). The acquirer firm's *Path dependency* was calculated using the following equation:

$$Path\ depedency = \frac{\#\ of\ self\_citations\ made\ by\ the\ acquirer\ firm_{(t-5,t-1)}}{Total\ \#\ of\ citations\ made\ by\ the\ acquirer\ firm_{(t-5,t-1)}}$$

Combinative capability measures the recombination capability of the acquirer firm, i.e.,

its capability to utilize knowledge from different knowledge areas to create new innovation (Phene and Almeida, 2008). Citations to other patents found in the acquirer firm's patents allow to identify which knowledge areas the acquirer firm combined in creating innovation (Jaffe and Trajtenberg, 2002). Specifically, for each of the acquirer firm's patents, the study compared the USPTO main-class of the focal patent and of the patents cited. *Combinative capability* is the ratio of citations to patents categorized by a different main-class compared with the corresponding patent to the total number of citations made by the acquirer firm, and was calculated using the following equation:

$$Combinative\ \ capability = \frac{\#\ of\ \ citations\ \ with\ \ different\ \ mainclass\ \ compared\ \ to\ \ the\ \ corresponding\ \ patent_{(t-5,t-1)}}{Total\ \#\ of\ \ citations\ \ made\ \ by\ \ the\ \ acquirer\ \ firm_{(t-5,t-1)}}$$

Inventor retention reflects the proportion of the target firm's inventors retained in the combined firm after the M&A deal. The number of retained inventors was calculated by comparing the information on inventors found in the patents granted to the target firm in the 5-year period before the M&A deal and in the patent granted to either the acquirer or the target firm after the M&A (5-year period starting two years after the M&A deal). Specifically, this comparison was performed using the individual IDs assigned to each inventor by Li et al. (2014). The proportion of retained inventor was then calculated using the following equation:

$$Inventor\ retention = \frac{\#\ of\ the\ target\ firm\acute{}s\ inventors\ retained\ after\ the\ M\&A\ deal_{(t+2,t+6)}}{\#\ of\ the\ target\ firm\acute{}s\ inventors\ before\ the\ M\&A\ deal_{(t-5,t-1)}}$$

5.3.2.3 Control variables

The study includes several control variables in order to control for other factors that may have a significant impact on the acquirer firm's post-M&A core knowledge base changes. First, *Acquirer knowledge base* was included in order to control for the effects of the firm's innovation capabilities, absorptive capacity, and size of accumulated knowledge stock. The variable *Acquirer knowledge base* is expressed by the number of patents granted to the acquirer firm during the 5 years preceding the M&A deal (Phene et al., 2012; Ahuja and Katila, 2001). Second, *Relative size of knowledge base* was included in order to control for the size difference between the acquirer and the target firm. It was defined as the number of the target firm's granted patent during the 5-year pre-M&A time period divided by the number of the acquirer firm's granted patents during the same time period (Ahuja and Katila, 2001). Third, *Firm size* was included in order to control for effects stemming from the acquirer firm's size. Firm size is expressed as the natural log of the number of employees of the acquirer firm (Cohen and Klepper, 1996; Rosenkopf and Almeida, 2003). Forth, *R&D intensity* was included in order to control for the effects of the acquirer firm's

R&D investments. Following prior research, R&D intensity was expressed as the ratio of annual R&D expenses over the total sales of the acquirer firm in the year before the M&A deal (Hall, Griliches, and Hausman, 1986). Fifth, *Knowledge relatedness* was included in order to control for the knowledge relatedness between the acquirer firm's and the target firm's knowledge bases. The control variable also allows to control for the intention of the M&A deal, i.e., whether the acquirer firm intended to acquire a target firm with a similar knowledge base or a target firm with a complementary or distant knowledge base. Knowledge relatedness was calculated as the ratio of the number of granted patent within overlapped knowledge areas, in which both the acquirer firm and the target firm were granted patents during pre-M&A time period, over the target firm's entire number of granted patents during the same time period (Ahuja and Katila, 2001; Makri et al., 2010). Last, the study includes several dummy variables to control for the effects of *M&A deal year, Industry, Foreign acquisition, Firm nationality, and Post-M&A inventor integration*.

5.3.3. Model

The dependent variable, *Core Knowledge Change*, is continuous, but due to it representing a proportion, it is limited to values from 0 to 1. If not accounting for this characteristic, the results from the regression, however, could fall outside this range. Consequently, the study utilized logit transformation (Warton and Hui, 2011). To deal with cases in which the variable is either 0 or 1, which would logit transform to negative / positive infinity, the

following equation proposed by Smithson and Verkuilen (2006) was applied before the logit transformation:

$$Core\ \ Knowledge\ \ Change^{'} = \frac{\left[Core\ \ Knowledge\ \ Change \times (N-1) + \frac{1}{2}\right]}{N}$$

The logit transformed dataset was subsequently analyzed using an ordinary linear regression model.

5.4. Results

5.4.1. Descriptive statistics

Table 5-1 shows the descriptive statistics and correlations among the variables included in the empirical analysis. All correlation values are under the 0.70 threshold (Cohen et al., 2003). Moreover, to rule out problems stemming from multicollinearity, a variance inflation factor (VIF) test was performed. The VIF values for each model have a value of less than 3, which confirms that no multicollinearity problem exists among the variables (Myers, 1990).

Table 5-1. Descriptive statistics and correlations among the variables

Variables	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9
Core Knowledge change	0.28	0.26	0.00	1.00	1.00								
Path dependency	0.09	0.10	0.00	0.64	-0.33	1.00							
Combinative capability	0.51	0.17	0.00	1.00	0.18	-0.06	1.00						
Inventor retention	0.07	0.22	0.00	2.33	-0.16	0.19	0.00	1.00					
Acquirer knowledge base	255.66	470.18	1.00	2617.00	-0.08	0.24	0.07	0.06	1.00				
Relative size of knowledge base	2.26	20.43	0.00	339.50	-0.01	-0.09	-0.09	-0.02	-0.06	1.00			
Firm size	3.69	0.92	1.00	5.15	-0.17	0.09	-0.14	0.01	0.47	-0.10	1.00		
R&D Intensity	89.86	1516.08	0.01	25684.40	0.07	-0.05	0.02	-0.02	-0.03	0.00	-0.06	1.00	
Knowledge relatedness	0.09	0.15	0.00	0.83	-0.02	-0.13	-0.12	-0.04	-0.19	0.07	-0.15	0.04	1.00

5.4.2. Logit transformed ordinary least squares regression

Table 5-2 shows the results from the ordinary least squares regression analysis. Model 1 includes only the control variables to investigate their influence on the core knowledge change of the firm. It can be seen that only the control variable Firm size has a significant effect on core knowledge change. Models 2 to 5 add the independent variables, moderator variable, and the interaction terms, and test the hypotheses of this research. The direct effect of path dependency of the acquirer firm's core knowledge change is negative and significant in both Model 2 ($p < 0.01$) and the full model, Model 5 ($p < 0.01$). These results support Hypothesis 5-1, which argues that the acquirer firm's path dependency negatively affects the core knowledge change of the firm. The direct effect of the acquirer firm's combinative capabilities is positive and significant in both Model 3 ($p < 0.10$) and the full model, Model 5 ($p < 0.05$). These results support Hypothesis 5-2, which argues that the acquirer firm's combinative capabilities positively affect the core knowledge change of the firm. The moderation effect of inventor retention on the direct effect of the path dependency of the acquirer firm is tested in Model 4 and the full model. While the direct effect term for path dependency is negative and significant in both Model 4 ($p < 0.01$) and Model 5 ($p < 0.01$), the interaction term of path dependency and inventor retention is positive and significant in both Model 4 ($p < 0.05$) and Model 5 ($p < 0.05$). These results support Hypothesis 5-3a, which argues that inventor retention alleviates the direct negative effect of path dependency on the core knowledge change. The moderation effect of inventor

retention on the relationship between combinative capabilities of the acquirer firm and the core knowledge change of the firm is investigated in Model 5. While the direct effect term of path dependency is negative and significant in Model 5 ($p < 0.05$), the interaction term of combinative capabilities and inventor retention is not significant. Thus, Hypothesis 5-3b, which argues that inventor retention enhances the direct positive effect of combinative capabilities on the core knowledge change, is not supported.

Table 5-2. Ordinary least squares regression results for post-M&A core knowledge change

Dependent Variable **Core Knowledge Change**	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Independent Variables					
Path dependency		-0.81**	-0.78**	-0.94**	-0.92**
		(0.15)	(0.15)	(0.16)	(0.17)
Combinative capability			0.17†	0.16†	0.19*
			(0.09)	(0.09)	(0.10)
Inventor retention				-0.32**	-0.04
				(0.12)	(0.28)
Path dependency x Inventor retention				1.12*	1.08*
				(0.47)	(0.47)
Combinative capability x Inventor retention					-0.54
					(0.49)
Control Variables					
Acquirer knowledge base	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Relative size of knowledge base	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Firm size (Log employees)	-0.04*	-0.05*	-0.04*	-0.05*	-0.05*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
R&D Intensity	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Knowledge relatedness	-0.03	-0.09	-0.06	-0.09	-0.09
	(0.11)	(0.10)	(0.10)	(0.10)	(0.10)
Constant	0.24	0.36*	0.27	0.33†	0.31†
	(0.17)	(0.16)	(0.17)	(0.17)	(0.17)
R^2	0.08	0.17	0.18	0.21	0.21
Adjusted R^2	0.05	0.14	0.15	0.17	0.17
Mean VIF	1.18	1.18	1.19	1.21	1.21
Max VIF	1.53	1.53	1.60	1.61	1.61

Notes: †p < 0.10; *p < 0.05; **p < 0.01

N=287 (Control dummy variables are included, Standard errors in parentheses)

5.5. Discussions

5.5.1. Conclusions and discussion

This study suggests technological M&A as a prominent external knowledge sourcing strategy for firms to prevent their knowledge portfolio obsolescence and achieve core knowledge change. It also suggests that the target firm's inventor retention is a crucial factor for an effective implementation of such a strategy. Specifically, the study investigates the direct effects of path dependency and combinative capabilities, which are the firm's specific factors that have important effects on the firm's knowledge portfolio renewal through external knowledge sourcing, on the firm's post-M&A core knowledge change. Moreover, the study examines the moderation effects of the target firm's inventor retention on each of the main direct effects. The results confirm that the target firm's inventor retention should be seen as a key success factor for core knowledge change through technological M&A as it reduces the negative direct effects of the acquirer firm's path dependency. The research results in several theoretical contributions:

First, this research makes contributions to the literature on technological M&As and strategic management by examining the effects of technological M&A on the acquirer firm's core knowledge change and investigating key success factors which allow to effectively implement the external knowledge sourcing strategy. Existing literature on technological M&As mostly examined the effects of technological M&As by focusing on

the amount of the acquirer firm's innovation created after the M&A deal, e.g., post-M&A innovation performance (Ahuja and Katila, 2001), post-M&A financial performance (Sears and Hoetker, 2014), and post-M&A inventor productivity (Kapoor and Lim, 2007). Besides the effects on various dimension of post-M&A performance, it is important to see how an M&A changes the acquirer firm's core knowledge portfolio, since it allows the absorption of a bundle of external knowledge at once. The study is the first to uncover the impact of M&A on core knowledge portfolio change.

Second, the research suggests new implications for research on the firm's learning-by-hiring by empirically demonstrating that technological M&A has a significant effect of learning-by-hiring through the absorption of the target firm's inventors. Prior research suggests hiring R&D personnel from technologically-distant knowledge fields as a solution to overcome the firm's technology obsolescence, and argues that such a hiring strategy allows to disrupt the firm's rigid routines and processes (Jain, 2016; March, 1991; Song et al., 2003). Song et al. (2003) suggests the concept of "learning by hiring", since R&D personnel can act as the knowledge reservoir of the firm's tacit knowledge. Jain (2016) examines that the hiring helps to disrupt the firm's core rigidities, enabling core knowledge change through acquiring new-to-the-firm innovation. Likewise, the research on "learning by hiring" argues that hiring R&D personnel allows the firm to undergo core knowledge portfolio changes by both acquiring tacit and new-to-the firm knowledge, and by disrupting the organization's path dependent activities (David, 2001). Following this stream of thought, the present research argues that inventors retained through technological M&As

provide a significant effect of learning-by-hiring. Since in technological M&A deals the entire R&D personnel of the target firm is acquired, retained inventors can impact the acquirer firm by disrupting routines and introducing new-to-the-firm knowledge. To the best of my knowledge, this research is the first study that investigates the impact of learning-by-hiring in the context of technological M&A.

In addition to the various contributions to the literature on technological M&As, this study also provides significant implications for other theoretical perspectives such as knowledge management, organizational learning theory and the evolutionary theory of the firm. By demonstrating the impact of path dependency and combinative capabilities on the firm's external knowledge sourcing through technological M&As, the research describes the detailed mechanism of the firm's core technology portfolio change (frequent small changes and amplification) and the key success factor for achieving it (decreasing NIH syndrome by breaking the firm's path dependency and enhancing knowledge exchange mechanisms through combinative capabilities). The stepwise mechanism of firm's core technology portfolio change suggested in this study helps firms to understand the detailed mechanism of organizational knowledge change. Therefore, this study contributes to knowledge management theory by empirically examining the impact of the firm's knowledge exchange characteristics on knowledge portfolio renewal through external knowledge sourcing.

Second, this study contributes to the literature on organizational learning and evolutionary theory by demonstrating that organizational path dependency, which often is

a hurdle for effective external knowledge sourcing and transfer through technological M&A, and the corresponding not-invented-here syndrome may be overcome through inventor retention. The evolutionary theory of the firm argues that the firm's routines and NIH syndrome as a result of the firm's path dependency are the factors that have the strongest effect on firm transformation (Hussinger and Wastyn, 2016). Prior research suggests the acquirer firm's rigid routines and organizational disruption due to the similarity of the acquired knowledge as main causes of the NIH syndrome, and argues that the acquirer firm is required to absorb knowledge with a moderate level of knowledge relatedness in order to resolve the problem of path dependency (Cloodt et al., 2006). While literature emphasizes the importance of relative knowledge characteristics between the acquiring knowledge and the existing knowledge, e.g. knowledge relatedness, the strategic characteristics that allow the acquirer firm to effectively absorb external knowledge were not closely examined. This study suggests a new remedy for the acquirer firm's path dependency by demonstrating that the post-M&A target firm's inventor retention has a significant impact on the acquirer achieving successful core portfolio change through technological M&A.

Chapter 6. Conclusive remarks

6.1. Summary and contributions

In conclusion, the dissertation contributes to discovering key success factors for technological M&As by investigating the sequential process of the strategy. In technological M&As, the acquirer firm selects a target firm, integrates its knowledge base resources after the acquisition, and enhances their core technology innovation utilizing the target firm's knowledge. Each building block significantly affects the success or failure of technological M&As, both totally and individually. The dissertation helps managers in practice to understand the trade-off relationships of each building block of technological M&As and how to leverage them strategically. Further, the dissertation provides numerous significant findings and contributions for each stage of technological M&As.

First, the dissertation examines the relationship between technological overlap and the qualitative aspects of acquiring knowledge. That is, to acquire the target firm's high quality knowledge, the knowledge overlap between the acquirer and target firm's knowledge bases is essential. Second, the dissertation explicates the target firm inventor retention in the post-M&A knowledge base integration phase. Not only the retention of target firm key inventors but also the retention of their organizational contexts is a significant factor in achieving the major goals of technological M&As. Third, the dissertation confirms the role of technological M&A as a firm's core technological portfolio renewal strategy. Extending

the previous literature on core knowledge change and post-M&A innovation in technological M&As (Jain, 2016; Phene et al., 2012), the study discovers significant organizational knowledge characteristics and strategic factors for achieving core technology renewal through technological M&As. These findings suggest firms to consider their path dependency and encourage combinative capabilities in order to successfully achieve corporate technology portfolio renewal through technological M&As. At the same time, the target firm's inventor retention is a significant strategic factor which moderates the effect of the firm's path dependency. Overall, the dissertation highlights the role of technological M&As as a prominent external knowledge sourcing strategy, which can be successful if the related processes are well understood and properly managed.

Complementing the overall contributions of this dissertation, each major chapter of the dissertation presents managerial implications both for the acquirer firm and the target firm of technological M&As in accordance with their findings. The implications for managers of acquirer firm in technological M&As that can be derived from the studies performed in each chapters are as follows:

The findings of Chapter 3 provide several practical implications: First, focusing only on obtaining high-quality knowledge of the target firm might negatively affect innovation performance. According to this research, integrating knowledge without considering the acquirer firm's knowledge base will incur high managerial and integration costs and low marginal returns. Therefore, an acquirer firm should look into the overlap between the target firm's and acquiring firm's knowledge bases to fully utilize the high-quality

knowledge of the target firm. There are some M&A cases in which acquiring a target firm with high-quality non-overlapped knowledge resulted in a failure to realize synergies through combining the knowledge bases. A good example is the case of Hewlett-Packard Company's (HP) acquisition of Palm, Inc. To cope with rival firms such as Google, Inc. and Microsoft Corporation entering the mobile market, HP acquired Palm, which was the leader of the Personal Digital Assistant (PDA) industry, with the purpose of acquiring knowledge in the mobile computing field. Palm was a technology-intensive firm that possessed a large amount of high-quality knowledge in the mobile computing field due to their accumulated intellectual properties and user experiences. Moreover, Palm was using its own world-class mobile WebOS and platforms at that time. However, HP, which had focused on its existing computer development, could not fully exploit Palm's knowledge due to a lack of overlapped knowledge. HP could not achieve successful learning through the M&A and ultimately failed to enter the mobile market. Another related example is the case of Microsoft Corporation's acquisition of aQuantive, Inc. In response to rival firm Google's acquisition of DoubleClick, Microsoft acquired mobile advertisement company aQuantive. aQuantive was a firm that possessed high-quality knowledge of an advertisement platform called Atlas, which competed with DoubleClick, a firm acquired by Google, and an advertisement network called DRIVEEpm, which is an advertisement platform for rich media such as online videos. However, the M&As resulted in failure, without pursuing joint projects, owing to the absence of a common knowledge background due to the insufficient knowledge overlap. These cases complement my argument that the

lack of overlapped knowledge causes a lack of absorptive capacity, thereby making it more difficult for the acquirer firm to obtain and benefit from the high-quality knowledge of the target firm.

Second, the knowledge overlap helps the acquirer firm to learn and utilize the target firm's high-quality knowledge. The technological M&A cases of Gilead Sciences, Inc. show the positive effect of high-quality knowledge acquisition when considering knowledge overlap. Gilead Sciences is a global biopharmaceutical company specialized in treatments for infectious diseases such as hepatitis and HIV. In 2003, Gilead Sciences acquired Triangle Pharmaceuticals, Inc., which also had strength in combatting infectious diseases, to gain access to the HIV treatment Emtriva, which is located in the overlapped knowledge area. Gilead Sciences recombined the acquired HIV treatment Emtriva with its existing HIV treatment, Viread, and successfully developed Truvada, which became the standard drug in the HIV treatment market. In 2011, Gilead Sciences acquired Pharmasset, Inc., which also had its strength (high-quality knowledge) in the treatments of infectious diseases. Pharmasset had developed infectious disease treatments such as Sofosbuvir, a treatment drug for hepatitis C. Gilead Sciences, Inc. launched Sovaldi, including Sofosbuvir as its main ingredient. Further, adding the internally developed substance ledipasvir onto Sovaldi allowed Gilead Sciences, Inc. to develop the subsequent drug Harvoni, which proved to be a great success. These cases show that the overlapped knowledge of Gilead Sciences positively affected the creation of novel recombinations when combined with the high-quality knowledge of the target firms, such as Triangle and

Pharmasset. Likewise, the overlapped knowledge base provides sufficient absorptive capacity for accommodating the complexity of the target firm's high-quality knowledge. Furthermore, to utilize the target firm's high-quality knowledge through technological M&As, paradoxically, the firm should possess overlapped knowledge in advance. As an acquirer firm's diverse knowledge base is more likely to overlap with the target firm's knowledge, acquirer firms need to possess diverse knowledge in order to successfully transfer knowledge and create subsequent innovation. As this research has verified, this overlap contributes to transferring the knowledge of the target firm after an M&A and creating new knowledge. Therefore, firms need to foster diversity in their own knowledge portfolio to successfully create innovation through technological M&As.

In summary, the overlap between acquirer and target firms should be wisely exploited in technological M&As. As this research suggests, firms are more likely to appreciate the value of knowledge and utilize it in areas where knowledge overlap exists. Thus, it is necessary to select a target firm with high-quality knowledge in overlapped areas and a sufficient quantity of knowledge in non-overlapped areas. In other words, the acquisition of high-quality knowledge is needed for innovation where acquirer and target firms share similar knowledge, while acquiring a moderate quantity of knowledge is needed for more innovation in areas unfamiliar to the acquirer firm.

Chapter 4 of this study provides the managerial implication for the acquirer firm that, for a successful technological M&A, it is important to consider not only the retention of key employees but also their organizational context. In addition, since the organizational

context of the target firm inventors affects knowledge exploitation and organizational creativity in different ways, managers need to carefully consider the firm's knowledge resources and think about the preservation of the target firm inventors' organizational context. That is, depending on the ultimate goal of the technological M&A, sometimes it might be better to disrupt the target firm knowledge and try to integrate both entities to foster a higher creativity of the merged entity and breaking path dependency.

Chapter 5 of this dissertation suggests the following practical implications for the acquirer firm: First, technological M&A is a suitable external knowledge sourcing strategy for firms wanting to change their core knowledge portfolios. However, firms need to consider their internal knowledge exchange patterns and the path dependency of their innovation patterns. In the dynamic environment of high-tech industries, firms' core knowledge is under a constant threat of becoming obsolete. Therefore, proper change in their core knowledge portfolio is crucial for firms to survive, especially for established firms. By suggesting technological M&A as a tool for core knowledge transformation, practitioners can reconsider their technological M&A strategy to aim not only for short term financial performance or post-M&A innovation performance, but also for long term competitive advantage through core portfolio change.

Second, the acquirer firm should carefully manage the target firm's inventors in order to increase their retention after the M&A. Inventor retention plays a significant role in transforming the acquirer firm's core knowledge portfolio through technological M&A. By fostering integration and communication between the two groups of inventors, i.e., existing

inventors and target firm inventors, the acquirer firm can maximize the effects of the technological M&A on the renewal of the firm's knowledge portfolio.

Besides these implications for acquirer firms in technological M&As, there are several implications for target firms and their inventors, which often face organizational disruption during technological M&As. Though previous literature focused more on acquirer firm perspectives for selecting targets and realizing synergies of technological M&As, target firm perspectives such as selecting a suitable acquirer firm and deciding the type of post-M&A cooperation, are important, especially when the target firm inventors will keep innovating in the merged entity.

In Chapter 3, when considering technological M&As, the target firm should also consider the knowledge overlap with the acquirer firm's knowledge base in order to realize synergies using acquirer firm's knowledge resources. When the acquirer firm has a certain amount of absorptive capacity, the target firm's high quality knowledge can be easily recognized and wisely exploited. Second, target firm inventors with high quality knowledge should consider their post-M&A retention in accordance with whether the acquirer firm has background knowledge of the high quality knowledge as the findings of this study contradicts the notion that inventors in overlapped knowledge areas would often face organizational disruption due to their knowledge redundancy. The study implicates that a certain amount of knowledge overlap would rather help target firm inventors possessing high quality knowledge to communicate with the acquirer firm's inventors, facilitating cooperation.

Chapter 4 of this dissertation implies that target firm inventors should understand the significance of the knowledge embedded in the inventor network. The findings of this study imply that low post-M&A productivity of target firm inventors stems not only from the departure of star scientists and inventors, but also the disruption of their organizational contexts. In order to overcome the fluctuations introduced by technological M&As, the target firm inventors should understand the significance of the knowledge embedded in the organizational context and decide how they can efficiently access the embedded knowledge in the combined organization. Furthermore, target firm inventors should understand the motivation of the acquirer firm in technological M&As and wisely utilize their retained pre-M&A organizational context according to the acquirer firm's desired performance.

In Chapter 5, the dissertation implies that when a technology intensive target firm considers technological M&A as its exit strategy, large firms whose technology portfolio becomes obsolete but possesses high resource munificence could be a suitable potential acquirer firm. The target firm's technology portfolio could serve as a fertilizer to change their core technology portfolio, which presents a good opportunity for the target firm inventors since they can utilize the acquirer firm's munificent resources and develop their own technology.

Second, target firms should specialize their knowledge portfolio in order to be acquired and get involved in the post-M&A organizational core technology portfolio renewal. The strong routines and specialized knowledge of the target firm would help to break the acquirer firm's path dependency and routines. That is, if a technology intensive firm intends

to be acquired and amplify their core technology combined with the acquirer firm's knowledge base resources, the firm should establish their own routines and technological language of their inventors and strive to retain them after the M&A.

Third, it is important to establish sufficient communication channels in order to overcome the post-M&A organizational disruption or fluctuation. The findings of this chapter imply that a rich face-to-face communication and more communication channels help to minimize the organizational conflict caused by the acquire firm's path dependency. The rich communication channels support the target firm inventors' adaptation to the merged entity and the cooperation with the acquirer firm inventors.

6.2. Use of patent data

This dissertation uses patent data to analyze the innovation and knowledge bases of firms involved in technological M&As. Patents are one of the most widely used proxies of innovation in the field of innovation and strategic management (Hall, Jaffe, and Trajtenberg, 2005). Using patent data to analyze innovation is efficient because patent data are systematically compiled, contain detailed information such as patent classes and citations, and can be adopted for multi-industry analysis (Song et al., 2003). However, patent data have some limitations with regards to the strength of their linkage with innovation. This research solves the limitations as follows: first, it can be argued that patents are not equal to innovation because not all innovations are patented (Kleinknecht, Van Montfort, and

Brouwer, 2002). This research uses data of firms within the biopharmaceutical and information technology industries. Firms in these industries tend to apply for patents for the majority of ideas to secure their profitability and intellectual properties. Both industries are characterized by a high appropriability regime with high incentives for patenting, resulting in a high propensity to patent new innovations (Puranam and Srikanth, 2007). Previous research also argues that the innovation-to-patent ratio of these industries is above the average of other industries (Arundel and Kabla, 1998). The industry selection of this study relieves the problem of whether innovation can be reflected by the analysis of firms' patents. In addition, to give general implications on technological M&As in high-tech industries, this study conducts a multi-industry analysis. Patents are a commonly used proxy for innovation in high-tech industries as they are heavily used in a broad range of industries.

Second, the patenting activity of a firm may not capture the various aspects of innovation performance, such as organizational learning and improvements to practice. According to previous studies, a patent is a record not merely of the explicit nature of an invented innovation, but also of the knowledge that is embedded in the patented innovation. Thus, it includes the organizational process, practice, and routine built during the process of invention (Almeida and Kogut, 1999; Song et al., 2003). Hence, although a patent itself may be considered explicit knowledge, considering the various aspects of knowledge that a patent encompasses, it is reasonable to consider the patent count to be an indicator representing far more than just explicit knowledge creation. Accordingly, previous research

on technological M&As and organizational learning have used patent count to measure the subsequent innovation performance of the acquirer firm (Ahuja and Katila, 2001; Hagedoorn and Duysters, 2002; Cloodt et al., 2006; Kapoor and Lim, 2007; Puranam and Srikanth, 2007; Rothaermel and Hess, 2007).

Third, it can be argued that the patent itself represents explicit knowledge, not tacit knowledge. However, Mowery, Oxley, and Silverman (1996) state that tacit knowledge is complementary to explicit knowledge, and the two are closely linked with each other. In high-technology industries, both tacit and explicit knowledge are used to create new innovations (Song and Shin, 2008). In other words, the transfer and application of tacit knowledge create innovation, which directly leads to patents (Song et al., 2003). Thus, this research also expects that both tacit and explicit knowledge are embedded within a patent and measures the quantity and quality of knowledge using patent data. This method has been widely used not only in the field of technological M&As, but also in a number of studies on knowledge management (Chen and Chang, 2010; Kim et al., 2012; Valentini, 2012; Yang et al., 2014).

6.3. Limitations and future research

Despite making a number of important contributions to the academic study and practice of technological M&As, this dissertation has a number of limitations. The major limitation stems from the use of patent data in all three studies of this dissertation. Although patent data has been extensively used to measure the firm's knowledge base and its innovation capabilities (Mowery, Oxley, and Silverman, 1998; Rothaermel and Alexandre, 2009; Song et al., 2003), patents might not fully reflect the firm's knowledge base and innovation due to a number of concerns: First, certain unpatented innovations can still be important parts of a firm's knowledge base (Kleinknecht et al., 2002). This dissertation minimizes this potential problem by focusing on firms operating in the IT and biopharmaceuticals industries, which has one of the highest innovation to patent ratios (Puranam and Srikanth, 2007). Second, patents merely reflect the explicit knowledge of the firm, not the tacit knowledge. However, patents also connote the organization's innovation process and practices which are created during the process of invention (Almeida and Kogut, 1999). Still, finding alternative measures for the concepts used in this study would enrich the research on firms' knowledge bases and innovations on technological M&As and further increase the validity of its results.

Second, the dissertation followed the definition of Ahuja and Katila (2001) when defining technological M&A and also adopted its sample selection criteria. Consequently, M&A deals for the acquisition of target firms with any patenting activities within the 5

years before the M&A deal are considered as technological M&A deals. While these criteria are widely used in studies on technological M&As (Cloodt et al., 2006; Sears and Hoetker, 2014), there is a certain gap between the sample selected following this criteria and the conceptual definition in the studies. Further, since each study investigates various aspects of technological M&As, such as pre-M&A knowledge base, post-M&A knowledge integration, and post-M&A innovation performance, there is a superficial difference between the definition and motivation for technological M&As. Further research can provide more comprehensive measures and definitions of technological M&As to minimize this gap.

There are further limitations and future research opportunities related to each chapter. Chapter 3 makes several important contributions and introduces a new perspective on the qualitative aspect of knowledge to the research on knowledge overlap in technological M&As. At the same time, there are limitations resulting from the data and definitions employed in the study. In Chapter 3, measuring the knowledge overlap using the USPC system can be incomplete because the USPC system categorizes only the field of the application of the patent and not the nature of the innovation. The research on knowledge overlap has continuously used this measure because common knowledge is embedded in different patents that share the same patent class (Diestre and Rajagopalan, 2012; Frankort, 2016). However, a more practical measure would allow to gain more insights on knowledge overlap. Future research could address these shortcomings by using additional data, such as statistics on new product development or surveys. Second, the granted patent count, the

dependent variable used in this study, can be affected by other innovation activities of the firm. Following much of the foundational research on technological M&As, the study used granted patent count as a dependent variable in order to maintain consistency with prior studies and discover distinctive findings using newly examined independent variables. However, there could be alternative performance measures which better reflect the impact of technological M&As. Employing alternative measures such as post-M&A inventor productivity or post-M&A target firm knowledge utilization could solidify the new findings of this study. Moreover, considering a larger variety of factors in measuring knowledge quality will result in a more refined framework for investigating the effects of qualitative features of knowledge on technological M&As and will thus help managers in identifying suitable target firms.

Chapter 4 has a number of limitations, partly resulting from the employed data. The study uses patent data to track the post-M&A retention of the target firm inventors and to measure their organizational context. Although patent data has been extensively used to measure inventor characteristics in previous research, there might be inventors which have not been listed on the firm's patents, but nevertheless are important contributors to the firm's innovation outcomes. The study minimizes this gap using a dataset comprised of firms from the biopharmaceutical industry (Zhang and Baden-Fuller, 2010), which is characterized by one of the highest innovation to patent ratios (Arundel and Kabla, 1998). By using a more refined dataset which includes, e.g., the results of surveys or interviews, future research could try to identify key inventors which are not captured by patent analysis.

Second, the motivation of technological M&A can differentiate the post-M&A target firm knowledge preservation and synergy realization. Consequently, this study makes a number of efforts to control for the original motivation of M&As such as whether the deal is technological, or whether firms wants to achieve exploration or exploitation through the target firm's knowledge, etc. However, the data employed by this study still has limitations in controlling for the firm's strategic decision or detailed motivation for acquiring the target firm's knowledge. Further research might be able to solve this question and focus more on the firm's detailed motivation for technological M&As and the resulting performance, which could add another dimension to the research on technological M&As.

Third, this study assumed that synergies are being realized through the knowledge integration process between the acquirer and the target firm. However, there can be other ways to recombine both firms' knowledge and realize synergies. Future studies could capture various types of synergy realization mechanisms to extend the present research.

Similar to Chapter 4, Chapter 5 also has the limitation of only capturing inventors which are listed as co-inventors on granted patents. However, in reality, other manpower of the target firm might also play important roles in facilitating core technology change. Future studies are encouraged to find other ways to capture information on key employees using non-patent measures.

Besides, the path dependency of the acquirer firm in technological M&As could also significantly affect the post-M&A target firm knowledge preservation and synergy realization. Thus, investigating the impact of path dependency on other performance

measures of technological M&A might lead to further meaningful results. This dissertation suggests future research to address this issue by examining various effects of the acquirer firm's path dependency on firm's organizational learning through technological M&As.

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국 문 초 록

빠르게 변화하는 외부환경과 짧은 기술 주기로 특징지어지는 하이테크 산업에서 기업은 지속 가능한 경쟁우위를 누리기 위해 끊임없이 혁신을 추구해야 한다. 기술혁신형 입수합병(technological mergers and acquisitions)은 피인수기업의 혁신 역량 및 자원을 흡수하여 새로운 혁신을 창출하기 위한 전략으로, 외부지식획득에 목마른 하이테크 산업의 기업들에게 주목받고 있다. 이미 컴퓨터 소프트웨어 및 하드웨어, 기계, 통신장비 및 생명공학 등의 하이테크 산업에서는 기술혁신형 인수합병이 매우 높은 빈도로 일어나고 있다.

기업의 기술혁신형 인수합병을 통한 지식 이전은 인수기업과 피인수기업이 보유한 두 지식기반의 통합으로 인해 형성된다. 또한 기술혁신형 인수합병은 피인수기업의 인적 자원을 포함한 지식 요소를 모두 획득할 수 있다는 점에서 전략적 제휴 등의 외부지식획득 전략과 비교된다. 이러한 현상에서부터 출발한 선행연구에서는 기술혁신형 인수합병의 성패에 영향을 미치는 요인을 크게 인수기업과 피인수기업의 지식

특성의 정합성에 대한 관점과 피인수기업 연구인력의 흡수 및 통합에 대한 관점으로 나누어 설명하고 있다.

선행 연구의 흐름과 기술혁신형 인수합병의 현실적 이슈를 고려하여 본 논문은 “인수기업의 인수합병 파트너 선정”, “인수 후 피인수기업 연구인력의 혁신 환경”, 그리고 궁극적으로 “기술혁신형 인수합병을 통한 기업의 근본적 혁신 방향 변화” 의 세 가지 구성요소를 각각 다루고 있는 세 개의 소 연구로 이루어져 있다. 각 구성요소는 서로 유기적으로 작용하며 기술혁신형 인수합병 전략의 전체적인 성패에 영향을 미치지만, 구성요소에서 각각 고려해야 할 전략적 함의 또한 존재한다. 첫 번째, 기술혁신형 인수합병을 위한 피인수기업을 선정할 때에는 피인수기업 지식기반의 높은 질의 지식(high quality knowledge)이 가진 흡수의 어려움과 흡수된 지식의 파급력의 양면성을 고려해야 한다. 두 번째, 피인수기업의 좋은 성과를 보유한 단일 연구인력의 유지 뿐 만 아니라, 피인수기업 전체의 인적자원 네트워크와 그들 업무 영역의 인수 후 유지가 인수 후 성과에 중요한 역할을 한다. 세 번째, 기술혁신형 인수합병은 기업 지식기반의 변화를 위해 매우 효과적인 전략이고, 피인수기

업 연구 인력의 인수 후 유지가 변화를 위한 인수합병 전략의 핵심적 요소가 될 수 있다. 본 논문은, 기술혁신형 인수합병 프로세스의 각 요소들이 인수합병 이후 혁신 성과 및 기업 지식기반에 미치는 변화를 계량분석을 통해 검증함으로써 기술혁신형 인수합병을 위한 기업의 성공요소(success factor)를 규명하는 것을 목표로 한다.

첫 번째 연구에서는 기술혁신형 인수합병의 실행 이전상황에서, 인수기업의 피인수기업 선택에 있어 고려해야 할 지식기반의 특성에 대해 고찰한다. 구체적으로, 해당 연구에서는 흡수역량과 조직학습이론을 바탕으로 인수기업과 피인수기업 간 지식의 중복(knowledge overlap)이 기술혁신형 인수합병 후 혁신 성과에 미치는 영향을 분석하였다. 기술혁신형 인수합병을 연구함에 있어 인수기업과 피인수기업의 지식의 양적 특성에만 집중한 선행 연구를 확장하여, 본 연구에서는 피인수기업의 지식의 질(quality)과 지식의 양(quantity)이 인수 후 혁신 성과에 미치는 영향을 지식 중복의 영역(overlapped knowledge)와 중복되지 않는 새로운 지식의 영역(non-overlapped knowledge)으로 각각 나누어 고찰해볼 수 있는 프레임워크를 제시하였다. 분석 결과, 피인수기업

의 높은 질의 지식은 지식의 중복이 존재하는 영역에서는 충분한 흡수 역량으로 인해 인수 후 성과에 긍정적 영향을 미치지만, 중복되지 않는 새로운 지식의 영역에서는 상대적 흡수역량의 부재로 인한 지식 이전의 어려움으로 인해 오히려 부정적 영향을 미침을 알 수 있었다. 본 연구의 분석 결과를 통해 피인수기업의 높은 질의 지식을 획득하기 위해서는 중복된 지식의 영역이 반드시 필요하다는 함의를 얻을 수 있다.

두 번째 연구에서는 기술혁신형 인수합병의 실행 이후 상황에 집중하여, 이후 유지 또는 변화 되는 피인수기업 연구인력의 혁신 환경적 특성에 따른 인수합병 이후 성과를 다면적으로 분석하였다. 인수합병 이후 얼마나 많은 숫자의 피인수기업 연구인력이 유지(target firm inventor retention)되어 있는지에 집중했던 선행 연구를 확장하여, 본 연구에서는 피인수기업 연구인력에 대한 보다 다양한 각도의 "혁신 환경 유지"에 집중한다. 구체적으로 본 연구는 피인수기업 "연구인력 네트워크"와 피인수기업 "연구인력 연구 분야"라는 두 가지 조직적 혁신 환경의 인수 후 유지가 인수 후 혁신 프로세스에 미치는 영향을 고찰하였다. 분석 결과 인수기업의 혁신 환경을 유지할 경우 피인수기

업이 보유한 지식의 보존에는 긍정적 영향을 미치지만, 인수 후 인수기업의 지식과 결합하여 새로운 혁신이 창출되는 시너지 창출에는 부정적 영향을 미침을 발견할 수 있었다. 본 연구의 결과는 인수기업이 피인수기업의 조직적 특성을 변화시킴으로써 기술혁신형 인수합병을 통해 얻고자 하는 혁신의 종류와 목적을 더 효율적으로 실현시킬 수 있음을 시사한다.

마지막 연구에서는 기술혁신형 인수합병을 통한 기업의 근본적 혁신 방향의 변화에 초점을 맞추고 있다. 해당 연구에서는 기술혁신형 인수합병을 기업의 지식 기반 변화를 위한 전략으로 제시하고, 전략의 효율적 실행을 위한 성공 요소를 제시한다. 구체적으로, 본 연구에서는 기업 진화론에서 제시하는 조직의 변화를 저해하는 요소인 인수기업의 경로 의존성(path dependency)과 조직 학습 이론에서 제시하는 조직의 변화를 촉진하는 요소인 인수기업의 재조합 역량(combinative capabilities)이 각각 기술혁신형 인수합병을 통한 지식 포트폴리오 변화에 미치는 영향을 규명한다. 다음으로, 이를 조절할 수 있는 인수합병의 전략적 요소로써 피인수기업의 연구인력 유지(inventor retention)

를 제시한다. 분석 결과 본 연구에서는 인수기업의 경로의존성은 피인수기업 지식의 유입을 저해하고, NIH(Not Invented Here)신드롬을 불러일으킴으로써 인수합병 이후 지식 포트폴리오의 변화에 부정적 영향을 미친다. 반면, 인수기업의 높은 재조합 역량은 인수합병을 통한 지식의 유입 이후 조직 내부 곳곳에서 세부적 변화를 촉진시키고 그 변화를 확산하는 데에 긍정적 영향을 미치며 궁극적으로 인수합병 이후 지식 포트폴리오의 변화에 긍정적 영향을 미친다. 또한, 연구 결과 피인수기업 연구인력의 유지는 기업의 경로의존성을 약화시킴으로써 조직의 변화에 긍정적 영향을 미침을 밝힐 수 있었다. 본 연구에서는 기술혁신형 인수합병이 “learning by hiring” 의 효과 또한 가지고 옴을 밝혔고 기술혁신형 인수합병을 통해 지식포트폴리오를 변화하려는 기업에 통찰을 제시해줄 수 있다.

결론적으로 본 논문은 기술혁신형 인수합병의 프로세스를 구성하는 주요 요소를 다루고 있으며, 이들이 인수를 통한 혁신 성과 창출에 주요한 역할을 하고 있음을 밝히고 있다. 실제로 기술혁신형 인수합병의 빈도가 점점 늘어나고 있는 반면, 대부분의 인수합병이 성공적인 지식

의 통합 및 시너지 창출에 성공하지 못하고 있다. 본 논문을 통해 기업이 기술혁신형 인수합병의 메커니즘을 더 잘 이해하고 전략을 수행할 수 있다면 서로 다른 지식 기반의 결합을 통한 창의적 혁신이 발현될 가능성이 더 높아짐으로써 궁극적으로 변화하는 환경에 빠르게 대응하는 동적 역량을 갖출 수 있을 것이다.

주요어: 기술혁신형 인수합병, 지식 중복, 인수합병 후 연구인력 유지, 인수합병 후 통합, 기업 핵심 지식 기반 변화
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