INNOVATION STRATEGIES OF LATECOMER FIRMS FROM EMERGING ECONOMIES

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DECLARATION

I hereby declare that the thesis is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in the thesis.

This thesis has also not been submitted for any degree in any university previously.

Zhao Yang-Yang

29 May, 2013

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SUMMARY

This thesis consists of three essays on the innovation strategies of latecomer firms from emerging economies. The main aim is twofold. The first is to study how these firms use the innovation strategy of the latest generation (Rothwell, 1994) – open innovation – for technological catching-up. The second is to further explore the application of open innovation in a specific type of innovation that could make latecomers an actual economic powerhouse – disruptive innovation (Christensen, 1997). The conceptual model is illustrated in Figure 0-1; the details are elaborated in the following paragraphs and Table 0-1.

According to Rothwell (1994) and Chesbrough (2003), the era of open innovation has arrived: it is critical for firms to draw on external resources through interfirm cooperation to amplify the value of their own innovation assets and achieve greater innovation performance. However, current literature indicates that the actual increase of a latecomer's innovation performance through open innovation may be debatable. In order to ascertain the effectiveness of open innovation to a latecomer's innovation performance, this study examines how latecomers use the two extreme ends of the open innovation spectrum: licensing and mergers and acquisitions (M&A).

Open innovation research operates through four different mechanisms, ranging from simple to complex, as shown in Figure 0-2. The lowest end, licensing, is the

most simple and the most common open innovation mechanism for latecomers to acquire technologies. M&A is the most complex, necessitating a full range of resources.

The literature thus far has demonstrated mixed results regarding the impact of inward technology licensing (ITL) on a latecomer's innovation performance. Based on a sample of 154 Chinese high-tech firms, Essay One firstly investigates whether ITL could promote a latecomer's innovation performance. I then discuss the importance of technology newness in ITL strategy, arguing that the strategic choice of the right technology does provide latecomers with the opportunity to gain the benefits from learning by licensing.

In the past decade, latecomers in China have attempted to swiftly catch up with technology trends by increasing M&A. Using a sample of 100 listed Chinese high-tech firms, Essay Two examines the substitution effect in M&A among latecomers in China. I investigate whether these latecomer acquirers substituted their own competency with that of the target firms in order to achieve growth through innovation. It was found that when an acquiring firm integrates a target firm with a relatively greater knowledge base from a distant technology domain, increased innovation could result.

Essay Three focuses on the role of open innovation in the disruptive innovation setting. I argue that disruptive innovation does not necessarily lead to competition between latecomers and incumbents, and investigate situations where both parties have cooperated, with beneficial results. In-depth case studies of disruptive innovation cases in China’s high-tech industries were conducted to substantiate this point.

This thesis attempts to fill a number of gaps in the literature. The findings would advance the knowledge of the strategic management literature of both open innovation and disruptive innovation, and contribute to the academic views of latecomer firms from emerging economies.

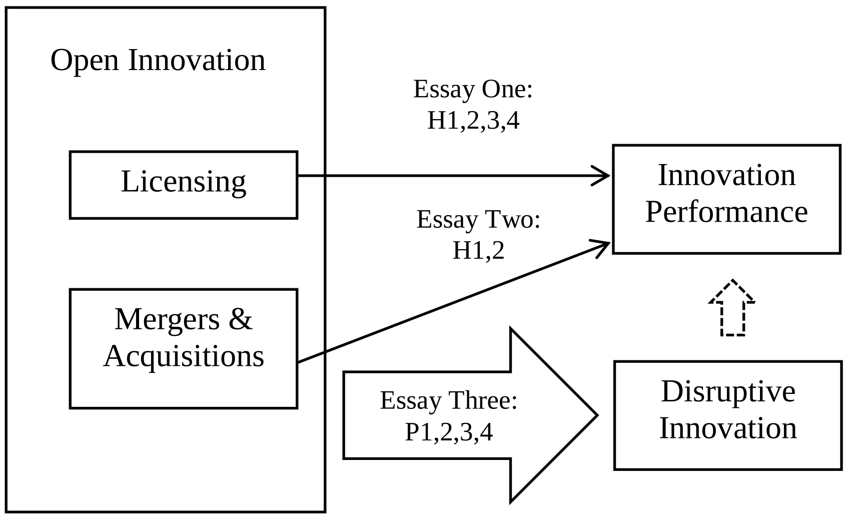

Figure 0-1. Conceptual model of the thesis

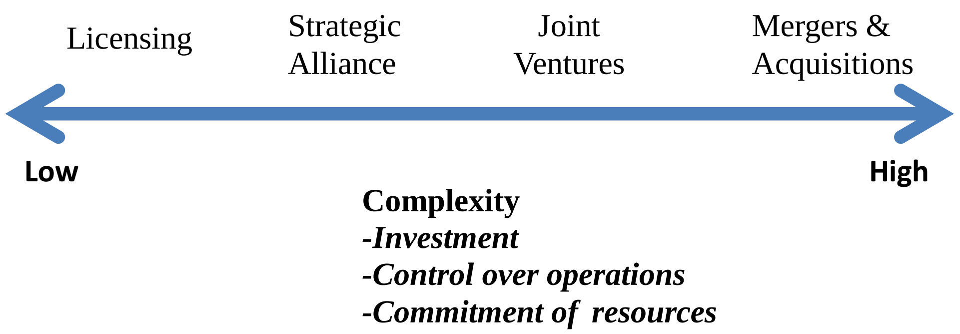

Figure 0-2. Complexity of open innovation mechanisms (Marks and Mirvis, 1998)

Table 0-1. Summary of the three essays

	Essay One Technology Licensing and Innovation Performance: Evidence from Chinese Latecomers in High-tech Industries	**Essay Two** Substitution Effect in Mergers and Acquisitions on Innovation Performance: Evidence from Chinese Latecomers in High-tech Industries	**Essay Three** Combining Open Innovation (OI) and Disruptive Innovation (DI): Evidence Based on Case Studies of Chinese Latecomers
Research Questions	The way by which licensing-in experience affects innovation performance focusing on the impacts of number of licenses, technology age and absorptive capacity.	Whether there is a substitution effect in M&A and when it takes place at the acquiring firm.	Whether latecomers could cooperate with incumbents (i.e., use OI) to commercialize DI and, if so, what are the conditions for a successful cooperation.
Hypothesis/ Propositions	H1. The number of licenses has a curvilinear (an inverted U) effect on the subsequent innovation performance of a licensee. H2. The age of licensed-in technology has a negative effect on the subsequent innovation performance of a licensee. H3. A licensee's existing technological capability positively moderates the relationship between the number of licenses and the subsequent innovation performance. H4. A licensee's existing technological capability negatively moderates the relationship between the age of licensed-in technology and the subsequent innovation performance.	H1. Technology distance has a negative effect on the subsequent innovation performance of an acquiring firm. H2. The relative knowledge base positively moderates the relationship between the technology distance and the subsequent innovation performance of an acquiring firm.	P1. In cases where latecomers have complementary assets and IP, DI can be achieved without OI. This may be because *de alio* latecomers are able to leverage complementary assets created in other markets. P2.In cases where latecomers lack complementary assets and IP in the target market, they may win by using OI practices in developing and introducing a DI into the market. However, this is only possible for latecomers who can subsequently develop their own complementary assets or IP. P3. In cases where latecomers have IP but not the required complementary assets, they can undertake OI strategies to gain access to external complementary assets to commercialize DI. P4. In cases where latecomers have the required complementary assets but without IP in the target market, they can source external technologies to achieve DI by engaging in OI.
Data	State Intellectual Property Office of China (SIPO) and firm websites	Taiwan Economic Journal, SIPO, firm annual reports and online reports	interviews, firm websites, academic papers, books and online reports

	Essay One	Essay Two	Essay Three
Unit of Analysis	Firm	Firm	Firm
Sample size	151	208	6
Methods	Negative binomial regression (firm level)	Negative binomial regression with random effects model (firm year panel)	Multiple case studies
Key Findings	• The newer the licensed-in technology is, the better the subsequent innovation performance is. • If technology age is not taken into account, the curvilinear (an inverted U) relationship between number of licenses and the subsequent innovation performance is obscured. • Firms with higher absorptive capacity have a more optimistic perception to adopt the larger number of licenses and newer technologies.	• The negative relationship between technology distance and the subsequent innovation performance is evidenced among Chinese latecomers, rather than an inverted U shape based on developed economies. • When an acquirer integrates a target firm with a relatively greater knowledge base from a distant technology domain, this better supports the substitution and promotes innovation.	• Whether or not to combine DI and OI would depend on the presence of complementary assets and intellectual property. • The three ways to benefit both latecomer disruptors and incumbents by engaging in OI are concluded as follows: (1) OI facilitates a latecomer's survival or the success of DI; (2) OI allows both latecomers and incumbents to be involved in DI; (3) OI, such as out-licensing and spin-offs, enables incumbents to disrupt themselves.
Contributio-ns and Implications	• Looking into the characteristics of licensed-in technologies to evaluate the effectiveness of Inward Technology Licensing (ITL) is a possible way to reconcile previous conflicting empirical evidences. • Being the first to verify the importance of technology age raises the needs to pay more attention to the strategic choice of licensed-in technologies. • How much a firm can gain from ITL depends very much on the firm itself.	• There is under-recognition of the substitution effect in the M&A literature. The strategic intention to undertake M&A (substitute or not) may be more important than the management challenges in maximizing synergies. • Highlighting the difference between firms from developed economies and latecomers from emerging economies in the resource integration with target firms may add on a more complete picture of the M&A literature.	• The identification of the important role of OI in establishing and sustaining DI development changes the sole competition scenario between latecomer disruptors and incumbents in the DI literature. • Firms should learn from the benefits of collaboration and promotes the co-development of DI by latecomers and incumbents. • Firms should learn to manage its innovation partners based on their own conditions.

CHAPTER1.

INTRODUCTION

1.1 Research Background and Motivation

In the last decade, emerging economies such as China, India, Russia and Brazil entered in the global competitive landscape, exhibiting unprecedented growth. The accelerating shift of global economic power has unleashed a vast number of opportunities to firms located in emerging economies. Firms from emerging economies generally enter late into the high-tech industries by necessity, not by their own choices, and thus are termed latecomers (Mathews, 2002). Indeed, some latecomers have managed to catch up with industry leaders from developed economies. However, though they may enjoy some initial advantages, latecomers face myriad challenges of technological catching-up, including poor technology resources, inferior pre-emption of assets, costly buyer switching costs and less National Innovation System (NIS) support (Lieberman and Montgomery, 1988; Cho et al., 1998; Mathews, 2002). To meet these challenges, latecomers are more likely to cooperate with others and become innovative in order to survive.

Innovation is critical to a latecomer’s survival. Any innovation strategy adopted by a latecomer would involve a value creation process that acknowledges the role of external resources in developing competitive advantages and improving the effectiveness of innovation. External resources, such as knowledge, assets and skills lie outside the boundaries of latecomers, and are usually owned by incumbents. Latecomers often access these external resources by cooperation with other firms. This kind of interfirm cooperation is conceptualized as a new paradigm, namely open innovation (Chesbrough, 2003; Chesbrough et al., 2006), which allows a firm to draw on external resources to amplify the value of their own assets. The focal firm (latecomer in this thesis) usually has weaker resource accumulation than incumbents (Mathews, 2002). The asymmetric nature of this relationship between latecomers and incumbents has not gained much attention in the extant open innovation literature (Chesbrough, 2003; Chesbrough et al., 2006). However, through the channel of open innovation, latecomers may recognize, assimilate and apply imported resources to create their own innovations. Once created, the new innovation is added to the resource pool in the open environment for other firms to use. For instance, incumbents may adopt a new innovation created by latecomers to renew their internal competency. Thus, dynamic cooperative interaction between latecomers and incumbents consists of bilateral resource flows in the value creation process, which is demonstrated in Figure 1-1.

When latecomers utilize external resources, the differences in the innovation performance that they create are strongly related to strategic management based on their internal capabilities. However, while this relationship suggests the coexistence of potential benefits and additional costs when latecomers adopt open innovation, open innovation itself does not automatically lead to a convergence of internal and external resources. Thus, an important task in innovation management is to optimally internalize the external resources, thereby promoting innovation.

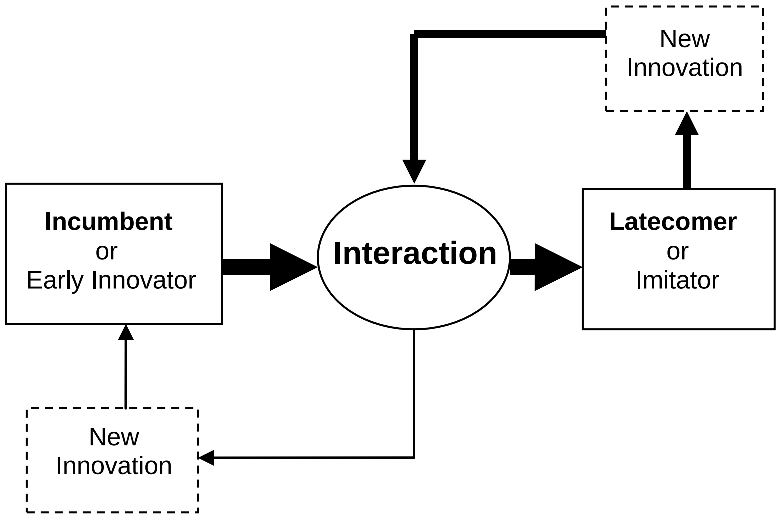

Figure 1-1. Value creation in an open source environment

The internalization of the external resources, especially technology resources, is associated with technological process in a broad sense. The technological process necessitates both indigenous R&D and the effective utilization of external technologies. These external technologies generated by other firms are also known as spillover technologies (Griliches, 1979). There are many factors that affect the overall technological process, including self-generation factors, dependent factors and the indirect factors, as shown in Figure 1-2 (Watanabe and Asgari, 2004). The self-generation factors represent a firm's own efforts in technology development, such as the R&D investment. The dependent factors include assimilated (absorbed) spillover technologies, learning effects and economies of scale. In addition, the indirect factors, such as labor, capital, managerial improvement, institutional revolution and policy, also affect the technological process. In this thesis, I focus on the innovation that contributes to technological development by latecomers, which can be attributed to collaborative work of learning, spillover technologies together with existing technology stock generated by internal R&D.

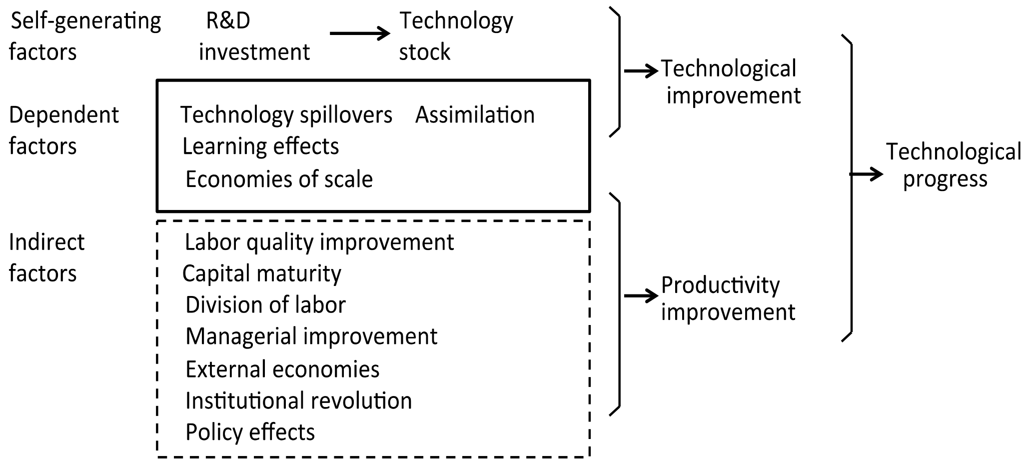

Figure 1-2. Composition of total factor productivity
(Source: Watanabe and Asgari, 2004)

To effectively utilize spillover technologies, latecomers should first be able to identify which external technology should be learnt, should not be learnt, or cannot be learnt. Then latecomers should import the technologies that should be learnt into the existing technology stock and internalize them. The success of this internalization is determined by the absorptive capacity of latecomers, and thus absorptive capacity is critical for the effective utilization of spillover technologies.

Absorptive capacity can be attributed to the accumulation of past learning experience. The learning experience results from incorporating the spillover technologies into the production system. Therefore, learning plays an important role of the effective utilization of spillover technologies. This process of internalizing spillover technologies is illustrated in Figure 1-3.

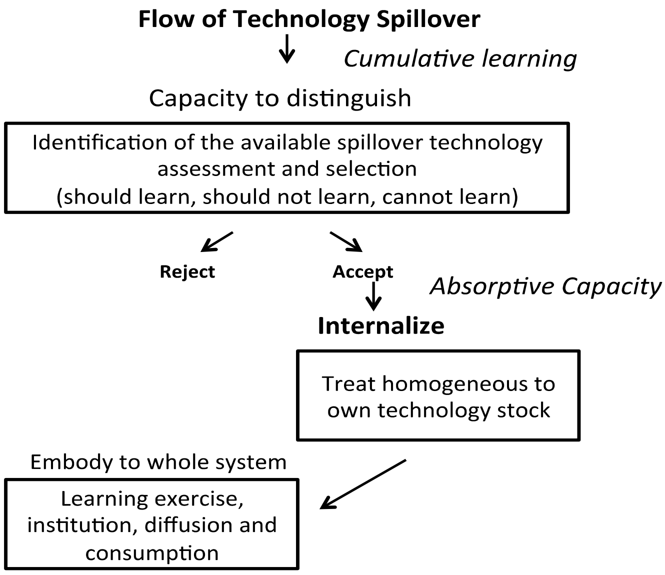

Figure1-3. The process of internalizing spillover technologies
(Source: Watanabe et al., 2001)

Although some latecomers can successfully internalize external resources, especially spillover technologies, into the innovation process through open innovation, others are not successful. In order to reveal the strategies behind the success stories, this thesis aims to examine how latecomers capture value from open innovation in the emerging economy context.

In the following sections, I will review the advantages and disadvantages of being a latecomer, as well as the innovation strategies that latecomers use to meet these challenges. A brief overview of previous and on-going research on the innovation strategies of latecomers will also be presented.

1.1.1 Disadvantages and Advantages of Latecomer Firms

The literature on technological innovation management has shown great interest in how latecomers are able to catch up with industry leaders. Ever since the entry order effect was first mentioned and examined by Bain (1956), scholars have endeavoured to identify latecomer disadvantages and advantages from different perspectives like the resourced-based view, institutional theory and transaction cost economics (Hobday, 1995; Cho et al., 1998; Hoskisson et al., 2000; Xie and Wu, 2003; Mathews, 2006; Tzeng, 2008).

Latecomer disadvantages have been mostly examined in four aspects: initial technology resources being poor, inferior pre-emption of assets, costly buyer switching costs and less NIS support (Lieberman and Montgomery, 1988; Cho et al., 1998; Mathews, 2002). As late entrants to an industry, latecomers face many roadblocks (Mathews, 2002). Unlike latecomers, early movers have developed technology leadership derived from long-term cumulative experience and learning. Incumbents may establish technology barriers for latecomers by applying for IP protection and leveraging industry standard settings (Katz and Shapiro, 1994).

Also, early movers may pre-emptively obtain the limited assets, such as locations, product characteristics, equipment investments and distribution channels (Lieberman and Montgomery, 1988). Latecomers' potential consumers may find the switching cost to be prohibitive, and will thus remain loyal to existing pioneer products. The switching cost, including investment to be a qualified innovation supplier, supplier-specific learning by the buyer and contractual switching cost, are costly for latecomers due to customers' loyalty to existing pioneer products (Lieberman and Montgomery, 1988; Cho et al., 1998). Latecomers from emerging economies are usually isolated from the firms that own most of the high-tech resources, namely incumbents from developed economies. Moreover, the underdeveloped NIS infrastructure in emerging economies provides insufficient incentives and protection to domestic firms.

However, latecomer advantages do exist and they shape these firms' catching-up strategies. One such advantage is the lower cost and risk of innovation (Mathews, 2002) than for early movers. For example, industry readiness is usually high in terms of educated consumers and trained workers when latecomers enter the market. More importantly, latecomers are able to be free-riders by exploiting the technology resources of early movers in three main ways. First, knowledge spillover and learning-based productivity improvements make the free-rider effect available to latecomers (Lieberman and Montgomery, 1988; Cho et al., 1998). Second, cost reduction can be achieved in the labour market by pre-employee screenings because early movers have already performed the verification and education of the past employees (Guasch and Weiss, 1980). Third, latecomers can take advantage of pre-empted assets by partnering with others. This partly stems from the complementary ownership of assets co-specialized with the underlying innovation. In addition, latecomers can learn from early movers' mistakes, both technological and otherwise. The market tests by early movers may spare latecomers from the risk of the unknown nature of customer response to an innovation.

The four basic characteristics of latecomer firms have been outlined by Mathews (2002) as follows: (1) Industry entry: late entrant to an industry, not by choice but by historical necessity; (2) Resources: initially resource poor, e.g., lacking technology and market access; (3) Strategic intent: focused on catching-up as its primary goal (Mathews and Cho, 1999); (4) Competitive position: some initial competitive advantages, such as low cost, which can be achieved by learning from proven technologies/prior experiences initiated by predecessors. Besides, latecomers from emerging economies have another characteristic of being close to emerging markets. In spite of their resource constraints, they may react to the latent needs in emerging markets actively due to less organizational inertia. To further achieve their strategic goal of catching-up, latecomers must be able to overcome their disadvantages and leverage their advantages. The latecomer challenges can be resolved by targeted strategies, which will be elaborated in the next section.

1.1.2 Innovation Strategies of Latecomer Firms

Rothwell's (1994) five generations of innovation are recognized worldwide as a milestone in the development of an understanding of innovation strategies. In the early 1950s, the rise of multinational firms in the west and Japan swelled the economy through high-tech development. Thus, **the first generation** of innovation was mainly driven by technology breakthroughs, and R&D was regarded as a firm's 'ivory tower'. From the 1960s to the 1970s, the battle for market shares shifted the innovation focus to **the second generation**, namely the 'market pull' generation. Subsequently, in the mid-1970s, the emergence of inflation and stagflation motivated firms to cut down on their operational costs. Hence, R&D and marketing became more tightly aligned, and this coupling is now referred to as **the third generation** of innovation. As the economy recovered in the early 1980s, the revolution of **the fourth generation** of innovation started from a 'time-based struggle' where the strategic focus was on integrated business processes and linkages between suppliers and leading customers were strengthened. From the 1990s onward, resource constraints became the central debate. As a critical part of their innovation management, firms began to look outside their boundaries for collaborative partnerships. This is called **the fifth generation**, also known as the era of open innovation, and is notable for its emphasis on system integration and networking. Chesbrough (2003) claimed that open innovation had become the new paradigm of external resource utilization. By doing so, a firm can move back and forth more flexibly via different mechanisms, as illustrated in Figure 1-4.

In contrast to the other four generations, the fifth generation is not clearly defined at an operational level. Although research has proven that open innovation is beneficial to incumbents, less attention has been paid to latecomers. Thus, there is much to investigate with regard to how open innovation may impact latecomers' growth.

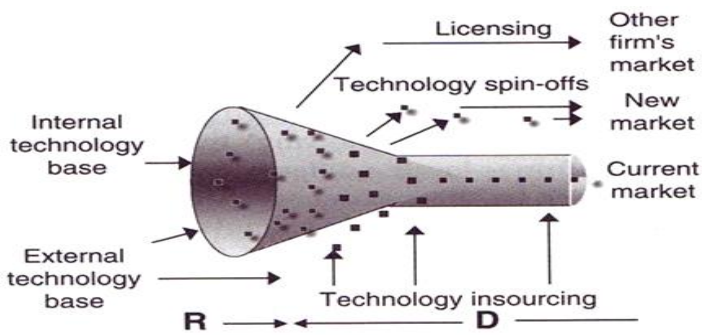

Figure 1-4. An open innovation paradigm (Chesbrough, 2003)

During the last decade, due to the decentralization of manufacturing and the Internet, this openness and access to information has sped up resource transfers around the globe. Hence, many firms have experienced change at a rate well beyond what could have been expected. Information symmetry has enhanced the freedom of technology transfer and created a new stream of innovators, i.e., latecomers. Unlike fast followers, these firms do not use open innovation passively; rather, they use external resources in order to innovate.

Furthermore, the type of innovation that a latecomer performs is selective, depending on its specific disadvantages and advantages. According to Tidd et al.

(2001) and Gatignon et al. (2002), innovations can be classified as incremental innovation (sustaining innovation and continuous innovation), radical innovation (sustaining innovation and discontinuous innovation) or disruptive innovation (discontinuous innovation). Next, I will examine all three types of innovation and explain why disruptive innovation has proven to be the most beneficial to latecomers.

Incremental Innovation: Through incremental innovation, a firm makes a sustainable improvement to an existing product and develops a critical competitive strategy in an established industry. However, incremental innovation does not appear to be an ideal candidate for those latecomers for two reasons: first, latecomers might not have the existing technology to incrementally improve; second, it is almost impossible for latecomers to succeed when competing directly with incumbents in an incremental innovation market.

Radical Innovation: Through radical innovation, a firm dramatically changes a product to create a high-end market with greater profits. Radical innovation is not suitable for latecomers, as they would not have sufficient time, financial resources and technological capabilities to create superior technologies.

Disruptive Innovation: Disruptive innovation enables firms to create a new ride, or to attack the mainstream market from the low-end, if their products are good enough. Even if latecomers have limited resources, they can successfully use disruptive innovation. This is particularly true for such firms in emerging economies, where many hidden needs may still be unmet at the bottom of the pyramid markets (Prahalad, 2004, 2012). To focus on the needed business model, latecomers likely require technological support from external partners. However, unlike latecomers, incumbents are usually not attracted to disruptive innovation in low-end or new niche markets (Christensen, 1997). Thus, incumbents feel less threatened and are willing to cooperate with latecomers. This cooperation allows incumbents to act as significant economic players in new or low-end markets.

The aforementioned five generations, each with its own specific innovation strategy, offer simple representations of a complex business world. The different innovation strategies belonging to the distinct generations can occur concurrently to bring about better and faster innovations. By focusing on latecomers' strategic dimensions, this thesis investigates the significance of the innovation strategy of the latest generation, namely open innovation, and the disruptive innovation strategy that offers the most favourable innovation trajectory for technological catching-up. Specifically, this thesis will examine the general impact of open innovation on latecomers' growth, as well as how this strategy affects the development of disruptive innovation. Thus, the next two subsections will review the literature on the impact of open innovation on latecomers' growth and the combined utilization of open innovation and disruptive innovation.

1.1.3 Open Innovation as a Critical Strategy for Latecomer Firms

The foundation of how well latecomers can create innovation is how well they formulate strategies through targeted catching-up efforts. Of these various strategies, technology acquisition through open innovation is especially useful for latecomers with limited resources to break technology barriers and renew their internal competency. As previously discussed, entering the industry late may give latecomers the unexpected advantage of being able to access already-developed advanced technologies. Latecomers can then use the proven technologies to create innovation at a lower cost, and do it more quickly than the early movers who initially developed the technologies. To secure such an advantage, latecomers must complete the following two steps. First, they should identify which technologies are useful and then secure access to them through the channel of open innovation. For example, inward technology licensing (ITL) is the most basic channel of technology transfer and has been widely adopted by latecomers. Second, the latecomers should evolve from learners to innovators, relying on their absorptive capacity. Absorptive capacity is a firm’s ability to recognize the value of technology, assimilate it, and then apply it for an innovation (Cohen and Levinthal, 1989). Some latecomers are indeed able to absorb imported technologies and quickly develop innovations in order to seize booming market opportunities. Others without enough absorptive capacity can use the most complex channel of open innovation, namely mergers and acquisitions (M&A). Although it is complex in terms of investment, operations and commitment of resources (Marks and Mirvis, 1998), M&A is the fastest track to acquire a full range of resources and allows latecomers to import technologies as well as other relevant innovation assets, such as absorptive capacity, complementary assets and R&D equipment. Thus, the research covering ITL and M&A is able to explain the effectiveness of open innovation on a latecomer's innovation performance.

The development of ITL has a long history. Since the mid-1980s, the establishment of intellectual property (IP) protection has increased firms' willingness to perform out-licensing and technology utilization beyond their boundaries (Gallini, 2002; Dahlander and Gannb, 2010). Latecomers may find innovative opportunities with other firms who own the IP. The gradual maturity of the IP system promotes latecomers as licensees to participate in the development of other components or associated products (Chesbrough et al., 2006). In addition to exploring the environmental readiness, researchers (Link et al., 1983; Atuahene-Gima, 1993) have investigated two important conditions used by latecomers to decide whether to license or not: (1) the firm's characteristics and (2) the management's perceptions. The transition from opportunity identification to licensing decision is one of the two stages needed for successful ITL (Atuahene-Gima, 1993). The other stage is the post-adoption stage that encompasses technology adoption to innovation performance (Atuahene-Gima, 1993). However, the determinants for the post-adoption stage are limited, primarily due to licensing experience, and the impact of licensing experience on actual innovation performance is still inconclusive (Ahuja and Katila, 2001; Álvarez et al., 2002; Johnson, 2002; Tsai and Wang, 2009). The existing literature has yet to view the determinants regarding the nature of technology as playing a significant role in ITL strategy

(Arora and Gambardella, 2010). Thus, I believe it would be promising to examine the determinants related to the nature of the technology in ITL adoption by latecomers. This research will shed new light on how the ITL strategy impacts innovation.

Though complex, M&A has advantages over the other open innovation mechanisms, because it allows latecomers to maximize the benefits of resources transfer from a target and also reduces the number of competitors in the field. Indeed, an increasing number of latecomers have used M&A as a way to increase innovation. However, earlier empirical studies concluded that M&A had a negative or an insignificant impact on a recipient’s innovation performance (Henderson and Cockburn, 1996; Ornaghi, 2006; Danzon et al., 2007). Hence, researchers find it difficult to explain why and how latecomers utilize M&A based on the traditional wisdom to maximize synergies in developed economies (Seth, 1990; Cording et al., 2002).

During M&A, the relatively low absorptive capacity associated with inferior knowledge accumulation places a lot of pressure on latecomers to internalize the acquired resources; this does not usually occur for incumbents in developed economies. Without the certain capability paired with optimized learning efforts, latecomers find it difficult to capture the value embedded in the acquired sources. As the nature of learning is neither costless nor automatic, latecomers need purposeful learning to astutely proceed with the strategic choice in the analysis of potential targets (Bell, 1984; Teece, 2000). Thus, it is particularly worthwhile to conduct a more in-depth study along the line of latecomers' strategic intentions and target selections.

The aforementioned scattered results from both ITL and M&A research still could not satisfactorily explain how open innovation affects a latecomer's innovation performance. Therefore, Essay One and Essay Two will attempt to resolve the above issues regarding the ITL and M&A practices of latecomers from emerging economies.

1.1.4 Combined Utilization of Open Innovation and Disruptive Innovation

After investigating the impact of open innovation on the innovation performance of latecomers, this thesis further explores the application of open innovation in a specific type of innovation – disruptive innovation. Disruptive innovation indicates the favourable innovation trajectory for latecomers making use of technology to achieve innovation. Without the external resources available through the channel of open innovation, latecomers may not be able to solve all of the challenges in developing disruptive innovation. However, the utilization of the two combined innovation strategies may promote innovation.

As one of the latecomer strategies, disruptive innovation has received increasing attention in the recent technological innovation management literature. Being technologically isolated from the world centres of innovation, latecomers, especially those from emerging economies, are more likely to develop simpler, cheaper products that are of a good-enough standard to enter a market that is less attractive to incumbents. Purposeful value creation for the low-end or a new market is known as a disruptive innovation path that enables latecomers to disrupt the incumbents. The success of latecomers' disruptive innovation depends on product competition and is triggered by the performance oversupply of existing products by incumbents in the mainstream market (Christensen, 1997). Thus far, the existing literature has only examined disruptive innovation from an independent firm's view – either the incumbent or the latecomer (Christensen and Raynor, 2003; Utterback and Acee, 2005; Govindarajan and Kopalle, 2006) without interaction between the two. However, the popularity of the open innovation strategy (Chesbrough et al., 2006) is due to its emphasis on the cooperation between firms. The existing literature seems to ignore the potential cooperation in developing disruptive innovation (Christensen and Raynor, 2003; Spedale, 2003; Utterback and Acee, 2005; Govindarajan and Kopalle, 2006; Hüsig and Hipp, 2009). Therefore, further exploration of the combined utilization of open innovation and disruptive innovation could have far-reaching implications. Essay Three will investigate this opportunity.

1.2 Objectives and Significance of the Thesis

The research gaps that this thesis addresses are summarized below:

A. The benefits of open innovation have been widely studied for firms in developed economies, but the existing literature has not adequately investigated the impact of open innovation on latecomer cases in emerging economies. Specifically, the degree of improvements to a latecomer's innovation performance through open innovation is still debatable. It is possible that latecomers with distinct characteristics have developed new strategies when conducting open innovation that account for their tremendous growth over the last decade. Furthermore, the important determinants regarding the nature of the technology affecting the effectiveness of open innovation have not received much attention. Few studies have examined these determinants in latecomers' strategic choice of a target (either technology or partner) through open innovation, or their impacts on the subsequent innovation performance.

B. With regard to the type of innovation favoured by latecomers, the application of open innovation in commercializing disruptive innovation needs to be investigated. Although disruptive innovation has been widely discussed as one of the most important catching-up strategies used by latecomers to economically surpass incumbents, cooperative scenarios between latecomers and incumbents via open innovation have yet to be studied. In other words, it is not known whether and how open innovation can be combined with disruptive innovation.

In line with the above research gaps, the research objectives of this thesis are summarized below:

To address Gap A, the two specific objectives are to:

- explore technology newness[1] as a determinant of a latecomer licensee's innovation performance and examine the impact of the ITL strategy.
- explore technology distance[2] as a determinant of a latecomer acquirer's innovation performance and examine the measure of successful M&A for latecomers in emerging economies.

Of the open innovation mechanisms, it is understood that ITL and M&A give an effective and efficient view for studying the effectiveness of technical learning from external resources. From simple technology transfer by ITL to a full range of resource acquisitions by M&A, this thesis attempts to discover latecomer strategies to internalize imported resources for indigenous R&D development. Other open innovation mechanisms, such as strategic alliance and joint venture, are not central to the investigation of open innovation in latecomer cases and are thus not discussed in this thesis.

To address Gap B, the specific objective is to:

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[1] Technology newness, being an important determinant regarding the nature of technologies – technology age, is an important representative of technology value in the extant licensing literature. The relevant details are given in Chapter Two.

[2] Technology distance, being an important determinant regarding the nature of technologies – technology domain, is an important proxy of the strategic intention of acquiring firm in the extant M&A literature. The relevant details are given in Chapter Three.

- investigate the role of open innovation in disruptive innovation processes and the conditions under which latecomers can combine open innovation and disruptive innovation for their technological catching-up.

The application of open innovation in the development of disruptive innovation can be considered an ideal strategic combination for latecomers' catching-up. Since the mid-1990s, there have been some remarkably successful disruptive innovation cases by latecomers. In contrast, the other two types of sustaining innovation, i.e., incremental and radical innovation, tend not to be favoured by technologically laggard firms, and are thus beyond the scope of this thesis.

It is clear from the reviews of China's high-tech industries[3] over the last decade that some latecomers have achieved remarkable catching-up with market leaders; others, however, have faced serious difficulties. This successful catching-up has undoubtedly contributed to China becoming the world's fastest growing economy, and thus the strategic reasons behind it are worth investigating. This thesis attempts to explain why some latecomers are able to use open innovation successfully while others are not. In this thesis, the latecomers are Chinese firms

[3] The widely adopted definition of high-tech industries was established by the Organization for Economic Co-operation and Development (OECD) in 1986. The high-tech industries were identified based upon their high R&D intensities (R&D spending as a percentage of production) relative to other manufacturing industries. Based on the OECD classification (Hatzichronoglou, 1997), the high-tech industries are cataloged by Chinese government into five sectors, namely pharmaceuticals, aircraft and spacecraft, electronic and telecommunications, computers and office machinery and medical equipments and meters. Among the five sectors, electronic and telecommunications has been the most developed sector and has performed the most innovation related activities in China. According to China Statistics Yearbook (2011), the sector of electronic and telecommunications had the best output value, the highest expenditure of new product development and the most patenting activities in the past decade. Thus, this thesis mainly studies the industries in this high-tech sector.

operating in high-tech industries that have caught up with existing incumbents mostly from developed economies, in several ways. The first two essays investigate the traditional ways of open innovation through ITL and M&A. The third essay explores the renewed type of innovation that successfully uses disruptive technologies; this is a small set of latecomers.

Although the findings in these essays are based on cases from China, the results may be generalized to latecomers from other emerging economies, particularly those with sizeable domestic markets, such as India, Brazil and Russia. This is because the main characteristics of the focal firms in this research are true of all latecomers in other countries. The results of this thesis would provide an in-depth view of utilization of open innovation by latecomers. It will add on to the strategic management of technological innovation literature. This thesis would offer insights regarding latecomers' strategic choice by considering the significant determinants of technology newness and technology distance in open innovation. The findings regarding these two significant determinants may uncover hidden management wisdoms about open innovation for latecomers. Further investigation of the application of open innovation in the context of the type of innovation favoured by latecomers, i.e., disruptive innovation, would provide more guidance for latecomers to effectively use open innovation strategies and catch up more surely and quickly.

1.3 Organization of the Thesis

This thesis is structured as follows. Chapter 2 (Essay One) elaborates the ITL strategy – the simplest open innovation mechanism – for latecomers. Chapter 3 (Essay Two) discusses M&A strategy – the most complex open innovation mechanism – for latecomers. After confirming the impact of open innovation on latecomers' growth in Chapters 2 and 3, Chapter 4 (Essay Three) investigates the application of open innovation in the disruptive innovation setting. Chapters 2 to 4 present the three essays, each with an introduction, theory and hypotheses, data and methods, results, discussion and summary. Chapter 5 concludes by discussing this thesis's contributions and implications, and making recommendations for future research.

CHAPTER 2.

TECHNOLOGY LICENSING AND INNOVATION PERFORMANCE

2.1 Introduction

The phenomenal rise in the number of latecomers from emerging economies who have become fast followers and caught up with industry leaders has drawn the attention of researchers. Inward technology licensing (ITL) has been emphasized as one of the most important strategies that latecomers use to build up their competitive advantage, especially in technology-intensive industries (Teece, 1986; Fosfuri, 2000, 2006; Johnson, 2002; Laursen et al., 2010). Successful ITL is associated with the process of identifying a licensing opportunity, making a licensing decision and adopting licensed-in technologies. Earlier studies have investigated the determinants of opportunity identification and licensing decisions, and have identified three categories, namely firm characteristics, management perceptions and external environment (Atuahene-Gima, 1993). However, the adoption of licensed-in technologies has received less attention. Thus, this essay aims to identify the important factors in adopting licensed-in technologies and reveal their relationships with innovation performance.

The stream of research exploring the relationship between firms' ITL strategy and their subsequent innovation performance has shown mixed results. Álvarez et al.'s (2002) findings underscored the significance of ITL strategy for accelerating a latecomer's technological catching-up. Ahuja and Katila (2001) examined the size of technology acquisitions and determined that size had a positive impact on a firm's innovation performance. On the contrary, Johnson's (2002) study showed that inward licensing experience had a negative impact on innovation performance. Although Johnson's (2002) work showed a firm's internal R&D to be an important factor influencing the association between licensing inputs and innovation performance, recent findings by Tsai and Wang (2009) have raised doubts about this association and showed that ITL expenditure did not contribute significantly to innovation performance in Taiwan, even under the moderating effect of internal R&D. Thus, the precise means by which inward licensing experience affects innovation performance is still inconclusive. Each of these studies furthered our understanding of the micro-foundation of licensing, but did not shed much light on the determinants of purposeful ITL strategy.

This essay attempts to resolve the above mixed results by investigating the learning by licensing effect among Chinese latecomers. Given Chinese latecomers' remarkable technological catching-up over the last decade, their learning is likely to have relied on technology transferred through licensing. Based on data from the World Bank (2007), Figure 2-1 shows how Chinese latecomers' licensing expenses increased dramatically from 1998 to 2005. Among my sample of four high-tech industries in China, pure technology transfer grew steadily from 1998 to 2003 and has dramatically increased since mid-2004, as shown by the number of licensing agreements in Figure 2-2. During the period 1995-2008, it was reported that China contributed 22.9% of the total number of patents filed with the World Intellectual Property Organization (WIPO), ranking third in the world for patenting after Japan and USA (WIPO, 2011). Some Chinese latecomers such as Huawei, ZTE and Haier, even ranked among top patent applicants in their particular fields (WIPO, 2011). Thus, investigating the licensing activities of Chinese latecomers will certainly help uncover the ITL strategies that promote innovation.

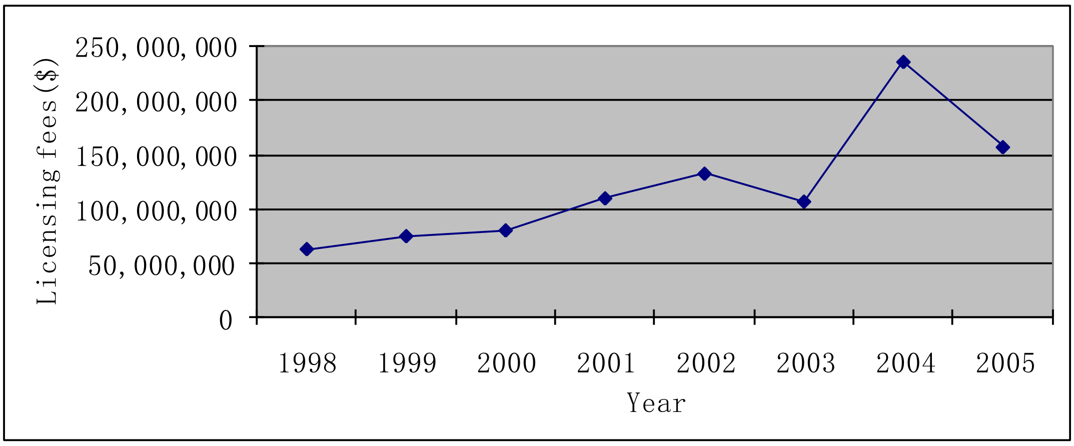

Figure 2-1. Licensing expenses in China (Work Bank, 2007)

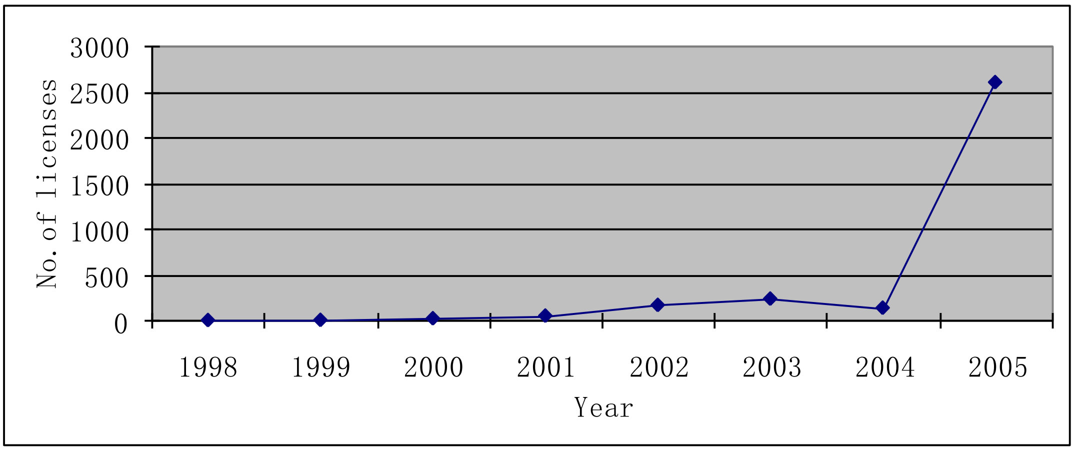

Figure 2-2. Number of licenses in China's high-tech industries
(Source: State Intellectual Property Office of China)

Considering the nature of latecomers' inferior resources, the two critical factors that can promote innovation performance are (1) the number of licenses and (2) the age of licensed-in technology; these represent the ITL strategic choice embedded in the overall strategy of the firm. The number of licenses is a direct measure of licensing activities and represents the extent of ITL, while the age of licensed-in technology is an important measure of its value. Although Rockett (1990a, b) extended the licensing literature to cover the role of technology age in outward licensing, there is a lack of research investigating this important factor in the post-adoption stage of ITL. By focusing on the above two factors, the main goal of this essay is to investigate the strategic choice of ITL on the growth of innovation in the post-adoption stage. This essay borrows from organizational learning theory[4] and examines the respective impacts of the number of licenses and the age of licensed-in technology on the subsequent innovation performance of a licensee, as well as the moderating effect of absorptive capacity on the above two relationships.

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[4] The concept of organizational learning theory is initiated by Cangelosi and Dill (1965) and origins from behavior and psychology theory (Cyert and March, 1963; Weick, 1979). The organizational learning theory studies models and theories about the way an organization learns and adapts. There are two levels of analysis of organizational learning theory, namely individual level and organizational level. In this study, I mainly focus on the organizational level. An organization is seen as an adaptive system that has the ability to sense the changes from its environment (both internal and external) and adapt accordingly in the organizational learning theory. The effectiveness of organizational learning is found strongly associated with absorptive capacity (Cohen and Levinthal, 1990), which is the part I mainly adopted from organizational learning theory. The absorptive capacity of an organization is treated as a trade-off between the efficiency of internal communication and the ability to explore and exploit information from other organizations or the environment (Cohen and Levinthal, 1990).

2.2 Theory and Hypothesis

A wide range of studies have identified licensing as one of the most important mechanisms of technology transfer (Davidson and McFetridge, 1985; Fosfuri, 2000; Chesbrough, 2003; Arora and Gambardella, 2010). This strategy adds additional inputs to a licensee's technology landscape and this inward flow of technology has the potential to help the licensee build competitive advantage by integrating internal R&D and external technologies (Grant, 1996). Leone et al. (2009) found that firms who undertake ITL have better innovation performances compared to non-licensing firms. Furthermore, Álvarez et al. (2002) claimed that technology acquisition by ITL is a potentially significant means for latecomers to accelerate their technological catching-up.

There are both environmental drives and internal motivations for latecomers to adopt ITL. Rapid technology change, aggressive competition in technological capability, and strengthened intellectual property protection create catching-up barriers for latecomers who want to access and adapt technological advances (Grant, 1996; Lee, 1996; Leone et al., 2009). However, licensing from industry leaders allows latecomers to tap into external resources. In addition, ITL helps latecomers leverage their initial competitive advantage to enjoy the free-rider effect (Lee and Lim, 2001; Mathews, 2002), which further promotes their internal motivations for ITL. The internal motivations for latecomers' ITL can be categorized as passive or active. The conventional research (Lubatkin, 1983;

Roberts and Berry, 1985; Atuahene-Gima, 1993; Chatterji, 1996; Kollmer and Dowlin, 2004) treated ITL as new product development or a market entry strategy to reduce the financial risk of R&D and time-to-market. Due to their initially weak technological capability and the entry order disadvantage (Mathews, 2002), ITL by latecomers has been traditionally viewed as a passive reaction to compensate for technological shortcomings or a means to break the industry's entry barrier (Hill, 1997; Lowe and Taylor, 1998). However, recent research has viewed ITL as a means to open up learning opportunities (Cohen and Levinthal, 1989; Pitkethly, 2001) and spur inventive activities (Leone et al., 2009). ITL has become a popular strategy for speeding up a licensee's endogenous technology change and technological capability development over time (Johnson, 2002; Tsai and Wang, 2009). By relying on a licensing channel to possess proven technology, latecomers can focus more on their own potentially superior or competing technology (Hill, 1997). Hence, ITL is widely accepted as a potential means for latecomers to build competitive advantages by adopting licensed-in technologies (Grant, 1996).

According to organizational learning theory, the adoption of licensed-in technology can be viewed as a learning process (Chesbrough, 2003; Laursen et al., 2010). The technologies available in the market are potential learning opportunities for licensees (Pitkethly, 2001; Johnson, 2002). Learning by licensing is associated with a firm's ability to identify and acquire licensed-in technology, and then process it into innovation. Moreover, it demands that licensees' R&D efforts act not only as a direct input to innovation performance, but also as a means of absorptive capacity (Cohen and Levinthal, 1989). Licensed-in technologies enlarge the licensee's pool of existing knowledge stock (Vanhaverbeke et al., 2004), and thus indirectly favours the absorptive capacity of the licensee (Katrak, 1997). If they possess a certain absorptive capacity, licensees may sense the potential of licensed-in technology to generate innovation by recombining the knowledge (Henderson and Cockburn, 1994). This knowledge recombination benefits from alternative technology inputs via ITL and is regarded as an important strategy for latecomers to catch up on their technology (Kodama, 1995; Kim, 1997). Thus, learning by licensing is a viable strategy to promote innovation for the licensee (Mathews and Cho, 1999; Johnson, 2002). In practice, not all licensees can successfully carry out the learning by licensing because the potential technological benefits depend on effective learning and implementation (Dahlman et al., 1987). Obtaining external technologies by purchasing patents together with relevant support, such as experience, expertise and R&D inputs, is required to realize the benefits of these technologies. Without adequate capability, licensees will have a hard time identifying technology opportunities and making full use of licensed-in technologies. The catching-up literature (Winiecki, 1987) also exposed the failure of Soviet-type economies' technology acquisitions and highlighted the difficulties in adopting licensed-in technologies thereby visualizing the importance of strategic management in ITL adoption.

The effectiveness of ITL adoption, along with subsequent innovation performance, has been widely studied. Research by Willmore (1991) and Lee (1996) presented the alleged positive effect of licensing on internal R&D. Johnson (2002) captured the positive relationship between inward licensing experience and patent generation by a licensee. Indeed, ITL has been proven to play an important role in influencing the innovation performance of a licensee, albeit most likely with a time lag (Xie and Wu, 2003; Fabrizio, 2009). Empirical evidence by Mansfield et al. (1982) indicated that the average “start-up lag” for international technology transfer is two years. This implies that licensees cannot immediately improve their innovation performance; rather, it results from the period of learning. Therefore, I use subsequent patent generation (within three years immediately after licensing) as a measurement of the innovation output of ITL strategy. This essay objectively analyzes patent generation by Chinese latecomers who adopted ITL in high-tech industries where knowledge is highly intensive, markets are difficult to penetrate, cost advantages are minimal, and strategies of linkage and leverage are important. Since all latecomers from China share a similar regulatory environment and experience roughly the same environmental forces (Xie and Wu, 2003), I am able to focus on the factors of strategic management in ITL adoption. This essay does not assert that these ITL factors are the only source of heterogeneity among licensees, only that they are the most important. This is further discussed in the following paragraphs.

In the latecomer context, one key factor embedded in the overall strategy of a licensee is the number of licenses. The number of licenses is a direct link to the extent of ITL and financial exposure of the latecomer. Since latecomers lack resources (Mathews, 2002), the limitations of R&D inputs and existing capability constrain the number of licenses and hinder the learning effect in ITL adoption. A larger number of licenses means that more licensed-in technologies can be translated into learning opportunities for the licensee. Moreover, licensing-in technologies can enlarge the internal knowledge base and extend the innovation scope by boosting knowledge recombination (Henderson and Cockburn, 1994; Ahuja and Katila, 2001; Vanhaverbeke et al., 2004). Beyond a certain level, latecomers may face difficulties absorbing a large number of licensed-in technologies (Cohen and Levinthal, 1989) due to their inferior technological capability; an excessive number of licensed-in technologies may hamper the efficiency of learning (March, 1991). This is because adopting more licensed-in technologies requires more R&D efforts to spur effective learning, including human and financial capital support. The extra effort required is unsustainable for latecomers who often suffer the resource constraints. For instance, internal intelligences are important assets for realizing both tangible and intangible technology transfers by cooperating with licensors (Atuahene-Gima, 1993; Fleisher et al., 2010). The fact is that these intelligences are always in short supply for latecomers in emerging economies due to the lack of human capital accumulation (Liu, 1998). Moreover, latecomers rarely have sufficient financial capital for external hires. Thus, it is difficult for latecomers to benefit from a large number of licensed-in technologies. Even worse, too much reliance on ITL may affect internal R&D development because it diminishes the staff's motivation to innovate themselves (Pillai, 1979). If a licensee only uses licensed-in technologies as they are or does not bother to adapt or customize the technologies according to its own needs, the benefits of learning cannot be optimized to develop its innovative capability. Therefore, I believe that excessive ITL impedes a licensee's subsequent innovation performance and propose Hypothesis 1:

H1. The number of licenses has a curvilinear (an inverted U) effect on the subsequent innovation performance of a licensee.

Considering the limited resources allocated to ITL, latecomers should carefully select the technology to be licensed to ensure that innovation can be achieved. Before licensing-in decisions, latecomers should have the capacity to identify which is the proper technology that they should learn from. It is because this possible technology change triggered by licensing-in decisions can be incorporated to the production and thus affects the productivity in the post-licensing stage (Nelson, 1964). As emphasized by Fosfuri (2000) and Ziedonis (2007), ITL is an important instrument of strategic choice regarding the vintage of technology (or the equivalent quality in their research) beyond a simple entry mode (or the right to use the technology). To examine the quality of technology, technology age was first proposed by Rockett (1990a, b) as an important determinant that licensors can use to extract rents from licensees. I argue that technology age can be used by a licensee as a measure to capture returns on innovation from ITL.

Technology age has been stressed as a critical factor affecting knowledge recombination and, as a result, innovation performance (Nerkar, 2003). All technologies depreciate in value as they grow old (Perez and Soete, 1988; Tanaka et al., 2007). Since old technologies have been extensively used by competing firms for extended periods and have likely been replaced by new technologies, they are less valuable as inputs that contribute to innovation (Katila, 2002). In contrast, recent technologies offer promising technological opportunities, and thus they are more interesting sources for knowledge recombination (Kodama, 1995; Sorensen and Stuart, 2000).

In addition, recent technologies can help latecomers maintain a good fit between themselves and the competitive environment (Sorensen and Stuart, 2000). In high-tech industries where the technology life cycle is short, new technologies may quickly become outdated. Besides endogenous technology development, latecomers can update their patent portfolios by importing recent patents. These recent patents can facilitate a market entry to an emerging technological field (Fosfuri, 2000). During the early development of a technological field, every firm is new to the area and the relevant patents available in the technology market are likely to be very recent. As the technology matures, latecomers who license the recent technology enjoy the learning curve advantages (Nelson, 1995; Shane, 2001). The learning curve embodies the initial difficulty of learning; the possible returns of learning come after the initial familiarity is gained (Ritter and Schooler, 2002). The initial learning takes latecomers some time, possibly years, to absorb the licensed-in technology to the level where they can generate innovation based on the accumulation of learning-by-doing (von Hippel, 1988). If the licensed-in technology is recent, it is more likely to be advantageous even after ITL adoption.

Based on the above arguments, I propose Hypothesis 2:

H2. The age of licensed-in technology has a negative effect on the subsequent innovation performance of a licensee.

The existing literature has suggested that cultivating an in-house technological capability is critical for maximizing the learning outcomes of ITL adoption (Kumar et al., 1999; Tsai and Wang, 2009). Song et al. (2005) pointed out that internal R&D efforts have a significant effect on the adoption of technology. Sen and Rubenstein (1990) claimed that the cumulative efficiency of past technology learning could increase the effectiveness of external technology adoption. In other words, by adding R&D inputs over time, technological knowledge can be accumulated (Drejer, 2000; Schoenecker and Swanson, 2002). Accumulative technological knowledge (as the notion of existing technological capability in this study) represents a licensee's absorptive capacity to recognize the value of technology, assimilate it, and apply it to innovation (Cohen and Levinthal, 1989; March, 1991; Hall et al., 2001). A number of scholars (e.g., Cohen and Levinthal, 1990; Stock et al., 2001) have hypothesized that a high level of accumulative technological knowledge can lead to inertia and rigidity, resulting in an inward-looking tendency. However, I do not expect this factor to be important in this study, which focuses on latecomers from China. Unlike firms in advanced countries, all of the latecomer firms covered in my study still have relatively low level of technological knowledge accumulation. Interestingly, a recent study of Taiwanese high-tech firms (Tsai and Wang, 2009) has also found a net positive moderating effect of accumulative technology capability. Given that the Taiwanese firms generally have higher level of knowledge accumulation than the Chinese firms (both samples in the same high-tech sector of electronic and telecommunications), I can safely infer that the inertia/rigidity factor is unlikely to be a significant factor for the latecomer firms in this study. Therefore, the well-established technological capability can improve the absorption of imported technologies from ITL and enhance the effectiveness of learning on latecomers' innovation performance (von Hippel, 1988; March, 1991; Gambardella, 1992; Mowery et al., 1996; Grünfeld, 2003). It implies that the existing level of the technological capability determines the extent to which licensee can efficiently adopt licensed-in technologies. When the number of licenses is certain, the strong existing technological capability may boost the effectiveness of adopting licensed-in technologies and result in a better innovation performance. If the number is uncertain, weak existing technological capability may limit adoption to a very small number of licenses due to the low level of absorptive capacity.

During the course of technology utilization, the post-licensing innovation performance may also be enhanced by knowledge recombination in an integrated knowledge pool (Henderson and Cockburn, 1996; Kogut and Zander, 1996;

Fleming, 2001). An enlarged knowledge pool can be created via external technology acquisition channels, such as ITL. Licensed-in technologies can add to the existing knowledge pool and serve as sources of possible knowledge recombination for renewed innovations. Furthermore, sizeable existing knowledge base (strong existing technological capability in this study) increases the possibilities for licensed-in technologies to be combined with existing technologies (Cohen and Levinthal, 1989, 1990; Henderson and Cockburn, 1996; Kogut and Zander, 1996; Fleming, 2001; Vanhaverbeke et al., 2004). The above arguments imply that, if a licensee imports a greater number of technologies, its subsequent innovation performance will only improve when it has a competent existing technological capability.

In addition, existing technological capability allows licensees to enjoy direct benefits from the vintages of licensed-in technologies, such as technology age. Old technology has limited value for innovation, while recent technology has greater potential (Perez and Soete, 1988; Katila, 2002; Tanaka et al., 2007). However, only firms with competent technological capability can realize the potential benefits of recent technology. As the level of existing technological capability increases, more technological opportunities embedded in the recent technology can be identified and explored (Cohen and Levinthal, 1989; March, 1991; Hall et al., 2001). Therefore, the more recent technologies a licensee imports, the better its subsequent innovation performance will be when it has a strong enough existing technological capability.

In sum, the above arguments lead to the following hypotheses regarding the moderating role of a licensee's existing technological capacity:

H3. A licensee's existing technological capability positively moderates the relationship between the number of licenses and the subsequent innovation performance.

H4. A licensee's existing technological capability negatively moderates the relationship between the age of licensed-in technology and the subsequent innovation performance.

2.3 Data and Methodology

2.3.1 Sample and Data

This essay uses a licensing dataset obtained from the State Intellectual Property Office of China (SIPO), which includes both domestic and international licenses obtained by Chinese licensees from 1998 to 2009. Each record contains the licensor's name, licensee's name, name and application number of the licensed-in patent and the registration date of licensing. This sample focuses on patent licensing transactions by Chinese firms in the high-tech sector of electronic and telecommunications, including telecommunications, mobile, IT, and consumer electronics industries, completed during the observation period from 1998 to 2005. This provides an initial set of 'licensing-in data points' for 154 firms.

The extra patent data for each licensee is also collected from SIPO. Additional information about each licensee, such as the year established and number of employees, is retrieved from the company website, annual reports, or public media. This additional information allows us to cross-link the original dataset with other sources of information that are necessary for my analysis. The extended data for three firms is unavailable, so they are not included in the empirical test.

2.3.2 Variables

Dependent Variable

Innovation performance: The number of patents has been widely used as a measurement of innovation performance in prior empirical research (Henderson and Cockburn, 1994; Ahuja and Lampert, 2001; Hall et al., 2001). Thus, I adopt this variable and use patent generation as a proxy indicator of the innovation performance for each licensee. I count the number of patents applied for by each licensee within three, four or five years after the licensing year. If the licensee has multiple licensing years, I average the patent counts. The average number of patents generated by each licensee within three years after licensing is considered as the dependent variable. The number of patents generated within four or five years is used to construct the variables that I use to check the robustness of the outcomes.

Independent Variables

Number of licenses (NL): This independent variable is the total number of licensing agreements for each licensee over the period 1998-2005. It includes both international patent licensing and domestic patent licensing.

Age of licensed-in technology (ALT): This independent variable is the time lag between the application year of the patent licensed in and the registration year of the licensing agreement from SIPO. First, I compute the time lag for each licensing agreement. Next, I average the time lags for each licensee over the period 1998-2005.

Moderating Variable

Existing technological capability (ETC): Because existing knowledge stock may influence the absorptive capacity for learning (Perez and Soete, 1988; Laursen et al., 2010), I use each licensee's existing patent stock in SIPO to measure this moderating variable. First, I count the number of patents applied for by each licensee during the five years prior to licensing at the level of each licensing agreement. Next, I average the cumulative number of patents during the five years prior to licensing for each licensee. This value is treated as the measurement of existing technological capability.

Control Variables

Age of internal technology (AIT): Theoretical research about learning (Sorensen and Stuart, 2000; Katila, 2002; Nerkar, 2003) suggests that technology age in the existing knowledge stock has a significant impact on innovation. Thus, the average age of internal technology is a variable that should be controlled for. Using data about each licensee's existing patent stock for the five years prior to licensing, this variable is calculated by computing the time lag between the application year of the patent and the first licensing year in SIPO.

Diversity age of internal technology (DAIT): The impact of the diversity of the age of internal technology is also considered an important factor (Cohen and Levinthal, 1989; Katila, 2002). Thus, I use a standard deviation of the age of the internal patent stock to measure the age of the licensee's internal technology.

Firm age: Since the number of years of operations can influence innovation performance, I include firm age as a control variable to capture prior experience in technology development activities. Firm age is defined as the number of years from the establishing year of the licensee to 2009.

Firm size dummy: Many studies have reported that firm size influences innovativeness in learning (Cohen and Levinthal, 1989; Henderson and Cockburn, 1996). The number of employees has been widely used as a measure of firm size (Ettlie and Rubenstein, 1987; Calof, 1994). To determine the size of each licensee, I count its employees. Since less than one third of the firms' employee numbers are listed and the numbers for private firms are unreliable, I transformed this variable into a dummy variable. In line with the Institute Für Mittelstandsforschung (Small Business Research Institute) and United Nations Conference on Trade and Development (UNCTAD), firms with less than 500 employees are defined as Small and Medium Enterprises (SMEs) and those with more than 500 employees are large enterprises (Commission of the European Communities, 1985; Corsten, 1987; Neelamegham, 1992). Thus, a value of 1 represents a large enterprise with more than 500 employees. If the employee number is equal to or less than 500, the value is coded as 0.

Regional dummy: Prior research has shown that regional institutional policies, geographical knowledge spillover, business ties and local competition affect how firms acquire products and process knowledge (Barney, 1991; Koschatzky, 1998). Therefore, a regional dummy is added as a control variable. I control this effect by identifying the Chinese province that each licensee is located in and sorting them based on the total number of patents from their province over the period 1985-2009. Since the number of 1,000,000 patents is about the average accumulated patent number of the province that my sample firms located, I use this average number as a benchmark to measure this dummy variable. The value of this variable is set to 1 for licensees located in Chinese provinces where the total number of patents is equal to or greater than 1,000,000, and 0 for licensees located in Chinese provinces where the total number of patents is less than 1,000,000.

Licensor dummy: I control the interrogate linkage between the licensor and licensee using this dummy variable. If the licensee has a sole licensor, meaning all of its patents are licensed from just one licensor, the value of licensor dummy is coded as 0. Otherwise, it is coded as 1.

Year dummy: This dummy variable indicates a particular licensing year recorded in SIPO over the period 1998-2005. The year is set to1998 by default. As there are not enough observations from 1999 to 2001, I combine the year dummy 1 (1999), year dummy 2 (2000) and year dummy 3 (2001) together and control for these years as year dummy 123. Year dummy 4, 5, 6 and 7 refer to the particular years 2002, 2003, 2004 and 2005, respectively.

2.3.3 Methods

This section describes the econometric approach used to conduct the empirical analysis in this essay; it is also adopted in the next essay. Because the dependent variable is a count variable – number of patents, this study uses a negative binomial regression analysis. The count data usually exhibits over-dispersion and has only non-negative integer values (Maddala, 1983). To analyze the count data, the linear regression model based on the assumption of homoscedasticity is violated to explain the normally distributed errors. The appropriate models for the count data are built on the Poisson probability distribution (Cameron and Trivedi, 1998; Greene, 2008). However, the basic Poisson model only applies to count data that has the same mean and variance. The Poisson model does not fit well for this study because the count data – number of patents – differs across observations (heterogeneity) and its variance usually exceeds the mean[5]. Thus, the negative binomial regression model is the standard choice for the over-dispersion data of countable patents (Hausman et al., 1984; Kennedy, 1998). The negative binomial regression model also has the advantage of capturing both observed and unobserved heterogeneity in the analysis, whereas only observed heterogeneity is captured in the Poisson regression model (Long, 1997). To avoid the negative value of the dependent variable, the negative binomial regression model parameterizes the independent variables as an exponential function (Long, 1997):

$$Y_j = \exp(\alpha X_{1j} + \beta^* X_{2j} + \ldots\ldots \gamma^* C_j + \varepsilon_j)$$

Where Y_j is the number of patents generated by a firm *j*, X_{nj} is the vector of the acquisition variables to be tested and C_j is the vector of the control variables affecting Y_j. This specification implies that the number of patents by a firm in any year is randomly distributed following the negative binomial model.

Based on the theoretical expectations regarding innovation performance and the determinants of the number of licenses, age of licensed-in technology and existing technological capability, the above model is used in this study to explain a licensee's innovation performance in terms of number of patents. Furthermore, this

[5] I calculate the Lagrange Multiplier (LM) test for overdispersion in this essay and the next essay. The LM test is used in the Poisson model versus the negative binomial model (Johansson, 1995; Cameron and Trivedi, 1998). The results indicate that the effects of overdispersion are statistically significant, which is against the Poisson assumption of the equality of the mean and variance. Thus, the negative binomial model that can accommodate overdispersion is more appropriate than the Poisson model.

study adopts a firm-level analysis rather than a firm-year panel due to an inherent problem with the data provided by the data source – SIPO. Specifically, in the period of observation, the number of inward licensing deals are not made available for every year, but are instead lumped together across several years, resulting in zero entries for some years and very high figures for certain years. Indeed, for many of the sampled firms[6], their licenses appear only in one particular licensing year, with zero entries for all other years. Because of this problem of data aggregation across multiple years, a firm-year panel analysis would not be appropriate. Indeed, I have run a firm-year panel test and found the results to be poor due to the violation of the pooled-analysis assumption of equal population variances. Thus, I adopt a firm-level negative binomial analysis. In addition, a sensitivity analysis is carried out later to test the robustness of the results.

2.4 Results

The descriptive statistics and correlations between variables are presented in Table 2-1. The coefficients reveal that the analysis does not suffer from multicollinearity in the interaction terms between existing technological capability (ETC), number of licenses (NL), and age of licensed-in technology (ALT). Table 2-2 shows the

[6] For example, Shenzhen Shanling Electronics Ltd., one of my sample firms, has 726 licensing-in deals registered in 2005; Dongwan DaXin Science and Technology Ltd. has 542 licensing-in deals only in the year of 2005; and Shenzhen Huajia Digital Ltd. has 368 licensing-in deals recorded in 2005.

results of the regression analysis on the effects of NL and ALT, as well as the moderating effect of ETC, on the innovation performance of a licensee. Model 1 presents the base model with all control variables. AIT has an inverted U relationship with innovation performance, which is similar to the results of prior work by Katila (2002). The impacts of the firm size and regional dummy turn out to be significant for the innovation performance. The effect of the licensor dummy is insignificant, which means that whether a firm has a sole licensor or many licensors does not have a strong impact on the innovation performance.

Table 2-1. Descriptive statistics - Mean, standard deviation and correlations

Variables	Mean	Standard deviation	1	2	3	4	5	6	7	8	9	10
1. Innovation performance	149.53	954.633	1									
2. NL	19	79.285	-.025	1								
3. ALT	7.87	2.709	-.098	.094	1							
4. ETC	10.80	62.951	.438**	-.031	-.066	1						
5. AIT	.613	1.335	.266**	-.051	-.099	.127	1					
6. DAIT	.175	.469	.176*	-.018	-101	.144	.640**	1				
7. Firm age	13.91	7.122	.061	-.075	.131	.183*	.138	.286**	1			
8. Firm size dummy	.36	.483	.191*	-.109	-.036	.216**	.108	.188*	.275**	1		
9. Regional dummy	.95	.225	.037	.043	.177*	.040	-.069	.025	-.051	-.005	1	
10. Licensor dummy	.29	.456	-.067	.084	-.022	.067	.048	.082	.063	.060	.022	1

**. Correlation is significant with the P value of 0.01 (2-tailed, significant at 10%)
*. Correlation is significant with the P value of 0.05 (2-tailed, significant at 5%)
Number of observations (N) =151
Notes: Year dummies were included in the analysis but not shown in this table.

Table 2-2. Negative binomial regression (Dependent variable = Innovation performance)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
		H1	H2	H1, H2	H1, H2	H3	H4	H3, H4
AIT	2.712* (1.599)	3.203** (1.620)	2.479** (1.187)	3.825** (1.583)	4.967*** (1.377)	4.379*** (1.167)	5.052*** (1.415)	4.519*** (1.179)
AIT^2	-.387* (.225)	-.451** (.227)	-.433** (.1808)	-.625*** (.229)	-.900*** (.215)	-.776*** (.192)	-.918*** (.220)	-.812*** (.190)
DAIT	-.613 (1.960)	-.959 (2.075)	.410 (1.724)	-.559 (2.164)	-1.913 (1.675)	-2.212 (1.354)	-1.569 (1.764)	-1.648 (1.443)
Firm age	.122 (.0925)	.125 (.0876)	.109 (.0768)	.118 (.0723)	.0586 (.0492)	.0608 (.0471)	.0618 (.0492)	.0571 (.0477)
Firm size dummy	2.160* (1.139)	1.738 (1.125)	1.980** (.889)	1.869** (.825)	-.0168 (.640)	-.335 (.601)	.132 (.638)	-.110 (.599)
Regional dummy	3.653* (2.030)	3.907** (1.956)	4.319** (1.790)	5.320*** (1.888)	4.042** (1.651)	3.818** (1.559)	4.014** (1.643)	3.769** (1.541)
Licensor dummy	-.497 (1.169)	-.651 (1.084)	.302 (.855)	.417 (.855)	.790 (.647)	1.139* (.624)	.840 (.649)	1.276** (.622)
Year dummy123	-1.943 (1.290)	-1.930 (1.271)	-2.261** (1.114)	-1.734 (1.138)	-1.221 (1.015)	-.858 (.930)	-1.067 (.984)	-.763 (.946)
Year dummy 4	-.814 (1.093)	-1.015 (1.018)	-1.917** (.903)	-1.719** (.840)	-1.208 (.749)	-1.096 (.675)	-1.166 (.724)	-1.119 (.709)
Year dummy 5	-.904 (1.000)	-1.034 (.956)	-2.332*** (.773)	-2.949*** (.807)	-.838 (.754)	-1.081 (.730)	-.600 (.777)	-.565 (.785)
Year dummy 6	.124 (.918)	.628 (1.037)	-.725 (.743)	-.277 (.705)	-.975 (.601)	-.524 (.635)	-.960 (.595)	-.690 (.621)
Year dummy 7	.388 (1.396)	.255 (1.222)	.594 (.960)	-.0094 (.886)	.0280 (.811)	.195 (.721)	.109 (.795)	.243 (.731)
Constants	-3.152 (2.984)	-3.775 (3.012)	1.665 (2.537)	.940 (2.616)	-.606 (2.162)	-.897 (2.003)	-1.028 (2.142)	-1.338 (2.022)

NL		.0758 (.0913)		.0952** (.0439)	.0775** (.0359)	.0586* (.0316)	.0780** (.0353)	.0624** (.0310)
NL^2		-.00041 (.00038)		-.00048** (.00019)	-.00042*** (.00016)	-.00031** (.00015)	-.00043*** (.00016)	-.00034** (.00015)
ALT			-.629*** (.129)	-.782*** (.152)	-.442*** (.136)	-.400*** (.120)	-.413*** (.139)	-.362*** (.124)
ETC					.0428*** (.0106)	.130*** (.0461)	.201*** (.0798)	.366*** (.101)
ETC * NL						-.0394** (.0189)		-.0598*** (.0199)
ETC * NL^2						.0037** (.0017)		.0050*** (.0017)
ETC * ALT							-.0249** (.0114)	-.0289*** (.0092)
Pseudo R^2	0.0627	0.0678	0.0879	0.0980	0.1258	0.1317	0.1273	0.1358
Log likelihood	-336.076	-334.237	-327.017	-323.415	-313.439	-311.335	-312.912	-309.861

***P<0.01, **P<0.05, * P<0.1 (2-tailed)
N=151; STANDARD ERRORS IN BRACKET

Model 2, Model 3 and Model 4 test Hypotheses 1 and 2. Model 2 shows that the estimated coefficient of NL does not have a significant effect on the innovation performance of a licensee, but Model 4 verifies the inverted U shape effect ($P<0.05$). The age of licensed-in technology (ALT) has a negative impact on innovation performance. The results in Model 3 and Model 4 show that ALT has a significant negative effect on the innovation performance of a licensee (as expected, $P<0.01$).

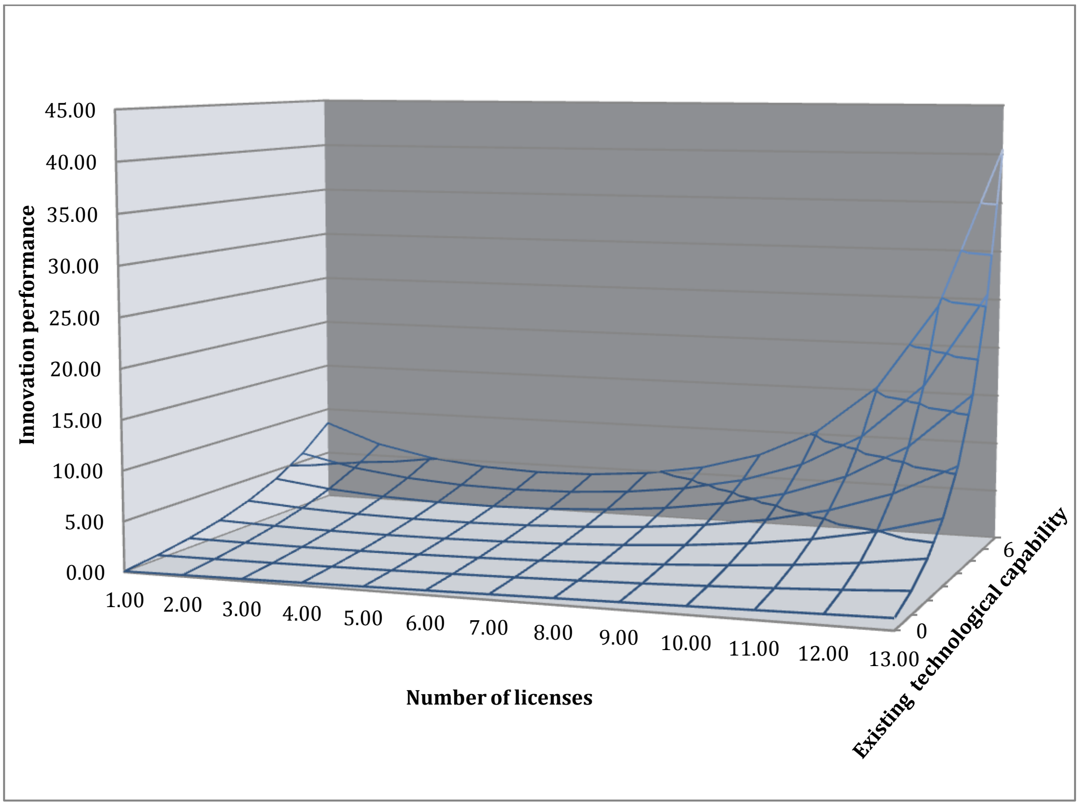
Thus far, the study focuses on the individual effects of NL and ALT on the subsequent innovation performance. The rest of the models examine the moderating effect of existing technological capability (ETC) on the above two relationships, which is visualized in Figure 2-3[7]. Model 5 shows that the moderating variable of ETC has a positive impact on the subsequent innovation performance. Model 6 and Model 8 examine the moderating effect of ETC on the effect of NL on innovation performance. The results from Model 6 show that ETC has an alleviating effect on the relationship between NL and innovation performance ($P<0.05$): the interaction term with the linear term of NL is negative, while that of the squared term is positive. To gain additional insights, I further draw the interaction plots in Set A, Figure 2-3, in support of Hypothesis 3. This figure, based on Model 8 and 90 percentiles of the data, shows that there are two

[7] Based on the coefficients of the negative binomial regressions in Table 2-2, I calculate how ETC changes the likelihood that a licensee will successfully generate innovation by adopting licensed-in technologies (so called incidence-ratio minus 1). The surfaces in both figures - Set A and Set B - show the impact of ETC on the chance that a firm will successfully adopt licensed-in technologies (under the measure of NL and ATL).

different ITL strategies that promote the post-licensing innovation. In the case of adopting only a few licenses, the licensee still needs to rely on its own R&D in order to achieve a better innovation performance. However, a licensee can obtain the benefits of a large number of licenses by internalizing licensed-in technologies. When importing many external technologies, it would not make sense for the quantity to affect the post-licensing innovation performance, only for the existing capability of the licensee to absorb the imported technologies. Model 7 and Model 8 investigate the interaction effect between ALT and ETC on the innovation performance of the licensee. The results show that the licensee's ETC negatively moderates the relationship between ALT and innovation performance ($P<0.01$), which supports Hypothesis 4. In other words, the absorptive capacity of the firm has a smaller positive impact on the subsequent innovation performance as the technology age increases. The interaction is plotted in Set B, Figure 2-3, based on Model 8 and 90 percentile of the data. The pattern is in line with the prediction that, with a high existing technological capability, latecomers can take greater advantage of recent licensed-in technologies. The positive effect on innovation performance only appears when the licensee acquires new technologies. Even with a strong existing technological capability, technologies that are more than 4.5 years old prior to licensing seem to have no value for subsequent innovation. This finding disagrees with the wisdom that "old is gold" (Nerkar, 2003) when exploring the value of internal knowledge.

Several robustness tests confirm the accuracy of the results. First, I add the industry dummy into the model. This shows the similar results as reported above. Second, I change the dependent variable of innovation performance in the analysis of the full models by adjusting the period of patent counts to three years, four years and five years after licensing. The estimated coefficients maintain similar empirical results, which support hypotheses H1 to H4.

Set A: Interaction of Number of Licenses and Existing Technological Capability



Set B: Interaction of Age of Licensed-in Technology and Existing Technological Capability

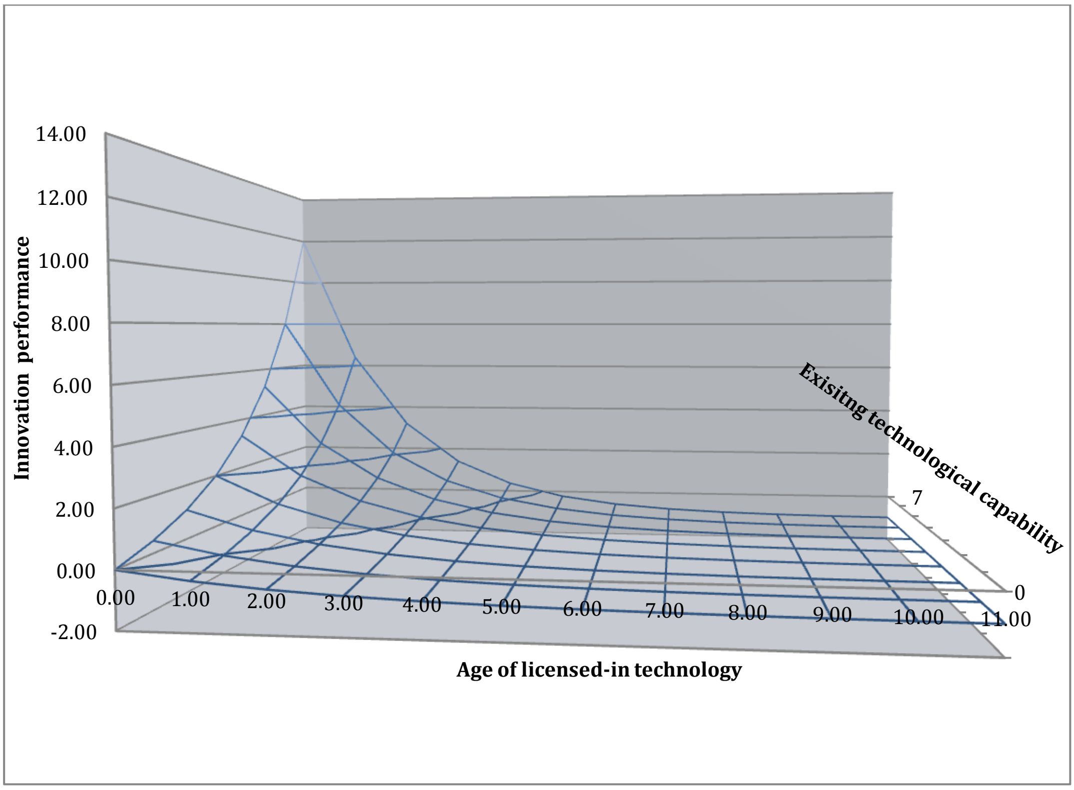


Figure 2-3. Interaction plots

2.5 Discussion and Summary

The existing literature has paid little attention to latecomers' ITL strategy for technological capability development. However, as a significant number of Chinese latecomers have successfully become top patent generators, this research topic deserves greater attention. Due to their weaker resources, it is important for latecomers to learn from forerunners and innovate effectively. Due to the dramatic increase in ITL activities that has been observed in China over the last decade, there is an urgent need to investigate the ITL strategy behind the success stories of Chinese latecomers. By treating ITL as an integral part of technological strategic management, this essay explores how latecomers can make proactive management decisions to minimize the risk of licensing and maximize their innovation performance.

This essay explores ITL strategy for latecomers by focusing on two critical factors: (1) the number of licenses and (2) the age of licensed-in technology. I found that the age of licensed-in technology is a critical factor for the subsequent innovation performance of the licensee. As technology becomes old, its value for inward licensing depreciates. The age of licensed-in technology also negatively affects the positive impact of existing technological capability on innovation performance, indicating that older technology is less valuable for implementing a catching-up strategy. By considering the factor of age of licensed-in technology, this essay reconciles the contradictory research findings about the impact of prior licensing experience and determines there is an inverted U relationship between the number of licenses and the subsequent innovation performance. Moreover, this relationship is positively moderated by a licensee's existing technological capability. That is, without complementary technological capability, excessive licensing impedes a licensee's learning. Subsequent to my research findings above, I have come across a very recent paper (Wang et al., 2013) that has made similar findings for H1 and H2 in China, for both high-tech and non-high tech manufacturing firms as well as service firms, albeit over a much shorter time period (2000-2003). Despite the differences in sector and time coverage of this new paper, I believe it further validates my research findings. My above empirical findings support the resource-based approach for determining what technology latecomers should license in, and help explain why some latecomers' innovation performance outshines others. This essay provides important empirical support for the recent trend of inward licensing as a strategy for latecomers to achieve technological catching-up.

Based on the above findings, the age of licensed-in technology is predicted as a hidden factor that influences the effectiveness of learning by licensing. Due to the concern over the mixed results of the linear relationship between licensing-in experience (number of licenses in this study) and subsequent innovation performance (Ahuja and Katila, 2001; Álvarez et al., 2002; Johnson, 2002; Tsai and Wang, 2009), this study further tests the moderating effect of the age of licensed-in technology on the above linear relationship. The analysis is conducted in line with the same set of variables in Table 2-2, and the results are shown in Table 2-3. Model 1 contains the same control variable as Table 2-2. The results from Model 2 are consistent with the existing finding of the insignificant linear effect of licensing-in experience (number of licenses in this study) on the subsequent innovation performance (Tsai and Wang, 2009). Model 3 adds the variable – age of licensed-in technology. Like the results from Table 2-2, Model 3 shows the same negative relationship between the age of licensed-in technology and the subsequent innovation performance. Ultimately, Model 4 employs all the variables and tests the interaction effect of the number of licenses and the age of licensed-in technology. The results from Model 4 reveal that the age of licensed-in technology positively moderates the relationship between the number of licenses and the subsequent innovation performance with a P-value of 0.071. The linear relationship between the number of licenses and the subsequent innovation performance turns out to be significantly negative ($P<0.1$), while the negative relationship between the age of licensed-in technology and the subsequent innovation performance remains the same ($P<0.01$). The finding of the significant moderation effect further supports the predication that the age of licensed-in technology is an important hidden factor that affects the effectiveness of licensing-in experience at promoting innovation. It is found that latecomers can import a large number of older technologies and internalize them to generate innovation. This finding can be explained by two underlying reasons. First, licensing is an important tool used by latecomers to break an industry's entry barriers. The fundamental technologies that emerge together with an industry's development are often old and thus the patents are available in the market. These patents are generally filed by the pioneers in the industry who often set the dominant designs or industry standards. For newcomers to the industry, it is impossible to circumvent the technical barriers to trade their products without licensing the fundamental technologies. For example, the two Chinese latecomers in telecommunications industry who have become the industry leaders, i.e., Huawei and ZTE, are in the list of licensees in the dataset. The patents that Huawei and

ZTE licensed are mainly fundamental ones from the firm that set the industry standards – Quantum Telecom. The second reason explaining why latecomers can make use of imported old technologies to generate innovation relates to the business model which is about how to make use of the technology. There are circumstances when new technologies are not available or too expensive to be licensed by latecomers. It is also reasonable that latecomers choose not to compete directly with incumbents for technology leadership, but to enter the market first by licensing old technologies and gradually accumulate the technological capability. The old licensed-in technology itself may not contribute much to the upcoming innovation by latecomers; however, the business model to use the old technology for the development of good-enough products to meet the needs of a low-end or new group of customers is favourable. In this way, how advanced or new of a technology maybe does not matter much for latecomers trying to innovate quickly, because the specific innovation trajectory may enable the imported old technologies to become visible in the market and favoured by the certain group of the customers. The details of the specific innovation trajectory will be discussed in Essay Three.

Finally, I would like to acknowledge several caveats in this essay. First, due to limitations of the data sources, a cross sectional dataset rather than panel data was used to conduct the empirical testing. Although I added in the year dummy as a control variable, this may have captured the limited differences between years when analyzing the firm level data, rather than the firm year panel. Second, besides the quantitative aspect, it would be interesting to test the qualitative aspect of the licensed-in technologies. However, the widely used measurement of weighted citation cannot be tested based on the SIPO database as there is citation data missing from 2004 to 2007 in the database. The missing citation data in SIPO precluded us from examining the more quality aspects such as the value of technologies in this essay. Due to the above concerns, more research along these lines is warranted.

Table 2-3. Negative binomial regression
(Dependent variable = Innovation performance)

Variables	Model 1	Model 2	Model 3	Model 4
AIT	2.712* (1.599)	2.386 (1.536)	2.434** (1.203)	3.257** (1.555)
AIT square	-.387* (.225)	-.359* (.214)	-.428** (.182)	-.551** (.227)
DAIT	-.613 (1.960)	-.169 (1.933)	.444 (1.722)	.161 (2.140)
Firm age	.122 (.0925)	.1082 (.0898)	.108 (.0772)	.109 (.078)
Firm size dummy	2.160* (1.139)	2.214* (1.133)	1.987** (.891)	1.918** (.841)
Regional dummy	3.653* (2.030)	3.441* (2.064)	4.282** (1.801)	4.319** (1.790)
Licensor dummy	-.497 (1.169)	-.745 (1.159)	.270 (.870)	.518 (.887)
Year dummy123	-1.943 (1.290)	-2.060 (1.273)	-2.278** (1.118)	-2.139* (1.171)
Year dummy 4	-.814 (1.093)	-.765 (1.082)	-1.905** (.910)	-1.864** (.909)
Year dummy 5	-.904 (1.000)	-1.012 (.995)	-2.316*** (.777)	-2.556** (.783)
Year dummy 6	.124 (.918)	-.0543 (.951)	-.735 (.749)	-.724 (.730)
Year dummy 7	.388 (1.396)	.720 (1.443)	.647 (1.004)	.138 (.990)
Constants	-3.152 (2.984)	-2.514 (2.971)	1.685 (2.539)	2.720 (2.768)
NL		-.0125 (.0134)	-.0013 (.0065)	-.0802* (.0433)
ALT			-.621*** (.134)	-.811*** (.176)
NL*ALT				.0081* (.0045)
Pseudo R^2	0.0627	0.0648	0.0880	0.0925
Log likelihood	-336.076	-335.322	-326.997	-325.360

***P<0.01, **P<0.05, * P<0.1 (2-tailed)
N=151; STANDARD ERRORS IN BRACKET

CHAPTER 3.

SUBSTITUTION EFFECT IN MERGERS AND ACQUISITIONS ON INNOVATION PERFORMANCE

3.1 Introduction

The fact that nearly 50% of all mergers and acquisitions (M&A)[8] fail makes M&A strategies a hot topic (Kitching, 1974; Rostand, 1994; Conn et al., 2001; Schoenberg, 2006). A central issue raised in the M&A literature is the strategic choice of target firms to explain the performance variance among acquiring firms. The strategic choice is based on the possible interaction between the target and acquiring firm after M&A. This interaction is characterized by complementarity and substitution. When there is synergy between the two organizations, they cooperate well and complement each other. If not, the target firm becomes a possible substitute serving the function of replacement. Much of the existing M&A literature on this subject has focused on the synergy effect (Seth, 1990; Ahuja and Katila, 2001; Capron and Piste, 2002; King et al., 2004; Koenig and Mezick, 2004; Cloodt et al., 2006), whereas less attention has been paid to the possible substitution.

Maximizing the synergy effect is the most widely adopted measure and is used as a

[8] There are two different activities embedded in the term "M&A": a merger is a consolidation of two firms into one legal entity, whereas an acquisition is a takeover of a smaller firm by a large one in terms of firm value.

strategic selection criterion in M&A. The synergy effect posits that the integration of the target and acquiring firm is more effective than the two firms operating separately (Cording et al., 2002). It has been found that the synergy effect in M&A leverages not only financial synergies, such as debt capacity and financial risk (Lewellen, 1971; Brunner, 1988; Leland, 2007), but also operational synergies, such as economies of scale, resource reallocation and cost reduction (Pautler, 2001). In line with the synergy effect, the under-performance of post-M&A innovation activities has been mainly attributed to the management challenges associated with the differences between the two firms during the integration process (Child et al., 1999; Schweiger and Very, 2003). Ahuja and Katila (2001) and Cloodt et al. (2006) examined the differences in the technology bases and found that an acquiring firm is not better off chooses a target firm with distant technologies and a large amount knowledge base. It is notable that technologically advanced firms can benefit from similar external resources that complement their existing competency. Since some technologically laggard firms, such as latecomers, do not possess good-enough competencies that can be complemented, they need to substitute many different technologies to swiftly catch up. The latecomer cases may invalidate the traditional view of the synergy effect based on the two critical measures of technology distance and relative knowledge size. This essay aims to uncover the contingencies where the traditional view on technology distance and its impact on post-M&A innovation outcomes are turned upside down.

Although there exists rich M&A literature in developed economies, it is insufficient without taking account of the new growth economies, such as China (Cooke, 2006). The fact of high failure rates (Kitching, 1974; Rostand, 1994; Conn et al., 2001; Schoenberg, 2006) has not stopped Chinese latecomers from engaging in M&A. To the contrary, they continue to employ M&A at ever increasing rates. After the economic crisis of 2003, the volume of M&A grew at a rate of 70% over the following five years in China (Chen and Shin, 2008). As of the first half year of 2012, the M&A in China accounted for 38.4% of the total volume of M&A in Asia, which makes China the world's second largest M&A market after the US (Reuters, 2012). Of all M&A participants in China, high-tech, materials and new energy related firms are the three main industries (Reuters, 2012). Higgins and Rodriguez (2006) highlighted that M&A could lead to cost reduction and solve the distress of outdated technological pipelines. These benefits make M&A a popular form of competency reconfiguration, especially for latecomers whose technological capability is poor and easy to elapse during technological evolution. This helps explain why some latecomers choose not to achieve catching-up by their own R&D, but rather to integrate external R&D capability through M&A. Moreover, the need to catch up with fast-changing technology trends may encourage latecomers to substitute new blood from target firms for their existing competency. However, whether there is any possible substitution in M&A and its effect on the innovation performance of an acquiring firm remain inconclusive.

In the context of Chinese latecomers, this essay investigates the situation where both synergy and substitution are possibilities in M&A, as shown in the upper left-hand quadrant Figure 3-1. Figure 3-1 clarifies the four fundamental situations based on the two dimensions, namely (1) technology disparity and (2) technological capability. According to Jaffe (1986), substitution only exists among related technologies, while non-related technologies do not necessarily substitute each other but are only acquired for diversification. To fit this situation, this study sampled both Chinese target and acquiring firms within the high-tech sector of electronic and telecommunications to avoid the situation of technological non-relatedness. Moreover, this essay acknowledges the fact that, as latecomers, Chinese high-tech firms are initially resource poor and thus have relatively low technological capabilities, especially compared to firms from developed economies (Mathews, 2002). This gives an important scope to this study.

Figure 3-1. Situations for possible substitution in M&A

Technological Capability of Acquiring Firms	Technology Disparity: *Related*	Technology Disparity: *Non-related*
Low	Acquiring for synergy and/or substitution (*The possible substitution is the focus of this study)	Acquiring for diversification (*Not covered in this study)
High	Acquiring for synergy (*The existing studies in developed economies)	Acquiring for diversification (*Not covered in this study)

Specifically, this essay examines the post-M&A innovation performance of 100

Chinese listed firms with a focus on the effects of technology distance and relative knowledge base between the target and acquiring firm. This essay views technology distance as a proxy for the possible strategy intention of substitution. Equally important, the relative knowledge base influences the success of substitution towards a greater innovation performance. Furthermore, the interaction effect between the technology distance and relative knowledge base will be examined in the empirical literature for the first time. By presenting new empirical findings, this essay contributes to the strategic management literature on M&A and adds to the substitution perspective of latecomers, rather than solely relying on the traditional view of firms in developed economies.

3.2 Theory and Hypothesis

A growing body of literature has shown interest in refining the boundaries of external resources for technology development. Innovations led by external resources beyond a firm's existing technology domain have a significant influence on technology development (Rosenkopf and Nerkar, 2001). The creation of innovation along a distinct technology trajectory is mainly determined by motivations, existing competency and external resources (Cohen and Levinthal, 1994; Teece et al., 1997). By focusing on M&A strategies for latecomers, this essay investigates the motivations, qualitative and quantitative dimensions of knowledge, as well as its impact on subsequent innovation performance, in the context of emerging economies.

Motivation of M&A by Latecomers

As a form of external resource importation, M&A is primarily known as an important gateway to facilitate market entry and growth (Hitt et al., 1996). The rationale for M&A can be broadly categorized as either proactive motivations or adaptive motivations (Burns et al., 2005). Firms may engage in M&A due to proactive motivations such as increasing economies of scale or bringing in new technologies, R&D equipment and intelligence to enhance their R&D productivity. Under the pressures of economic and technological changes, firms are motivated to acquire other firms in order to adapt to fast-changing technology trends and reconfigure their competency.

To acquire or not to acquire is an important purchasing or self-making decision for acquiring firms. It was found M&A can help acquiring firms overcome resource constraints and promotes resource reintegration, thereby increasing the overall value of the knowledge stock by cost-cutting. According to a Centre Watch report (2000), acquiring firms, on average, experience a 34% reduction in R&D activities three years after M&A. This reduction of duplicate R&D is driven by resource reintegration, which implicitly assumes to substitute for the need to perform internal R&D. This might be a possible form of substitution, but most likely happen to technologically advanced firms: instead of throwing away their throwing away their existing technologies, they will try to integrate the newly acquired technologies with their existing technologies. However, there might be another form of substitution in the case of acquiring firms that are latecomers with relatively low level of accumulated technologies: the acquiring firm may stop using what it has already accumulated earlier, and switch to using the new technologies acquired through M&A instead. Indeed, it has been found that firms with relatively weaker technology pipelines, like latecomers, have a higher probability of undertaking M&A (Higgins and Rodriguez, 2006). Similarly, firms with inferior or outdated R&D portfolios, like latecomers, tend to engage in M&A (Danzon et al., 2007). It is also true that it usually take years for a latecomer to develop its own technological capability. As an alternative, M&A may enable a latecomer to speed up its competency reconfiguration. Thus, it is possible that the acquiring firm simply replaces its existing technological assets with that of the target firm. It is this second meaning of substitution that I would like to focus on in this study.

Technology Boundaries and Post-M&A Innovation Performance

M&A is associated with the process of integrating the internal resources of an acquiring firm and the external resources from a target firm. Innovation as an outcome of the integration process is closely related to the technology boundaries of the knowledge bases (Breschi et al., 2003). As firms tend to gradually increase their knowledge coherence by patenting in closely related technological fields

(Lippman and Rumelt, 1982; Breschi et al., 2003), great efforts are needed if a firm is active in two or more technology fields. It has been pointed out that in which direction a firm decides to develop its technological competency depends on linkages between technology fields (Lippman and Rumelt, 1982; Breschi et al., 2003). A firm's competency evolves by acquiring external resources. However, firms often have difficulties moving away from an existing technology track due to knowledge and organizational inertia. A firm's existing legacy leads to technology development along a particular path and may lock out opportunities to upgrade technological competency (Teece et al., 1997; Cohen and Levinthal, 1994). The efficiency of integration in M&A is maximized when there are no differences between the technology domain, cognitive range and form of thought (Nooteboom, 2000). However, a target and an acquiring firm are never identical, and the major differences can result in management difficulties during the integration process as well as innovation outputs. Acquiring a target firm with non-distant knowledge is recommended because the familiar knowledge is associated with common forms of thought, shared cognitive ranges and similar innovation routines (Spender, 1989; Kogut and Zander, 1996), and the similar knowledge elements will facilitate technological learning (Cohen and Levinthal, 1989; Lane and Lubatkin, 1998). In contrast, integrating distant knowledge can be resource-consuming (Haspeslagh and Jemison, 1991; Singh and Zollo, 1997).

The absorptive capacity theory has been widely employed in the organizational learning literature to explain the effectiveness of assimilating the unfamiliar knowledge (Cohen and Levinthal, 1990; Mowery et al., 1996; Ahuja and Katila, 2001; Tsai, 2001; Zahra and George, 2002; Lane et al., 2006; Makri et al., 2010). On one hand, the learning capability is enhanced when acquiring familiar knowledge (Cohen and Levinthal, 1990; Grant, 1996; Kogut and Zander, 1996). On the other hand, interaction with unfamiliar knowledge may lead to solving old problems in new ways, which is termed the "cross-fertilization effect" (Cohen and Levinthal, 1990; Ahuja and Katila, 2001). Ahuja and Katila (2001) suggested that integrating too similar knowledge could limit the benefits of organizational learning. Furthermore, they pointed that a moderate degree of relatedness between the acquired and existing knowledge benefits an acquiring firm the most by creating synergy in the post-M&A stage. Thus, Ahuja and Katila (2001) and Cloodt et al. (2006) found a curvilinear (an inverted U) relationship between the relatedness of the acquired knowledge and the subsequent innovation performance. It is worthwhile to mention that the studies by Ahuja and Katila (2001) and Cloodt et al. (2006) were under the context of developed economies where firms' technological capability is advanced. On average, latecomers from emerging economies are not so technologically advanced. This essay examines cases in emerging economies (i.e., China) and thus may expect to find a different function of using distant knowledge.

In line with the absorptive capacity argument, a lower level of knowledge accumulation makes it difficult for latecomers to achieve synergy when acquiring distant knowledge (Cohen and Levinthal, 1990; Grant, 1996; Kogut and Zander, 1996). When a latecomer acquires the non-distant knowledge, it reduces the integration cost of inappropriate routines and also enhances the technological learning that will allow it to delve deeper into a specialized domain (Berger and Luckmann, 1967). As the technology distance becomes shorter, acquired knowledge is more likely to enhance the latecomers' exploration capability for continuous innovation, especially the innovation with shared technology domains. Thus, I propose Hypothesis 1:

H1. Technology distance has a negative effect on the subsequent innovation performance of an acquiring firm.

Quantitative Dimension of Knowledge and Post-M&A Innovation Performance

Despite the importance of technology distance, the quantity of acquired knowledge remains a preliminary condition for a firm to benefit from M&A. In the pre-M&A stage, the accumulative existing knowledge of the acquiring firm determines its absorptive capacity to integrate external resources (Ahuja and Katila, 2001; Cloodt et al., 2006). Ideally, the acquired knowledge from the target firm is added to the existing knowledge pool of the acquiring firm and becomes part of the integrated absorptive capacity after M&A (Ahuja and Katila, 2001; Cloodt et al., 2006). However, the transition of organizational forms during the integration process can be risky (Amburgey et al., 1993; Capron, 1999), since either the acquired knowledge or existing knowledge has been encapsulated in certain skills and routines (Nelson and Winter, 1982). During the integration process, the acquired knowledge base needs to transition and be united with the existing organizational forms. A large quantity of acquired knowledge usually results in a high level of organizational disruption due to management distrust, business model differences and other inherent routine differences. Even if the transition period is not long-lasting, the subsequent benefits in terms of innovation under the newly shared organizational form are at risk (Kogut and Zander, 1996). This risk can be significant, especially when the existing knowledge base is not large enough to absorb the acquired one. Thus, the relative knowledge base between the size of the knowledge base of a target firm and that of an acquiring firm has been identified as a critical integration factor influencing post-M&A innovation performance (Ahuja and Katila, 2001; Cloodt et al., 2006). Ahuja and Katila (2001) and Cloodt et al. (2006) have suggested a negative relationship between the relative knowledge base and the subsequent innovation performance of acquiring firms in developed economies. In comparison with developed economies, the management culture of emerging economies, such as power distance and uncertainty avoidance in China, may result in a lack of incentives in cross-organizational integrations (Hofestede and Bond, 1988; Pieper, 1990). This management culture, which profoundly influences the individual, group and organizational behaviors, may cause further organizational disruptions in the integration process. Thus, my theory in the context of emerging economies suggests the same: the integration process occurs fitfully when there is an overload of the acquired knowledge (as the notion of high relative knowledge base), and the subsequent integration difficulties impair the innovation activities and potential growth.

Needs of Integration and Post-M&A Innovation Performance

There has been mounting concern of the ways to promote a firm's post-M&A innovation performance. The existing literature consistently supports that an acquiring firm should create innovation together with a target firm by capturing synergies, but should not to acquire an innovative firm with unfamiliar technology for diversification (Jensen and Ruback, 1983; Jarrel et al., 1988; Andrade et al., 2001; Akbulut and Matsusaka, 2010). For instance, Andrade et al. (2001) and Akbulut and Matsusaka (2010) found that undiversified firms are valued higher than their diversified counterparts after M&A. The above strategy is based on the assumption that the main strategic goal of M&A is to achieve synergy (Lewellen, 1971; Brunner, 1988; Pautler, 2001; Leland, 2007). This may be true in developed economies where firms undertake M&A for the subsequent synergy value because it can extend its existing competency. However, latecomers in emerging economies have a different reason for engaging in M&A. Due to the concern that latecomers are not technologically advanced, they are more likely to take root by acquiring unfamiliar technology from an innovative firm and using it as it is.

However, the strategy that latecomers undertake in M&A tends to be substitution, not diversification. Scholars have investigated the phenomenon of the "diversification discount" where the value of a firm that pursues diversifying

M&A activities declines (Campa and Kedia, 2002; Lamont and Polk, 2002 and Villalonga, 2004). This phenomenon has been articulated since the fall of diversifying M&A in the 1950s (Shleifer and Vishny, 1991; Matsusaka, 1993; Akbulut and Matsusaka, 2010). The common cause of this value destroying effect associated with diversifying M&A is the limitation of resource exchange where only a small part of the existing and acquired knowledge is involved in the post-M&A integration process. Despite the integration efforts, the indigestibility of the non-integrated parts, which is mostly attributed to the unfamiliar knowledge, from the target firms results in organizational disruption and hurts the value of the acquiring firm (Hennart and Reddy, 1997). It should be noted that the acquiring firms generally have negative abnormal returns in M&A diversification, whereas the target firms can have positive abnormal returns (Jensen and Ruback, 1983; Jarrell et al., 1988; Andrade et al., 2001). Technologically laggard firms, such as latecomers from emerging economies, may just replace their existing competency with that of the target firm; therefore, integration is not necessary in the post-M&A stage. If there is no integration of the acquiring and target knowledge bases, I predict there will be substitution.

This essay examines the requirements for integrating the two knowledge bases via the joint effect of the two integration factors, namely the technology distance and relative knowledge base. The possibility of integration decreases as the technology characteristics of the two knowledge bases become incompatible with each other. As the technology distance between the target and acquiring firm increases, the acquired knowledge becomes more likely to be from outside the explorative scope of the existing absorptive capacity, and thus the compatibility of the two knowledge bases collapses. On the other hand, the practical needs of organizational integration are associated with the initial strategic selection during M&A. The cost of organizational integration depends on the size of the two knowledge bases: the larger the acquired knowledge base, the higher the integration cost, e.g., time and efforts, that the existing organization must pay to prevent organizational disruption. Thus, the needs of integration further decreases as the acquired knowledge base grows relative to the existing one (as the notion of relative knowledge base). To obtain the benefits of M&A, latecomers can reduce integration costs by eliminating the outdated technology and shifting their R&D focus to the emerging field. Some latecomers may choose to simply add new businesses and replace existing technology with the new R&D because they do not need to be integrated.

Under the circumstance of non-integration, latecomers do not need to worry that the overload of the acquired knowledge base will impair its existing competency. Sevilir and Tian (2012) found evidence that acquiring the target firms with greater R&D intensity and knowledge accumulation significantly boosts the subsequent returns. That is, when acquiring distant knowledge, the sizeable knowledge base of the target firm helps the acquiring firm achieve better innovation in the possible new direction. Given that latecomers have difficulties in integrating unfamiliar technologies in Hypothesis 1, latecomer may opt to mitigate this need of integration by resorting to acquiring the external technologies to substitute (replace) it own technologies instead. The success of this substitution is more likely to appear when the acquired distant knowledge base is relatively larger than the existing one, because the large relative knowledge base not only can further reduce the needs of integration but also help promote innovation after substitution. Therefore, when the relative knowledge base is getting larger and the technology distance is getting longer, increased innovation could result in the post-M&A stage.

Based on the above arguments, I propose Hypothesis 2:

H2. The relative knowledge base positively moderates the relationship between the technology distance and the subsequent innovation performance of an acquiring firm.

3.3 Data and Methodology

3.3.1 Sample and Data

The source for M&A activities was originally based on the Taiwan Economic Journal (TEJ) database. Sample selection started with the entire population of listed Chinese firms in the observation period from 2003 to 2008 in the high-tech sector of electronic and telecommunications, which includes the electronics, IT, mobile and telecommunications industries. Years prior to 2003 were excluded from the sample due to the absence of M&A activities recorded in the TEJ database. The dataset contains the names of the acquiring and target firms, the merger year and the year the acquiring firm was established. After carefully selecting the target firms without technology disparity from the TEJ database (Jaffe, 1986), the initial panel sample consisted of 100 firms, 208 firm-year observations, and 1210 M&A deals. Next, I added the patent and firm heterogeneity data to the panel. Data related to the firms' patent information was obtained from the State Intellectual Property Office of China (SIPO) database and additional firm heterogeneity information, such as the number of employees in the acquiring firm, the number of R&D employees in the acquiring firm and the registered capital on initial public offering (IPO), was collected from annual reports. Finally, I processed the relevant data according to the following variable definition for numerical analysis.

3.3.2 Variables

Dependent Variable

Innovation performance: The number of patents has been widely used as a measurement of innovation performance in prior empirical research (Henderson and Cockburn, 1994; Ahuja and Lampert, 2001; Hall et al., 2001). Thus, I adopt this variable and use patent generation as a proxy indicator of the innovation performance for each acquiring firm. I count the number of patents applied for by each licensee within one, two and three years after the M&A year. The average number of patents generated by each licensee within two years after the M&A year is considered the dependent variable. The number of patents generated within one year and three years after the M&A year is used in the robustness test.

Independent Variables

Technology distance (TD): This variable is a knowledge-relatedness measure between every two patents by the target and acquiring firm. All patent applications in SIPO are observed for a period of three years prior to the M&A year. In line with Jaffe's (1986), Engelsman and van Raan's (1992) and Breshi et al.'s (2003) measure of knowledge-relatedness, technology distance is computed by

Technology distance = 1-S;

$$S = \frac{\sum_{k=1}^{n} A_k T_k}{\sqrt{\sum_{k=1}^{n} A_k^2}\ \sqrt{\sum_{k=1}^{n} T_k^2}}$$

where A_k is the number of patents by the acquiring firm that are classified in primary technological field *k*, T_k is the number of patents by the target firm that are classified in primary technological field *k* and *n* is the maximum number of classification codes. The classification codes are collected from the three stages of IPC codes of each patent that the target and acquiring firm applied for in SIPO. The cosine index S represents the co-occurrence of the acquiring and target firm;

the greater the S value, the more the target and acquiring firm co-appear in the same technological field.

Moderating Variable

Relative knowledge base (RKB): This variable is a ratio obtained by dividing the knowledge base of the target firm by the sum of the knowledge base of the acquiring firm and the prior acquired knowledge base of the target firm. The knowledge base of the target firm is the cumulative number of patents applied for by the target firm in SIPO three years prior to the M&A year. The knowledge base of the acquiring firm is the cumulative number of patents applied for by the acquiring firm in SIPO three years prior to the M&A year.

Control Variables

Number of M&A: Many researchers (Henderson and Cockburn, 1996; Ornaghi, 2006; Danzon et al., 2007) have studied the effects of M&A on the subsequent R&D performance and found both negative and insignificant effects, though negative effects seem dominant. Thus, I control for total number of M&A deals per year over the observation period from 2003 to 2008.

R&D capability: Prior research has shown that innovation performance is directly associated with R&D capability (Cohen and Levinthal, 1989; Griliches, 1998). The number of R&D employees, R&D expenses and knowledge stock have been widely adopted as measures of the R&D capability of a firm. I use the number of

R&D employees of each acquiring firm as recorded in the annual report as the control variable. In practice, there is no official record of R&D expenses in the annual reports of Chinese listed firms. However, I am able to count the number of patents applied for by the acquiring firms during the three years prior to the M&A year and use it as the measure of the R&D capability in the robustness test.

Firm size: Early studies have reported that firm size influences innovation performance (Ettlie and Rubenstein, 1987; Cohen and Levinthal, 1989; Henderson and Cockburn, 1996). The number of employees has been used as a measure of firm size in empirical studies (Atuahene-Gima, 1993). Thus, firm size is defined as the total number of employees recorded in the acquiring firm's annual report.

Registered capital: The initial capital status is important to a firm's performance, especially to latecomers with resource constraints. I include registered capital as a control variable to control for the financial capital of each acquiring firm. The recorded registered capital is the amount of money registered with the acquiring firm when the IPO occurred.

Location dummy: Schoenberg (2000), Cartwright (2005) and Phene et al. (2006) have shown that whether an acquisition is domestic or foreign affects the subsequent innovation performance. Thus, I include this location dummy in the control variables. If the M&A is domestic, the value is defined as 0; if the M&A is international, the value is defined as 1.

3.3.3 Methods

This study uses a negative binomial regression analysis, which is the same as the method in Essay One, because the dependent variable is measured by a countable number of patents. In this study, the tested dataset is a firm-year panel. A Hausman specification test[9] is conducted to decide whether to use a random-effects model or fixed-effects model (Hausman et al., 1984). As the results of the Hausman test are insignificant, I use a negative binomial regression analysis with a random-effects model. A sensitivity analysis is later carried out to test the firmness of the results.

3.4 Results

Table 3-1 presents the descriptive statistics and correlations of all the variables. The mean value and relative standard deviation of the dependent variable show more than a five-fold difference, which confirms the choice to use a negative binomial regression rather than a Poisson regression in this study. Moreover, the independent variables of technology distance and relative knowledge base are, for the most part, not highly correlated with the control variables.

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[9] This method contrasts with the fix-effects and random-effects models and it helps choose the random-effects over the fix-effects model in this study for methodological reasons. The fixed-effects model is limited to estimations of samples that have variation in the dependent variable over time. However, in my sample, some firms would be dropped out because they have no patents during the observation period. Moreover, the random-effects model has the advantage of estimating time-invariant dummy variables such as the location dummy.

Table 3-1. Descriptive statistics - Mean, standard deviation and correlations

Variables	Mean	Standard deviation	1	2	3	4	5	6	7	8
1. Innovation performance	166.981	1158.819	1							
2. TD	.850	.317	-.052	1						
3. RKB	1.129	4.287	-.035	-.352**	1					
4. Number of M&A	5.817	10.492	.349**	-.307**	.082	1				
5. R&D capability	658.111	1772.471	-.049	-.110	.069	.023	1			
6. Firm size	2871.966	7286.195	. 653**	-.133	-.005	.251**	.673**	1		
7. Registered capital	90044.7	252922.2	.132	-.085	-.025	.042	.891**	-.093	1	
8. Location dummy	.0384	.180	.343**	-.160*	.113	.344**	.080	-.017	.046	1

**. Correlation is significant with the P value of 0.01 (2-tailed, significant at 10%)
*. Correlation is significant with the P value of 0.05 (2-tailed, significant at 5%)
Number of observations (N) = 208.

Table 3-2. Negative binomial regression
(Dependent variable = Innovation performance)

Variables	Model 1	Model 2a	Model 2b	Model 3a	Model 3b
		H1		H2	
Number of M&A	-.0034 (.0065)	-.0082 (.0107)	-.0188 (.0116)	-.0068 (.0106)	-.0182 (.0118)
R&D capability	.00010 (.00020)	.00018 (.00016)	.00021 (.00016)	.00042* (.00023)	.00039* (.00024)
Firm size	.00007*** (.00002)	.00009** (.00004)	.00009** (.00004)	.00004** (.00004)	.00009** (.00004)
Registered capital/1000	-.0021 (.0017)	-.0034** (.0015)	-.0034** (.0014)	-.0051*** (.0019)	-.0046** (.0020)
Location dummy	.951* (.497)	-.0329 (.578)	.170 (.591)	.0047 (.514)	.0915 (.559)
Constants	-.219 (.241)	.816** (.325)	.125 (.505)	1.009*** (.332)	.413 (.506)
TD		-1.293*** (.286)	4.142 (2.846)	-1.501*** (.304)	4.328 (2.788)
TD^2			-4.817* (2.495)		-5.115** (2.447)
RKB				-.0772** (.0318)	-.0192 (.0488)
TD*RKB				.216** (.0915)	-.178 (.246)
TD^2*RKB					.447* (.096)
Wald chi2	32.25	48.91	54.25	53.49	64.01
Log likelihood	-624.297	-614.598	-612.968	-611.891	-608.936

***P<0.01, **P<0.05, * P<0.1(two-tailed)
N=208; STANDARD ERRORS IN BRACKET

Table 3-2 shows the results of the negative binomial analysis with the estimators of Log likelihood and Wald chi-square. The likelihood ratio tests for all the models are within three significance levels (1%, 5% and 10%, two-tailed). Model 1 shows the basic model with all of the control variables. Of the control variables, firm size and location dummy show a significant positive effect on the dependent variable of innovation performance while the number of M&A has an insignificant effect on the post-M&A innovation performance, which is consistent with prior findings (Henderson and Cockburn, 1996; Danzon et al., 2007). The other control variables also show insignificant effects.

Model 2 includes the key independent variable of technology distance and tests its impact on the post-M&A innovation performance. The result from Model 2a shows a significant negative effect ($P<0.001$), thereby supporting Hypothesis 1. This is the primary hypothesis to determine if acquiring firms have difficulties integrating target firms from distant technology domains. Hypothesis 1 indicates that acquiring firms have the strategic intention of using substitution when a target firm is chosen from a distant technology domain. In Model 2b, I added the variable of technology distance and squared it to test the curvilinear effect. Since the result shown in Model 2b is not significant, I dropped the squared variable in the analysis of the full model.

The M&A behavior of one of the latecomers examined in the sample –

UTStarcom[10] – supports my prediction of Hypothesis 1. Since 1997, UTStarcom's fame has risen due to its seizure of the Personal Handy-phone System (PHS) in China. In the late 1990s and early 2000s, PHS was a low-end technology and UTStarcom's only product, and its sales made up nearly 80% of the firm's total revenue. When China's Ministry of Information Industry lifted its ban on the penetration of PHS in 2003, many competitors appeared due to the low entry barriers, and, as a result, the revenue of UTStarcom dropped dramatically. Thereafter, UTStarcom decided to find new growth to differentiate its production line. To do so, UTStarcom changed their R&D focus to CDMA, a high-end technology and compeletely different terminal solution (one of the 3G solutions) from PHS. Since 2003, UTStarcom has begun around 50 M&A in order to reconfigure their competency. For example, in the early 2003, UTStarcom spent US$100 million on purchasing part of CommWorks, the subsidiary of 3COM in China, which was a dominant CDMA supplier in China. In 2004, UTStarcom acquired the mobile sector from Audiovox Communications Corp. and the CDMA equipment supplier Syscomm under Korea's Hyundai Corp. at the cost of US$165 million, as well as the firm, Telos from Canada. These targets from different countries supported the entire value chain of CDMA terminals, which supposedly would lift UTStarcom's business performance. However, no matter how UTStarcom tried to integrate CDMA terminals as their core business, it was too

[10] The data of UTStarcom case are collected from the following firm website and online report: http://www.utstar.com.cn/; Liu, H.F. and Yu, J.Y. 2010. Life and Death—UTStarcom's strategy (original title: 生死"小灵通"—UT 斯达康之路). Modern Reading Magazine (现代阅读), 10.

hard to compete with other strong competitors in the cell phone market. As of 2006, UTStarcom has almost given up the business of CDMA terminals.

In Model 3a, I added the moderating variable of relative knowledge base, and further tested the interaction between this variable and technology distance. Model 3a employs all of the variables and presents the final analysis of this study. Though Model 3b tests the moderating effect of the relative knowledge base based on Model 2b, there are no clear results and thus it will not be further discussed.

The result of Model 3a are consistent with the earlier studies (Ahuja and Katila, 2001; Cloodt et al., 2006) which found that the relative knowledge base has a negative impact ($P<0.05$) on innovation performance. A fitting analogy to this phenomenon would be a lion trying to swallow an elephant, even though it lacks a big enough stomach. Merging with a firm that has a strong and large technological capacity requires extra resources to repair the disruptions, such as disruptions to the organizational routines (Hitt et al., 1996). These repairs may result in management difficulties for the newly integrated firm. Due to similar reasons, the cases of the mergers between TCL[11] (a large Chinese cell phone and TV producer) and Alcatel (a world player in the cell phone market) as well as TCL and Thomson Electronics Corp. (a world player in the TV market) in 2004 both ended with huge

[11] The data of TCL case are collected from the following firm website, online report and academic paper: http://www.tcl.com/en.php/news/about/id/143.html; http://baike.baidu.com/view/5085.htm; Su, L.F. and Zhang, Z.L. 2007. The cross-border M&A of TCL: Only for internationalization? (original title: TCL 的跨国并购：为国际化而国际化？) *Economics and Management* (经济与管理), 21(9): 38-43.

losses. However, the merger between Lenovo[12] (a Chinese PC producer) and IBM PC (a world player) in 2005 was considered successful by Lenovo's CEO, based on the maintenance of their market share and stock price. It is reasonable that management capabilities may affect the rate of success of M&A. However, there is no doubt that with acquiring a larger volume of assets will also come additional management challenges for the integrating firm, even though the giants, such as Alcatel, Thomson and IBM PC, bring benefits such as brand awareness, sales channels and IP that aid the acquirers' internationalization.

In Model 3a, Hypothesis 2 is verified by the results of the positive coefficient ($P<0.05$) between the interaction term (between technology distance and relative knowledge base) and the post-M&A innovation performance. The interaction plots based on Model 3a lends further support to my prediction, as shown in Figure 3-2. Figure 3-2 shows that acquisitions with a relatively small technology base (the minimum value of 0 in the sample) lead to a decrease in the post-M&A innovation performance as the technology distance between a target and an acquiring firm increases. This is the case for most firms as the relative technology base is relatively small. In contrast, acquiring targets with a relatively big technology base (the maximum value of 10 in the sample) leads to an improvement of the technological performance as the technology distance increases. This may appear to be at odds with arguments that found a decreasing absorptive capacity with

[12] The data of Lenovo case are collected from the following online reports:
http://en.wikipedia.org/wiki/Lenovo; http://industry.caijing.com.cn/2013-03-21/112610222.html

increasing technology distance (Nooteboom et al., 2007). However, this phenomenon can be explained by the fact that firms that acquire targets with strong technological assets at a large distance from their existing technological competencies do not need to integrate the two technology bases. It may be the case that the old technology is replaced by the technology of the target firm. A second characteristic of the figure is that for very small technology distance (<0.35) a higher relative technology base of the target firm implies a poorer innovation performance; at higher values of technology distance the opposite is true. This confirms that, when the acquired technologies are not too distant from existing technologies, the latecomers are likely to try to achieve synergy between the acquired and own technologies, but when technology distance is high, they are likely to switch to a substitution approach instead (i.e., positive values for high technological distance combined with a large relative technology base of the target).

This substitution can be illustrated using an example of China's top management solution provider, namely UFIDA[13]. Their growing-up story through M&A further evidences the finding in Hypothesis 2. In UFIDA's early days (1997-1998), its product development focused on middleware platform and ERP software. However, because the middleware platform market was dominated by giants like

[13] The data of UFIDA are collected from the following firm website and online reports: http://www.yonyou.com/about/index.aspx; http://business.sohu.com/50/13/article205611350.shtml; http://tech.sina.com.cn/s/n/2003-08 25/1140225041.shtml

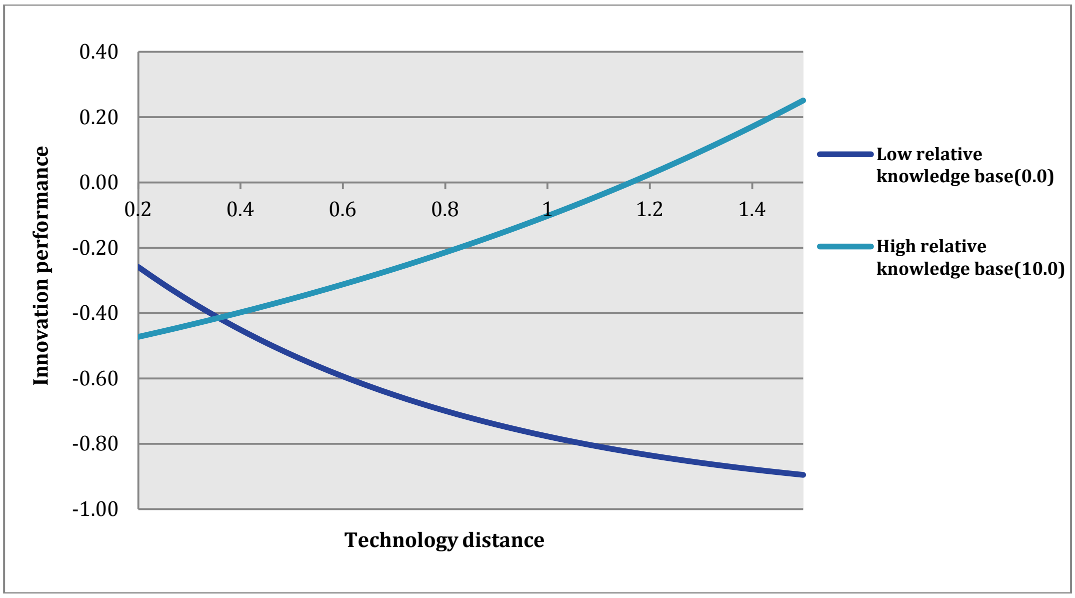

Figure 3-2. Interaction plots

IBM and Oracle, UFIDA decided to give up self-developing middleware platform and cooperate with IBM's Websphere platform instead. Since then, UFIDA has concentrated on ERP development for local enterprises where their technology capabilities have a good reputation and they can enjoy more localized advantages than foreign competitors. Thus, UFIDA acquired several domestic firms to facilitate specialization in ERP solutions. When UFIDA was established in 1988, the financial module in its existing enterprise software was the only product. Gradually, UFIDA added in new management modules by integrating with stronger counterparts. For example, in 2003, UFIDA acquired Beijing Huili IT Ltd. and Beijing AnYi Software Ltd., two strong players in the management software industry that specialize in production capital and e-commerce management respectively. Over the following three years, the new ERP modules in production capital and e-commerce leveraged the market potential and helped UFIDA gain the majority share of the Chinese ERP software market. In 2006, UFIDA's market share even rapidly rose to 21%, completely surpassing other domestic and foreign players. This prominent performance shows that the above acquisitions helped UFIDA successfully substitute middleware platform with ERP development.

Several robustness tests confirmed the accuracy of the results. First, the analysis of the full models assessed changes in the dependent variable of innovation performance by adjusting the period of the patent counts from one year to three years after M&A. Second, the number of R&D employees was replaced by the existing knowledge base of the acquiring firms. Third, I changed the relative knowledge base to the total acquired knowledge base from the target firms. The estimated coefficients from the above three independent tests all produced similar empirical results, which support both Hypothesis 1 and Hypothesis 2.

3.5 Discussion and Summary

This essay has investigated the substitution effect in M&A in emerging economies for assisting latecomers' competency building. Using China as the context, I identified how latecomers' strategic choices differ from the smooth acquisition process of related technologies and found the contingencies where the substitution effect can improve the post-M&A innovation performance. The striking finding is that when the technology distance between a target and an acquiring firm increases, a greater acquired knowledge base will reverse the negative effect of technology distance on innovation performance. The results reveal that M&A can create a more flexible set of strategic choices than simply aiming for the incremental complements portrayed in the traditional view of the synergy effect. Overall, acquiring for substitution is also an important alternative strategic choice for acquiring firms.

This essay has made the following empirical contributions. Although prior literature has investigated the impact of technology similarity and relative knowledge base on innovation performance, this essay is among the earliest to examine their interaction effect on innovation performance in the M&A literature. The finding of the negative effect of relative knowledge base on post-M&A innovation performance is consistent with earlier works (Ahuja and Katila, 2001; Cloodt et al., 2006). However, I found a negative effect between the technology distance and post-M&A innovation performance in emerging economies. This result is not entirely surprising because the prior finding of a curvilinear correlation between technology similarity and innovation performance was based on developed economies (Ahuja and Katila, 2001; Cloodt et al., 2006). Unlike acquiring firms in developed economies, latecomers in emerging economies often lack the absorptive capacity to integrate distant knowledge from target firms. Furthermore, this essay proves the fact that the acquired absorptive capacity tested by the relative knowledge base plays an important moderating role in the relationship between the technology distance and the post-M&A innovation performance.

Finally, I would like to acknowledge the caveats in this essay. First, of all the situations in Figure 3-1, this study focused on the substitution effect in M&A among latecomers within the scope of technological relatedness in emerging economies. Besides well-established research in firms within the scope of technological relatedness in developed economies, another two situations of acquiring target firms with technological disparity are left for future research. Second, the basic argument of this study has been based on the assumption that acquiring firms obtain the target firms with valuable assets (as the notion of a “good buy”). Because the assets of the target firms are undervalued by the market, the potential of a “good buy” motivates the acquiring firms to undertake M&A (Pautler, 2001). Despite the good intention, the actual value of the assets is not measured in this study, because there is insufficient data to introduce a variable that measures the value of the sample firms. Since this study employs patent data as a proxy of the innovation performance, patent citations can be measured as the value of innovation. Unfortunately, there is missing citation data from the period 2004-2007 in the SIPO database. This suggests the need for further research on the value laggards between a target and an acquiring firm, as well as the need for more fine-grained measures of technology bases.

CHAPTER 4.

COMBINING OPEN INNOVATION AND DISRUPTIVE INNOVATION

4.1 Introduction

With the growing importance of emerging economies, disruptive innovation (DI) has attracted renewed attention in the literature. The DI theory has been articulated as a powerful means for latecomers to "attack from below" and eventually overtake the global market by introducing simple, convenient and low cost products (Christensen, 1997; Adner, 2002; Charitou and Markides, 2003; Christensen and Raynor, 2003; Gillbert, 2003; Govindarajan and Kopalle, 2006; Yu and Hang, 2010). When a latecomer introduces a disruptive technology into the marketplace, it results in competition with the incumbents and can potentially make the latecomer the new market leader. Prior research has emphasized this aspect of head-on competition (Christensen, 1997). Thus, DI has been analyzed from the perspective of either the latecomer or the incumbent (Christensen and Raynor, 2003; Utterback and Acee, 2005; Govindarajan and Kopalle, 2006). The possible interaction that occurs between the two has not been examined and remains a gap in the DI research.

The latecomer-incumbent cooperation does occur and this cooperation has been examined in other types of discontinuous technological change. For instance, Spedale (2003) investigated the types of cooperation that take place between latecomers and incumbents in response to the introduction of a radical technology, specifically the application of Fibre-optics in optical communication. However, the results might not be applicable to disruptive technology, which is very different from radical technology. Recently, Hüsig and Hipp (2009) explored whether incumbents could integrate the potential disruptive technology – WiFi, in order to complement the existing product towards the development of sustaining innovation. This internal-external resource integration strategy described as open innovation (OI) (Chesbrough, 2003), is known to benefit incumbents at large. However, latecomers who have resource constraints (Mathews, 2002) may also choose to undertake OI to access external resources and to cooperate with incumbents in DI development because incumbents usually do not pursue their own DIs owing to asymmetric motivation (Christensen, 1997; Yu and Hang, 2010).

Existing studies (Spedale, 2003; Hüsig and Hipp, 2009) have examined the latecomer-incumbent cooperation only in relation to the goal of sustaining innovation, whereas this essay will study this collaboration aiming at creating DIs. This present study will also go beyond the telecommunications industry to cover cases in a number of high-tech industries. From a latecomer's perspective, I raise the following research questions:

(1) Whether latecomer disruptors could cooperate with incumbents (i.e., use OI) to commercialize DI?
(2) If so, what are the conditions for a successful cooperation?

The research questions are addressed through multiple case studies describing the experience of latecomers in China's high-tech industries. From these case studies, I have discovered that DI does not always lead to competition between latecomers and incumbents and that collaborative ties can be important in determining the market success of DI. The cases have also enabled me to analyze the favourable conditions under which OI can combine with DI and to explore the benefits for latecomer disruptors and incumbents to undertake OI.

4.2 Theory Background

4.2.1 Latecomers' Disruptive Innovation Path

To achieve catching-up, latecomers frequently adopt DI into their business models (Christensen and Raynor, 2003; Wu et al., 2010) to establish a market foothold with a new disruptive technology. The disruptive product or service disrupts the market by attacking the over-served market from the low-end or by stimulating a need that expands the market (Christensen, 1997; Utterback and Acee, 2005). The disruptive technology is typically inferior on many attributes compared to products in the mainstream market, but makes up for this deficit with features that are attractive to the low-end or a new market (Christensen, 1997). As there are usually many latecomers competing in the same market segment, this essay clearly distinguishes the two stages in the DI path (as shown in Figure 4-1): the foothold stage when the latecomer initially enters the market; the competitive stage when the latecomer competes with other disruptors. A vast portion of the DI literature elaborates the foothold stage with respect to how latecomers gain a foothold in a market, and pays less attention to the competitive stage which has been widely implied but not explicitly emphasized (Christensen, 1997; Rafii and Kampas, 2002; Christensen and Raynor, 2003; Christensen et al., 2004; Keller and Hüsig, 2009). For a DI to be successful, the technology on which it is based should improve continuously throughout the competitive stage. Latecomers are often challenged by two types of firms, fast disruptive followers and incumbents. Competition with fast disruptive followers usually occurs early in the competitive stage, while competition with incumbents usually occurs later once the disruptive technology has threatened the incumbents' established business. An incumbent's position may be disrupted, if the performance of the latecomer's product or service reaches a level acceptable to the mainstream market after traversing the entire DI path.

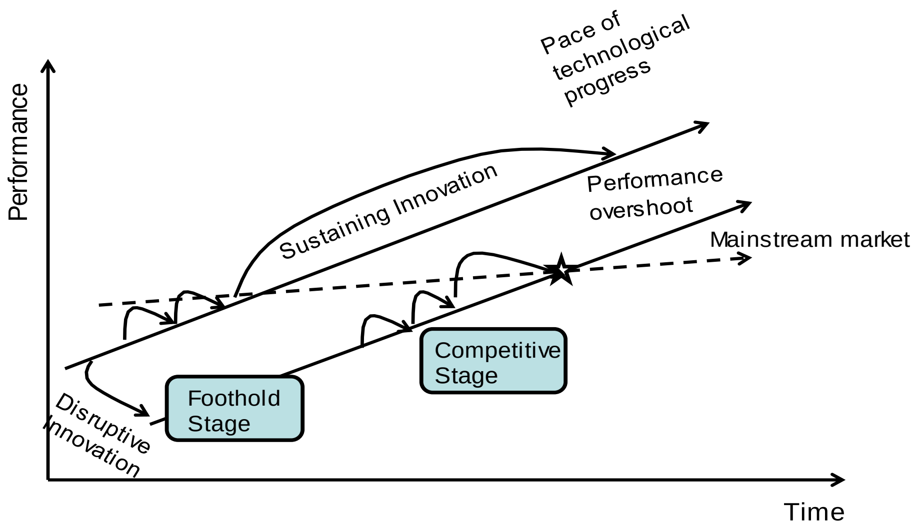

Figure 4-1. Two-stage disruptive innovation path

4.2.2 Latecomers' Perspective of Cooperation

One of the main challenges for latecomers is shortage of technology (Mathews, 2002, 2006). To compensate, they may cooperate with incumbents to tap into advanced technologies and bypass steps in the technology trajectory in order to catch up quickly (Lee and Lim, 2001). The strategic goal of latecomers is to raise their position towards market leadership by swift innovation (Lim, 1997; Mathews, 2002). Latecomers have a competitive advantage in exploiting emerging opportunities and responding to relevant technologies compared to incumbents who are often locked into existing business and sustaining innovation (Christensen, 2006; Henderson, 2006). However, latecomers rarely have the ownership advantages enjoyed by incumbents that are needed to develop technology and leverage the commercialization. By cooperating with incumbents, latecomers may pursue their goal of catching-up and eventually rising to the top of the market. Therefore, it is critical for latecomers to cooperate strategically with incumbents to complement their missing resources.

Building on Teece's (1986) framework regarding the two key drivers that affect the cooperation strategies and outcomes of innovators – complementary assets and appropriability regime – this study tries to understand whether latecomers can cooperate with incumbents in commercializing DI and raise their market position.

Complementary assets such as distribution networks, service capabilities, complementary technologies, brands and competitive manufacturing are necessary in commercializing a technology (Teece, 1986; Gans and Stern, 2003). The existing players in the market always leverage their pre-emption rights of those complementary assets (Lieberman and Montgomery, 1998). If complementary assets are owned by a competitor or a third party, it is critical for latecomers to obtain them through cooperation so that they can rapidly commercialize their innovation. For instance, having been the world's manufacturers for many years, some Chinese latecomers have accumulated the necessary capacity in the downstream of value chain to appropriate value from innovations in the local market. However, unlike the incumbents, they generally do not have other complementary assets, especially the brand, distribution channels and complementary technologies. Cooperation with incumbents may, under particular circumstances, be the easiest route for latecomers to obtain the missing complementary assets, so that they can rapidly grow and capture the local market. Though this can be difficult in the same market segment, it may be attractive to incumbents in a new market, especially given the large population of potential customers in China.

Appropriability regime is the other important driver that has been identified to shape cooperation between latecomers and incumbents, especially in high-tech industries (Teece, 1986; Gans and Stern, 2003). Appropriability regime refers to an environment that allows markets for technology to coalesce and function efficiently (Teece, 1986). In the context of a sole country such as China, firms share the similar state of democracy and economic environment that determine the degree of appropriability regime (Liu, 2005). Looking into the functional content, appropriability regime has been regarded as a function of the legal intellectual property rights regime (Orozco, 2007). Intellectual property (IP) is an exclusive right for the creator of IP to capture value over the use of an invention or technology (Wagner, 2003). IP is protected primarily to stimulate the transfer of technology in the form of licensing, joint venture and foreign direct investment (Gould and Gruben, 1996). This involves technology markets where IP rights and contracts are well defined, litigation is predictable and damages can be assessed. In addition, appropriability regime is also a function of the degree to which the technology behind the innovation is tacit, i.e., the degree to which it is imitable (Orozco, 2007). Teece (1986) demonstrated that tacit or poorly codified knowledge is harder to transmit and harder to appropriate. Because the ownership of technology is a major incentive for cooperation between firms, this study mainly concentrates on the transferable part of the appropriability regime, namely IP.

In the field of discontinuous technological change, early contributions by Spedale (2003) gave evidence for the existence of cooperation strategies for both new entrants (as the notion of latecomer in this context) and incumbents at times of radical technology. Spedale (2003) found that incumbents tend to undertake structured cooperation (at inter-organizational level) with the latecomer for the new technology and apply the technology to their traditional market (market-pull strategy). Whereas, the unstructured cooperation (at individual level) is likely to appear in the specialist niches where latecomer with new technology tends to concentrate (technology push). As the other type of the discontinuous technology, disruptive technology has also been found to have an enhancing effect on the existing sustaining innovation for incumbents who cooperates it (Hüsig and Hipp, 2009). However, little research has been done on cooperation for developing DI, especially from latecomers' perspective. Since the latecomer characteristics discussed above may be applicable to DI, the dynamics underlying this cooperation between latecomer disruptors and incumbents will be discussed in the next sub-section.

4.2.3 Dynamics between Latecomers and Incumbents in Disruptive Innovation

Earlier studies have investigated how latecomers' DI may cause incumbents to lose their dominant position (Christensen, 1997, 2006; Christensen and Raynor, 2003; Henderson, 2006; Wu et al., 2010; Yu and Hang, 2010). Christensen (1997) found that incumbents have a hard time sensing or appreciating DI opportunities and therefore tend to ignore them. Limited by their organizational routines and sole focus on existing customers, incumbents may miss new market trends and make wrong decisions about future directions. The incumbents are preoccupied with competitors in sustaining innovation and usually do not pay enough attention to the disruptive power especially in the low-end market. This ignorance gives latecomers an opportunity to start and grow. Thus, DI creates avenues for latecomers to enter from the low-end or create a new niche market. Incumbents are rarely motivated to pursue DI because their existing customers are not interested in the initially inferior DI products and the DI market is often associated with a small group of under-served customers who are not seen as particularly profitable. However, Christensen (1997) found that the disruptive technology will improve over time and its performance may eventually be improved to a level suitable for the mainstream market. By competing from an unexpected direction, latecomers may gradually catch up with and out-compete incumbents who only monitor competitors in the sustaining direction in the existing market (Afuah and Utterback, 1991; Christensen, 1997).

Although incumbents often miss DI opportunities, this does not imply that latecomers may take it for granted that their DI efforts will be successful. If latecomers can develop their own disruptive technology and successfully commercialize it, they could capture the overlooked market. However, if latecomers simply have disruptive ideas based on more recent knowledge, without the ability to quickly realize them, they may attempt to cooperate with incumbents in order to gain access to their complementary resources, e.g., manufacturing technology, distribution channels, etc. In the same situation, a small entrant firm may have capability to gain a foothold in disruptive innovation, but insufficient resources to compete and grow rapidly; it will then be a need for tapping the resources of incumbents if a win-win arrangement could be made. For incumbents, this type of cooperation with latecomers is only worthwhile if they can expect value in return in the form of disruptive ideas, licensing fees, etc. (Narula, 2006). As key drivers, complementary assets and IP may significantly affect potential cooperation between latecomer disruptors and incumbents (Gans et al., 2002; Gans and Stern, 2003; He et al., 2006). Moreover, the importance of these drivers varies with the market segments. In an existing market where complementary assets and IP are mainly controlled by incumbents, the traditional DI path is to create a foothold at the low-end using the existing technology. Thus, for cooperation to occur the latecomers must be able to offer incumbents new ideas. In a new market where both complementary assets and IP are underdeveloped, cooperation between latecomers and incumbents is mutually beneficial because it will accelerate the commercialization of DI and create a bigger threat to other competitors.

Cooperation to share complementary assets and IP can be achieved by different OI strategies including joint ventures, alliances, corporate venture capital, acquisitions, outsourcing deals, licensing agreements, and spin-offs (Shenkar and Li, 1999; Chesbrough et al., 2006; Van de Vrande et al., 2009a, b). OI can offer latecomers a channel to directly contract complementary assets and IP in order to commercialize their potentially disruptive ideas. Alternatively, latecomers can indirectly access complementary assets and IP by allying with their owners. Instead of treating latecomers as threats, incumbents are increasingly interested in sourcing interesting ideas from latecomers or even investing in them. Consequently, OI may create a win-win situation where both latecomers and incumbents are better off than in a competitive DI scenario.

To further explore how OI and DI could interact, I examine Chinese latecomers who launched successful DI technologies. These case studies are described in the following section.

4.3 Methodology

4.3.1 Research Strategy

Case study has been recognized as a useful research strategy for creating theoretical constructs, propositions and midrange theories based on real events (Eisenhardt and Graebner, 2007). In general, research based on multiple case studies is considered more robust than research based on a single case study (Eisenhardt and Graebner, 2007). This essay uses multiple case studies to offer a broader perspective on China's high-tech industries. The process of theory building through case studies is divided into two major stages (Carlile and Christensen, 2005): a descriptive stage and a normative stage. The former recognizes important attributes through careful observation and correlates them with patterns to address the research interest. The latter refines the theory built during the descriptive stage through detailed empirical and ethnographic observation. For the purpose of this essay, I used the descriptive stage over multiple case studies.

To conduct the descriptive stage, I followed a sequence of three steps: design-observation, categorization and association.

First step: I selected the technology that has been proven to be successful DIs in the mainstream market to serve as the source of case studies. The unit of case studied is per disruptive innovation. As a collective pool of raw data, the cases were carefully filtered based on Govindarajan and Kopalle's (2005) five criteria for DI: (1) inferior on the attributes that mainstream customers value; (2) offering new features relative to existing products; (3) sold at a lower price; (4) attractive to a low-end, price sensitive or new market segment; (5) improvements to potentially attract mainstream customers. Since DI theory has only been extant over the past decade, not many empirical examples have been thoroughly studied or documented. Finally, I was able to identify six DI cases that meet the above criteria, and provide sufficient data support, derived from five Chinese latecomers. The six cases[14] based on the DI criteria are summarized in Table 4-1 and the details are presented in the following section.

Second Step: I analyzed the cases by examining OI practices in terms of different mechanisms such as licensing, M&A as well as other contractual modes, for each DI. Then I classified the latecomers according to cooperation, complementary assets and IP. The details are presented in Section 4.4.1.

Third Step: I used this evidence to articulate the conditions for combining DI and OI. Based on observations from the cases, I further provided the ways for both

14 Among the six cases, the data of the three cases by the two Chinese disruptors, namely, e-bike case by LuYuan, mini magic child washer case and wine cellar case by Haier, were collected from interviews. The interviews were conducted face to face during the on-site visits to the firms. The interviewees of the e-bike case were the founders and top managers in LuYuan headquarters, Zhejiang, China. The interviewees of the mini magic child washer case and wine cellar case were the team leaders of the R&D center in Haier headquarters, Qingdao, China.
Due to the limitation of the linkages to the rest three Chinese disruptors, I was not able to conduct interviews with them. Thus, the three cases, namely Galanz microwave oven, CIMC stainless steel refrigerated container and UFIDA U9, were mainly based on the second-hand but reliable data, including firm websites, academic papers, books and online reports. The details of the data sources are indicated in the footnote of the three cases respectively.

latecomers and incumbents to benefit from using OI in the context of DI. The details are presented in Section 4.4.2.

Table 4-1. Case summary at unit of each innovation

Case No.	DI product/ service	Mainstream product/ service	DI features	Market segmentation
1	“Mini Magical Child” washer	Large cubage (5kg) washer at a high price	Smaller (1.5kg), electricity and space saving, and pricing low	Targeting the non-consumption summer market in China – new market disruption
2	Wine cellar	Niche premium product sold at a high price in America	Simpler (without agitator), cheaper (40%)	Growing form niche market to mainstream – new market disruption
3	Microwave oven	Big size and expensive model mainly populated in developed countries	Smaller size and cheaper	Localizing the existing product and meeting the needs of the emerging middle class in China –new market disruption
4	Electric-bike (e-bike)	Motorbikes –pollution, hard to operate, expensive	Environmental friendly, lighter, easy to park and cheaper	Seizing the opportunity of two-wheeler’s revolution driven by Chinese government (to restrict motorbikes in major cities) – new market disruption
5	Stainless steel refrigerated container	Aluminum refrigerated container – expensive, light weight, advanced foaming technology	Cheaper (lower cost by reengineering the manufacturing process and improving the efficiently)	Using an existing inferior technology to enter a market and continuously improving price-performance of products to disrupt the dominator (the Japanese giant) – low-end disruption
6	U9 (an software platform)	A platform with a whole suite of fixed applications – time costly and intensive human capital involvement	Flexible structure (based on service oriented architecture), shorter delivery time, cheaper and real time communication	Using a new technology to enter a market and attack from the low-end to gain a share from existing players (SAP, Oracle) in China – low-end disruption

4.3.2 Disruptive Innovation Cases by Chinese Latecomers

In this section, six DI cases from China are presented. The cases are drawn from a broad range of high-tech areas including consumer electronics, refrigerated containers, IT and transportation.

4.3.2.1 Haier: Success with the Non-Consuming Market

Haier created a successful DI example by designing a mini washing machine for China’s huge untapped market. In the early 1990s, Haier started to manufacture conventional washing machines to meet Chinese consumption needs. At one point, the interesting phenomenon that washing machine sales severely dropped every summer drew the attention of Haier’s top management. After analyzing the market, Haier found that (1) the Chinese family size was shrinking due to the one-child policy and (2) the market was mainly dominated by the 5 kg cubage washing machine. People wanted smaller washing machines, but they were not available. Thus, Haier identified the demand for the mini washing machine.

In 1995, Haier designed a washing machine suitable for daily use called the “mini magical child” with 1.5 kg cubage, low noise and high efficiency. The mini model saved water, electricity and space, and was sold at a lower price. In the first year, its sales volume achieved 30,000 units and the next year it hit one million units. Haier continued to improve the functions and developed twelve generations of “mini magical child" products in two years. Patents were also filed worldwide to protect this innovation.

4.3.2.2 Haier America: The Leader in Niche Markets

In 1995, Haier started to sell its refrigerators in the US. To support global R&D activities, the Haier Research Institute was established in 1996 and allied with 28 incumbents from US, Japan, Germany, etc. Haier America was founded in 1999 as a joint venture between Haier and Welbilt Appliances Inc., an established American home appliance distributor. To support Haier America, Haier invested in its own factory located in South Carolina. Hoping to extend its DI success story in the US market, Haier America recruited local employees to identify local needs and relied on their partners to distribute the products. With the help of Welbilt Appliances, a large distribution network was established between Haier America and BestBuy, Wal-Mart, Sears, Lowe's, Home Depot and Target.

Haier America's first successful DI product – a wine cellar – had previously been considered a premium product for a niche market. However, as a serial disruptor, Haier saw the growth potential of this niche market. Haier America's wine cellar was designed without an agitator that made it 40% cheaper than the existing Whirlpool model. The good-enough features coupled with a much lower price stimulated the growth of this niche market all over the world. Just two years later, Haier had captured 60% of the market in the US. Eventually, Haier has around 60%

of the global market share for wine cellars and its reputation has helped open up the US market for other Haier white goods.

4.3.2.3 Galanz[15]: New Designs for Emerging Markets

In the early 1990s, microwave ovens were popular in the mass markets of developed countries. However, due to their high price and large size, only 2% of Chinese families owned one. The annual market capacity in China was estimated to be around 20,000 units and was mainly dominated by foreign incumbents. Despite a technology shortage and inexperience in the consumer electronics industry, Galanz decided to enter the microwave oven market and designed its products for the emerging middle class. Galanz built its R&D team by seconding five senior engineers from Shanghai FeiYue, one of four microwave oven manufacturers in China, and imported the production line from Toshiba. In 1993, Galanz introduced its own small, energy-efficient microwave oven at an affordable price and quickly captured 10% of the market share in China. Since then, Galanz has unlocked the latent mass market in China and achieved annual sales of over 25 million units in 2007.

After establishing itself in China, Galanz pursued an original equipment manufacturer (OEM) role in the global value chain. Rather than competing in the international microwave oven market directly, Galanz expanded its production scale

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[15] The data of Galanz microwave oven case were collected from the following firm website and online report: http://www.galanz.com/about.shtml; Hang, C.C., Chen, J. and Subramian, A.M. 2010. Developing Disruptive Products from Emerging Economies: Lessons from Asian Cases. http://www.eng.nus.edu.sg/etm/research/publications/30.pdf

and cooperated with foreign incumbents. To disrupt the mainstream market in developed countries, Galanz continued its R&D efforts to master the key technologies for manufacturing microwave ovens and improved their performance to the satisfaction level of high-end markets. As Galanz's manufacturing capabilities continuously improved, more and more overseas incumbents moved their production lines to Galanz. This helped Galanz develop its own core competency as an OEM. By 2008, Galanz had applied for 508 patents and some of them, such as light-wave microwave ovens, have become the new industry standard. From its humble beginning in China, Galanz has become an internationally acclaimed brand and the world leader in microwave oven sales since 1998.

4.3.2.4 The Zhejiang E-bike Community: A Two-wheeler Revolution

First appearing in the late 1990s, two-wheeler electric vehicles (e-bikes) have become well known as a unique Chinese DI. After the Chinese government restricted motorcycles in major cities in the early to mid-2000s, the large scale commercialization of e-bikes took off. The design of the e-bike was based on the manual bicycle with the simple additions of a hub motor at either the front or the rear wheel, a battery at the back seat and a simple electronic controller mounted on the handlebars. The attractive characteristics of e-bikes compared to motorcycles, such as their small size, light weight, lower pollution and lower price, created a new trend in public transportation. E-bikes especially met the needs of people in cities who required a basic means of transport that is relatively fast, easy to operate and convenient to park. Annual sales of e-bikes grew explosively from the initial 60,000 vehicles in 1998 to over 21 million in 2008. At present, China accounts for more than 90% of global e-bike sales and has become the world's largest producer, consumer and exporter of e-bikes.

The e-bike's success did not result from a single firm but from a community of affiliated firms. The three largest e-bike communities are clustered in three Chinese localities, namely Zhejiang, Tianjin and Jiangsu. These communities cooperated to obtain government support for e-bikes and the Zhejiang government began offering e-bike licenses in 1998. The legitimization of e-bikes triggered the boom of the e-bike business with production growing exponentially from 50,000 in 1998 to 4 million in 2009 in Zhejiang alone. Further using Zhejiang as an example, I illustrate how the development of the e-bike industry can be attributed to the highly modularized industry structure. This organized structure allows manufacturers to cooperate with modular suppliers to obtain the main e-bike components, including the battery, motor and frame. For example, TianNeng Electronic Co. Ltd and ChaoWei Power Co. Ltd. in Zhejiang currently supply about 90% of all e-bike batteries. XinDaYang Group Co. Ltd, a Zhejiang motorcycle firm specializing in motor development, invented the brushless motor widely adopted for use in e-bikes. The frames of e-bikes are not much different from traditional bicycles and so can be sourced from any bicycle frame manufacturer. Zhejiang LuYuan Electric Vehicle Co. Ltd. was established in 1997 and became a pioneer e-bike manufacturer. During the early days, in partnership with several other manufacturers, LuYuan established the parameters for outsourcing e-bike components. Although the gross margin of manufacturing one e-bike was only about 100 or 200 Chinese Yuan, close cooperation within the value chain allowed e-bike firms to maintain their low cost advantage and shorten the whole production cycle time. This grassroots level innovation coupled with low costs and swift response to customer demands has made e-bike manufacturers a formidable threat to the motorcycle firms. Some famous Chinese motorcycle firms, including the Geely Group and Zhejiang QianJiang Motorcycle Co. Ltd., tried to produce their own e-bikes, but ultimately gave up. Even some e-bike firms could not survive the furious price-performance competition. While the number of e-bike firms in Zhejiang peaked at 330, only about 200 firms currently remain. One of these survivors is LuYuan.

In late 1998, LuYuan suffered a large-scale battery crisis due to quality issues. Worse yet, the battery supplier refused to accept the returns or solve the problem. Though LuYuan took the responsibility to accept the returns, thousands of broken batteries threatened its reputation and caused great financial loss. After the crisis, LuYuan realized the importance of advanced technology and manufacturing capacity to guarantee the quality of e-bike batteries. LuYuan invested heavily in its own R&D and developed its own battery related IP. To eliminate the possibility of another battery crisis, LuYuan now has its own battery factory and battery brand. As evidence of its continuous efforts to innovate, every year LuYuan files for about ten patents and every month LuYuan introduces about five new models of e-bikes. With accumulated capital and technology, LuYuan has gradually integrated the core components into its manufacturing system. Over the last ten years, LuYuan has built its competitiveness by controlling product cost, quality and performance.

4.3.2.5 CIMC[16]: Giving Big Opportunities to Spin-offs

Since the early 1990s, CIMC (China International Marine Containers Group) has been the world's largest manufacturer of low-tech dry-cargo containers. To diversify their production line, CIMC entered the refrigerated container market in 1995 with the hope of competing with the Japanese incumbent in this high-tech segment. There were two product streams in the refrigerated container market: aluminum containers based on full foaming technology and stainless steel containers based on sandwich foaming technology. The foaming technologies used by these two products were totally different. Sandwich foaming technology was relatively inferior to full foaming technology in terms of the quality of foams. Even if the quality of foams can be improved, the costs were found to be very much the same. This is why the choice of application in which metal mostly depends on costs. The aluminum containers were light-weight, while the stainless steel containers were heavy and relatively expensive. At the time, aluminum containers based on full foaming technology, namely aluminum refrigerated containers, were mainstream and the

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[16] The data of CIMC Stainless steel refrigerated container case were collected from the following firm website, book and online reports: http://www.cimc.com/about/company/management/; http://atandsonline.com/articles/press-releases/steel-cargo-containers-vs-aluminum-shipping-containers/; Joerss, M. and Zhang, H. 2008. A Pioneer in Chinese Globalization: An Interview with CIMC's President. http://www.mckinseychina.com/wp-content/uploads/2011/01/cimc08.pdf
Banhart, J. and Seeliger. H.W. 2012. Trends in aluminum foam sandwich technology. *Advanced Engineering Materials. Special Issue: Highly Porous Metals and Ceramics*, 14(2): 1082-1087.
Zeng, M. 2007. *Dragons at Your Door: How Chinese Cost Innovation Is Disrupting Global Competition.* Boston: Harvard Business School Press.

Japanese incumbents dominated 95% of the market share. To enter the market, CIMC started a spin-off called Shanghai CIMC Reefer Container Co., Ltd. (SCRC) and licensed sandwich foaming technology from Graaff Transport System GmbH, a German incumbent with a minority share of the market. Due to the high technology barrier, CIMC also established a joint venture with Graaff, giving Graaff a 2% share of SCRC and hiring its technological experts to lead R&D.

CIMC rapidly absorbed Graaff's technology and increased its production efficiency. When the production line was originally transferred from Graaff, the manufacturing time was twenty minutes per container. CIMC reduced it to ten minutes per container in 2002, then to five minutes per container in 2004. This increased efficiency was achieved through process reengineering and also lowered production costs. To improve thermal insulation, CIMC creatively applied automobile technology to their refrigerated container development and improved the technology originally licensed from Graaff.

In less than eight years, CIMC replaced the market standard with its more affordable stainless steel refrigerated containers. In 2003, CIMC captured 44% of the global market share and became the world's leading supplier of refrigerated containers. That same year, the Japanese incumbents pulled out of the refrigerated container market as their aluminum products could not compete with CIMC's performance and price. In 2005, CIMC bought 77 patents from Graaff and has since owned the whole series of patents related to stainless steel refrigerated containers.

4.3.2.6 UFIDA[17]: Slow and Steady Wins the Race

Founded in 1988, UFIDA Software Company has grown to be the largest vendor of software with enterprise applications in China. UFIDA has dominated the low-end small and medium enterprises (SME) market since the early 2000s. UFIDA then started to gain some market share from the leading high-end global vendors, such as SAP and Oracle. UFIDA's strategy has been to seize the DI opportunity created by maturing Chinese enterprises that require management applications to increase their productivity. As a consequence, UFIDA has changed its strategic focus to operation expansion so it can maintain its leadership position in China. Since 2003, UFIDA has invested in R&D on service oriented architecture (SOA). In 2007, UFIDA formed a "SOA creative centre" with IBM, the number one player in the SOA industry. SOA is an IT architectural platform used to turn business applications into functions and processes customized for individual businesses. UFIDA creatively implemented SOA in enterprise application development and in 2008 introduced "U9", the world's first enterprise application based on the SOA platform.

Unlike the conventional service provider oriented model, UFIDA's U9 is a DI based on a client oriented model. Using enterprise resource planning (ERP) as an example, the conventional product is a platform with a whole suite of fixed applications. The delivery time for a SME version is around three to six months, while a large

[17] The data of UFIDA U9 case were collected from the following firm website and online reports: http://www.yonyou.com/about/index.aspx;http://oracle.sys-con.com/node/355113; Goldman Sachs, 2010. Global Software and Services: China emerging, more of an IT services force for now. http://www.kingdee.com/pub/139208306/2010/files/20100822-Goldman%20Sachs-Global%20Technology%20Software.pdf; http://www.yunnao.com/shownews.aspx?newsid=326

enterprise version usually needs more than one year to complete. Moreover, the vendor has to adjust the system for each client after implementation, which has a very high cost. Thus, leading global vendors such as SAP and Oracle target the high-end market in order to increase their margins. However, by using SOA, U9 loosely couples the distributed applications based on the individual client's needs. As a result, U9 costs about 40% less than equivalent enterprise applications by the leading global vendors. To accommodate growing Chinese enterprises with diverse needs and management styles, UFIDA localized the design and implementation and also introduced new features like real time reaction and global operations for medium and large enterprises. By offering flexible solutions at a competitive price, U9 appealed to clients unable to afford the traditional high-end applications. While SAP and Oracle are still popular among the highest ranking enterprises, U9 has been rapidly adopted by Chinese enterprises with relatively low level but customized requirements in the high-end ERP market.

Within just twelve months of its launch, UFIDA's U 9 entered five new markets and client numbers and sales increased by 5%. UFIDA captured 49.2% of the Chinese high-end market by the end of 2008 and became an appealing alternative to incumbents like SAP and Oracle. U9's share of the high-end market has rapidly increased over the past few years and, considering the ever-rising demands of Chinese enterprises, still has room to grow.

4.4 Discussion

The six cases described in the previous section give evidences that latecomer disruptors and incumbents might openly cooperate to commercialize DI. The details of the interactions between those firms are summarized in Table 4-2. In this section, I discuss the conditions for combining OI and DI as well as the propositions for both latecomers and incumbents to undertake OI when commercializing DI.

4.4.1 Conditions for Combining Open Innovation and Disruptive Innovation

When dealing with their inadequate resources, latecomers may find it is too late to create their own. As a result, latecomers will be keen to pursue external resources such as complementary assets and IP. Based on ownership of complementary assets, latecomers can be divided into two categories: those with and those without complementary assets. Latecomers with complementary assets are usually *de alio* entrants who have accumulated complementary assets from other markets and are able to deploy them in the target market. Latecomers without complementary assets are either *de novo* entrants (start-ups) or *de alio* entrants whose complementary assets from other markets are not applicable to the target market. Alternatively, based on IP ownership, latecomers can be divided into two categories: those with IP and those without IP. Some latecomers have their own disruptive technologies and the associated IP. This exclusive ownership creates entry barriers for potential competitors and builds the latecomers' competitive advantage in the market. Since DI usually does not require ground-breaking technologies (Hobday, 1995), latecomers with appropriate ideas but without IP can introduce DI by importing available technology from incumbents who have greater bargaining power in technology markets.

Table 4-2. Case summary at firm level

Case No.	**Latecomer disruptor**	**OI practice in the foothold stage of DI**	**OI practice in the competitive stage of DI**	**Performance**
1	Haier Group	No (self-development)	No (self -development)	Worlds' No.1 share in mini washing market
2	Haier America	1996 – Haier allied with 28 foreign incumbents to support technology development 1999 – founded as a joint venture between Haier and Welbilt Appliances Inc., an established American home appliance distributor	Partnership with Best Buy, Wal-Mart, Sears, Lowe's, Home Depot and Target to develop a distribution network	Worlds' No. 1 share in mini refrigerated market
3	Galanz Group	Early 1990s – imported the production line from Toshiba and seconded engineers from Shanhai Feiyue, one of four Chinese microwave oven manufactures	Vertically cooperating with overseas incumbents by being their original equipment manufacturer (OEM)	Worlds' No. 1 share in microwave oven manufacturing
4	Zhejiang LuYuan Electric Vehicle Co. Ltd. (LuYuan)	1997 – vertically cooperated with component suppliers and partnered with other e-bike manufactures for e-bike's litigation and parameters setting	No (Because a battery crisis happened in Dec. 1998, LuYuan realized the importance of the advanced-technology and quality control, and started to invest its own component factories)	Top player in e-bike market and a key player in e-bike's international standard setting
5	China International Marine Container Group (CIMC)	1995 – spun off Shanghai CIMC Reefer Container Co., Ltd. and established a joint venture with Graaff, a German incumbent	Acquiring Graaff's refrigerated container related patents	Worlds' No. 1 share in the refrigerated container market
6	UFIDA Software Company	2007 – formed a "SOA creative centre " with IBM and became the leader of the SOA application in enterprise software industry	Continuously work with IBM and use its distribution network to expand overseas markets	Top player in China's high-end enterprise market

As cooperation depends on ownership of complementary assets and IP, I examine these together. Figure 4-2 summarizes these conditions and analyzes when OI has been introduced in the DI sample cases. Each DI case is considered as one unit of analysis. In Figure 4-2, the upper quadrants show the presence of OI and OI strategy while the lower quadrants show the DI outcome.

OI strategy / ***DI outcome***	***Latecomer with IP***	***Latecomer without IP***
Latecomer with complementary assets	***OI not used*** Haier “mini magical child” won	***OI (licensing, spin-off, joint venture, alliance)*** CIMC “refrigerated container” & UFIDA “U9” won
Latecomer without complementary assets	***OI (joint venture, alliance)*** Haier America “wine cellar” won	***OI (licensing, alliance)*** Galanz“microwave oven”&LuYuan“e-bike” won by later developing complementary assets or IP

Figure 4-2. Conditions for combining open innovation and disruptive innovation for latecomers

In cases where latecomers have complementary assets and IP, DI can be achieved without OI. This is because *de alio* latecomers are able to leverage complementary assets created in other markets (He et al., 2006). These applicable complementary assets enable the latecomer to gain some time to develop or utilize its IP for DI development. By using this IP, the latecomer secures the competitive advantage to commercialize the DI. The success of Haier's "mini magical child" is a good evidence to support the above proposition. Before starting DI, Haier had accumulated manufacturing experience in consumer electronics. The complementary technologies, manufacturing capability, distribution channels, brand and supplier relationships had been established during the development of their prior conventional washing machine. Thus, Haier was self-reliant with regard to technology and made rapid inroads into a new market disruption. To expand the "mini magical child" product line, Haier further developed its IP and designed various versions based on the initial model to secure a dominant position in the mini washing machine market. The case illustrates that OI is not necessary for successful DI when latecomers own complementary assets and IP.

In cases where latecomers lack complementary assets and IP in the target market, latecomers may start by using OI practices in developing and introducing a DI into the market. However, this is only possible in cases such as Galanz and LuYuan where latecomers are able to later develop their own complementary assets or IP. Though OI can lower the entry barriers and allow latecomers to gain a foothold, if they do not eventually develop these resources, latecomers will struggle to survive in the competitive stage. Galanz was a textile OEM before entering the microwave oven market, but this experience did not provide the firm with any complementary assets applicable to the consumer electronics industry. By using OI to access outside experts and import Toshiba's production line, Galanz gained an immediate foothold and eventually unlocked the potentially huge, emerging Chinese market. To become a global player, Galanz cooperated with foreign incumbents and established itself as an OEM after many years of OI. Though it entered the market without complementary assets and IP, Galanz has become the world's largest microwave oven manufacturer and controls key manufacturing and IP. Similarly, LuYuan successfully entered the e-bike industry without complementary assets and IP. In a highly modularized industry such as e-bikes, manufacturing efficiency was most important. Thus, lack of IP was a minor disadvantage to LuYuan, a *de novo* latecomer, which used OI to work with component suppliers to establish a foothold. The e-bike's modularized design made cooperation with suppliers easy and lowered the entry barriers. But the benefits of OI always come with risks and LuYuan experienced problems with its battery supplier. Once it became important to have a competitive advantage through better batteries, LuYuan invested in its own battery factory and created related IP. The success of Galanz's microwave oven and LuYuan's e-bike gives evidence that OI is critical during the foothold stage for latecomer disruptors without complementary assets and IP. It also shows that the further development of competitive advantage through complementary assets and IP is necessary in the competitive stage.

In cases where latecomers have IP but not the required complementary assets, latecomers can achieve DI by using OI strategies. *De alio* latecomers with IP may face organizational inertia when repeating DI success, but OI can help these firms become serial disruptors. After the miracle of the “mini magical child” in China, the joint venture Haier America and local factory was created to serve US niche markets. When Haier made its entry into the US, this was without complementary assets such as brand and distribution channel. However, its wine cellar, a DI case based on existing technology, opened up a niche market. The success of this DI was only possible through cooperation with US incumbent Welbilt Appliances which developed the Haier brand and built alliances with major retailers like BestBuy, Sears, Target, etc. for distribution. This cooperation between one latecomer (Haier America) and multiple incumbents was a win-win situation for all partners involved. Supported by the Haier Research Institute in China, Haier America diversified its product line during the competitive stage. Haier America has since enjoyed a good reputation and has the majority of the market share for compact fridges worldwide. This case illustrates how OI can help a latecomer without complementary assets to exploit a DI opportunity.

In cases where latecomers have applicable complementary assets but without IP in the target market, they can also achieve DI by engaging in OI. *De alio* entrants may utilize their accumulated complementary assets for DI in different segments of the same industry. This is how firms such as CIMC and UFIDA were able to capture the mainstream market with a low-end disruption. CIMC had complementary assets in container manufacturing before it became a disruptor. To enter the refrigerated container market, CIMC spun off SCRC and developed a joint venture with a

German incumbent Graaff. CIMC started from scratch and eventually improved the product and lowered the cost to the point that the Japanese incumbent was forced to exit the market. To protect its newly earned position as the market leader, CIMC purchased IP from Graaff to enhance its control of the related technology. Similarly, UFIDA established a strategic alliance with an incumbent to develop a world-class product. Though UFIDA started R&D on its own SOA, cooperation with IBM allowed them to catch up more quickly and create the U9 enterprise application. Besides technology support, the alliance with IBM provided guidance in function development, code management and program testing. In this way, UFIDA eventually gained the ability to serve the high-end markets. IBM's distribution networks also expedited UFIDA's entry into overseas markets including Hong Kong, Japan and other Asian countries. These two cases show that DI is not driven only by technology – sometimes DI is more about how to make use of technology. Latecomers may share disruptive ideas with incumbents and incumbents may work with latecomers to commercialize DI. In these two case studies, it is clear that cooperation was a win-win situation for the latecomers (CIMC, UFIDA) and the incumbents (Graaff, IBM).

To summarize, the above case analysis is based on Teece's (1986) classic framework examining whether and when OI happens in the DI context. The OI strategies are shown in the form of different modes, such as licensing, strategic alliance, joint venture, etc. The results of the case studies show promise that OI strategies are applicable in DI development. They also clearly show that OI strategies occur under certain circumstances in the Chinese latecomer cases. Thus, I make the following four propositions based on the above case analysis.

Proposition 1. In cases where latecomers have complementary assets and IP, DI can be achieved without OI. This may be because *de alio* latecomers are able to leverage complementary assets created in other markets.

Proposition 2. In cases where latecomers lack complementary assets and IP in the target market, they may win by using OI practices in developing and introducing a DI into the market. However, this is only possible for the latecomers who can subsequently develop their own complementary assets or IP.

Proposition 3. In cases where latecomers have IP but not the required complementary assets, they can undertake OI strategies to gain access to external complementary assets to commercialize DI.

Proposition 4. In cases where latecomers have the required complementary assets but without IP in the target market, they can source external technologies to achieve DI by engaging in OI.

4.4.2Utilization of Open Innovation by Latecomer Disruptors and Incumbents

Based on the above multiple-case analysis, this essay provides three ways to benefit both latecomer disruptors and incumbents to combine OI and DI. These may occur during the foothold stage and/or the competitive stage of DI. This section describes each way in more detail.

Way 1. OI facilitates a latecomer's survival or the success of DI.

Latecomer disruptors can leverage OI to reduce investment risk and time to market. For example, the rise of e-bike firms during the foothold stage can be attributed to cooperation between specialized firms. Close cooperation among members in the e-bike community allowed them to share risk, reduce costs and quickly respond to customers. Similarly, UFIDA's cooperation with IBM greatly reduced the time to market for U9 and assured its quality. It is also important to note that, in order to be a successful disruptor, the disruptive technology must improve continuously during the competitive stage. OI, such as cooperation with other firms, can help latecomers improve more quickly. For example, Galanz cooperated with incumbents to gain complementary assets before it became the leading OEM. This core competence as a manufacturer was essential to the global success of Galanz's microwave ovens.

Regarding the choice of OI modes in the DI cases, latecomers commonly used the contractual mode, such as licensing, strategic alliance or joint venture, but seldom used the acquisition mode, such as M&A. One possible reason is that latecomers cannot commit a large amount of resources or manage the complexity of the operations of two firms during M&A. The other key reason is that the acquired firms are already in an existing market. That is, the acquiring mode usually facilitates the entry into an existing market rather than new market creation. Thus, the latecomers who engaged in M&A are most likely trying to catch up with market trends rather than trying to disrupt others.

Way 2. OI allows both latecomers and incumbents to be involved in DI.

Latecomers and incumbents may struggle to innovate effectively if they rely solely on internal R&D. The incumbents in the case studies, namely Graaff and IBM, as well as many others have started to explore the possibility of increasing their R&D productivity by tapping into externally developed innovations. In many cases, high-tech latecomers in emerging economies are an interesting source of ideas and technologies. One reason is that they are closer to emerging markets and sensitive to their latent needs. For instance, UFIDA effectively localized U9 to meet the increasing needs of Chinese enterprises. Even though SAP and Oracle were aware of SOA's potential in enterprise applications, their existing clients were resistant to new software. Secondly, latecomers' fresh knowledge promotes innovation and has the potential to trigger DI opportunities. Thirdly, less constraint from the organizational routine allows latecomers to take risks and take advantage of changes in resources, processes and values. Often rich in ideas, latecomers may wish to cooperate with incumbents to make up for their lack of resources. For example, the successful commercialization of Haier America's wine cellar relied on incumbents' distribution channels and technological support. The involvement of OI in commercializing DI allows both latecomers and incumbents to seize potentially huge growth opportunities and share the high risk of uncertain markets. Moreover, many contractual modes of OI in the DI cases, i.e., licensing, strategic alliance and joint venture, allow the co-existence of latecomers and incumbents.

Way 3. OI enables incumbents to disrupt themselves.

Incumbents can learn a lot from the e-bike case, as well as CIMC and Haier's success stories of DI. It is possible for an incumbent to disrupt themselves by engaging in OI. This can be illustrated by the case of XinDaYang Group Co. Ltd in China's two-wheeler revolution (the e-bike case in this study). As a domestic motorcycle manufacturing incumbent, XinDaYang Group was supposed to be disrupted by e-bike producers; however, this did not happen. Instead of being disrupted by others, XinDaYang Group became a pioneer propelling the e-bikes revolution by leveraging their technology advantage of motor development. When e-bike emerged in the late 1990s, XinDaYang Group started to develop a specialized motor for e-bikes. This brushless motor was introduced by XinDaYang Group in 2003, and significantly improved the e-bike's performance in terms of efficiency, reliability and other key performance measures. Shortly after, XinDaYang Group established partnerships with the key e-bike producers (e.g., LuYuan) through OI, and has since become a core component supplier for the entire industry.

When dealing with innovations that do not fit with the current business model, firms could also spin them off or license them out. In the case of CIMC's refrigerated containers, licensing agreements signed with German incumbent Graaff provided the key technology resources to pursue the disruptive opportunity and reengineer the product. However, this does not necessarily mean the technology stimulates the disruptive features e.g., simple, low cost, etc. There is a need of a systematic way to check for disruptiveness, such as a modified stage gate process (Danneels, 2004; Yu and Hang, 2011). To ensure that spin-offs or licensees do not become their disruptor, firms can position them in different market segments to explore opportunities for new growth. For instance, rather than replacing Haier's existing products, Haier America's wine cellar expanded the market territory. Alternatively, firms can include clauses that allow them to use new technology developed by their spin-offs and licensees. In this way, incumbents can protect themselves from potential disruption and disrupt themselves.

4.5 Summary

This essay explored the conditions of applying OI to commercialize DI and then identified situations where cooperation between latecomer disruptors and incumbents benefitted both firms. It has contributed three important research implications to the literature, which are summarized as follows.

Though a great number of studies have examined how latecomers disrupt the mainstream market and surpass incumbents, few have investigated the possibilities of cooperation between latecomers and incumbents in developing DI. This study concurs with Christensen (1997) that there is competition between latecomer disruptors and incumbents, but it is shown that this only happens at the point in the competition when the disruptive product and existing product meet in the same tier of the market. Utterback and Acee (2005) contended that the true importance of disruptive technology could be to create new markets rather than to displace existing products. Cooper and Schendel (1976) pointed out that latecomers' market expansion is less of a threat to incumbents than other firms introducing substitute products. Thus, latecomer disruptors and incumbents are potentially well suited to cooperate with each other. The finding of the importance of OI between latecomers and incumbents in many DI cases gives a fresh perspective to the existing DI literature that focuses on competition (Christensen, 1997). I found that OI could facilitate latecomer disruptors and incumbents to work together to create new value, especially in the pursuit of emerging and non-consumption markets. The cooperative scenarios found in the case studies provide us with better understanding of the role of OI in developing DI.

This essay underscored the implications of the model of Gans and Stern (2003) in the context of DI. The contingencies whether latecomer disruptors openly cooperate with incumbents are closely related to complementary assets and IP that they own. Gans and Stern's (2003) classical analysis of cooperation possibilities between latecomers and incumbents was adapted to identify these conditions and predict whether cooperation is a strategic choice. This essay identified an additional situation from the DI cases, which was overlooked by the model of Gans and Stern's (2003). In a situation where complementary assets and IP are not important for commercializing a new technology, Gans and Stern (2003) expected competition and cooperation strategies would both be effective and latecomers would compete with incumbents for technology priority. However, in the e-bike case study, there was no technology competition between the latecomers (e-bike firms) and incumbents (motorbike firms), and the situation favoured the latecomers (e-bike firms). This was partially caused by government policy which supported the e-bike industry for its environmental benefits. Moreover, most of the motorbike firms were probably unwilling to enter the e-bike industry in view of its low profit margins.

This essay enhances the understanding of cooperation strategies at times of technological discontinuities (Spedale, 2003; Hüsig and Hipp, 2009). The implications of cooperation strategies evidenced in the context of radical technological change by Spedale (2003) are not applicable for latecomers in DI development. In contrast, the essay gave evidence that latecomers, such as UFIDA, who concentrate on specialized markets, can undertake structured cooperation (at the inter-organizational level) and successfully sustain the development of the new technology. Though radical and disruptive technology both can lead to discontinuous innovation, the former appears to be a greater threat to existing products. This is because the beauty of DI development is more about the business model, rather than the technology itself like radical innovation. Thus, latecomers may find the technology with disruptive potential in the market and cooperate with the technology owner. Besides trading for technologies, in the case of UFIDA's U9, cooperation with the incumbent – IBM – help build the competitive advantage in terms of reputation, international distribution network, etc. Similarly, Spedale's (2003) finding – "latecomers tend to concentrate in specialist niches where leading-edge applications are explored and developed (specialist, technology-push strategy) at times of radical technological change" – cannot be generalized in the context of DI. I found the latecomers in the specialist niches, such as Haier America, can apply the market pull strategy in developing DI. Moreover, the essay identified the latecomers, such as CIMC, who utilize technology-pull strategy also can successfully capture the traditional mainstream market. Despite more difficulties in disrupting the existing technology in the traditional mainstream than the specialist niches, latecomers can strategically partner with less dominate players to raise the chance to win. Without structured cooperation with others, fierce competition in the competitive stage of DI will challenge latecomers to survive even though they may enter from the low-end of the foothold market. And only if latecomers are *de alio* entrants with strong complementary assets in the target market, as in the case of CIMC's refrigerated containers, are they likely to achieve the performance improvement and eventually disrupt the industry leader. In addition, it was clearly observed that there are more cases, such as Haier's "mini magical child", Galanz microwave and e-bike, related to the market-pull strategy. All latecomers in those cases uncovered the latent needs in developing economies and then rapidly grew the market, and eventually became strong global players.

CHAPTER 5.

CONCLUSION

5.1 Summary of Theoretical Contributions

Latecomer firms from emerging economies have long wowed the world with their technological catching-up over the last decade. This thesis explores the reasons why some latecomers could become upcoming innovators by utilizing external resources, i.e., open innovation. Despite the vast literature on open innovation strategies in developed economies, it is insufficient to use current understanding to explain the catching-up cases in emerging economies. In fact, latecomers deserve special attention in the strategic management literature, because they face the critical "do or die" situation where every action they take needs to be prudent in order to survive. Furthermore, the uncertainties caused by resource constraints mean that latecomers cannot afford to make any wrong decisions. The extant literature on external resource utilization has not investigated enough details of these survival strategies.

To fill the research gap, this thesis provides important strategic guidance for latecomers to effectively turn external resources into innovative capabilities. The findings reveal that the latent relationships between the key determinants in the strategic choice of which target to acquire affects the subsequent innovation performance. The uniqueness of latecomers – the nature of being a technological laggard and special catching-up trajectory – largely causes them to undertake open innovation differently from incumbents. By examining this uniqueness, this thesis presents both quantitative and qualitative findings that contribute broadly to the strategic management literature.

I have concluded that open innovation can help latecomers promote innovation under certain contingencies. Specifically, I investigated latecomer strategies in using open innovation's two extreme mechanisms according to the complexity ranking, i.e., licensing and M&A. Furthermore, I investigated the combinative utilization of licensing and M&A, as well as other open innovation mechanisms, in latecomers' favourable catching-up trajectory, i.e., disruptive innovation. The main theoretical contributions throughout the whole thesis include the three following aspects:

First, the age of licensed-in technology is the first being investigated in this thesis. The existing literature mainly focuses on the impact of the quantity of licenses and shows mixed results of the linear relationship (i.e., positive, negative or insignificant) with innovation performance (Ahuja and Katila, 2001; Álvarez et al., 2002; Johnson, 2002; Tsai and Wang, 2009). By considering the technology age, I found a curvilinear (an inverted U) relationship between the number of licenses and the licensee's innovation performance (H1). The inverted U shape reveals that a moderate level of the quantity of licenses should be compatible with the existing absorptive capacity. Indeed, the technology recency most positively affects the growth of innovation (H2). The positive effects of the number of licenses and technology recency are more likely to be observed in latecomers with high absorptive capacity (H3, H4).

Second, substitution effect in M&A is found to be more important for latecomers. The existing literature mainly treats M&A as a strategy to maximize synergies and further identifies an inverted U relationship between technology similarity and innovation performance (Ahuja and Katila, 2001; Cloodt et al., 2006). In the context of technologically laggard firms, this thesis discovers that latecomers do not have enough absorptive capacity to acquire different technologies (H1). However, latecomers can acquire a target with competent new technologies to substitute their existing technologies. This substitution will result in an innovation performance that is proportional to the joint effect of the size and the distance of the technology acquired (H2).

Third, this thesis presents novel research in the application of open innovation to develop disruptive innovation. Disruptive innovation is the trajectory that best enables latecomers to enter a market and potentially become leaders. This kind of competition with incumbents has been greatly emphasized in the existing disruptive innovation literature (Christensen, 1997; Christensen, 2003; Utterback and Acee, 2005). However, cooperation with incumbents through open innovation has yet to be studied as a viable strategy for disruptive innovation. This thesis suggests several ways that open innovation can be successfully applied in disruptive innovation under certain conditions. The basic conditions for combining open innovation and disruptive innovation are based on the complementary assets and IP owned by latecomers. Furthermore, latecomers need to develop the acquired assets in a complementary way to enhance the competitive advantage. The enabling role of open innovation for latecomers and incumbents to cooperate indeed aids the success of disruptive innovation in three ways, which extend the view of open innovation in disruptive innovation theory: (1) open innovation facilitates a latecomer's survival or the success of disruptive innovation; (2) open innovation allows both latecomers and incumbents to be involved in disruptive innovation; and (3) open innovation enables incumbents to disrupt themselves when needed.

5.2 Summary of Managerial Implications

Based on the above findings, this thesis offers the following important managerial implications. First of all, latecomers have more flexible strategic choices than incumbents and more determinants to consider when utilizing open innovation. Besides the common determinants like the quantity of technology (size of the knowledge base in this thesis), latecomers need to address the characteristics of the technology in their open innovation strategy, such as the age, technology distance and interactions among determinants. This thesis sheds light on latecomers' new strategies for growth. To a certain extent, the first two essays represent an attempt to open the "black box" – how to integrate the external resources – through a closer empirical investigation of the above determinants. In addition to the empirical investigation, the qualitative study in the last essay offers new insights for using open innovation in the specific innovation trajectory favoured by latecomers. The managerial implications are detailed below.

The thesis reveals latecomer strategies for successful learning by licensing. It discloses that latecomers' ITL strategy is not only about how much learning can be achieved from licensing, but also about identifying the right technology resources to learn. The direct implication is that ITL enables latecomers to enlarge their knowledge pool in a short period of time, although extra time and resources are required to fully absorb licensed-in technologies. Licensed-in technologies can serve as seeds that spur internal R&D development, but resource allocation to internal R&D development is critical in the long run. In the case where competitors are not willing to license out some of their core technologies, latecomers must accumulate technological capability to compensate for the shortage of technology available in the market. Thus, latecomers need to optimize their resource allocation between ITL and internal R&D development. The other important implication of this study is for the long-term planning of technological capability development. Latecomers may not be fully motivated to purchase patents to compensate for their technology shortfalls, but building them into their patent portfolios is the best approach for promoting their technological capability development. In high-tech fields, licensing as a fast track to transfer technology may spur a firm's technological learning and innovation for competency building. Furthermore, learning from the latest technology rather than older technology has prominent advantages, especially for latecomers who have been accumulating absorptive capacity. Instead of passive licensing to fill technology gaps, updating their technology portfolios by strategically importing the right technology is a wiser way for latecomers to grow steadily and achieve technological catching-up.

On the other hand, when the assumption that external resources have to be integrated is dropped, a flexible strategic choice to substitute the competency of target for the existing one should be recognized. This is the main focus of the second essay in this thesis. The empirical findings provide guidance to managers who are increasingly involved with technological catching-up via M&A, and suggest that firms should manage strategic choices based on the characteristics of their technology bases. Essay Two emphasizes that both the quantitative (e.g., knowledge base) and qualitative dimensions (e.g., technological distance) between the target and acquiring firm matter a great deal for the post-M&A innovation performance. Although this essay focuses on situations where the acquiring firms have low technological capabilities relative to firms in developed economies (Mathews, 2002) and where the target firms are technology-related (Jaffe, 1986), it provides takeaways for managing the success of post-M&A innovation performance, as summarized in Figure 5-1. In the case of latecomers in emerging economies, their primary goal is to realize the potential technological catching-up. Substituting the existing competency with an advanced one through M&A is probably the easiest and fastest way to catch up, especially for latecomers without the burden of knowledge rigidity and organizational inertia. Even though some latecomers acquire in order to achieve economies of scale, the inferior absorptive capacity and management challenges in the integrating firm would easily kill the chance of success in M&A, and thus it is only possible to acquire for quantitative complementarity. However, when a firm with a high technological capability acquires a target with similar technology, it is reasonable the firm to maximize synergies to complement its existing competency. This occurs because this firm is likely a forerunner in its field and if the firm already possesses a well-established technological capability, there is no reason to sacrifice the existing competency for a new one. In the case of acquiring target firms that are technologically unrelated to the existing business, more management challenges appear in the integrated organization and M&A can only be successful if they are conquered. This is the case even for firms in developed economies. In cases where latecomers have low technological capabilities, the post-M&A innovation is only achievable by qualitative complementarity, not quantitative complementarity. It is possible to innovate by combining technologies from totally different industries, but the inferior absorptive capacity associated with a poor technology accumulation goes nowhere for latecomers to spend additional efforts integrating a large amount of external resources.

Figure 5-1. Proposed matrix for measuring successful M&A

Technological Capability of Acquiring Firms	Technology Disparity: *Related*	Technology Disparity: *Non-related*
Low	Renewing the competency for adapting advanced technology, or expecting economies of scale for quantitative complementarity	Possible qualitative complement leading to synergy effect if successful
High	Purchasing synergy for complementarity	Expecting synergy to complement competency by conquering management challenges if successful

Furthermore, this thesis has investigated the innovation trajectories for latecomers from emerging economies. The empirically verified strategies in the first two essays support that latecomers could use open innovation, such as M&A, to enter a market by external resources acquisition and become innovators. To promote innovation, latecomers may import multiple old technologies through licensing and make use of them. This implies that innovation trajectory undertaken by technologically laggard firms is not about technology itself, but how to use technology. Disruptive innovation, one of the three major types of innovation (Gatignon et al., 2002), fits well with latecomers' innovation trajectory. This is the context of the third essay in this thesis. My study of Chinese disruptive innovation cases has provided some insightful managerial learning points regarding both open innovation and disruptive innovation.

Regarding the use of open innovation in the context of disruptive innovation development, licensing appears to be an essential strategy. Licensing is the most commonly adopted strategy to access technology in all the cases, while M&A occurs less frequently. It is understood that fewer latecomers can pursue M&A due to its greater complexity (Marks and Mirvis, 1998). The underlying cause can be also tracked by the specific innovation trajectory and revels that not every catching-up firm conducts disruptive innovation. A firm that pursues M&A tends to enter the existing market that the target firm are in, and thus does not create a new market or disrupt others. In other words, the strategy to pursue disruptive innovation may be viewed as an alternative to M&A.

The in-depth case studies also provide insights into opportunity exploitation for disruptive innovation. The three ways to exploit disruptive opportunities are summarized. First, a latecomer may seek opportunities to cooperate with an incumbent that is less dominant in the market. This may lead to a collaborative effort, which eventually allows the firms to disrupt the market. CIMC's refrigerated container is a typical case illustrating how a latecomer seized an opportunity at a time when the incumbent was failing and created a good-enough product with a much lower price that eventually came to dominate the market. Second, niche markets can serve as shortcuts for latecomers to enter new fields. Since incumbents often underestimate niche markets, they are good places for latecomers to develop disruptive innovation. For instance, Haier America's wine cellar served as an important starting point for Haier to enter the global compact fridge market. Third, some latecomers are able to foresee booming opportunities that incumbents miss due to their focus on sustaining innovation (Christensen, 1997). After UFIDA nearly missed an opportunity to enter the high-end market, it was motivated to seek new solutions. The success of UFIDA's U9 demonstrated the importance of anticipating market trends that can allow latecomers to jump into new areas and enlarge the market.

In addition, the third essay challenges the traditional globalization strategy of "think global, act local". It demonstrates that open innovation helps local innovations grow as global applications, albeit its effectiveness is contingent upon the firm itself. That is, it is possible for latecomers to introduce pioneer innovations in emerging economies and then become international players. Latecomers may adopt the strategy of "design local, go global" by climbing up the value chain to become innovators, despite their humble beginning from downstream, such as manufacturing. It is also notable that most of the disruptive innovation cases are new market disruptions that meet latent needs at the bottom of the pyramid markets (Prahalad, 2004, 2012; Ray and Ray, 2011). Thus, the traditional top-down approach of "think global, act local" may not be suitable for latecomer firms from emerging economies.

Finally, policy makers can largely contribute to facilitating open innovation implementation as "invisible hands" (Ahmad, 1990). This thesis confirms that the presence of markets for technology and markets for ideas facilitate technological learning and innovation, especially for technologically laggard firms. Developing the ecosystem that facilitates technology and idea transfer is an important instrument that policy makers can employ to promote technological development. In this way, policy makers in emerging economies can pay more attention to the market order and an appropriate IPR environment in order to motivate business activities. Similarly, formulating policies that encourage domestic firms to actively adopt open innovation strategies to make market entry is necessary because external resource acquisition plays an important role in the formation of innovative capabilities. Furthermore, policy makers may provide incentives for firms to climb the industry value chain and gradually develop their innovation capabilities. For instance, Chinese e-bike firms greatly benefited from the decentralized manufacturing and the industry modularity. Even though they come from humble beginnings, firms can tap into the disruptive opportunities and eventually become the industry leaders.

5.3 Recommendations for Future Work

This thesis is subject to various qualifications and raises a number of questions for further work.

First, the analysis of the effect of licensing and M&A on R&D outcomes was carried out from the angle of the demand side, i.e., the licensees and acquiring firms. The dynamics between being a recipient and a supplier in a technology market have not been addressed from a latecomer's perspective. A host of interesting research questions may arise about the drivers and conditions of the role of shifting between technology recipient and supplier from both the strategic and economic efficiency views.

Second, the technology strategic literature indicates there are different open innovation mechanisms that help latecomers access external resources to achieve technological catching-up. I believe that different open innovation mechanisms may have different success rates when utilized by different types of latecomers. Of the various open innovation strategies examined in this thesis, I did not try to identify which one was ideal and only used them to illustrate their supporting roles in innovation development. For example, even though the latecomers included *de novo* and *de alio* entrants, I did not go further to analyze if there exist any differences in their use of open innovation in order to stay the focus. This may open a potential line of new research investigating which mechanism is a desirable alternative for latecomers and when these alternatives are complementary, e.g., licensing and M&A.

Third, this thesis focuses on some factors with regard to the qualitative and quantitative dimensions of technology, such as technology age, technology distance and knowledge base. Latecomers' success is also driven by other factors, such as public policy, management perceptions, organizational routines, cultures, etc., which have not been addressed in this thesis. Analysis of those additional factors may give a more comprehensive view of latecomer strategies. For instance, research could expand on the conditions for acquiring new or old technologies by examining the managements' perceptions of whether the acquisition was motivated by exploration or exploitation in organisational learning.

Fourth, this thesis looked into latecomer strategies and mainly addressed the research questions from a latecomer's perspective. For instance, the third essay concentrates on the conditions leading to open innovation that help latecomers achieve disruptive innovation; the essay did not focus on the outcomes for incumbents. Only in two cases (UFIDA's U9 and e-bike) did I address how cooperation with a latecomer helped an incumbent (IBM and XinDaYang Group) extend its market presence. This open innovation eventually led to fierce competition with other incumbents (SAP/Oracle and motorcycle manufacturers). In the value creation network, it would be interesting to study the feedback loop to the incumbent's side. The same research questions could be examined from the incumbent's perspective to uncover how incumbents may learn from latecomers through open innovation.

Finally, the studies in this thesis are based on the context of high-tech firms in China, one of the fastest growing economic embodiments within the last decade. The strategies demonstrated in this thesis highlight the strategic development routes for latecomers on the rise in high-tech industries. However, these strategies for technological catching-up may be context-sensitive. For example, firms from South Korea and other Asian “four tigers” economies followed the export-growth path for technological catching-up (Xie and Wu, 2003), while firms from China and Japan started from the local market-focused path. A comparative study of the research questions over different countries will offer a deeper understanding of latecomer strategies that takes into account contextual factors. Nevertheless, this thesis could serve as a basic reference for further research in diverse contexts, as more emerging economies catch up on R&D and innovation.

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PUBLICATIONS

(Relevant to the contents in the thesis)

1. Zhao, Y.Y., Wong, P.K., Subramanian, A. and Hang, C.C. 2011. ***New insight into technology licensing strategy and innovation performance: The evidence on Chinese latecomers in high-tech industries***. The IEEE international conference on Industrial Engineering and Engineering Management, Dec. 2011, Singapore. (The journal version is under preparation for submission to Technovation.)

2. Zhao, Y.Y., Wong, P.K. and Hang, C.C. 2012. ***Mergers and acquisitions for latecomers in emerging economies: The substitution effect on innovation performance***. Strategic Management Society conference, Dec. 2012, China. (The journal version is under preparation for submission to Strategic Management Journal.)

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