Masters Dissertation in Economics

The Impact of Knowledge Stock on Exploration Decision and Performance

- Success Breeds Success -

축적된 지식이 탐험의 결정과 그 성과에 미치는 영향
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- Success Breeds More Success -

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이 논문을 경영학석사학위 논문으로 제출함

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Abstract

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This study explores the impact of firm's knowledge stock on firm's decision to choose exploration and performance afterwards. Due to the rising complexity of technology and the increasing difficulties in technological innovation, the attention to the firm's knowledge stock is rising, since it represents their core-competence, absorptive capacities, and innovation capabilities in general. Therefore, in this study, firm's accumulated knowledge stock and its' role on firm's exploration decision and performance is examined. Moreover, the effectiveness of the method of knowledge accumulation is accesses. Empirical analysis is conducted using probit-model on Korean

manufacturing firms' patent and financial data. Our findings suggest that first, firm's accumulated knowledge stock increases firm's likelihood of choosing exploration. Second, firm's knowledge stock has positive relation with firm's performance after exploration. Third, internally accumulated knowledge stock shows stronger relation with firm performance after their exploration decision.

Keywords: Knowledge stock, knowledge accumulation, exploration, innovation, firm-performance

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Contents

List of Tables

List of Figures

Chapter 1. Introduction

1.1 Research Background

The history of South Korea's innovation and development in manufacturing sector has been one of the most robust cases in the 20th century's global economies. South Korea's manufacturing sector, over the last 70 years, has been growing exponentially, while continuously exploring for new opportunities. Lacking in technical capability and knowledge, most South Korean manufacturing firms heavily relied on governmental support and external knowledge from foreign firms, especially from those of Japanese and American firms (Kim 1997). There exist abundant researches on how Korea has rapidly transformed into highly industrialized economy from virtually nothing (Hitomi 2002; Ohno 2009; Lee 2015; Im 2015). One of the primary arguments regarding Korea's industrial growth is introduced in Kim's *Imitation to Innovation.* Kim (1997) argued that from original equipment manufacturing (OEM) to original design manufacturing (ODM) to original brand manufacturing (OBM), Korea's manufacturing firms initially built their innovation capability from imitating advanced firms' products (Hobday 1995; Chung 2007). However, as Korean manufacturing firms move into more capital and technology intensive industries, and as they are becoming more and more competitive in the global market, Korean firms' past strategies, that is, acquiring the technological knowledge from

advanced firms and accumulate knowledge by production, learning-by-doing, and imitation, was getting increasingly difficult. Especially, advanced firms were getting more and more reluctant in transferring knowledge to Korean firms due to their rapid growth in competitive power in the market. Therefore, turning into 1980s, Korea's manufacturing firms started to build up a base for R&D and innovation in order to accumulate and generate knowledge by themselves, in the hopes of enhancing their innovation capability and competitiveness in the market (Park 1990; Park 1994; Kim 1997; KOITA 2007). Figure 1 shows the trend of R&D expenditure trend of Korean manufacturing sector from 1960s to 2007.

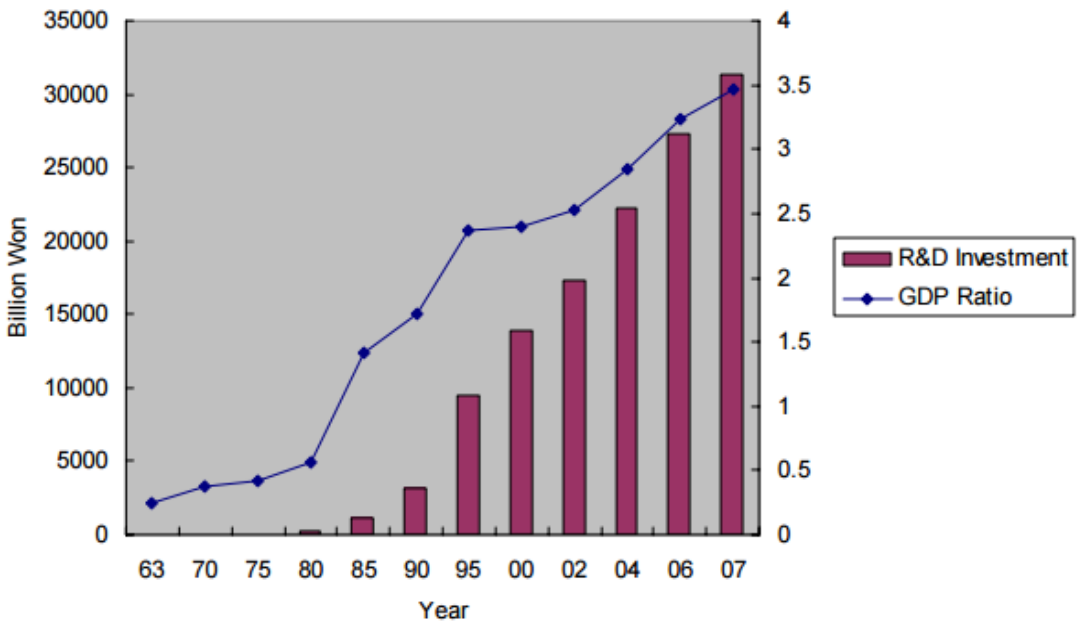

Figure 1. R&D investment Trend in Korean manufacturing sector: 1963-2007

The shift from imitation to innovation in Korea's industrial environment resulted in a rapid accumulation of knowledge, which can be observed in **Table 1** below[1].

Table 1. Number of KIPO Patents Applied: 1980~2010

	1980	1985	1990	1995	2000	2005	2010
Number of KIPO Patents Applied	4,061	3,407	11,808	20,060	68,338	131,115	125,633

It can be observed from both **Figure 1** and **Table 1** that Korean firms have exponentially increased their quantitative innovation input and output over the short period of time. According to OECD report[2], Korea is 6th largest spender in R&D among OECD countries as of 2008, and they are continuing to increase this amount in both the private and the public sectors. Moreover, number of US patents granted to Korean citizens was 6,295 in 2008[3], which ranked Korea 4th place in the world. However, despite of these quantitative results, the effectiveness of these efforts must be examined as the complexity and the cost of technology is on the rise (Cantwell et al., 2004). And the competition within the markets are getting severe, driving many Korean manufacturing firms to struggle in both the domestic and the global market. Especially, since many of Korean firms have been accumulating substantial quantitative knowledge since the 1980s, exploring the impacts of firms' knowledge stock on innovation and innovation

[1] KIPO (2012): KIPO stand for Korean Intellectual Property Office
[2] OECD (2008)
[3] USPTO (2008): United States Patent and Trademark Office

performance is necessary to access the current status of Korean firms, so that they may revisit and improve their innovation strategies. Moreover, since the early 2000s, South Korean firms constantly tried to explore new opportunities and expand onto other industries. As the industries, such as steel, electronics, shipbuilding, and automobile, was getting more competitive and mature, it has become a pivotal objective of many Korean manufacturing firms to expand their boundaries to secure their survival. In addition, Korea's Government also shifted their industrial policies' focus to the creation of new industries and the upbringing of SMEs with strong innovation capabilities to maintain global competitiveness as an nation with strong economic dependence on export[4] (Hong et al,. 2011). There have been lots of policies that were designed to promote new industries, however despite of these comprehensive efforts, quantitatively large amount of input on knowledge acquisition and large knowledge stocks, many Korean firms do not perform well after they enter into other 'new' industries. Of course there exist some successful cases of exploration, but it is relatively rare, considering many Korean firms' past successes. Moreover successful cases seem to be concentrated only on few firms. Current situation in Korea's manufacturing industry raises the following questions. First, what factor determines firm's exploration decision. Second, what factors make exploration successful? Third, what is the relation between firms' knowledge stock, exploration and its' performance. And fourth, is there a difference in performance

[4] Especially, as Chinese manufacturing firms' technological ability will exceed or already exceeding that of Korea's, expand to new boundaries and exploiting new industries is pivotal to Korea's survival in the future (KERI 2016).

depending on the way of knowledge accumulation?

The importance of technological knowledge has been constantly increasing in both management and innovation, as most firms continue to diversify their products and technological knowledge in order to expand and explore more opportunities and to stay ahead of their competitors (Granstrand et al., 1998; Cantwell et al., 2004; Kim et al., 2015). Firms' knowledge base, whether it is residing in an individual or an organization, shows the organization's past-paths, its current capabilities, and possibly its future projection. Therefore, the understanding of firms' knowledge base is critical in the analysis of firms' innovation activity, capability, and performance. Due to this reason, management scholars have intensively researched on the influence of organizational knowledge on innovation, especially in terms of firms' technological knowledge base that can be represented by its' prior knowledge (Glynn 1996; Taylor and Greve 2006; Collinson and Wang 2012).

There are various definitions of innovation. Schumpeter defined innovation as the process of generating novel combinations from existing resources and ideas (Schumpeter 1934). Other researches define innovation as the combination and recombination of existing knowledge, past ideas and artifacts, and new ideas (Hargadon 2002; Stiglitz and Greenwald 2014). In addition, innovation in terms of management can be defined as the process of translating an idea or invention into a good or service that creates value for the firm. Thus, firms need to innovate in order to survive and remain competitive in the market, driving them to constantly attempt to diversify their products and technological

knowledge in order to expand and explore more opportunities (Granstrand et al., 1997; Cantwell et al., 2004; Kim et al., 2015). The importance of innovation in management has been emphasized enough that there exist general consensus on the necessity of innovation. In addition, firms' technological knowledge stock has become one of the most important indicators when analyzing firms' innovation capability, due to the growing complexity and diversity in technology in virtually every industry sector. For instance, Carden argued in the McKinsey Global Survey of Business Executives that "executives overwhelmingly say that innovation is what their companies need most for growth" (Carden 2005). Therefore, examining the influence of firms' knowledge base on their innovation performance is pivotal to predict the potentials of each firm.

The method of innovation and the ways of knowledge accumulation to innovate may vary depending on a firm and its' management strategy. Some firms may choose to acquire knowledge externally, whether through M&A, hiring external experts, joint-venture, and so on, and the success of external knowledge acquisition is largely dependent on firms' absorptive capacity (Zahra and George 2002), their core–competence (Kim et al., 2015), and firms' adaptive process (Schumpeter 1934; Kuran 1988; March 1991). Similarly, firms may choose to accumulate and acquire knowledge internally, whether through internal Research and Development (R&D) or learning from production (Stiglitz and Greenwald 2014), and the success of internal knowledge accumulation also depends on the same factors mentioned above. Interestingly, primary factor that was used in previous researches in analyzing absorptive capacity, core-competence, and other

innovation capabilities is firm's knowledge stock (Breschi et al., 2003; Granstrand et al., 1997; Patel and Pavitt, 1997). The main purpose of firms' knowledge search and their knowledge accumulation is to perform the exploration of new possibilities and the exploitation of old certainties (March 1991). According to March, firms' adaptive processes, by refining exploitation more rapidly than exploration, are likely to become effective in the short-run but self-destructive in the long run (March 1991). Therefore, fine balance between exploration and exploitation is critical in securing firm's survival. March's argument is supported by many researches (Cohen and Levinthal 1990; Grant 1996; Klette and Griliches 2000; Lee 2010) and they all agree that firms only focusing on exploitation may lose their competitive advantage that in the long run, they may be forced to exit the market. In the same way, firms that are only focusing on exploration of new opportunities, without refining and internalizing acquired knowledge (March 1991) can be harmful to their performance, since they will have low appropriability. However, although there are abundant researches that are focusing on the importance of exploration, there are lack of analysis on whether exploration is always good for a firm performance, which firm will have successful exploration outcomes, and whether there are relation between firms' knowledge stock and innovation performance when the management chooses the exploration strategy. As mentioned above, the attention on firms' knowledge stock and its influence on firms' management decision and innovation performance are on the rise, and therefore it will be important to access those shortfalls.

1.2 Research Purpose and Outline of Study

To fill the gap, this study attempts to analyze the influence of firms' knowledge stock on their decision to choose exploration and the relation between firms' accumulated knowledge stock and performance after exploration. The main objective of this study is as follows. First, the impact of firms' knowledge stock on their decision to choose exploration will be verified. Second, the relation between firms' knowledge stock and its' performance after they have chosen the exploration strategy will be analyzed. Lastly, to observe the difference in the methods of knowledge accumulation, that is, whether firms' knowledge stock were accumulated externally or internally, the relation between each method and firms' performance after exploration is estimated separately.

This paper is organized as follows. First, literature review on firms' knowledge stock and exploration and exploitation will be provided in detail in next section. Then, general trend and characteristics of South Korea's manufacturing firms and manufacturing industry will be briefly introduced. On the following section, the data source used to conduct this study is briefly introduced. Furthermore, the method of estimating firms' knowledge stock and its influence on firm performance after they choose exploration strategy is introduced. Afterwards, the empirical analysis of the data is performed and the results are presented. Finally, discussions and implications of this study and some limitations of this study are stated, with possible future researches. Our estimation results show that first there is positive relation between firm's knowledge stock and its decision

to choose exploration. Second, firm's high knowledge stock brings good exploration performance. Third, externally acquired knowledge stock has positive impact on Korean manufacturing firm's exploration decision. Fourth, internally accumulated knowledge stock is a factor that causes good firm performance after exploration.

Chapter 2. Literature Review

2.1 Exploration and Exploitation: What Drives Exploration?

According to March (1991), firms' learning process can be divided in to two types, exploratory learning and exploitative learning. Viewing organization as a learning mechanism, March defined exploratory learning as a conscious attempt to move away from current organizational processes, routines and knowledge in dealing with exiting or potential problems and to seek new information or knowledge (March 1991; Miner et al,. 2001; Lee and Huang 2012). On the other hand, exploitative learning denotes a use of knowledge closely related to an organization's prior knowledge base to solve the problem (March 1991; Helfat 1994; Lee and Huang 2012). In March's view, firms' management must not be trapped into only one of the method, which will bring them to suboptimal stable equilibria, and therefore, finding and maintaining an appropriate balance between exploration and exploitation is a key to the survival and the prosperity of firms (March 1991; Decarolis and Deeds 1999; Vega 2006). In many researches, exploration is defined as search, variation, risk-taking, experimentation, play, flexibility, discovery, innovation, while exploitation is defined as refinement, choice, production, efficiency, selection, implementation, and execution (Schumpeter 1934; Kuran 1988; March 1991; Miner et al., 2001). On many cases, firms choose exploitation over exploration, because of high

uncertainty involved in exploration (March 1991), desire to maintain status-quo and strong resistance to new ideas in case of good past performance (Lant and Mezias 1992), competency trap (Liu 2006), confirmation bias (Park 2012), and so on. On other cases, some firms choose exploration without refining their core-competencies, absorptive capacity, and the application of knowledge, which can result in poor performance. Thus, an optimum balance of exploration and exploitation is critical to firms survival and good performance, because numerous researches suggest that it is the root of organizational capability and the performance (Ghemawat and Ricard 1991; Costa, 1993; Benner and Tushman, 2003; Li and Lin 2008; Prieto et al., 2009; Uotila et al., 2009; Bodwell and Chermack, 2010).

As prior researches has already suggested, good innovation performance can be originated from various sources, such as adaptive process (March 1991; Bener and Tushman 2003), meta-routines (Adler et al., 1999), TMT arrangement (Lant et al., 1992; Talke et al., 2010), and many other sources. Nonetheless, a factor that is more intensively explored currently is firm's knowledge stock and its relation to innovation performance. A firm's knowledge stock is the amount of knowledge that a firm has accumulated over time (Dierickx and Cool 1989), and by examining firm's knowledge stock, it's past path, current capability and future projection can be drawn, since firms' existing knowledge stock defines the extent to which new knowledge is created (Smith et al., 2005). Firm's accumulated knowledge stock not only determines the performance of exploitation (Bierly and Chakrabarti, 1996), but also determines the direction and effectiveness of

exploration (Cohen and Levinthal 1990). It seems evident that firm's knowledge stock may play a pivotal role on a management decision to choose exploration strategy and may be a key determinant of good exploration performance. However, the role of knowledge stock on exploration and innovation performance has been still unexplored. To fill this gap, this study aims to examine whether firm's knowledge stock play a mediating role in firm's decision to choose exploration strategy. Following hypothesis is drawn after examining the gap.

- **Hypothesis 1. There is positive relation between firm's knowledge stock and its likelihood of choosing exploration.**

2.2 Knowledge-Stock: What Factors Make Exploration Successful?

The importance of knowledge cannot be emphasized enough when discussing about firms' innovation capabilities and performances. As Grant argued, the firm is conceptualized as an institution for integrating knowledge, given the assumptions about the characteristics of knowledge and the knowledge requirements of production (Grant 1996). In addition, Foray and Lundvall (2009) also stated that in order to understand the role of knowledge and learning in economic development, it is pivotal to make a clear distinction between different types of knowledge. Depending on the researchers' perspectives, a distinction of knowledge may vary. For example, Lundvall and Johnson

(1994) introduced four different types of knowledge, know-what, know-why, know-how, and know-who. Furthermore, Foray and Lundvall (1994) proposed that knowledge should be divided into knowledge as complex information and knowledge as a set of skills and competencies. Other researchers argue that knowledge may exist in an explicit form, such as patents, production manuals, database and so on, or knowledge may exist in an implicit form, such as knowledge residing within the individual, company culture, organizational structure and so on (Grant 1996; Liebeskind 1996; Linder and Wald 2011; Williams et al,. 2017). However, despite of varying definitions and distinctions of knowledge, most literatures agree that all of knowledge, regardless of types, within the firm forms its knowledge stock, which has significant impact on firm's innovation capability and performance.

Dierickx and Cool (1989) conceptualized knowledge as knowledge stocks and knowledge flows, which is a major determinants of good firm performance. Firm's knowledge stock is its' accumulated knowledge assets that are internal to the firm and firm's knowledge flow is knowledge streams flowing into the firm from external sources or knowledge that has not fully been assimilated within the firm. Considering that firm's knowledge flow is eventually integrated into its' knowledge stock, analyzing the relationship between knowledge stock and performance can give us an insight on which firm is more likely to succeed when they choose to expand their boundaries. Especially in industries like manufacturing sector, in which the cost of diversifying into other area is very high, analyzing the role of knowledge stock on exploration performance can give

interesting implications for many manufacturing firms, which have either failed after attempting on expansion or deciding whether to choose exploration strategy.

The simplest way of measuring firm's innovation performance is its sales (Wu and Shanley 2007; Kim et al., 2015). Especially in manufacturing sector, which the sales on products is the primary source of revenue, firm's sales growth is a simple, but a powerful measure of its innovation performance. The measure of firm's knowledge stock also varies depending on the studies. It can be measured by its number of new products, its R&D expenditure and expenditure history, its past technological performances, and finally its number of owned and applied patents. Patents, despite of its' limitations, are one of the most widely used measure of knowledge stock.

Due to the maturing industry, increase in competition and changing in technology, manufacturing companies cannot rely solely on internal knowledge development or rely solely on current market situation. They need to absorb relevant knowledge from external sources and expand their boundaries in the market in order to survive. To do so, a firm needs to improve their absorptive capacity through accumulating effective and quality knowledge stock (Cohen and Levinthal, 1990). In a market condition where rapid knowledge accumulation and expansion to other businesses is necessary, manufacturing companies need to build stronger competitive advantage which largely depends on the continual accumulation of relevant knowledge (Decarolis and Deeds 1999). Given these conditions, the performance of manufacturing firms should be dependent on its knowledge stock.

- **Hypothesis 2.** There is positive relationship between firms' knowledge-stock and firm performance after exploration.

2.3 Knowledge Accumulation: Is the Method of Accumulation Matters?

Due to the rising importance of knowledge in innovation, many firms' one of the primary management strategies is to accumulate strong and effective knowledge stock in order to enhance their technical knowledge base, absorptive capacity, core competence, and so on (Breschi et al., 2003; Granstrand et al., 1997; Patel and Pavitt, 1997). The ways of accumulating knowledge may differ in detail, but it can be generally divided into two ways, either acquire knowledge from external sources or acquire it through internal development. On one hand, firms may develop their internal knowledge stock, mostly through in-house Research and Development (R&D). These in-house efforts, which involve learning-by-doing (Stiglitz 2010), trial-n-error learning (March 1991; March 1996; Lee 2015), and implementation (Agenor et al., 2012), is accumulated within the firm, which will eventually enhance firms' innovation capabilities (Decarolis and Deeds 1999). However, in today's complex technological environment, even the most innovative organizations cannot rely only on internal sourcing; they need to search for knowledge from beyond their boundaries to have successful innovation (Rggby and Zook 2002; Cassiman and Veugelers 2006). On the other hand, firms may acquire knowledge from

external sources through licensing, R&D outsourcing, M&A, joint-venture, or hiring relevant experts (Arora and Gambardella 1990; Cockburn and Henderson 1998; Granstrand et al., 1992; Kim et al., 2015). But relying only on external sources to acquire and generate knowledge can be harmful to firm's innovation capability, because of following reasons. First, external knowledge takes time to be fully internalized. Second moral hazard and information asymmetry problem makes dependence on external knowledge acquisition more costly. And third, it weakens firms' absorptive capacity and core-competence (Kang 2012).

There are much on-going discussions regarding the effectiveness of each method, but in most of cases, firms conduct both the internal and external knowledge acquisition activities simultaneously, although they might differ in their tendency or weight of using each method. For this reason, knowledge acquisition methods are considered to be complementary. In other words, the increase in the intensity of one activity causes the marginal return to the other activity to increase as well. If a company has very in-depth and wide breath of knowledge, it will increase its marginal return to acquired external knowledge. This is the argument introduced by Cohen and Levinthal (1989) and their 'absorptive capacity', which emphasizes the importance of knowledge stock or 'a stock of prior knowledge', which enables the scan, screen, and absorb external information. Although there exist views which consider the substitutional relation between in-house R&D activities and external knowledge acquisition (Williamson 1985; Pisano 1990), rigorous empirical researches show that there is a complimentary relationship between in-

house knowledge accumulation and external knowledge acquisition.

Rothwell (1974) showed in his empirical studies that firms with best innovation performance had developed swift internal and external communication network, which enabled them to exploit external information more efficient use of external knowledge. Furthermore, Freeman (1991) showed that in-house basic research capability, added with the external technological expertise, is a primary driver of successful innovation. Rigby and Zook (2002) introduced the concept of "open-market" innovation, which suggest the advantages of opening up the innovation process to external knowledge flow. More recently, Garcia and Valasco (2007) found that successful technological diversification require both the strong absorptive capacity and efficient flow of external knowledge through explorative search. In addition, Lee and Huang (2012) also argued that an optimum balance between in-house and external knowledge accumulation is a contributor to organizational performance.

Their case studies show that the ability to combine internal and external information sourcing is a critical source of gaining competitive advantage in some of the fastest growing and most profitable industries. Considering these complimentary relations between each method and also considering the fact that all knowledge acquired by a firm is eventually internalized and adds up to firm's knowledge stock, distinguishing the impact of firm's in-house knowledge stock and externally acquired knowledge stock on innovation activities is appropriate to clearly observe the effectiveness of each method.

As discussed above, a firm that shows the successful innovation performance is likely

a firm that finds a good balance between internal and external knowledge acquisition. Thus, following hypothesis is drawn to examine the influence of knowledge accumulation method.

- **Hypothesis 3a.** Firms' high in-house knowledge stock will increase the likelihood of exploration
- **Hypothesis 3b.** Firms' high external knowledge stock will increase the likelihood of exploration

2.4 Exploration in Manufacturing Sector

As discussed in introduction, Korean companies shifted their focus from imitation to innovation, starting from early 1980s (Kim 1997; Chung 2007). Ever since, there has been rapid increase, especially in terms of quantitative efforts, in inputs and outputs of innovation, such as R&D inputs and patents applications. However, the evaluation of Korean companies' performance of R&D and innovation activities show mixed results (Chung 2007; Shin 2007). In case of R&D spending, South Korea is one of the highest spending countries among the OECD nations. However its output is way behind (Chung 2007). Other researches argue that the outcomes from innovation activities are not effectively translated into industrial uses and market performance (Bae 2006). Besides such criticisms, researchers do not deny the contributions of Korean companies' innovation efforts that helped them to survive and remain competitive in the market. One

of the most outstanding improvements in innovation output is patents. The number of patents applied at KIPO (Korea Industrial Property Office) was 3,407 in 1985, but it increased up to 125,633 patents in 2010. Knowledge output, in terms of patents, increased more than 35 times since they started to shift their focus on knowledge accumulation and generation. This indicates that Korea has been rapidly gaining in technological competitiveness.

One of the primary reasons Korean companies started to build on technological competitiveness was to reduce their technological dependency on advanced foreign firms (Kim 1997). However, due to the lack of accumulated knowledge and technological capability, Korean companies' reliance on foreign technology has not been reduced substantially (Chung 2007). On many of key industry sectors in Korea, such as automobile, CDMA technology, electronics, and smart-phones, almost all leading companies pay large amount of loyalties to foreign companies that own the core technology[5]. More concerning fact is that Korea's overseas royalty payments are concentrated in the areas where Korea is known to have international competitiveness. This phenomenon is largely due to the Korea's industrial R&D and innovation activities, which have been focused too much on implementation, efficiency, learning by doing, and commercialization rather than on developing original technologies with learning-by-building and trial-n-error learning[6]. Strong reliance on foreign technology of Korean

[5] Bae et al., STEPI policy report, "Innovation Strategy for Growth and Job Creation".
[6] [6] Lee (2015) "Time of Accumulation" and Lee (2017) "Way of Accumulation"

firms restricts their competitiveness in the current market and reduces the likelihood of successful expansion onto other industries (Cantwell 2003). Thus, analysis on the effectiveness of Korean companies knowledge stock and verification on whether the methods of knowledge accumulation have different influence on firm performance. By examining this, implications can be drawn as to which firm showed good exploration performance depending on their knowledge accumulation methods. Following hypothesis is drawn after accessing the issue.

- **Hypothesis 4a.** There is positive relationship between firms' in-house knowledge-stock and performance after exploration
- **Hypothesis 4b.** There is positive relationship between firms' external knowledge stock and performance after exploration

Chapter 3. Data and Methodology

3.1 Sample and Data

The database used in this study is Business Activity Research from Korea National Statistical Office (KOSTAT). Business Activity Research was started in 2005 in Korea, as the complexity and boundaries of Korean companies' activities increased. Statistical data from Business Activity Research if often used to comprehensively and thoroughly analyze diverse company activities, including R&D, management strategy, activities abroad and so on.[7] The dataset is consist of Korean companies' financial data, including assets, debts and capital, its management strategies, such as strategic alliance, going abroad, R&D investment, intellectual property, and diversification, and other basic information such as the number of employees, foundation year, and whether the company went IPO or not. Data other than administrative and financial data, which can be acquired through quarterly financial report of each firm, is collected through surveys and interviews conducted both online and offline. As of 2015, the dataset contains 14,304 manufacturing firms' data and 246,872 patents.[8] In this study, we sampled Korean

[7] The need for such research was first suggested in Korea Development Institute's (KDI) report "Improvement on Korean Business' Statistical Activities". First research was conducted in 2006 and ever since, KOSTAT has been releasing yearly report, forming a panel data now.

[8] KOSTAT (2016); in this research, panel data analysis was conducted between years 2006 to 2014.

manufacturing firms' data from year 2006 to 2014. Each firm's number of patents they owned yearly was used as an indicator of firm's knowledge stock. To address the unbalanced panel data, firms with less than 5 years of data were deleted. Moreover, firms that had missing data were also eliminated. Firm's decision to choose exploration strategy is indicated by their response on KOSTAT yearly survey on whether their firm explored in to new businesses that year. After sampling, total of 4,019 manufacturing firms with 26,337 observations from 2006 to 2014 were determined.

3.2 Variables

3.2.1 Dependent Variables

Decision to Exploration. A management decision to choose exploration is difficult to measure in general. Exploration can happen on various different occasions, such as R&D on new areas, hiring new personnel, and diversifying their technological capability and businesses. In this study, exploration is set as firm's decision to launch a new business and this decision is collected from responses on Firm Activity Research surveys. Considering that the ultimate goal of most firms are to generate profit, largely through providing products and services, firm's decision to enter into new businesses can be one of the primary outcomes of exploration (Garcia and Velasco 2008), since it requires additional capability building and it can bring additional sources of profit for a firm. It is

used as an dummy variable.

Performance. Firm's performance is measured by its sales growth after exploration. Sales are used as the measure of firm performance in various researches (Decarolis and Deeds 1999; Katila and Ahuja 2002; Kim 2015). Especially in case of manufacturing companies, which in general sell products in the market for revenues, firms' sales growth can be relatively accurate measure of firm performance.

3.2.2 Independent Variables

Knowledge Stock. As discussed above, there are different types of knowledge that firm owns. However, in case of implicit knowledge or tacit knowledge, as the term denotes, it is extremely difficult to measure in that it is invisible (Wagner and Sternberg 1985; Erlam 2006). Therefore, in this study, we use firm's explicit knowledge, number of patents they own, to measure its' knowledge stock. Despite of its limitations, patents are considered as one of the primary representations of stocks of organizational knowledge. Patents are physical, codifiable outcomes of innovation ideas, technics, and products that depict the knowledge of one, several, or entire employees (Decrolis and Deeds 1999). The influence of patents is associated with innovative performance on many different levels, such as regions, country, and company. Furthermore, patents are widely used measures of firm's capabilities in the eyes of policy-makers (Van der Eerden and Saelens 1991). There is some concern with using simple patent counts as a measure of firm's knowledge stock,

however it is still widely accepted as relevant measure in many researches.

3.2.3 Control Variables

Various other factors influence firm's decision to choose exploration and performance afterwards. We included five control variables in the panel data that has relation to exploration and firm performance

Number of Employee. Number of employees is one of the most widely used measures of firm-size (Acs and Audretsch 1987; Santarelli and Sterlacchini 1990). Exploration and innovation is generally long-term, costly, and has high uncertainties (March 1991; Cohen and Levinthal 1991), that only the firms with large amount of capital and financial stability can persistently try it. Moreover, in case of innovation activities, such as R&D, number of personnel working on research can have substantial impact on innovation outputs. More generally, controlling for firm size is essential when analyzing issues of firms.

Strategic Alliance. In the manufacturing industry, the development of new technology and product is a complex and specific process, which requires in-depth and broad range of knowledge (Teece 1986; Decarolis and Deeds 1999). Under this environment, even the most innovation active firms cannot develop relevant knowledge by themselves. Therefore, attempt to acquire external knowledge through strategic alliance is less risky

and costly way of efficiently accumulate new knowledge for companies. In addition, many literatures suggest the positive relation between the number of firm's strategic alliance and firm performance (Deeds and Hill 1996; Shan et al., 1994; Perry et al., 2004). It this study, decision to have strategic alliance is used as a dummy variable. .

Decision to Go Abroad. Korea is strong export-oriented country. In addition to insufficient domestic market size, exploring international markets to seize more opportunities in the global market is pivotal in the survival of the company. Many Korean companies were successful in the international market and will continue to expand their market at a global level. It is used as an dummy variable in this research.

Debt-Ratio. Firms' debt-ratio shows firm's financial stability and sometimes it is used as a measure of firm characteristics (Acs and Isberg 1991). Although debt-ratio cannot capture the innovative capabilities of a firm, it has definitely has influence on firm's decision to exploration and expand onto new businesses. Some firms may have risk-loving top management teams (TMT), which may invest their capital aggressively on exploration, M&A and joint ventures, diversification, and innovation (Hovakimian 2001). On the contrary, some TMTs can be more risk aversive and tries to reduce the financial instability via minimizing its debt.

Profit-Ratio. Firms' profit ratio generally captures the effectiveness of their current business. In some knowledge-intensive industries, such as biotechnology, profit and sales may not represent the true performance and status of firm, since they usually do not generate revenues from selling products (DeCarolis and Deeds 1999). Also, high profit-

ratio may work in both ways, when it comes down to management's decision to exploration. On one hand, high profit may give additional slacks for firms to engage in exploratory searches (Hull and Lio 2006). On the other hand, due to the competency trap (March 1991), high profit can give signal to the management that they are doing very well, which may drive them to focus more on exploitation of current capabilities. To control these impacts, we used profit ratio as one of control variables in this study.

3.3 Methodology

3.3.1 Probit analysis: Effect of Knowledge Stock on Exploration

In order to perform estimations on panel data, regression was conducted using probit model. The idea of the probit function was introduced by Bliss (1934) in a 1934 article in *Science* on how to treat data such as the percentage of a pest killed by a pesticles. The likelihood of certain events is measured by each 'probability unit' or 'probit', with its value ranging from 0 to 1. A probit model is a way to perform regression for binary outcome variables. Binary outcome variables are dependent variables with two possibilities, like yes/no, positive test result/negative test result or single/not single. The word "probit" is a combination of the words probability and unit; the probit model estimates the probability a value will fall into one of the two possible binary (i.e. unit) outcomes. In the process of setting and analyzing the model, sometimes the dependent variable is only 0 or 1. In this study, the model used for estimation is a binary response

model. It directly describes the response probabilities P(yi = 1) of the dependent variable yi. Furthermore, probit model is used to examine the effects of a set of independent variables (Xs) on the probability of success or failure on the dependent variable, P(Y). To observe the determinants of firm's decision to choose exploration, following equation was formulated.

$$Y_{it} = \beta_0 + \beta_j X_{ij,(t-1)} + \beta_j C_{ij,(t-1)} + e_{it} \quad (1)$$

Where i: firm, t: year (of exploration), Y: exploration, X: explanatory variables, C: control variables, e: error terms.

3.3.2 Fixed Effect[9]: Moderating role of knowledge stock between exploration and firm growth

To observe the impact of knowledge stock on exploration and firm performance after exploration, below equation was designed for estimation. After performing Hausman test, we determined that fixed effect model should be used to test the relationship between knowledge stock, exploration, and firm growth. A fixed effects model represents the observed quantities in terms of explanatory variables that are treated as if the quantities were non-random. This is in contrast to random effect model and mixed-effect model in which either all or some of the explanatory variables are treated as if they arise from

[9] After hausman-test, we determined that fixed effects model should be used to test the relationship between knowledge stock, exploration and firm growth.

random causes. In panel data analysis, the term fixed effects estimator (also known as the within estimator) is used to refer to an estimator for the coefficients in the regression model. If we assume fixed effects, we impose time independent effects for each entity that are possibly correlated with the regressors. Fixed effects estimation is also considered as another method to eliminate the time invariant unobserved effect. Therefore, fixed effects model can be useful in analyzing the impact of variables that vary over time. This estimator explores the relationship between predictor and outcome variables within an entity (company). Each entity has its own individual characteristics that may or may not influence the predictor variables. When using fixed effects model we assume that something within the entity may impact or bias the predictor or outcome variables and we need to control for this. This is the rationale behind the assumption of the correlation between entity's error term and predictor variables. Fixed effects model removes the effect of those time-invariant characteristics so we can assess the net effect of the predictors on the outcome variable. Another important assumption of the fixed effects model is that those time-invariant characteristics are unique to the individual and should not be correlated with other individual characteristics. Each entity is different therefore the entity's error term and the constant (which captures individual characteristics) should not be correlated with the others. If the error terms are correlated, then FE is no suitable since inferences may not be correct and you need to model that relationship (probably using random-effects), this is the main rationale for the Hausman test. Model below is used in our estimation.

$$Y_{it} = \beta_0 + \beta_j X_{i(t-2)} + \beta_j C_{i(t-1)} + u_t + \alpha_i + e_{it} \quad (2)$$

Where Y=sales growth rate, i: firm, t: year, u_t: time variable, α_i: unknown intercept for each entity.

Table 2 below shows the variables and methods we used to calculate each variable. One thing to consider is the devaluation of knowledge. As suggested in previous literatures (Drew 1988; Rochon 2006), the value of knowledge may also depreciate as time pass by. Especially, considering the fast-developing technologies in current manufacturing industry, we adopted the concept of knowledge devaluation in order to properly capture the effectiveness of each firm's knowledge stock. To do so, firm's accumulated knowledge stock (number of patents owned) are multiplied by 0.85 (Rochon 2006) yearly, so that the amount of patent knowledge stock depreciates yearly, just like the interest rate, if new knowledge is not generated. Furthermore, another reason for using patent stock of three years period, instead of certain year's patent stock is first to address the robustness problem. Second to take firms' knowledge accumulation attempts into consideration (Drew 1988; Nutter et al., 2002; Rochon 2006).

Moreover, firms' sales growth is measured by increase in sales growth 2 years after the exploration decision. According to rigorous literatures, firms' exploration (March 1991), diversification (French and Poterba 1991), and innovation all takes relatively long period to appropriate its benefits and show good performance (Kim 2015). Therefore,

since our study set exploration as starting a new business, we give 2 years lag for firms to show meaning changes in performance.

Variables	Type	Method used to measure
Newbiz (exploration)	Dependent(Dummy)	Decision to start new business in manufacturing sector(survey data)
Growth	Dependent	[(ln_sale-ln_sale(t-2)/2]*100
Total Knowledge-Stock (ln_stock)	Independent	ln[Patent owned + 0.85*patent owned(t-1) + 0.85^2*patent owned(t-2)]
Inhouse-stock(ln_inhouse)	Independent	ln[patent_inhouse+(0.85)*patent_inhouse (t-1)+0.85^2*patent_inhosue(t-2)]
Ext stock(ln_ext)	Independent	ln[ext_patent+0.85*ext_patent (t-1)+0.85^2*ext_patent(t-2)]
Empl	Control	ln[empl_sum]
Stgal (strategic alliance)	Control(dummy)	Whether firm choose to have strategic alliance or not
Debt_ratio	Control	Firms debt ratio provided from "기업활동조사"
Profit_ratio	Control	Firms' profit ratio provided from "기업활동조사"
Go_abroad	Control(dummy)	Whether firm choose to go abroad

Table 2. Variables

Chapter 4. Results and Discussion

On this section, estimation results from using above variables and equations will be presented. On the first stage, the relation between firm's knowledge stock and decision to choose exploration is verified, using probit-model analysis. On the next stage, using exploration as fixed effect, the statistical relation between firm's knowledge stock and performance after exploration. Then, firm's knowledge stock is divided into two different types; internally accumulated knowledge stock and externally acquired knowledge stock, and same estimation process is conducted. This study uses STATA 14.1 software for estimation. Table below shows basic statistics of our dataset. Basic statistics of our dataset is provided in the table below.

Table 3. Correlation Table

Variable	Obs	Mean	S.D.	1	2	3	4	5	6	7	8	9
1. D_newbiz	14,280	0.051	0.221	1								
2. Ln_stock	14,280	1.84	1.768	0.0613	1							
3. ln_inhouse	14,280	1.84	1.768	0.061	0.858	1						
4. ln_ext	14,280	0.768	1.38	0.0524	0.622	0.489	1					
5. ln_empl	14,280	2.075	1.379	0.048	0.466	0.453	0.376	1				
6. D_stgal	14,280	0.107	0.31	0.062	0.126	0.108	0.153	0.049	1			
8. D_go_abroad	14,280	0.839	0.731	0.018	-0.025	-0.028	-0.024	-0.004	0.0256	1		
9. Profit_ratio	14,280	0.031	0.16	-0.017	-0.018	-0.022	0.055	0.01	-0.381	0.025	1	
13. Debt_ratio	14,280	0.542	0.255	0.0272	-0.087	-0.052	-0.079	-0.021	-0.002	-0.012	-0,328	1

4.1 Effect of Knowledge Stock on Exploration

On the first stage of this study, the statistical relation between firm's knowledge stock and their strategic decision to expand their boundaries to new businesses was explored. Estimation results of probit model are provided in Table 4. As can be seen, statistically significant relation between firm's knowledge stock and its' decision to explore new businesses is observed. This result is in agreement with many previous researches (Argyres 1996; Talke et al., 2010; Lee and Huang 2012; Kim et al., 2015) that higher the firm's knowledge stock, higher the firm's technological capabilities, which enables them to have more explorative searching process. When searching for new opportunities, in this case, new businesses, high knowledge stock provides difference in information, knowledge, and perspectives on innovation that it increases a firm's likelihood to be more adventurous and confident when searching for new opportunities (Leifer et al., 2000; Talke et al., 2009). Therefore, **H1.** is accepted. Moving on to other estimation results, following variables; number of employees, debt-ratio, and profit-ratio, show no significant relation with firm's decision to diversify into other businesses. One variable that showed unexpected result is the firm size (number of employees). Intuitively, it was expected that larger the firm size, higher the likelihood of exploration decision, in that large firms are more likely to be operating stable and mature businesses, which will eventually require them to expand their boundaries. In case of decision to have strategic alliance and decision to go abroad, statistically significant and positive influence on

firm's decision to conduct exploration is observed. Strategic alliance between companies is one of the primary ways to acquire and increase the flow of external knowledge, while reducing the risk and cost of internal development or M&A (Hamel 1991; Osland and Yapark 1995; Perry et al., 2004). Moreover, decision to form strategic alliance itself is an attempt to increase the scope of search and increase the variation in information acquisition (Deeds and Hill 1996; Zollo et al., 2002). Thus, positive relation between decision to have strategic alliance and decision to choose exploration can be explained. In the same way, firm's decision to go abroad, in other words, exports, gives a firm greater market opportunities to explore (Lederman and Klinger 2006; Hesse 2009). In addition, in order to survive in the global market, where the competition is much more severe than domestic market in most countries, firms must put constant effort in exploring and improving their innovation capabilities.

Table 4. Effect of knowledge stock on Exploration

Dependent variable: newbiz(exploration)	Model (1)	Model (2) (All)
	Coef. (std. err)	Coef. (std. err)
Ln_stock (t-1)		**0.031** **(0.016)**
Ln_empl (t-1)	**0.085*** **(0.022)**	**.0455** **(0.062)**
D_stgal	**0.106**** **(0.05)**	**0.144**** **(0..062)**
Dept_ratio	**0.073** **(0.079)**	**0.075** **(0.094)**
D_go_abroad	**0.129*** **(0.033)**	**0.086**** **(0.04)**
Profit_ratio(t-1)	**0.203*** **(0.117)**	**0.135** **(0.150)**
Industry	**Included**	**Included**
Year	**Included**	**Included**
Constant	**-2.49*** **(.147.)**	**-2.17*** **(0.033)**
Firms	**4,019**	**4,019**
Observations	**26,337**	**18,299**
Log Likelihood	**-2889.825**	**-2675.213**
Chi Squared	**168.58**	**156.52**

Numbers in parentheses are standard errors; * p < 0.10; ** p < 0.05; *** p < 0.01

4.2 Moderating Effect of Knowledge Stock

Table 5 shows the estimation results of fixed effect model; the moderating role of knowledge stock between exploration and firm growth. Analyzing estimation results of model (3), we find strong negative relation between the decision to start new business and firm growth. Two possible interpretations can be given. First, exploration to new businesses can be costly and may require a longer time to successfully secure their position in the market, which can cause their short term performance to be relatively poor (Gomez-Mejia 1992; Sabherwal and Sabherwal 2005). Second, as Lang and Stulz (1994) argued, firms which choose to diversify show poorer performance relative to 'pure-play' firms. Lang and Stulz (1994) further stated that they find no evidence that diversification brings valuable intangible asset to firm (Anthony and Muturi 2017; Guerry and Wallmeier 2017; Rong and Xiao 2017). Next, we find that firm's knowledge stock has no significant relationship with firm performance. This result implies that although the importance of knowledge stock is on the rise, firm need to eventually expand their territory through exploration in order to fully exploit their knowledge stock's value. There are rigorous literatures arguing that if a firm only focuses on refining exploitation more rapidly than exploration, they will likely be effective in short run but 'self-destructive' in the long run (March 1991; Grant 1996; Zahra and George 2002; Benner and Tushman 2003). Therefore, at one point, a firm should explore and enter into new industry to diversify its

business. The moderating effect of knowledge stock between exploration and firm growth is observed to be positive and statistically significant. Therefore, H2 is accepted. This positive relation between knowledge stock and good firm performance, especially after the exploration, is confirmed by many literatures (Clercq and Dimov 2007; Wu and Shanley 2009; Matusik and Fitza 2011) that investing and exploring in industries in which a firm has more knowledge enhances its' performance. In addition, regarding the factors that makes exploration successful, our estimation result shows that firm's accumulated knowledge stock play a major role when starting a new business. Therefore, the importance of knowledge stock on innovation and exploration performance is confirmed.

Other control variables show all positive and significant relation with firm performance, except the decision to go abroad. In case of number of employees, the estimation result is intuitive that in general, a firm hires more people when their business is booming and they are going through expansion period. Thus, positive relation between number of employees and firm growth can be easily inferred. Next case, decision to have strategic alliance variable also shows strong positive correlation with firm growth. This result demonstrates the effectiveness of acquiring various kinds of knowledge from external sources. Due to the increasing complexity and diversity of technologies, even the most innovation-active firm cannot survive solely relying on internal development (Cohen and Levinthal 1990; Smith et al., 2005; Kim et al., 2015). And, our estimation result suggests that strategic alliance can be one of the effective ways of acquiring

external knowledge.

Table 5. Moderating role of knowledge stock between exploration and firm growth

Dependent variable: growth	Model (1)	Model (2)	Model (3)
	Coef. (std. err)	Coef. (std. err)	Coef. (std. err)
D_newbiz(t-2)	-0.555 (0.685)	-0.342 (0.787)	-3.125** (1.252)
Ln_stock(t-2)		0.535* (0.320)	0.468 (0.291)
D_newbiz* ln_stock(t-2)			1.213** (0.425)
Ln_empl(t-1)	4.64*** (0.708)	3.176*** (0.880)	3.793*** (0.88)
D_stgal(t-1)	1.081** (0.514)	0.94* (0.562)	1.006* (0.562)
Debt_ratio(t-1)	8.246*** (1.370)	4.45** (1.859)	.405** (1.858)
D_go_abroad(t-1)	0.437 (0.273)	-0.169 (0.282)	-0.151 (0.282)
Profit_ratio(t-1)	3.684*** (1.142)	2.848*** (1.293)	2.44*** (1.293)
Constant	0.834*** (0.816)	0.924*** (0.672)	0.924*** (0.653)
R2 overall	0.45	0.66	0.67
Firms	4,019	4,019	4,019
Observations	22,318	14,280	14,280

Numbers in parentheses are standard errors; * p < 0.10; ** p < 0.05; *** p < 0.01

4.3 Estimation result of the effect of in-house and external knowledge stock on Exploration

In this section, estimation results of the effect of internally accumulated knowledge stock and externally acquired knowledge stock on exploration is discussed. When looking at results from Table 6, we can observe that in model (1) and model (3), there is no statistical relation between internally accumulated stock and decision to exploration. This is unlike our projection, and H3a. is rejected. Possible explanation for this result is path-dependence (Lant and Mezias 1992) competency trap (Liu 2006), or confirmation bias (Park 2012), all of which drive a firm to maintain its current status, especially when they are showing good or average performance. Moreover, as March (1991) and Nickerson (1998) mentioned, high internal capability and good past performance cause organization to be more risk-aversive and to look for ways of problem-solving internally. Next, in case of externally acquired knowledge stock, results from both model (2) and model (3) confirms that there is positive and statistically significant relationship between external knowledge stock and strategic decision to exploration. Therefore, H3b. is accepted. As discussed above, firm's ability to acquire and exploit external knowledge often determines its exploration capability, largely due to the characteristics of exploration, because it requires experimentation, variation, and discovery (March 1991) that external knowledge acquisition is necessary to have successful exploration (Zack 1999; Bierly and

Damanpour 2009; Raisch et al., 2009; Hoang and Rothaermel 2010). As this result confirms, it can be inferred that Korean manufacturing firms seek to acquire knowledge externally when they are making strategic decision to diversify and enter into new businesses, while some of them overlooking the importance of internally accumulated knowledge stock. Then, how about in terms of firm performance? Next section will discuss the effectiveness of each knowledge accumulation method when a firm decides to diversify.

Other control variables show same statistical significance even after internally accumulated knowledge and externally acquired knowledge variables are estimated separately. Thus, we assume that the statistical relations between variables and exploration is same as reasons provided in section 4.1

Table 6. Effect of internal and external knowledge stock on Exploration

Dependent variable: Newbiz	Model (1)	Model (2)	Model (3)
	Coef. (std. err)	Coef. (std. err)	Coef. (std. err)
Ln_inhouse(t-1)	0.011 (0.016)		0.018 (0.016)
Ln_ext(t-1)		0.047*** (0.017)	0.041** (0.018)
Ln_empl(t-1)	0.046 (0.03)	0.044 (0.028)	0.030 (0.031)
D_stgal(t-1)	0.144** (0.062)	0.147* (0.062)	0.143** (0.062)
Debt_ratio(t-1)	0.075 (0.094)	0.066 (0.094)	0.072 (0.094)
D_go_abroad(t-1)	0.086** (0.04)	0.087** (0.04)	0.086** (0.04)
Profit_ratio(t-1)	0.135 (0.15)	0.132 (0.149)	0.139 (0.149)
Industry	Included	Included	Included
Year	Included	Included	Included
Constant	-2.24*** (0.053)	-2.13*** (0.189)	-2.096*** (0.193)
Firms	4019	4019	4,019
Log likelihood	-2889.925	-2885.624	-2887.270
Chi Squared	168.5	168.5	166.25
Observations	18,299	18,299	18,299

Numbers in parentheses are standard errors; * p < 0.10; ** p < 0.05; *** p < 0.01

4.4 Moderating role of knowledge Stock (internal & external) between exploration and firm growth

In this section, estimation results of moderating role of knowledge stock, both internal and external stock, between exploration and firm growth is discussed. In case of internally accumulated knowledge stock (ln_inhouse), we confirm that it has strong positive and statistically significant relationship with firm performance after firm's exploration decision. Thus, H4a. is accepted. Firm's internal knowledge stock, which is accumulated through internal R&D, learning-by-doing (Stiglitz and Greenwald 2015), trial-n-error learning (March 1991), and so on, represent firm's innovation capability and absorptive capacity that its effectiveness spills-over to even unknown areas when a firm is exploring for new opportunities. This result is supported by many previous literatures that internally accumulated knowledge stock, in other words, firm's prior knowledge base, is a driving factor that determines firm's superior innovation and market performance (Rugman 1980; Devarolis and Deeds 1999; Rosenbusch 2011; Zahra and Nielsen 2002). Of course, on many of these literatures, internally accumulated knowledge stock also includes implicit-knowledge, which may resides either in individual (Reber 1989; Zahra and Nielsen 2002), or organizational routines and cultures (Feldman and Pentland 2003; Cohen and Bacdayan 1994; Feldman 2000; Becker 2004), and the combination and mobility between explicit and implicit knowledge within the organization is a pivotal

factor that determines the successful innovation (Leonard and Sensiper 1998; Smith 2001; Dhanaraj et al., 2004). Therefore, if a firm has high internally accumulated knowledge stock, it can be said that they have strong innovation capability and will have a good chance of having successful exploration result, especially when they are entering the new areas outside of their original boundaries.

Unlike internally accumulated knowledge stock, externally acquired knowledge stock showed no significant relation with firm performance after firm's decision to exploration. Therefore, H4b. is rejected. Few interpretations can be given for this result. First, in order for a firm to exploit externally acquired knowledge, a firm needs to integrate, adapt, and internalize it (Steensma and Fiarbank 1999; Liesch and Knight 1999; Rugman and Verveke 2003; Lichtenthaler 2008), which takes time depending on firm's absorptive capacity (Cohen and Levinthal 1990; Tsai 2001; Lane et al., 2001). Therefore, it can be the case that externally acquired knowledge stocks of these firms were not fully internalized that they had no influence on firm performance. Second, a firm can acquire knowledge from external sources, but it does not become firm's knowledge stock. According to Marsh and Stock (2006), external knowledge acquisition is the process of increasing knowledge flow, determining what to retain and integrating it with prior knowledge bases. In other words, externally acquired knowledge stock does not exist, because externally acquired knowledge becomes firm's internal knowledge stock, after internalization (Marsh and Stock 2006). Furthermore, Menon and Pfeffer (2003) argue that management's valuation of externally acquired knowledge is higher than its actual

value, in terms of performance, that increasing the flow of knowledge from external sources, although its return is not satisficing, often is the firm management's decision. In addition, Arora and Gambardella (1990) further argued that it is important to strengthen the firm's internal knowledge stock by maintaining relevant and efficient external knowledge flow through external linkages to sustain good firm performance. In other words, using external knowledge 'flow' to increase its' internal knowledge stock is important, instead of stocking the externally acquired knowledge.

This argument is further supported by the estimation results of the other variable; decision to have strategic alliance. On all of this study's estimation results, decision to have strategic alliance had statistically significant and strong positive relation with decision to choose exploration and firm performance after. Although our dataset does not describe the specific terms of alliances, whether it is a research contract, joint-venture, or simple training exchange programs, it is evident from our results that increasing external knowledge flow is a significant factor that determines the decision to exploration and its outcome. Increasing external knowledge flow, assuming that it is a relevant knowledge for exploration, enhances firm's search scope and depth (Katila and Ahuja 2002; Chen and Chen 2011), strengthen the determination to maintain explorative search (Marchionini 2006), and enriches the firm's knowledge diversity (Cassiman and Reinhilde 2006; Kang and Kang 2009) that it increases the likelihood of successful innovation.

Table 7. Moderating role of knowledge stock (internal & external) between exploration and firm growth

Dependent variable: growth	Model(1)	Model (2)	Model (3)	Model (4)
	Coef. (std.err)	Coef. (std. err)	Coef. (std. err)	Coef. (std. err)
D_newbiz(t-2) (A)	-0.555 (0.685)	-2.881** (1.25)	-1.043 (0.947)	-2.142** (1.252)
Ln_inhouse(t-2) (B)		0.468 (0.321)		0.496 (0.322)
(A*B)t-2)		1.21*** (0.425)		1.247*** (0.491)
Ln_ext(t-2) (C)			0.198 (0.234)	0.273 (0.235)
(A*C)(t-2)			0.666 (0.495)	-0.080 (0.573)
Ln_empl(t-1)	4.640*** (0.709)	3.189*** (0.880)	3.176*** (0.880)	3.178*** (0.880)
D_stgal(t-1)	1.081* (0.514)	1.006* (0.562)	0.94* (0.562)	1.006* (0.562)
Debt_ratio(t-1)	8.246*** (1.371)	4.41** (0.562)	4.45** (1.859)	4.39** (1.858)

D_go_abroad(t-1)	**0.437** **(0.273)**	**-0.151** **(0.282)**	**-0.169** **(0.282)**	**-0.166** **(0.282)**
Profit_ratio(t-1)	**3.683***** **(10142)**	**2.844***** **(1.293)**	**2.848***** **(1.293)**	**2.85***** **(1.293)**
Industry	**Included**	**Included**	**Included**	**Included**
Year	**Included**	**Included**	**Included**	**Included**
Constant	**0.834***** **(0.081)**	**0.831***** **(0.392)**	**0.854***** **(0.494)**	**0.924***** **(0.484)**
R2 overall	**0.64**	**0.61**	**0.66**	**0.67**
Firms	**4,019**	**4,019**	**4,019**	**4,019**
Observations	**22,318**	**14,280**	**18,299**	**14,280**

Numbers in parentheses are standard errors; * p < 0.10; ** p < 0.05; *** p < 0.01

Chapter 5. Conclusion and Implication

5.1 Implications

In this study, the impact of firm's knowledge stock on its strategic decision to choose exploration and its performance after exploration is analyzed. Our estimation result shows that first firm's high knowledge stock increases the likelihood of its exploration and shows strong relation with firm performance after exploration. Second, externally acquired knowledge stock has stronger influence on decision to start new business in Korean manufacturing sector. Third, internally accumulated knowledge enhances firm performance, after exploration, while externally acquired knowledge stock do not. Accessing these results, following implications can be drawn.

First, the importance of accumulated knowledge stock on innovation and innovation performance is confirmed. Therefore, for firm's management, increasing their knowledge stock, through internal R&D, strengthening absorptive capacity, training its workers, and forming efficient knowledge flow and application system, is important factor that can secure survival and success in current environment. Especially, as mentioned in Section 1, the complexity of technology and the pace of technological change are rapidly rising in today's market (Singh 1997; Amsden 2003; Cantwell et al., 2004). It is getting more and more difficult to innovate and the competition of acquiring

relevant knowledge is also on the rise. Therefore, in order to remain competitive, a firm should consistently improve their knowledge stock via above methods, to address fast changing technical environment.

Second, the method of accumulation matters. As discussed in section 4.4, internally accumulated knowledge stock has significant positive relationship to firm performance after exploration. Internal knowledge accumulation requires a firm to go through many, sometimes not preferable processes. It requires intensive train-n-error learning (March 1991; Lee 2015), massive amount of learning by doing (Stiglitz and Greenwald 2015), large amount of risk-taking (Dewett 2007), R&D persistence (Alston 2009; Kang 2015), and TMT composition that maintains this process (Wu et al., 2002; Carpenter and Geletkanycz 2004; Alexiev et al., 2010). As can be seen, the prerequisite to successful internal knowledge accumulation is various and it can be easily inferred that it will be difficult to maintain these efforts. However, our results suggest that despite of these uncertainties and difficulties, a firm must continue or increase their effort to accumulate knowledge internally, so that when they spot the window of opportunities, they can explore it and have successful outcomes. The importance of in-house knowledge accumulation and its effort is stressed in many literatures (Kim 1997; Siddharthan 1988; Narula 2001; Becker and Dietz 2004; Lee 2015), and without going through this process of trial-n-error itself, a firm will likely perform poorly after they have entered into new businesses. A firm needs to be successful in their area first, in terms of forming effective and relevant knowledge stock, to be successful in other areas unknown to them.

Third, in the perspective of investors, both in the private and the public sectors, our study suggest that when a firm is exploring into new businesses, their accumulated knowledge stock and the method of knowledge accumulation are key factors to consider, when making investment decisions. Since the beginning of the 21st century, Korean government and companies have consistently attempted to develop their competitive strength in so called 'New Industries'. As the industries that Korea had strength, such as electronics, automobiles, and steel, are getting more mature and competitive10, many Korean manufacturing firms were forced to explore other areas, preferably more tech-intensive industries (Lee 2004), but the outcome of such exploration was relatively much poorer than their past exploration (Lee 2012). From ICT industry to biotechnology and pharmaceutical industry to renewable energy and electronic vehicle to artificial intelligence, Korea has attempted to explore and secure their position in the global market in each industry. Some firms were successful while some were not. Our study suggests that it may be possible to predict who will be successful by examining their knowledge stock and knowledge accumulation method. Investors should examine firms' history of in-house efforts, in the forms of R&D investment, patent application, and other internal efforts to enhance its knowledge capacity, when making investment decision, especially when a firm is expanding its boundaries into other businesses. More importantly, for

[10] Lee(2015): One of the major factors are rising economic and technical capabilities of Chinese companies. Moreover, as industries mature, Korean firms were not able to continue their fast-follower and catch-up strategies, which make it difficult for them to be successful continuously

policy makers, policies that facilitate and promote in-house knowledge accumulation can be an effective way of building competitiveness in unexplored industries. Furthermore, when determining which firm to give governmental subsidies, governmental official must examine the effectiveness of each firm's knowledge stock, especially that of internally accumulated knowledge stock. According to Lee et al., (2005) and Kim (2016), some firms, in order to get governmental subsidies for innovation activities, purchase patents externally to inflate their technological capabilities. Therefore, distinguishing internally accumulated knowledge stock with externally acquired knowledge can be an important ways to screen and select innovation-active firms and allows them to continue their in-house efforts to be successful later.

5.2 Limitations

There are some limitations to this study. First, in regard to exploration variable (D_newbiz) used in this study, our dataset does not show the characteristics of new business and its adjacency or relevance with their current businesses. All industries, even those that seem closely related, have their unique characteristics, technologies, and market structures that there exists clear difference between each industry. However, some industries are clearly more distant to each other to the point that they seem almost irrelevant. For example, Fuji Film expanded their business to cosmetics and even

pharmaceuticals industry11 in 2007. Rigorous case studies are conducted on this case and they concluded that Fuji Film's chemical technologies used to refine and produce film has close relation with some branch of cosmetics' that they were able to successfully adapt their technology into cosmetics (Na 2010; Shin 2015). This study cannot examine these differences in exploration distance, in terms of technological difference within the industries. Second, the relation between firm's knowledge stock and performance may not be direct. Although patents are one of the most widely used measure of firm's knowledge stock (Decarolis and Deeds 1999), its direct relation to firm performance, in this study's case, sales growth, can be vague. Some of firm's applied and granted patents can be used to produce certain products, which will generate revenue, while some patents are not used or even used in terms of strategic ways for other benefits12. This study cannot access these differences. Third, firm's tacit knowledge capability is overlooked. Firm's tacit or implicit knowledge, which reside in individuals and organizational routines (Masters 1992; Schacter 1992; Leonardi and Bailey 2008), is as important factor in firm's knowledge stock as its explicit knowledge. Since our study does not take implicit knowledge into account in firm performance, some bias on our estimation result may exist.

[11] Na (2010) "Why does FujiFilm making cosmetics?"
[12] As mentioned in section 4.1, some firms purchases patents externally to acquire government subsidies. Moreover, innovation-active firms with severely competitive market apply for numerous patents to keep the competition down and restrict new entries to the market.

5.3 Conclusion

In this study, analysis on the impact of knowledge stock and the method of knowledge accumulation on firm's exploration decision and performance afterwards is provided. Our results show that higher the firm's knowledge stock, higher the likelihood of exploration and higher the knowledge stock, higher the firm performance after exploration. Furthermore, manufacturing firms in Korea showed tendency to start new business by relying on external knowledge acquisition more than internally accumulated knowledge, although internally accumulated knowledge stock showed strong positive relation with firm performance after exploration. Following implications are drawn from estimation results. First, firms need to persistently accumulate knowledge, both internally and externally, since it is a factor that determines the success of exploration. Second, firms need to increase their in-house efforts of knowledge accumulation to strengthen their capabilities in absorption and application of knowledge. If a firm was not successful in knowledge accumulation in their main area, it is likely that they will not be successful when exploring for other opportunities. Last, for policy makers, providing policy tools that facilitate and promote firm's in-house knowledge accumulation will be an effective way of promoting new businesses.

This research contributes to a better understanding of the relationship between a knowledge stock, knowledge accumulation method, and firm performance. The findings

have theoretical and managerial implications in that they demonstrate the importance of knowledge stock, especially that of internally accumulated ones. These results can provide some insight on identifying firms that have high chance of successful exploration and further research on the relation between firm's knowledge stock and innovation performance can be promoted.

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Abstract (Korean)

기술의 복잡성과 기술혁신에 대한 어려움이 지속적으로 증가하고 있는 상황에서 기업의 지식 스톡(knowledge-stock)과 혁신성과에 대한 관계성이 점점 더 주목 받고 있는데, 이는 기업의 지식 스톡이 그들의 핵심역량, 흡수역량, 그리고 혁신역량을 측정할 수 있는 지표로 활용되고 있기 때문일 것이다. 따라서 본 연구에서는 기업의 축적된 지식이 기업의 탐험 결정과 탐험 후의 성과에 미치는 영향에 대해 분석하였다. 본 연구에서는 프로빗 리그레션 모델을 활용하여 한국 제조업 기업들의 특허와 재무지표를 분석하였다. 분석결과 다음과 같은 결과를 도출하였다. 첫째, 기업의 축적된 지식이 기업의 탐험결정과 양의 관계를 보인다. 둘째, 기업의 축적된 지식과 기업의 탐험 결정 후의 성과는 서로 양의 관계를 보인다. 셋째, 내부적으로 축적된 지식이 외부에서 얻어온 지식보다 기업의 탐험 후 성과에 더 긍정적인 영향을 준다.

주요어 : 지식스톡, 축적, 탐험, 혁신성과, 제조업
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