Ph. D. Dissertation in Economics

Study on the Strategic Entrepreneurship in Korean Bio-medical Industry

- Firm's Origin, Business Model, and Survival -

한국 바이오의약산업에서의 전략적 기업가정신에 대한 연구

- 기업의 창업특성, 비즈니스 모델, 생존을 중심으로 -

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Kwangsoo Shin

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지도교수 박하영

이 논문을 경제학박사학위 논문으로 제출함

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협동과정 기술경영경제정책 전공

신광수

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부위원장 _____(인)

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위 원 _____(인)

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Abstract

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Kwangsoo Shin
Technology Management, Economics and Policy Program
College of Engineering
Seoul National University

Along with the pharmaceutical industry, the bio-medical industry has also come into the spotlight in most countries as a new growth engine. Many countries, including pioneers and latecomers into this industry, are striving to make adequate preparations to be a part of this forthcoming era of bio-economy. However, despite such high expectations, the bio-medical industry faces challenges in several aspects, from basic R&D to the commercialization stage, caused by the unique characteristics of the biotechnology field. Therefore, bio-medical firms should strive to become technology-intensive and manage their business risk, and consider complementary relationships with investors, government, universities, hospitals, and other firms such as other bio-medical, or pharmaceutical firms. Moreover, latecomers experience greater difficulties due to global competition and

deficiency of the industrial ecosystem, than the pioneers do in this industry. Nonetheless, latecomers should not unconditionally mimic the growth strategies of pioneers, because of differences in their respective industrial ecosystem. Therefore, these latecomer countries need to define their unique strategies for growth.

This dissertation focuses on the bio-medical industry in Korea, being one of the latecomers. Korea has a high distribution of small-sized entrepreneurial firms. The country has developed as a government-led latecomer in this industry. Moreover, connectivity with the development of the ICT industry and the conglomerate-oriented industrial structure of Korea are advantages enabling its industrial growth. Such context of the Korean bio-medical industry acutely reflects the need of strategic entrepreneurship to simultaneously consider their unique competitive advantages in founding and growth strategies. In particular, this dissertation emphasizes the following properties—a firm's origin of entrepreneurs or entrepreneurial firms as the input, business model as the process, and a firm's survival as the ultimate outcome in the view of strategic entrepreneurship. For each research, this dissertation used a database developed by a project team of the Science and Technology Policy Institute (STEPI) as part of a project launched in 2013 to formulate a national strategy for the future of bio-economy in Korea.

The first study in Chapter 3 intended to demonstrate the differences in Korean bio-medical firms' respective strategies and performances, depending on properties of firm's origin of an entrepreneur or entrepreneurial team. Concretely, it examined the impact of the characteristics of independent venture established by entrepreneurs from research

organizations and corporate venture spin-offs from the parent company on strategies and performances of the firms. This study found that bio-medical firms established by entrepreneurs from research organizations had a positive influence on R&D intensity, R&D alliance, and technological innovation performance. Although these represent technology-intensive characteristics, confirming direct and mediating effects among them, they were still insufficient in creating firms' financial performance. This result implies that they are striving to resolve this through technology commercialization and business model innovation. In particular, it also implies the need for entrepreneurs and entrepreneurial firms to undertake efforts focusing on enhancing commercial capabilities and policies for managerial support. On the other hand, regarding spin-offs from parent companies, the origin of the firms positively affected manufacturing & marketing alliances, and financial performance. It is confirmed that the parent company mainly classified pharmaceutical companies and conglomerates, and their experiences in the manufacturing & marketing process, or managerial support like financing and consulting, enable differentiated business activities. Therefore, this study suggests that spin-off bio-medical firms can form an alternative founding model in Korea, where private investment like venture capital is deficient. In addition, this study also suggests that such companies need to make significant efforts to enhance their technological innovation capacity from the long-term perspective.

The second study in Chapter 4 intended to identify the different types of business models in the Korean bio-medical industry, and compare their characteristics and

performances. Although there are various definitions of a business model, it can be regarded as a bundle of strategies for profit generation, in that entrepreneurs or entrepreneur firms proactively select in their contextual circumstances. This study classifies Korean bio-medical firms with critical criteria of the business model on the levels of vertical integration, business diversification, R&D, and manufacturing & marketing alliances, by the clustering method. This study identified three types of business models in the Korean bio-medical industry; 1) business diversified firms with weak strategic alliances; 2) vertical integrated firms with strong strategic alliances; and 3) non-diversified R&D firms. Among them, the firm group with a competitive advantage in Korea is the cluster of vertical-integrated firms with strong strategic alliances. These firms showed vertical integration more than product development on average, and had robust strategic alliances for various purposes in several forms. They demonstrated excellent technological innovation and financial performance, more than any other clusters in the industry. Second, the cluster of business-diversified firms with weak strategic alliance had two or more business diversification areas on average, and had utilized a few strategic alliances for R&D and marketing. In addition, these firms have a relatively excellent financial performance by predominance in the bio-medical segment, although they have a lower level of R&D intensity and technological innovation performance than vertical integrated firms with strong strategic alliances. It shows the feature of Korean bio-medical firms that should consider their profit through business diversification at founding because of shortage of risk money, and on the other hand, the

growth path for incumbents like pharmaceutical companies and biotechnology firms with core technologies related to functional food and cosmetics in Korea. Finally, non-diversified R&D firms describe the existence of infant firms within Korean bio-medical industry. These firms have a single business area in basic R&D stage of value chain, and few strategic alliances. In particular, although they are similar to business diversified firms from the perspective of R&D intensity and technological innovation performance, they are more vulnerable in terms of financial performance. Therefore, this study suggests the necessity of firm's growth strategies and policy supports for their growth.

The third study in Chapter 5 concentrated on the internal and external survival factors of Korean bio-medical firms from the long-term performance perspective. The characteristics of an entrepreneur with experience in other firms and spin-offs of a parent firm, or alternately, the characteristics of firms that originated from other firms, and the business property of platform & service segment were considered internal factors. The government's R&D funding and strategic alliances were considered external factors emphasizing a firm's proactive strategic choice of its environment. From such an integrated view, the factors—firms' origin by an entrepreneur with career in other firm, platform & service segment, and government R&D funding—positively influenced the survival of Korean bio-medical firms. However, against the expectation, the factors—firms' origin by spin-offs of a parent firm, and strategic alliances—negatively influenced the survival of these firms. In addition, it is not confirmed significant effect of R&D alliances on firm's survival, but found the effect of manufacturing & marketing alliances

on it. Furthermore, through additive research, firm exits in Korea resulted from bankruptcy, and mergers and acquisitions (M&A), and this study confirmed that cases of bankruptcy are more than M&A cases in Korea. In particular, in cases of M&A, the most motivated creation of synergy between the acquirer and target and payback of target bio-medical firm, and there are M&A events for backdoor listing of an acquirer as a minority. Therefore, this study eliminated cases of M&A events for backdoor listing, and only included events for creating synergy for both, and payback of target. Through it, this study found that the properties of a firm's origin by spin-off firms and strategic alliances prevent their bankruptcy, and promote M&A events in the Korean bio-medical industry. Consequently, the properties of a firm's origin from other firms, and business property in the platform & service segment are opportunities for survival. Further, sustainable government R&D funding and securing profit though manufacturing & marketing alliances are required for their survival in Korean bio-medical industry.

In sum, this dissertation argued the necessity of strategic entrepreneurship to simultaneously consider their unique competitive advantage at founding and growth strategies. This was accomplished through three studies on firms' origin, business model, and survival. In addition, the study contributes to understanding the managerial and policy implications on business model and performance depending on the type of firm's origin and growth strategies. Amidst propagation of some Korean bio-medical firms in the global market, this dissertation expects to be visible the growth of Korean bio-medical firms.

Keywords: Strategic Entrepreneurship, Firm's Origin, Business Model, Survival, Bio-medical Firm

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Chapter 1. Introduction

1.1 Research Background

1.1.1 The Bio-economy Era and Biotechnology Industry

The biotechnology industry is the industry developing medically and industrially useful products, processes, and services using biotechnology which any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify (Morrison and Giovannetti, 1998; Walsh, 2002). Biotechnology appears in various business domains including pharmaceuticals, food, chemistry, energy, and electronics. Its use has created totally new businesses from previous or current businesses through progress in biotechnology and its convergence with other technologies in other industries (Pisano, 2006).

These characteristics have generated rapid growth, at a rate of 10 % on average globally per year. The industry is expected to be a next-generation growth engine in major countries, heralding a bio-economy era in the 2030s (OECD, 2009). The EU (2012) forecasts that the bio-economy's ripple effect will generate an economic value of 10 EUR for every 1 EUR of investment in 2025. Battelle and Bio (2012) also predict that the bio-technology industry will play a significant role in creating jobs in the future, given the results of studies on knowledge-based industries between 2001 and 2010 showing that industries such as finance and insurance, IT services and telecommunications, and aerospace declining in employment, while that in the bio-technology industry increased

by 6.4 %.

Based on these expectations, the US announced the “National Bio-Economy Blueprint” in 2012 and suggested five strategic objectives to realize the potential of the county’s biotechnology industry (The White House, 2012), and the UK and Germany set up “Bio Science 2015” and “Bio Industrie 2021”, respectively, to strengthen policies to support biotechnology industry growth at the national level (McCormick and Kautto, 2013). Japan also announced the “BT Strategy Outline” and a detailed code of conduct to secure advanced technologies to support the industry as led by the government, concentrating on “Industrialization strategies for bioinformatics” in the post-genomic era (Chauhan and Bhatnagar, 2014). Moreover, countries outside of those more advanced in the industry, including India, China, Brazil, and Russia are implementing strategies at the national level to develop the biotechnology industry (Liang and Mackey, 2012).

Similarly, the biotechnology industry in Korea has been highlighted as a future growth engine that will lead the nation’s economic development (Lim, 2009). The biotechnology industry in Korea has existed for over 30 years, since the “Korea Genetic Engineering Research Association” and the “Korea Genetic Engineering Academic Association” were established in 1982 (Science and Technology Policy Institute of the Republic of Korea, 2013). Although developing this industry has been on Korean national development agenda since 1984, when a law aimed to promote the industry was enacted, the government did not commit significant R&D support until the mid-2000s (Ministry of Science, ICT and Future Planning and Biotech Policy Research Center of the Republic of

Korea, 2014).

At 0.52 percent of GDP, or KRW 7 trillion 523.8 billion in 2013, the scale of the biotechnology industry is much smaller than other sectors of the Korean economy such as electronics, automobile, and shipbuilding industries and miniscule compared to its scale in the US, UK, and Japan (Ministry of Science, ICT and Future Planning and Biotech Policy Research Center of the Republic of Korea, 2014; OECD, 2014). In addition, the industry in Korea has a significantly high proportion of small firms compared with other advanced countries (OECD, 2014), as 58.6 percent of all biotechnology firms in Korea had fewer than 50 employees in 2012 (OECD, 2014).

However, the industry expanded at double-digit rates between 2009 and 2011. Furthermore, biotechnology R&D as a percentage of government R&D expenditures were 18.7 percent in 2012, compared to 2.7 percent in the private sector, it was the fifth largest among OECD countries in 2011, following the US, France, Japan, and Germany (Ministry of Science, ICT and Future Planning and Biotech Policy Research Center of the Republic of Korea, 2014; Ministry of Science, ICT and Future Planning and Korea Institute of S&T Evaluation and Planning of the Republic of Korea, 2013; OECD, 2013).

In addition, there are high expectations about the industry's future development, considering increases in technology transfers, joint R&D collaborations, or M&As and IPO (Science and Technology Policy Institute of the Republic of Korea, 2013). These recent industrial shifts indicate its "potential feasibility", compared to the early 2000s, when most bio-medical firms in Korea were more in the stage of "possibility". Therefore,

to realize its potential, the biotechnology industry in Korea requires firm- and national-level strategies to catch up to more advanced countries.

1.1.2 Bio-medical Industry

In particular, among various sectors in the biotechnology industry, the bio-medical industry has highlighted social-economic problems that increase of medical costs and impair medical finance savings at the national level due to the aging population, increases in chronic diseases, and changes in health care needs from life expectancy to healthy lives. The bio-medical industry has developed innovative products and services to prevent, diagnose, and treat human diseases, and was originally composed of two primary segments: 1) pharmaceuticals (including biopharmaceuticals) and 2) medical devices (Löffler and Stern, 2006). This dissertation focuses on the biopharmaceutical segment, though it involves other segments that could be necessary to complement these with other products and services to develop new biopharmaceutical drugs, such as diagnostic devices and platform & service infrastructure.

The biopharmaceutical segment is the mainstay of bio-medical industry, emerging commercially about 30 years ago. Cost-effective biopharmaceutical drugs are the engine of innovation in the pharmaceutical industry. The biopharmaceutical market shows a growth trend globally as patent rights to earlier blockbuster drugs expire and R&D productivity slows down in the pharmaceutical industry overall (Rader, 2013). Deloitte (2014) reported that the biopharmaceutical market was 23.4 %, or USD 288.7 billion of

the global pharmaceutical market (USD 1 trillion 230 billion) in 2014. EvaluatePharma (2012) also anticipates an increase in biopharmaceutical drugs sales in the top 100 worldwide pharmaceutical markets from 34 % in 2011 to over 50 % in 2020. There are several factors driving the rapid growth of the biopharmaceutical market over the chemical pharmaceuticals market, including better efficacy, fewer side effects, relatively shorter development periods, and their more advantageous pricing (Sahoo et al., 2009). The growth and advantages have prompted many pharmaceutical companies to expand their businesses to include the biopharmaceutical sector, and large global pharmaceutical companies have already established biopharmaceutical divisions or have engaged in strategic alliances and M&A with bio-medical firms with excellent technological competitiveness (Shimura et al., 2014). In particular, the recent rapid growth in the biotechnology funds allocated by global pharmaceutical companies signals the importance of biopharmaceuticals in the pharmaceutical industry globally (Ernst and Young, 2013).

Biopharmaceutical drugs are produced based on materials or ingredients originating from human or other living organisms, and include biological formulations such as vaccines or plasma derivatives, protein recombination drugs, anti-body drugs, cell therapy products, and gene therapy products depending on the type of main component. Anti-body drugs targeting specific antigens are protein drugs in some cases, though have been classified separately of late (Notification on bio-medical products' approval and evaluation of the Korea Food and Drug Administration, Article 2, Feb. 2013, modified).

Moreover, the biopharmaceutical segment actively develops bio-betters or super bio-similars with enhanced safety, efficacy, or effectiveness (in terms of drug compliance and convenience, etc.) compared with already approved biopharmaceuticals, and biosimilars with proven comparative equivalence to existing biopharmaceuticals (Rader, 2013).

Biopharmaceuticals have more properties than chemical drugs and complex structures (Ryu et al., 2012). Biopharmaceuticals are susceptible to changes caused by impurities due to the complex manufacturing process using organisms, while they have low toxicity and distinct action mechanisms with excellent effects in refractory and chronic diseases (Zhu, 2012). Biopharmaceuticals are developed from first-generation biologics like vaccines, plasma derivatives, and human hormones to protein recombination drugs by gene modification and cell culture technology (Pavlou and Reichert, 2004; Blackstone and Fuhr Jr., 2007). Advanced high-tech products such as monoclonal antibody drugs, cell therapy products, and gene therapy products have been recently developed by combining gene and cell fusion and bioinformatics technology (Ryu et al., 2012).

Future biopharmaceutical R&D especially requires diagnostic kits and reagents, and platform & service infrastructure for translational research and personalized medicine. Butler (2008) argued that bio-medical research has a gap between it and patients' needs. Biopharmaceutical R&D has high uncertainty at each step, including finding disease mechanisms to releasing new products and services, resulting in significant costs. Bio-medical scholars like Zerhouni (2007) and Collins (2011) claim that translational research is an efficient strategy to increase the cost-benefits of biopharmaceutical R&D.

Translational research aims to decrease the probability of R&D failures and increase translatability with short R&D periods and low cost by integrating basic science using bio-markers confirmed through genomic-, molecular-based biology with clinical trials in two ways: from bench to bedside and from bedside to bench (Goldblatt and Lee, 2010).

In addition, increased awareness of personalized medicine could lead to medical care provided by selecting drugs based on individual gene-types (Ginsburg and McCarthy, 2001; Woodcock, 2007). The feasibility of personalized medicine relies on accurate diagnostic tests and analysis that identify patients who can benefit from targeted therapies (Hamburg and Collins, 2010). Therefore, directions like translational research and personalized medicines in biopharmaceutical R&D has essentially called for diagnostic devices for In Vitro Diagnostics (IVD), such as diagnostic kits & reagents, and platform & service infrastructure, such as gene synthesis services and sequencing and analysis services, cell banking services, experiment animal breeding for pre-clinical tests, clinical trial agencies, and equipment for measurement and analysis. Consequently, this dissertation defines the target industry as *bio-medical industry-related biopharmaceutical R&D* that involves diagnostic kits & reagents, platform & service segment as well as biopharmaceutical segment.

1.2 Problem Statement

Although interest in the bio-medical industry has increased due to social-economic problems and potential, bio-medical industry is faced with many challenges from basic R&D to commercialization stage which are resulted from unique characteristics of biotechnology. They are the challenges of *"science business"*, because biotechnology is generally science-based. Pisano (2006), and Carayannopoulos and Auster (2010) emphasized that, above all, bio-medical firms should understand the three properties of biotechnology for their growth in the bio-medical industry: 1) uncertainty, 2) multidisciplinary, and 3) cumulativeness, representing the high risks and tacit properties of biotechnology. Such technological properties lead to fundamental challenges in biotechnology development such as managing the risk arising from uncertainty, problems integrating heterogeneous and complex knowledge, and gaining knowledge accumulated through failures (Pisano, 2006). Therefore, the bio-medical firms should establish strategies to solve fundamental challenges for their growth.

Such strategies are especially necessary for latecomers rather than for countries with more advanced bio-medical industries in the context of global competition and the lack of an industrial ecosystem (Mathews, 2002; Zhang et al., 2010; Niosi, 2014). Each country has different national and sectoral innovation systems and contextual circumstances (Malerba, 2002), so latecomers in the bio-medical industry should not blindly imitate the growth strategies of advanced countries. Therefore, the bio-medical industry in Korea, as a latecomer, should also understand their industrial context to eliminate obstacles to

industrial development and establish policies with country-specific strategies for growth of bio-medical firms.

It means identifying opportunity for growth of bio-medical firms in *"Korean context"*. Above all, Korean bio-medical industry has a high proportion of small-sized entrepreneurial firms (OECD, 2014). This context poses many challenges by their constraining resources and capabilities. In addition, private investment to support them at founding, such as venture capital is relatively inactive compared to advanced countries like the US as yet. In such a context, hitherto, Korean bio-medical industry has well-developed by government-led system (Casper, 2009). Moreover, there are unique national advantages for growth of Korean bio-medical industry, such as connectivity bio-medical technologies with developed information and communication technologies and conglomerate-oriented industrial structure (Casper, 2009; Wang et al., 2012). Such an industrial context in Korea shows that bio-medical firms should go strategically forward to identify opportunities for their growth along with business challenges from small business and shortage of private investment (Mullins and Komisar, 2009).

Therefore, the challenges and opportunities in both *"science business"* and *"Korean context"* definitely reflect the need of *"strategic entrepreneurship"* to simultaneously consider property of entrepreneurship, and strategic management to develop Korean bio-medical firms (Hitt et al., 2011). However, there are few studies on the growth of bio-medical firms taking a strategic entrepreneurship approach. Therefore, this dissertation cares to deal with strategic entrepreneurship for growth of Korean bio-medical firms. In

particular, this dissertation emphasizes the properties of firm's origin from entrepreneurs or entrepreneurial firms as input, business model as process and a firm's survival as ultimate outcome in the view of strategic entrepreneurship.

1.3 Research Purpose, Question and Outline

This dissertation emphasizes firm's origin, business model, and survival as input, process, and outcome in strategic entrepreneurship, an area covered by relatively few studies, and addresses three research questions. First, strategic entrepreneurship highlights how entrepreneurs or entrepreneurial firms with business restriction at founding strategically manage or coordinate resources or capabilities to maximize their performance in terms of competitive advantage (Ireland et al., 2001; 2003; Ireland and Webb, 2007). Above all, an entrepreneurs or entrepreneurial firms are considered the most important *"input"*, themselves or resource and capability for firm growth (Colombo and Grilli, 2005; Hitt et al., 2011). In particular, their tacit knowledge about basic science, of entrepreneurs from research organizations like universities, hospitals, and government-funded institutes, is critical for growth of bio-medical firms (Lynskey, 2004; Pisano, 2006; Zucker and Darby, 2001).

In addition, it has emerged that there are spin-offs from parent companies in Korean bio-medical industry. Such a different firm's origins seem to result in different strategies and performances depending on their properties. Therefore, this study addresses the research question: In the Korean bio-medical industry, how do the characteristics of firms established by entrepreneurs from research organizations and spin-offs from parent companies affect their strategies and performances? For it, this study examines the effects on strategies and performances according to the firm's origins as input in strategic entrepreneurship.

[Research Question 1] *How do the characteristics of firms established by entrepreneurs from research organizations and spin-offs from parent companies affect their strategies and performances in the Korean bio-medical industry?*

Second, strategic entrepreneurship emphasizes how entrepreneurs or entrepreneurial firms identify their opportunities to create and capture value. Particularly, the strategic entrepreneurship view emphasizes how they proactively work within their circumstances instead of passively working against it (Hitt et al., 2001), so it is important to look at entrepreneurs' or entrepreneurial firms' strategic choices in their circumstances as a *"process"* to create and capture value, or how performance is achieved with their strategic choices (Hitt et al., 2011; Demil et al., 2015). To this end, this dissertation identifies their business models, viewed as a bundle of strategies for their growth, considering that there is no clear definition of a business model as yet. Previous studies on bio-medical firms' business models categorized these based on the level of vertical integration and business diversification (Burns, 2005; Fisken and Rutherford, 2002; Willemstein et al., 2007).

In addition, the federated model through formation of value network by strategic alliance has recently stood out as new business model, considering productivity, profitability, and sustainable growth (March-Chordà and Yagüe-Perales, 2011; Rusu et al., 2011). Therefore, this study addresses the research question: Which strategic properties

do Korean bio-medical firms' business models have? Moreover, which business model has created better performance in their context? This study views business models in terms of the results from creating and capturing value, and observing varying characteristics and performances according to business model.

[Research Question 2] *Which strategic properties do Korean bio-medical firms' business models have? Moreover, which business model has created better performance in their context?*

Third, strategic entrepreneurship has mainly focused on the influence of entrepreneurs' or entrepreneurial firms' strategic choices on short-term performance (Kuratko and Audretsch, 2009). However, firm's strategic decisions focusing to short-term performance may harm strategies to the long-term perspective (Duchesneau and Gartner, 1990), as this relates to attitudes and vision to generate future benefits (Ryu et al., 2007; Sheth and Parvatiyar, 1992). Entrepreneurial firms with a long-term perspective are ultimately concerned about their survival as the *"outcome"*, and not short-term profit (Klepper, 1996; 2002). Firm's survival means successful founding of new firms, which ultimately encourages growth of the industry (Thompson, 2005).

In addition, firms focus on sustainable interdependency or co-evolution with their environment for their survival (Nelson, 1995), meaning that firms should select successful business strategies to find legitimacy for their survival (DiMaggio and Powell,

1983; Rao et al., 2001), especially in latecomers of bio-medical industry like Korea lacked of industrial ecosystems (Aldrich and Fiol, 1994; Zahra, 2007; Hermelo and Vassolo, 2010). It means that study on firm's survival should considered both firm's internal and external factors. Therefore, this study addresses the research question: What are the internal and external factors for survival of bio-medical firms in Korea? This study provides Korean bio-medical firms with guidance related to survival.

[Research Question 3] *What are the internal and external factors for survival of bio-medical firms in Korea?*

Comprehensively, outline of three studies are summarized in Figure 1.

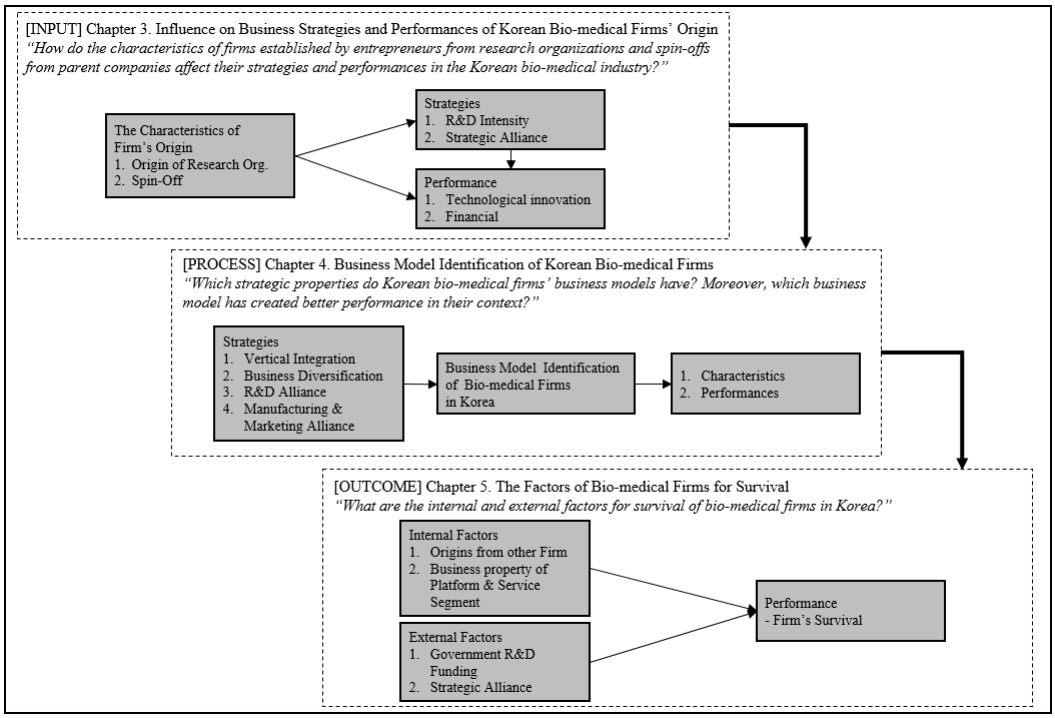


Figure 1. Research outline

1.4 Research Contributions

Chapter 3 analyzes the impact of firm's origin on its strategies and performances through a generalized structural equation model assuming that the most important resources or capabilities in Korean bio-medical industry are the entrepreneurs' or entrepreneurial firms' characteristics. This study's findings determine the differing effects of the characteristics of entrepreneurs from research organizations and those of spin-offs from parent companies on the strategies and performances of bio-medical firms.

Chapter 4 identifies business models of firms in Korean bio-medical industry through cluster analysis by level of vertical integration, business diversification, R&D, and manufacturing & marketing alliances, the most important strategies for creating and capturing business opportunities. This study also finds the different characteristics of these business models in the Korean context and discusses their merits in terms of technological innovation and financial performance.

Chapter 5 examines the internal and external factors for survival of bio-medical firms in terms of long-term performance. This study determines the internal factors from microscopic viewpoint, and the external factors from a mesoscopic viewpoint as a result of networking with other organizations. Additionally, this study also follows survival and exit status of bio-medical firms, and find two reasons of firm's exit by bankruptcy and M&A, which additionally analyzes survival factors depending on type of firm's exit.

Overall, this dissertation contributes strategic managerial implications for firm growth, further policy implications in terms of firm origin, business model, and survival from strategic entrepreneurship perspective for industrial development for blooming latecomers of bio-medical industry like Korea. Specifically, this dissertation suggests that types of firm's origin (or entrepreneurship) and growth strategies influence formation of their business model and performance, ultimately survival. That is, it will give managerial and policy implications by identifying factors of strategic entrepreneurship involving firm's origins and growth strategies and matching their business model and performances.

1.5 Research Structure

Chapter 2 examines the economic origin of entrepreneurship and emergence background of strategic entrepreneurship through previous studies and deduces the critical implications related to the research questions on firm's origin, business model, and survival. Chapter 3 investigates the influence of the characteristics of firm's origin, those of entrepreneurs compared to research organizations, and of spin-offs from parent companies on the strategies and performance of bio-medical firms in Korea. Chapter 4 identifies business models of firms in the Korean bio-medical industry based on 4 critical criteria, and which business model created better performance in Korean context. Chapter 5 examines the critical factors affecting the survival of bio-medical firms in Korea, and additionally follows survival and exit status of bio-medical firms analyzes survival factors depending on type of firm's exit. Chapter 6 comprehensively considers managerial and policy implications for the growth of the bio-medical firms in Korea in that factors of strategic entrepreneurship involving firms' origin and growth strategies influence on their business model and performances, based on the discussions from Chapter 2 to 5.

Chapter 2. Theoretical Background

2.1 Strategic Entrepreneurship

2.1.1 Economic Importance and Origin of Entrepreneurship

Entrepreneurs and entrepreneurial firms are critical for economic growth (Wennekers and Thurik, 1999). There have been recent efforts by economists to insert the role of entrepreneurs into an endogenous economic growth model (Minniti and Lévesque, 2008). Solow (1956) argued that economic growth is mainly concerned with labor and capital problems in considering drivers of economic growth. To this end, entrepreneurs and entrepreneurial firms contribute labor, human, and knowledge capital for economic growth through job creation and knowledge spillover (Gilbert et al., 2006; Delmar et al., 2011). Previous studies described the significance of entrepreneurs and entrepreneurial firms in job creation (Dunne et al., 1988; Mueller, 1992; Spletzer, 2000; Neumark et al., 2006; 2011), particularly entrepreneurial firms' contribution to economic growth and wealth through job creation (Acs et al., 1999; Van Praag and Vesloot, 2007; Malchow-Møller et al., 2011). Moreover, Acs et al. (2004; 2005) underlined that one way to develop an endogenous economic growth model is through knowledge spillover from entrepreneurs and entrepreneurial firms. Audretsch and Keilbach (2004; 2005) also argued that entrepreneurs and entrepreneurial firms are crucial in the process of selecting innovation, which creates more variety in knowledge, promotes knowledge transfer among organizations, and ultimately results in economic growth.

In general, an *"entrepreneurship"* of entrepreneurs and entrepreneurial firms is defined as *a process that an individual or an organization pursues new economic opportunity despite shortfall in resources or capabilities that can be controlled* (Stevenson and Jarillo, 1990). There are two origins of Schumpeterians and Kirznerians for the economic perspectives of entrepreneurship. First, Schumpeter argued that entrepreneurs and entrepreneurial firms as innovators were the cornerstone of economic growth (Casson, 2005). Entrepreneurs and entrepreneur firms relate to economic growth through endogenous technological progress (Lucas, 1988; Romer, 1990; Temple, 1999, van Praag and Versloot, 2007). Technological progress generated by innovation and competition among organizations with resources and capabilities (Teece, 1992). Entrepreneurship as the intermediate link through innovation and competition for economic growth (Wennekers and Thurik, 1999; Carree and Thurik, 2003). Therefore, Schumpeter (1942) considered the birth of start-ups by entrepreneurship as "disequilibrating phenomenon" in economic circumstances, because old technologies and business models are destroyed in the process of creative destruction by start-ups with more innovative technologies and effective new business models.

In this context, Schumpeterians emphasize that entrepreneurs and entrepreneurial firms focus on innovative and proactive behaviors to create wealth (Lumpkin and Dess, 1996). To them, entrepreneurship are recognized as behaviors to take risks in uncertain environments and to implement business activities (Carree and Thurik, 2003). In particular, from the Schumpeterian perspective, innovation is the most decisive factor

characterizing entrepreneurs and entrepreneurial firms (Covin and Slevin, 1989; Karagozoglu and Brown, 1988; Miller, 1983; Miller and Friesen, 1982). Schumpeterians perceive entrepreneurs and entrepreneurial firms as the creators of new combination of resources and capabilities for innovation (Schumpeter, 1934; 1942). Furthermore, innovation suggest new insight into their boundaries, considering competition and cooperation with external organization (Foss et al., 2007). Therefore, from the Schumpeterian viewpoint, studies on entrepreneurs and entrepreneurial firms consider innovative and proactive behavior for production of recombinants with competitive advantage (Parker, 2004; Kyrgidou and Hughes, 2010).

Second, Kirzner (1973) differentiated advantage maximizing behavior and entrepreneurial behavior, and emphasized that there were “entrepreneurial incentives”, distinct from the Schumpeterian view (Kirzner, 1985). It emphasized entrepreneurial incentive resulted from the encouragement of entrepreneurs and entrepreneurial firms to select a particular path among already perceived alternatives. Entrepreneurial incentives are the motivating force imposing choice between benefits and costs, shifting the opportunity-cost relationship (Kirzner, 1985). It argued that economist had ignored entrepreneurs’ and entrepreneurial firms’ economic incentives. Kirzner (1999) claimed that his arguments differ from those of Schumpeterians, in that it involved the discovery of opportunities in their markets.

In this context, Kirznerians highlight that entrepreneurs and entrepreneurial firms also sought opportunities in competitive situations, including the importance of innovation

from Schumpeterian arguments (Lumpkin and Dess, 1996; Kirzner, 2009). In addition, they emphasize uncertainty in the context of entrepreneurship (Pedler et al., 1998), which implies that entrepreneurship enables entrepreneurs and entrepreneurial firms to identify and utilize new business opportunities with different uncertainties depending on their circumstances (Shane and Venkataraman, 2000). In this view, Kirznerians' approach may encompass that of Schumpeterians, considering the creation of opportunity via innovation and the discovery of opportunity in uncoordinated situations by ignorance.

2.1.2 Current State of Entrepreneurship in Economics

Although studies on entrepreneurs and entrepreneurial firms may be interpreted based on classical or neoclassical economics, which consider production as a function linked to labor and capital (Audretsch and Keilbach, 2007), there are still few universal theories and concepts in the entrepreneurship literature (Agarwal et al., 2010), from two reasons: 1) *the bounded rationality of entrepreneurial behavior* and 2) *the importance of contextual circumstances*. First, classical or neoclassical economics draws conclusions based on perfect rationality, whereas studies on entrepreneurship should pay more attention to individuals' fragmented strategic behaviors based on bounded rationality (De Bruin and Dupuis, 2000; Felin et al., 2014). Simon (1992) argued that bounded rationality could be distinguished from the perfect rationality assumed in classical or neoclassical economic theory through the generalization of human behavior observed in economic life. This emphasizes intentional rationality, but only in a limited, localized and socially

embedded manner, which is ultimately inconsistent (Kaufman, 1999; De Carolis and Saparito, 2006).

Second, studies on entrepreneurship must sufficiently consider contextual factors. Gartner and Shane (1995) called for entrepreneurship research to recognize the context in which entrepreneurship takes place. In particular, Kirznerians emphasizes the identification of initially perceived opportunities in contextual circumstances (Alvarez and Barney, 2010; De Jong and Marsili, 2015). Whetten (1989) argued that the “where” and “when” dimensions were important contextual factors in studies on entrepreneurship. Here, “where” considers the various locations in which entrepreneurship occurs, such as business, social, spatial, or institutional. The “when” viewpoint focuses on temporal or historical contexts. It apparently differs from classical or neoclassical economics in that it ignores social effects such as political or cultural relationships.

Thus, entrepreneurship research seems ill-suited to classical or neoclassical economics. Entrepreneurs and entrepreneurial firms with bounded rationality should beware of firm failure from self-verification and self-determination, and further more concentrate on their contextual circumstances and feedback from this environment (Fiet, 1996; Shepherd and Haynie, 2011). As a result, the elements of bounded rationality and contextual circumstances prohibit the generation of a singular aggregated product function from various producers and environments (De Jong and Marsili, 2015). Therefore, the assumptions of classical or neoclassical economics are not appropriate to studies of entrepreneurship (Barreto, 1989). However, the viewpoints of Schumpeterians and

Kirznerians' approach distinctly reflect that entrepreneurs or entrepreneurial firms are critical factors of economic evolution (Luke et al., 2011).

2.1.3 Emergence of Strategic Entrepreneurship

Entrepreneurs and entrepreneurial firms aim to grow their firm. To ensure the growth of the firm, entrepreneurs and entrepreneurial firms need to capitalize business opportunities (Perez and Soete, 1988). Entrepreneurs need to open the so-called "*window of opportunity"* in order to capitalize the opportunities (Perez and Soete, 1988; Singh, 2001; Lee et al., 2005). Generally, entrepreneurs and entrepreneurial firms are people and organizations (teams) who identify opportunities and turn them into successful businesses (Short et al., 2010). Some examples of opportunities are new technology, new products, new services, and market niche. According to Schumpeterians and Kirznerians, in terms of economics, the behavior of opening a window of opportunity has two aspects: advantage seeking behavior, where they aim to secure competitive advantage, and opportunity seeking behavior, where they attempt to identify opportunities in their context (Kyrgidou and Hughes, 2010). However, these behavioral properties of entrepreneurs and entrepreneurial firms for opening window of opportunity should be strategically interactive in the view of the growth of firm (Shepherd, 2015).

In her book entitled "The theory of the growth of the firm", Penrose argued that a firm is the set of production resources organized in an administrative framework (Penrose, 1959). The main purpose of a firm in this context is to produce technologies, products,

and services by combining its internal resources with the resources it obtained from outside the firm, thereby generating profit. This concept enables the expansion of the productive opportunity set, i.e., the set of opportunities that a firm can pursue. In such circumstance, the behavior of the firm to obtain opportunities are presented by firm strategies composed of internal growth strategy to secure competitive advantage, like vertical integration and business diversification through key internal resources and capabilities of a firm and external growth strategy such as external financing and strategic alliance. Entrepreneurial firms achieve growth through such internal and external growth strategies to seek new opportunities.

However, with regard to the study of entrepreneurship, the extant research on the strategic behaviors of entrepreneurs and entrepreneurial firms in opening a window of opportunity is insufficient (Meyer and Heppard, 2000; Venkataraman and Sarasvathy, 2001; Hitt et al., 2001). Meyer and Heppard (2000) emphasized that the two functions of entrepreneurship and strategic management developed independently. Venkataraman and Sarasvathy (2001) reported that prior studies on entrepreneurship had not integrated the perspective of strategic management, and vice versa. Additionally, Hitt et al. (2001) argued that entrepreneurship involves not only identifying and exploiting entrepreneurial incentives but also strategically creating value by entrepreneurs and entrepreneurial firms.

In fact, strategic management aims to form the firm’s competitive advantage (Chen et al., 2009), regarded as the bundle of commitments, decisions, and actions required for a firm to achieve competitiveness (Ketchen et al., 2007). It implies that entrepreneurship

and strategic management are commonly objects for individual, organizational, and economic growth (Hitt et al., 2001; Ireland et al., 2003; Ireland and Hitt, 2005). In the context, from the early 2000s, many scholars have argued necessity of integration of strategic management in studies on entrepreneurship. *"Strategic entrepreneurship"* was born in this background.

Hitt et al. (2001; 2011) defined strategic entrepreneurship is *entrepreneurial action with a strategic perspective*. Ireland and Webb (2007; 2009) discussed strategic entrepreneurship *as the means through which firms simultaneously exploit their current competitive advantages while exploring future opportunities*. Kyrgidou and Hughes (2010) defined strategic entrepreneurship *as a process to make strategic efforts to clarify opportunities*. Kuratko and Audretsch (2009) also defined strategic entrepreneurship *as the new term that has arisen in the literature to represent the intersection of strategic management and entrepreneurship*, meaning that the primary question of strategic entrepreneurship is how the firm creates and sustains their competitive advantage, while simultaneously identify their opportunities. Moreover, it emphasizes the importance of identifying the central entrepreneurial elements and understanding the strategic context (Shane and Venkataraman, 2000; Alvarez and Busenitz, 2001). Therefore, in terms of strategic entrepreneurship, there is a single undividable discipline to open window of opportunity (Ireland et al., 2001; 2003).

2.2 Strategic Entrepreneurship for Korean Bio-medical Firm

2.2.1 Context of Korean Bio-medical Industry

As each industry has different sectoral innovation systems (SIS), the unique innovation system of the bio-medical industry needs to be understood. Prior studies examined the structure of the bio-medical industry's sectoral innovation system. Etzkowitz and Leydesdorff (2000) and Etzkowitz (2003) emphasized that the advantages of science-based knowledge in universities need to be combined with the business advantage of firms, and that the government needs to institutionally support universities and firms via the "triple helix model" involving universities, firms, and the government. Coriat et al. (2003) highlighted the importance of the specialization of bio-medical firms through patent applications for technology because of the science-based characteristics of the bio-medical industry and the role of continuous investment and strategic alliances for R&D or commercialization. Niosi (2003) claimed that continuous investment is made since science-based knowledge is patented in the bio-medical industry, which promotes strategic alliances for the commercialization of technologies or products, eventually leading to a firm's growth. Khilji et al. (2006) proposed an integrated innovation model for bio-medical firms and demonstrated that patented technologies could lead to a business or could be manufactured as products and distributed through investments and alliances, thereby enabling firms to generate profit and achieve growth. Pisano (2006) emphasized that it is important to understand the unique characteristics of biotechnology

in order to understand the industry innovation system of the bio-medical industry. In his book *"Science Business"*, Pisano highlighted the role of firm organization and strategic alliances in risk management, technology integration, and learning. Additionally, Pisano (2006) claimed that sustainable public and private investment is crucial because of the industry's relatively long product development period from R&D to commercialization compared to the product development period in other industries as well as the huge development cost associated with this industry. These show that the importance of the internal characteristics of bio-medical firms and their relations with research organizations, other companies, investors, and the government are emphasized for growth of bio-medical firm, as shown in Figure 2.

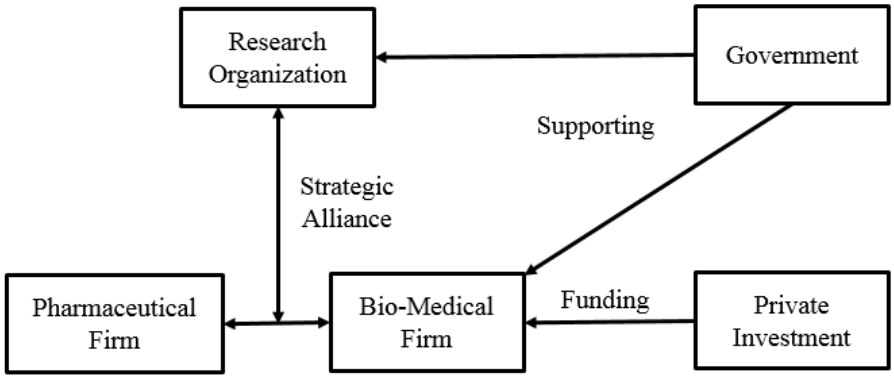


Figure 2. Structural model for business in the bio-medical industry

Source: Modified from Pisano (2006)

In general, the Korean bio-medical industry could be considered to have such a

sectoral innovation system. However, in Korea as a latecomer in the bio-medical industry, the components of the sectoral innovation system that are emphasized are slightly different. Korea Health Industry Development Institute (2006) highlighted the importance of each entity including universities, government-funded research centers, firms, and the government for the development of the Korean bio-medical industry. Moon (2006) reported that since the influence of private investment was deficient in the Korean bio-medical industry, continuous investment by the government has been required. According to Kang and Lee (2006), the factors affecting the innovation activities of Korean biotechnology firms are the internal capabilities of a firm, the firm's network with external organizations, and government subsidies. Kang and Lee (2006) argued that the business history and size of a firm, R&D costs compared to sales, and the share of researchers among the total number of employees may be proxies of critical internal capabilities. Jung et al. (2007) reported the positive effect of the size of R&D human resources and the ratio of R&D human resources with a doctoral degree or equivalent qualification on the technological innovation performance of Korean biotechnology firms. Moreover, they reported the positive effect of strategic alliance when absorptive capacity is strong. Cho et al. (2007) forecasted the Korean biotechnology industry's potential to catch up and highly evaluated the growth potential of the bio-medical sector with the appearance of a large number of entrepreneurial firms and intensive support from the government. Additionally, they emphasized the importance of private investments such as venture capital for the industry's development. Kang and Lee (2008) confirmed the

positive influence that a biotechnology firm's internal factors such as R&D intensity, entrepreneur's work experience in research organizations, the government's R&D funding, and strategic alliance have on the firm's technical innovation performance, despite the fact that Korea is a latecomer in the biotechnology industry. Lim (2009) described that there is co-existence of both dedicated firms in bio-medical segment and diversified firms in various segment such as food and cosmetic in Korean bio-medical industry. In addition, Lim (2009) argued that the major force of growth of Korean bio-medical industry was the synergy by government policy and by entrepreneurship of firms. Casper (2009) reported that private investment is insufficient for the development of the Korean bio-medical industry, and that the national characteristic of a well-developed bank-backed financing system should be considered. Further, he reported that the government-led development was successful so far. Moreover, he suggested the possibility that the conglomerate-oriented industrial structure and the development of the ICT industry could have positive effects on the bio-medical industry's development. According to Wang et al. (2012), the Korean bio-medical industry came under the spotlight as a new growth engine industry in 2005. Moreover, Korea has unique characteristics compared to other countries, which make it possible for the conglomerate-oriented industrial structure to lead the bio-medical industry development; therefore, conglomerates such as Samsung, LG, SK, and CJ joined the industry. Kang and Park (2012) confirmed the positive effect of R&D human resources and R&D investment and alliances on technical innovation performance and demonstrated the importance of government subsidization through the direct and indirect

effects of the government's R&D subsidy. Science and Technology Policy Institute of the Republic of Korea (2013) suggested the possibility of a different development route based on the characteristics of an entrepreneur. In particular, it was pointed out that a large number of firms in Korea founded by entrepreneurs with prior experience in other firm, which is different from the case in the bio-medical industry of advanced countries such as the US and the UK, where the entrepreneurs generally worked in research organizations before establishing their firm. They also argued that the importance of the government's R&D subsidy as initial investment in a firm and the vitalization of strategic alliance are critical factors in a firm's development.

The results of these studies highlight the unique national characteristics of Korea compared to the characteristics of the science-based bio-medical industry. The origin of Korean bio-medical firms is different from that of firms in the bio-medical industry of advanced countries, which traditionally emphasize entrepreneurship by entrepreneurs from research organizations. The human resources or R&D intensity and competitiveness in the ICT-fused segment are emphasized as internal growth factors, while connections with research organizations such as universities, hospitals, and government-funded institutes, or other firms, especially conglomerates, other bio-medical firms, and pharmaceutical companies are emphasized as external growth factors in the prior studies on the growth of Korean bio-medical firms. That is, prior studies emphasized that the characteristics of entrepreneurs and entrepreneurial firms need to be taken into consideration because of the industrial nature, which is characterized by a high

distribution of small-sized entrepreneurial firms. In addition, they emphasized the development of the ICT industry, the important role of large companies in the conglomerate-oriented industrial structure of Korea, and the importance of the government's support amid sluggish private investment. This context of the Korean bio-medical industry indicates the need for studies on *"strategic entrepreneurship"* to consider the characteristics of entrepreneurship and strategic management simultaneously in order to lead it to performance through the acquisition and orchestration of internal and external resources and capabilities.

2.2.2 Three Studies in Strategic Entrepreneurship for Growth of Korean Bio-medical Firm

Many scholars emphasize strategic entrepreneurship adopting three central themes: 1) internal and external resources for competitive advantage at the input level, 2) strategies for orchestration (coordination) of resources and capabilities to create and capture value at the process level, and 3) the ultimate growth and wealth creation at outcome level (Ireland and Webb, 2009; Kuratko and Audretsch, 2009; Kyrgidou and Hughes, 2010; Luke et al., 2011; Hitt et al., 2011). In particular, Hitt et al. (2011) suggested a strategic entrepreneurship as input-process-outcome model. It summarized strategic entrepreneurship the resource inputs, explored the resource coordination processes, and the outcomes of value or wealth creation along the individual, organization, and society

dimensions like Figure 3. Under input-process-outcome model of strategic entrepreneurship, this dissertation include three studies on firm's origin, business model, and survival for growth of Korean bio-medical firms.

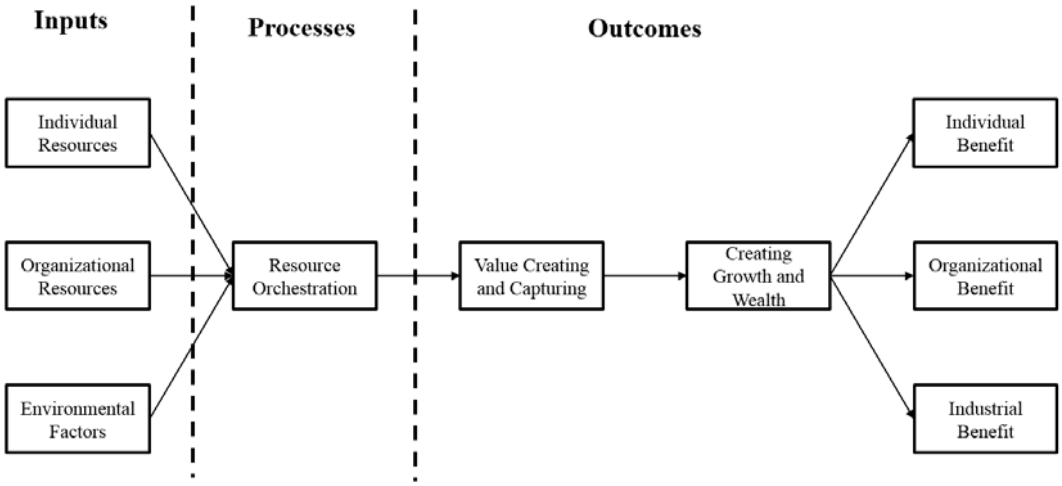


Figure 3. Input-Process-Outcome model of strategic entrepreneurship

Source: Modified from Hitt et al. (2011)

2.2.2.1 Firm's Origin as Input Strategic Entrepreneurship

Strategic entrepreneurship, above all, emphasizes the strategic management of resources or capabilities with the goal of creating opportunities and company growth (Ireland et al., 2003). In that sense, the strategic entrepreneurship significantly integrates the resource-based theory of the firm, which provides a widely accepted explanation for why firms differ and how they achieve and sustain competitive advantage (Barney, 1991). The core assumption of the resource-based theory is that a firm is a unique aggregation of

heterogeneous tangible and intangible resources and capabilities. A firm achieves short-term performance from benefits generated by specific (internal and external) resources and capabilities, which accumulate and are not easily traded, thus securing a dominant position in the long-term (Wade and Hulland, 2004). In this sense, it determines the boundary of the firm, and forms a different path to firm growth (Gilbert et al., 2006).

A central tenet of the resource-based theory is that superior resources and capabilities result in superior performance (Barney, 1991; Peteraf, 1993), called a firm's first-order or ordinary competence (Danneels, 2002; Winter, 2003). A firm's ability to create new resources and capabilities is its second-order competence (Danneels, 2002; 2008). Firms with second-order competences can create new resources that allow them to imitate and substitute the resources and capabilities of competing firms. In this way, second-order competences create "flow" in the "stock" of resources and competences (Dierickx and Cool, 1989; Ambrosini and Bowman, 2009). Markides and Williamson (1994) pointed out that the existence of only strategic assets will not create long-term competitive advantage, and second-order competencies contribute to explain firms' heterogeneity in the long-term perspective.

Particularly, in studies on strategic entrepreneurship, the characteristics of the origins of the entrepreneurs and entrepreneurial team are further emphasized (Sirmon et al., 2007) for two reasons. First, the entrepreneur and entrepreneurial team are important human resources for the firm itself. They can contribute to the firm's competitive advantage by offering their labor based on inherited knowledge (Davidsson and Honig,

2003). In addition, their social capital as the competitive advantage may influence business planning and performance (De Carolis and Saparito, 2006). Santarelli and Tran (2013) confirmed the interplays labor resources and social capital in shaping entrepreneurial performance. Second, the entrepreneur and entrepreneurial team strategically allocate the firm's resources and capabilities, which are related to strategic actions to facilitate their effective management (Hitt et al., 2011; Ndofor et al., 2011). Entrepreneurial firms might be particularly characterized by limited resources and capabilities, and should therefore be more selective about their actions (Katila et al., 2012). More specifically, they influence firm performance by structuring the firm's resources and capabilities portfolio, bundling and leveraging them in the marketplace (Ireland et al., 2003; Sirmon et al., 2007; Hitt et al., 2011).

Previous studies have shown that the entrepreneurs and entrepreneurial teams themselves are competitive advantage of their firm in terms of human resource and orchestration of their resources and capabilities. Alvarez and Busenitz (2001) indicated that the entrepreneurs and entrepreneurial teams have specific accumulated resources and capabilities to recognize new opportunities and combine them to create value. Dencker et al. (2009) argued that the entrepreneur's knowledge acquired from prior experience may enhance his/her absorptive capacity in planning, collecting, and analyzing new information. Sardana and Scott-Kemmis (2010) confirmed that entrepreneurs' and entrepreneurial teams' prior experience have a significant influence on managerial decision-making related to resources or capabilities. Patzelt and Shepherd (2011)

emphasized that their knowledge and experience was critical for identifying their business opportunities. Farmer et al. (2011) found that work experience in prior organization moderated the relationship between identity aspiration is related to entrepreneurial self-engagement and exploitation behaviors of entrepreneurs. Baron and Tang (2011) argued that entrepreneurs' knowledge and experience give major effects on the entrepreneurial process. Zhao et al. (2013) argued that cumulated capabilities of founding team directly influenced new venture performance, mediating role of strategic positional advantages.

In addition, recently, advantages of spin-off from parent company has been emphasized. Though corporate entrepreneurial motivation is various (Fini et al., 2012), new venture founding from parent company are significantly likely to survive than vice versa (Wilson et al., 2013). Parent company can solve the problem of organizational inertia through corporate ventures, as it grows (Campbell et al., 2003). On the other hand, it also means that corporate venture has advantages for their growth in terms of business resources and capabilities network with parent company (Arregle et al., 2013). These evidences show that understanding on origin of entrepreneurs and entrepreneurial teams generally contribute to figure out how they influence firm's growth. Therefore, studies on firm's origin of entrepreneur and entrepreneurial team are important for identifying business opportunities by confirming competitive advantages in entrepreneurial firms.

2.2.2.2 Business Model as Process Strategic Entrepreneurship

The strategic entrepreneurship research field originated from the necessary intersection of

strategic management and entrepreneurship for growth and wealth creation by enhancing the business value of entrepreneurial firms (Hitt et al., 2011), meaning that entrepreneurial firms pursue value creation and capture by securing competitive advantage and by identifying business opportunities in their context (Brandenburger and Stuart, 1996). Priem (2007) likened the relationship of value creation and capture to two sides of the same coin, in that entrepreneurial firms should be managed by considering strategic actions with an entrepreneurial orientation. Scholars such as He and Wong (2004), Lubatkin et al. (2006), and Sirén (2012) emphasized organizational ambidexterity for competitive advantage via exploratory and exploitative innovation. Alvarez and Barney (2007; 2010) identified two routes to identify opportunity. One is discovering opportunities from an exogenous shock in an industry, and the other is the endogenous creation of opportunities by entrepreneurs through their process. This shows the two sides of value creation and value capture. The business model can explain the ambidextrous characteristics of strategic entrepreneurship, as the mirror of realized strategies, though this has no clear definitions as yet (Demil et al., 2015).

The business model can put them into an integrated perspective at the system level (Zott et al., 2011; Demil et al., 2015), explaining strategies on how entrepreneurial firms operate and how they create and capture value for business opportunity (Afuah and Tucci, 2001; Amit and Zott, 2001). Demil and Lecocq (2010) expressed the business model as a holistic view of the organizational strategies in the same context. The business model facilitates explanations about the resources and capabilities allocation mechanism by

integrating strategies for firm's growth. The resource based view has been criticized, as it does not explain how firms use their resources and capabilities (Barney, 2001; Priem and Butler, 2001). Thus, it calls for an integration of strategic viewpoints (Barney, 2001). The business model could be suitable to explain recombination process of resources and capabilities (Amit and Zott, 2001).

In addition, the business model reflects strategic choices within their context (Snihur and Zott, 2014). Demil and Lecocq (2010) stressed that the business model proactively crafted by entrepreneurs and entrepreneurial firms selected their circumstances in their evolution process. Above all, studies on strategic entrepreneurship were concerned with contingent factors (Raisch and Birkinshaw, 2008), such that the business model concept may include strategic choices for which entrepreneurs and entrepreneurial firms proactively select among various strategies. Langley (1999), Zahra (2008), and Zahra and Wright (2011) argued that studies tracing entrepreneurial firms' strategic choices can enhance implications suggested in terms of contextual characteristics because contextual conditions should be managed by enabling or constraining behaviors of actors (Pentland, 1999; Burg and Romme, 2014). Demil and Lecocq (2010), and Casadesus-Masanell and Ricart (2010) claimed that the significance of strategic choices within a business model were a logic which encapsulates the appropriate system of a firm within their environments. This highlights that entrepreneurs and entrepreneurial firms proactively respond to the environment or select an environments, or can even create a favorable environment (Child, 1972). This approach emphasizes the possibility of discretional

choice to create and capture value (Hitt et al., 2001).

Moreover, the strategic framework though the business model creates legitimacy under contextual circumstances. Bingham et al. (2007) and Davis et al. (2009) found that entrepreneurs and entrepreneurial firms made decisions via heuristics, which positively influenced their performance. Milgrom and Roberts (1995) argued that the business model may be difficult to imitate if the characteristics of the firm's strategic choices are self-reinforcing, meaning that high legitimacy in an environment and the firm's unique bundle of competitive strategic choices may it protect from imitation by their competitors (Snihur and Zott, 2014). Therefore, studies on entrepreneurial firms' business models are necessary, in that it can suggest an integrated view of strategic actions and show the heuristic and voluntary self-reinforcing strategic choices under contextual circumstances.

2.2.2.3 Survival as Outcome Strategic Entrepreneurship

Studies into strategic entrepreneurship focus on growth and wealth creation for individuals, organizations, and the economy through the creation and capture of value (Hitt et al., 2011). However, Kuratko and Audretsch (2009) pointed out that previous studies on strategic entrepreneurship have so far mainly concentrated on short-term technological or financial performance. Sonfield and Luccier (1997) argued that entrepreneurs and entrepreneurial firms should clearly understand the trade-off relationship between gains from their behaviors and loss through risk-taking in the future. Thus, there is a concern about entrepreneurial failure from adhering to short-term

performance by selecting the second best or harmful strategies from the long term perspective (Duchesneau and Gartner, 1990). Therefore, strategic entrepreneurship research requires studies beyond the short-term to consider the long-term perspective.

The long-term perspective is generally regarded as entrepreneurial firms' attitude or vision regarding the future benefits from their strategic choices (Ryu et al., 2007; Sheth and Parvatiyar, 1992). Entrepreneurial firms with a long-term perspective consider their inter-interdependence with their industrial environments, hoping to co-evolve in the long run (Nelson, 1995; Lewin et al., 1999; Malerba, 2007). The object of entrepreneurial firms from the long-term perspective causes them concern about their survival (Klepper, 1996; 2002). On the other hand, entrepreneurial firms focusing on the short-term perspective are interested in technological progress or maximizing profits (Van der Stede, 2000). Such differing perspectives may result in different interpretations of the meaning of goal for firm growth (Kyrgidou and Hughes, 2010).

Scholars such Geroski and Schwalbach (1991), Thurik (2003), and Van Stel et al. (2005) argued that new firms formed through entrepreneurship generally contribute toward economic growth. Entrepreneurs' and entrepreneurial firms' strategic choices create the potential economic outcome by recombining resources and capabilities, whether they intend to or not. Thus, they allow the principle of economic evolution (Grebel et al., 2003; Bruton et al., 2013), suggesting that industrial and economic growth results from endogenous factors induced by entrepreneurs and entrepreneurial firms (Acs et al., 2009; Braunerhjelm et al., 2010; Delmar et al., 2011). Furthermore, it shows that

new firms can encourage the emergence of new industries and economic development (Thompson, 2005). Therefore, studies on entrepreneurial firms' survival or hazards can explain the evolutionary reasons behind industries and economies.

In particular, entrepreneurial firms survival rates are very low (Santarelli and Vivarelli, 2007). Entrepreneurial firms are generally more likely to face resource and capability constraints, while larger firms are more likely to suffer from organizational constraints such as organizational inertia (Hewitt-Dundas, 2006; Kor et al., 2007). Therefore, entrepreneurial firms should have a vision for survival under their resource and capability constraints in the long-term perspective. Moreover, the context in a developing industry or economy should be carefully considered due to the high industrial uncertainty (Hoskisson et al., 2000; Casson, 2003; Wright et al., 2005; Zahra, 2007; Hermelo and Vassolo, 2010) resulting from a lack of an industrial ecosystem in the organizational and institutional context (Baum and Oliver, 1991; 1996; Aldrich and Fiol, 1994). In this circumstance, entrepreneurial firms tend to unconditionally mimic the behaviors of firms with successful business strategies to create legitimacy (DiMaggio and Powell, 1983; Rao et al., 2001). However, paradoxically, these behaviors do not guarantee industrial legitimacy, leading to firm failure (Human and Provan, 2000; Bansal and Clelland, 2004). The high uncertainty prevents mortality reduction through isomorphism, increasing organizational hazard rates in superstitious learning (Miller, 2012). Therefore, studies investigating entrepreneurial firms' survival factors are necessary, as they could contribute a strategic fit to create industrial legitimacy in their contextual circumstances.

Chapter 3. Influence on Business Strategies and Performances of Korean Bio-medical Firms' Origin

3.1 Introduction

Features that distinguish the bio-medical industry among others, are technology- and research-intensiveness (Hagedoorn, 1993) as well as high distribution of small-sized entrepreneur firms (Pfeffer, 2012). In addition, the performance of bio-medical firms tends to be influenced by the human capital of their entrepreneurs, who often come from research organizations. Studies have shown that although factors affecting the performance of startups are complex and interrelated, the work experience of entrepreneurs or entrepreneurial firm is most important (Baum et al., 2001; Colombo and Grilli, 2005). Zahra (1996) and Zahra and George (1999) compared the technological innovation and financial performance of independent and corporate biotechnology ventures, and found that the two groups have advantages in different areas of operation. However, few studies have examined the influential characteristics of "*incubating organizations*", or "*firm's origin*", on the strategy and performance of bio-medical firms throughout their value chains. An incubating organization refers to one in which an entrepreneur had worked to accumulate experience in technology, business management, and marketing before establishing his or her own business (Cooper, 1985). A number of

studies have expanded the meaning of incubating organizations such that the definition encompasses the work experience of entrepreneurs or the characteristics of entrepreneurial firm (Grimaldi and Grandi, 2005; Heirman and Clarysse, 2004). This study hereafter uses the terminology, *"firm's origin"*, as an alternative to incubating organizations.

This study proposes that the properties of firm's origin of bio-medical firms—that is, independent or corporate ventures—affect a firm's strategy and performance regarding R&D investments, alliances, and innovation and financial performance. This study first establishes a set of structural relationships based on R&D intensity, upstream (R&D) and downstream (manufacturing & marketing) alliances with other organizations, and technological innovation and financial performances. It then proceeds to investigate influences of firm's origin on R&D and alliance strategies and subsequently examine their effects on technological innovation and financial performances.

The rest of this paper is structured into four sections. In chapter 3.2, it presents the theories of firm resources, knowledge, and performance as well as the study hypotheses. Then, it describes the study design in chapter 3.3, and follow up with the presentation of study results and a discussion in chapter 3.4 and 3.5.

3.2 Theories and Hypotheses

This study search for the effect of firm's origins in bio-medical industry on its strategies and performance: 1) *Firms established by entrepreneurs from research organizations*, 2) *Spin-offs from parent company*. Previous studies have shown that the entrepreneurial capital composed of human and social capital, identifying by background of entrepreneurs or entrepreneurial firm (Jo and Lee, 1996), which they show is important in the process of founding a new firm and its subsequent performance (BarNir and Smith, 2002; Elfring and Hulsink, 2003; Morrison et al., 2003; Schenkel et al., 2012; Street and Cameron, 2007). Studies on entrepreneurial capital demonstrated that resource and capabilities, particularly knowledge, of entrepreneurs and entrepreneurial firms play significant roles in the success or failure of businesses (Chandler and Hanks, 1994; Kessler and Frank, 2009; Zahra et al., 2006). Therefore, this study argues how their resources and capabilities influences on strategies and performance in the resource and knowledge based view.

The resource-based view argues that the difference in the resources and capabilities of firms determines their growth (Barney, 1991). It is based on the assumption that a firm is a unique aggregate of tangible and intangible resources and capabilities. From the benefits stemming from specific resources and capabilities, a firm achieves a short-term performance, and when this performance is internalized as organizational capacity that cannot be easily transacted, the firm can realize sustainable growth based on its long-term advantages (Wade and Hulland, 2004). In particular, knowledge as intangible resource is

an essential propellant for achieving excellent performance in high-tech industry like bio-medical industry (Kogut and Zander, 1992). It implies that difference in knowledge-base of firm can determine their growth (Grant, 1996). Schumpeterians explained that the firm was regarded as cognitive subject that described the technological innovation (Dosi et al., 1988). Knowledge difference in each firm results in patterns of different technological innovation performance (Nelson and Winter, 1982). In this perspective, the firm proactively seeks to find and learn complementary asset, which ultimately decides firm's boundary (Foss, 1996; Cassiman and Veugelers, 2006). Therefore, the knowledge based view can facilitate to explain firm's behaviors for technological innovation.

3.2.1 R&D, Business Strategies, and Performances of Bio-medical Firms

The bio-medical industry is characterized by high R&D intensity and formation of many alliances as business strategies, and studies have examined their effects on technology innovation performance, financial performance, and their structural relations. High R&D intensity positively influences technology innovation performance and the number of R&D alliances (George et al., 2001; Hall and Bagchi-Sen, 2001, 2002; Kang and Lee, 2008; Kang and Park, 2012). R&D intensity reflects the strategic intention for technology development as well as willingness to realize technological innovations (Kleinknecht et al., 2002). Especially in technology-intensive industries, such as the bio-medical sector,

an increase in R&D investments plays a key role in achieving technological innovation performance (Hall and Bagchi-Sen, 2002). In addition, an increase of the R&D intensity could lead to an increase in R&D alliances directly by facilitating access to valuable resources and capabilities and indirectly by enhancing absorptive capacity (Bagchi-Sen, 2004; Lin et al., 2012; Kang and Park, 2012; Laursen and Salter, 2006; Veugelers, 1997; Zhang et al., 2007). In addition, by offering access to knowledge and technologies from external organizations, R&D alliances have positive effects on technological innovation performance, specifically in the ability to solve integration problems and find technological opportunities (Baum et al., 2000; Faems et al., 2005; Laursen and Salter, 2006).

Although several study results contradict each other, one can say that technological innovation performance added to financial performance in the bio-medical industry (Hall and Bagchi-Sen, 2002; 2007). In addition to placing their products on market, bio-medical firms generate profits by transferring their technologies to others (Arora et al., 2001; Pisano, 2006), implying that technological innovation performance itself means profit generation beyond the aspect of direct technology competitiveness in the bio-medical industry. Moreover, stimulating the utilization of internal technologies for technology and product commercialization enhances technological innovation and financial performance (Lane et al., 2006; Lichtenthaler and Lichtenthaler, 2009). In addition, the increase in technological innovation performance in bio-medical firms leads to an increase in manufacturing & marketing alliances through which complementary

resources and capabilities for manufacturing & marketing are utilized, which consequently exerts a positive impact on firms' financial performance (Rothaermel and Deeds, 2004).

In sum, these bio-medical industry studies show that structural relationships between business strategies of R&D investment and alliances affect technological innovation and financial performance. Therefore, to find the effects of firm's origin, one must understand each element and relationship of business strategies and performances. This study explores the various impacts that the characteristics of firm's origin exerts on each business strategy and performance.

3.2.2 Independent Bio-medical Venture Established by Entrepreneurs from Research Organizations

Bio-medical R&D is typically based on scientific knowledge (Coriat et al., 2003; Gittelman and Kogut, 2003), which is inherently tacit to its producers and is thus difficult to transfer (Gurney et al., 2014; Souitaris, 2002). Corolleur et al. (2004) showed that entrepreneurs' basic science knowledge and experience with research were important to the foundation, growth, and survival of new bio-medical firms. Lynskey (2004) also stressed that entrepreneurs who have experiences on basic science were more willing to found new bio-medical firms than were those without such a background. As a consequence, human resources with rich experience and know-how in basic science fields

are more important than any other factors with regard to bio-medical R&D. To substantiate this viewpoint, a series of studies have emphasized the important role of entrepreneurs experienced as researchers, such as university professors or star scientists, in bio-medical R&D efforts (Oliver, 2004; Zucker and Darby, 1997).

Entrepreneurs from research organizations tend to focus on applied research to commercialize their basic research knowledge (Baum and Silverman, 2004; Kato et al., 2014). Because others readily see the potential of innovative technologies offered by entrepreneurs from research organizations (Heirman and Clarysse, 2004), the market receives a positive signal important in raising both the value of firms and the funds. In this fashion, entrepreneurs from research organizations are likely to attract the financing required for R&D activities of their firms from government funds, venture capital sourcing, pharmaceutical investment through R&D collaboration, or corporate venture capital (Baum and Silverman, 2004; Chan et al., 2001; Pisano, 2006). Therefore, bio-medical firms established by entrepreneurs from research organizations tend to reach high R&D intensity levels. Therefore, this study verifies the following hypothesis:

H1-1. Bio-medical firms established by entrepreneurs from research organizations give positive influence on their R&D intensity.

Basic science knowledge generated at research organizations tends to be more tacit than explicit. Sometimes too much innovation translates into insufficient scientific

evidences and low reproducibility that is difficult to effectively commercialize (Debackere and Veugelers, 2005). In addition, biotechnology discoveries generally accumulate, and most of bio-medical firms enter into business by securing one or two specialized core technologies (Carayannopoulos and Auster, 2010; Pisano, 2006). Therefore, some suggest that entrepreneurs from research organizations should develop their basic science knowledge further by integrating other complementary technologies through applied research (Cardinal, 2001; Pisano, 1994).

However, integrating basic science knowledge with complementary technologies for commercialization can complicate applied research projects goals because biotechnology is not easily modularized and often features complex multidisciplinary aspects (Pisano, 2006). The integration of technology in the biotechnology development process is, therefore, a challenge for independent bio-medical firms established by entrepreneurs from research organizations, who may remedy this difficulty by increasing R&D alliances so that they can integrate their own basic science knowledge with complementary technologies (Oliver, 2004). Through R&D alliances, they may externalize their own basic science knowledge and internalize the complementary knowledge assets from external organizations (Becerra-Fernandez and Sabherwal, 2001). In sum, entrepreneurs from research organizations have an incentive to increase the level of interaction among external organizations through R&D alliances. To explore the role of alliances, this study verifies the following hypothesis:

H1-2. Bio-medical firms established by entrepreneurs from research organizations give positive influence on R&D alliances.

Entrepreneurs from research organizations are willing to solve problems that emerge during the process of technology commercialization by going back to basic science research (Etzkowitz, 2003). As a result, they can play an important role in the interaction between basic and applied research for technology innovation (Kato et al., 2014). Furthermore, in the rapidly changing industry environment, bio-medical firms must find niches among competitors and sometimes they can achieve the radical innovation performances by capitalizing on the unique basic science knowledge inherited by entrepreneurs from research organizations (Nerkar and Shane, 2003). Therefore, bio-medical firms established by entrepreneurs from research organizations may have an incentive to better technological innovation performance.

In addition, bio-medical firms established by entrepreneurs from research organizations mainly have been formed near them (Casper, 2007). Many have sprung up around biotechnology top-tier universities such as Oxford and Cambridge in the UK, and in the US, renowned universities and hospitals in California (Casper, 2007; Smith et al., 2008). Their fortuitous locations allow entrepreneurs from research organizations to easily acquire competent human resources for enhancing the firms' R&D capabilities. Moreover, entrepreneurs from research organizations actually tend to form new firms with their colleagues from research organizations (Steffensen et al., 2000), which likely

creates a predominance of human capital in the new firm. These advantages also positively affect their technological innovation performance. Therefore, this study verifies the following hypothesis:

H1-3. Bio-medical firms established by entrepreneurs from research organizations give positive influence on technological innovation performance.

3.2.3 Corporate Bio-medical Venture by Spin-off

As it grows, a new firm gradually experiences organizational inertia, and the decision-making activities and transactions that accompany it can prevent progressive decision making and undermine the challenging spirit of the entrepreneurial firm (Kelly and Amburgey, 1991). Corporate ventures can solve the problem of organizational inertia by encouraging growth through market economy principles. Campbell et al. (2003) categorized corporate venturing into external venturing, in which firms invest in other promising companies, and internal venturing, in which they establish a corporate venture and spin off an internal promising business with the benefit of affiliation. Further, they broke down internal venturing into harvest- and innovation-oriented categories. Harvest-oriented venturing refers to a firm that spins off one of its units for the purpose of business portfolio expansion so that it can achieve more profits in fields related to its core businesses. Innovation-oriented venturing refers to a firm that spins off its own business in an area unassociated with the current business, when uncertainty and the risk of failure

are high in the new enterprise.

In bio-medical industry, spin-offs from parent company may include two cases both harvest-oriented venturing and innovation-oriented venturing, depending on their strategic mission (Zahra, 1996; Zahra and George, 1999). Nonetheless, in many cases, spin-off bio-medical firms aim to gain more revenues by diversifying their business portfolio in terms of harvest-oriented venture in initial stage. In fact, though parent companies announce the object of spin-off is innovation in new sector, they intend to prevent their management aggression that results from internal financing at first, and hope to induce external financing for spin-offs (Parhankangas and Arenius, 2003). In addition, corporate ventures may have a hard time to realizing innovation-oriented venturing, because of cumulative property of biotechnology by learning (Pisano, 2006). Subsequently, they try out innovation activities, while simultaneously conducting strategic activities to exploit their competitive advantage for ensuring the firm's spontaneity.

In the most cases, independent bio-medical venture generally feature operational R&D functions, but they may not have created the best processes for manufacturing & marketing (Rothaermel, 2001; Rothaermel and Deeds, 2004). To secure manufacturing & marketing capacity, bio-medical firms may need to make enormous investments in large-scale facilities that meet regulations such as the "Good Manufacturing Practice" guideline (Sahoo et al., 2009) and must establish a positive reputation as well as marketing distribution networks (Zucker et al., 2002). Corporate ventures may enjoy easier access to

the internal human capital and financing, manufacturing facilities and know-how (Stopford and Baden-Fuller, 1994), and marketing resources (Todeva and Knoke, 2005) of their parent firms. That is, they are likely to achieve additional revenue by differentiating their business because of easier access to the resources and capabilities of parent company (Arora and Gambardella, 1990). This implies that corporate ventures may have unique competitive advantage in the manufacturing & marketing business.

In particular, benefit of corporate ventures from their parent firms on established reputation as well as utilization of resources and capabilities are important for promoting manufacturing & marketing alliance. It helps the corporate venture enhance its own reliability and thus make alliances relatively easily with external organizations (Barrett et al., 2000; Zahra, 1996). Stuart (2000) argued that firms strongly consider a potential partner's reputation as an indicator of reliability for searching their alliance partners, which helps ameliorate the uncertainty caused by information asymmetry among partners (Gulati, 1995). Corporate ventures, which benefit from the reputation of parent firms, gain advantages for forming alliances. In sum, corporate ventures in bio-medical industry are more likely to enter into alliances for manufacturing & marketing than those pursuing independent ventures. Therefore, this study verifies the following hypothesis:

H2-1. Spin-off bio-medical firms give positive influence on manufacturing & marketing alliances.

Parent firms found corporate ventures as an important strategy in acquiring sustainable growth and risk diversification. Thus, they thoroughly try to manage funds invested and the investment performance of their corporate ventures (Covin and Miles, 2007). That is, parent firms generally manage the business planning and processes of corporate ventures from commercializing idea-level items to connecting them to a business model so that they can complement parent firms' core businesses or implement a new business as a growth engine for the parent firm (Hill and Birkinshaw, 2008). Consequently, to maximize investment performance, corporate ventures may be consulted by their parent firms like coach.

In this context, corporate ventures in bio-medical industry were superior to independent ventures that relatively centered technological innovation, for production innovation with wide product lines for covering product portfolio of parent company (Zahra and George, 1999; Sapienza et al., 2004). It implies that corporate ventures would be likely to access into market rather than independent venture. Moreover, corporate ventures received a variety of benefits from their parent firms, who thereby can overcome business risks beyond limitations of their own resources and capabilities in their businesses and encroach into the market (Wallin and Dahlstrand, 2006). These benefits of spin-off bio-medical firms provide advantages in better financial performance. Therefore, this study verifies the following hypothesis:

H2-2. Spin-off bio-medical firms give positive influence on financial performance.

The conceptual model and study hypotheses are summarized in Figure 4.

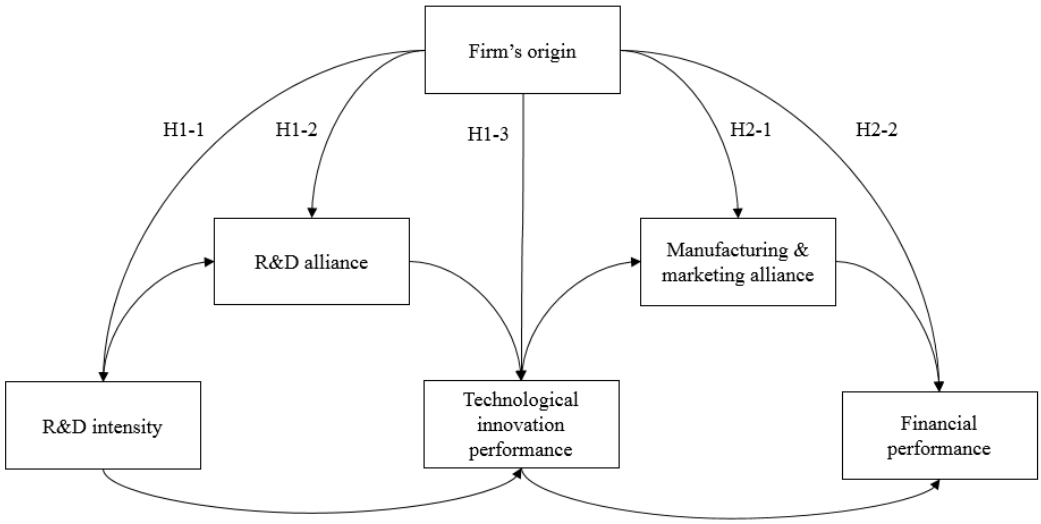


Figure 4. Study hypotheses in study on firm's origin

3.3 Methods

3.3.1 Data

This study used the database (hereinafter DB) of bio-medical firms constructed by the Science and Technology Policy Institute of the Republic of Korea (STEPI) in 2013. Based on “the List of Korean Biotechnology Firms” produced by the Korea Biotechnology Industry Organization and its own DB, STEPI secured information from 2,441 companies that were in operation from 1992 to 2012. The total number of cases was reduced by excluding firms specialized in overseas import and distribution operations as well as foreign corporations. The final DB consisted of 1,504 cases.

The data items in this DB include 1) basic characteristic information such as the careers of the entrepreneurs, affiliation to another firm or business group, the number of employees, the firm’s age, and areas of business; 2) financial information such as revenues and R&D expenses; 3) alliance information for the purpose of R&D, production, and sales; 4) information about government research funding; and 5) the status of patent registrations. The basic and financial information was collected from the DB of the Korean Enterprise Data, while the information on government research funding was from the DB of the National Science & Technology Information Service. The patent information was from the DB of Thompson Reuters based on the number of patents registered at the Korean Intellectual Property Office. The alliance information was gathered through a search of news items on alliance contracts reported by media outlets

such as Datamonitor and the MedTrack DB of the US and the UK. E-mails that the Korea Biotechnology Industry Organization and the Biotech Policy Research Center provided to their subscribers through their news push services every day and every other day, respectively, were also searched. These latter two organizations started their services in 2005; thus, STEPI's DB on bio-medical firms used in this study contains data from 2005 to 2012.

To ensure the homogeneity of firms analyzed in terms of their industry characteristics, this study utilized data on only the bio-medical firms identified from STEPI's DB. Among the 756 bio-medical firms found in the research DB, 167 firms more than 20 years old as of 2012 and 8 firms that only perform product development and manufacturing service for codification of variable on the level of vertical integration were excluded to limit the study to the research subjects relatively young companies that may be affected by the characteristics of entrepreneurs and entrepreneurial firms. Moreover, this study excluded 151 companies that could weaken the robustness of analysis due to a lack of information on revenues or considerable amount of other data. Therefore, 430 bio-medical firms comprised the study DB. This study further categorized the firms to four groups based on their main focuses of businesses according to Willemstein et al. (2007): bio-medicine, diagnostic kits & reagents, supporting service, and measurement & analysis equipment related with biopharmaceutical and platform & service segment.

Table 1 shows the size, age, business area, and the characteristics of firm's origin. There were 391 companies (90.93 %) categorized as small because they employed fewer

than 50 people. The number of firms under 10 years old was 397 (92.33 %). They shows the high distribution of small-sized entrepreneurial firms in Korean bio-medical industry. Among the total number of firms, 285 (66.28 %) were considered therapeutic product-oriented firms and were made up of 235 bio-medicine and 50 diagnostic kits & reagents manufacturing firms. There were 145 infrastructure firms (33.72 %); 106 of them featured supporting services, and 39 offered measurement & analysis equipment. This study found that 114 firms (26.51 %) were independent ventures established by entrepreneurs from research organizations, while 22 firms (5.12 %) of them were corporate ventures.

Table 1. General characteristics of firms in study on firm's origin

Characteristic	Number of firms	Percentage
Size (number of employees)		
Small (<50)	391	90.93
Medium (51-100)	39	9.07
Large (>100)	0	0.00
Age (years since formation)		
Young (<10)	397	92.33
Established (>10)	33	7.67
Main business area		
Bio-medicine	235	54.65
Diagnostics kits & regents	50	11.63
Supporting service	106	24.65
Measurement & analysis equipment	39	9.07
Firm's origin		
Independent venture established by entrepreneurs from research organizations	114	26.51
Corporate venture spun-off from parent firms	22	5.12
Others (youth entrepreneurs, other independent ventures)	294	68.37

3.3.2 Definition of Variables

If entrepreneurs were from universities, hospitals, or government-funded research institutes, the firm's origin was classified as an independent venture established by entrepreneurs from a research organization (Pelz, 1956; Wennberg et al., 2011). Spin-off firms established in the form of an affiliation were classified as a corporate venture (Covin and Miles, 2007).

The R&D intensity was used to estimate the size of the input for R&D activities. The

R&D intensity is typically calculated by dividing the R&D expenditures by the size of the firm with the amount of revenues or the number of employees indicating the size of firm (Lin et al., 2006). In this study, this study calculated the R&D intensity using the number of employees as the proxy indicating the size of firm because some firms did not have revenues during the period of analysis.

To measure the effect of alliances, previous studies show proxies such as alliances (or not), the number of alliances, and indicators of the alliance network (centrality, etc.) (Baum et al., 2000; Kang and Park, 2012; Owen-Smith and Powell, 2004). This study used the number of alliances to measure the alliance size. R&D alliances included technology transfers provided with rights of usage or possession from external organizations as well as R&D collaborations in the form of projects. Manufacturing & marketing alliances included those based on requests made from or to external organizations for consignment manufacturing & marketing agency services with exclusive sales rights, and consignment sales to external organizations.

Technological innovation performance has been typically measured by the number of patents or new products (Kleinknecht et al., 2002). For the bio-medical industry, patent rights, along with human resources, have been emphasized as important resources for R&D competitiveness (Gittelman and Kogut, 2003). Because of the unique and competitive technologies they represent, patent rights can be used as a yardstick to determine a firm’s competitiveness, and a number of existing studies have measured technological innovation performance as the number of patent applications or

registrations (Baum et al., 2000; George et al., 2002). In particular, bio-medical firms with unique or competitive patent rights tend to be highly regarded despite a lack of business model for profit (Hall et al., 2005). For these reasons, this study measured technological innovation performance based on the number of patent registrations of the current year.

To measure the financial performance of a firm, researchers typically use revenues and profit as they apply to growth and profitability (Zhu, 2000). Nevertheless, due to the characteristics of biotechnology, which is associated with relatively long development periods compared to other industries, it takes a fairly long time from the initiation of a new business to the generation of revenues, and even longer to make a profit. Therefore, this study measured revenues as a proxy of financial performance in a relatively short analysis period of 8 years: from 2005 to 2012 (Baum et al., 2000; Zahra, 1996).

For control variables, this study chose the size and age of firm, independent venture by entrepreneurs with career in other firm or not, the level of vertical integration, the levels of business diversification, levels of government R&D funding, and the main business areas. For the size of firm, the number of employees was used, and for the age of firm, this study looked at the different values between the current and the founding year. Generally, the size and age of firms are proportionally related to their technological innovation and financial performances (Baum et al., 2000; Shan et al., 1994), as larger and older firms naturally have accumulated more resources and greater capacity, and consequently they have greater ability to manage business risk than their smaller or

younger counterparts. However, several studies pointed out that they could also experience greater organizational inertia that exerts a negative impact on company performance (Shimizu and Hitt, 2005).

Additionally, this study uses control variable of whether the bio-medical firms is independent venture by entrepreneurs with career in other firm or not. In Korea, the portion of firm founding by them is distinctively higher than any other type (Science and Technology Policy Institute of Korea, 2013). Though this study don't discuss their influence on firm strategies and performances, it is representative entrepreneurial type in Korea. Their business experience in previous firm may play much more important role to entrepreneurial process and performance with superiorities of commercial knowledge (Wennberg et al., 2011).

Moreover, this study examined the distribution of each firm's business functions in a value chain to check the level of vertical integration. The operational function of value chain in bio-medical industry can be divided into four stages of basic R&D, product development, manufacturing, and marketing (Konde, 2009). This study operationally defines that firms with only basic R&D function are "1", firms with basic R&D and product development are "2", the firms with all of basic R&D, product development, manufacturing and marketing functions are "3". In addition, this study uses the level of business diversification as control variable. The level of business diversification was measured using the number of business areas including bio-medicine, diagnostic kits & reagents, supporting services, and measurement & analysis equipment. The level of

vertical integration and business diversification can be referred as not only to the business scale and scope of firm, but also risk management by process efficiency and risk diversification, which affects the performance of the firm (Rumelt, 1982; Harrigan, 1985). This study also uses as control variable if platform & service firms is or not. According to Willemstein et al. (2007), the bio-medical firms can be classified as therapeutic product-oriented firms and infrastructure firms including platform & service segment. The infrastructure firms in platform & service segment may have fewer technical demands due to their strong service characteristics, or have mechanical or electronic mechanism–oriented technologies as their core competency. Thus, they are expected to be very different from those of therapeutic product-oriented firms, further to influence on their strategies and performance (Casper and Kettler, 2001; Chiaroni et al., 2009).

Moreover, the Korean bio-medical industry has been developed according to government-led policies, which has had a significant effect on initial performance of bio-medical firms (Kang and Park, 2012; Science and Technology Policy Institute of the Republic of Korea, 2013). Therefore, the influence of government support needs to be controlled. Government support can be divided into institutional strategies such as those associated with tax benefits, and direct investments, such as support for R&D expenses. Specifically, government research funding accounts for the largest portion of direct government investments (Science and Technology Policy Institute of the Republic of Korea, 2013). Thus, in this study, the total amount of government R&D funding for the current year was used as a control variable.

Table 2 describes the names and operational definition of the variables used in the analysis to examine the study hypotheses.

Table 2. Definition of variables in study on firm's origin

Abbreviation of variable	Variable	Definition
RIV	Independent venture established by entrepreneurs from research organization	1 if the entrepreneur had career in research organizations, 0 otherwise
CV	Corporate venture	1 if the firm spun-off from a parent firm, 0 otherwise
RD	R&D intensity	Log-transformed ratio of R&D expenses to number of employees
ARD	R&D alliance	Number of R&D alliances
AMM	Manufacturing & marketing alliance	Number of manufacturing & marketing alliances
PAT	Technological Innovation performance	Number of patents registered with the Korean Intellectual Property Organization
REV	Financial performance	Log-transformed total revenues
SIZE	Firm size	Number of employees
AGE	Firm age	Number of years since founding
FIV	Independent venture established by entrepreneurs with career in other firm	1 if the entrepreneur had career in other firm, 0 otherwise
INTE	The level of vertical integration	1 if the firm is in basic R&D stage of value chain 2 if the firm is in basic R&D and product development of value chain 3 if the firm is a full-integrated firm (involving basic R&D, product development, manufacturing, and marketing of value chain)
DIV	The level of business diversification	Number of business areas in which the firm is engaged
PLAT	Platform & service business segment	1 if the type of firm's final output is platform technology and service, 0 otherwise
GOV	Government R&D funding	Total amount of R&D expenses supported by the government

3.3.3 Analytical Method

Previous studies show a systemic connection between business strategies, such as R&D intensity and alliances, and their effect on performance. In addition, the differences in resources and capabilities depend on the characteristics of firm's origin, as defined by the types of entrepreneur and entrepreneurial team, creating potential differences in R&D intensity and the propensity for creating alliances, which subsequently leads to differences in technological innovation and financial performances. Therefore, to consider the structural mechanisms between business strategies and performances in the bio-medical industry, this study systemically analyzed the various impacts that the characteristics of bio-medical firms established by entrepreneurs from research organizations, and spun-off from parent company, can exert on business strategy and performance.

Therefore, this study used a generalized structural equation model to analyze the process of input–output–outcome among the variables related to the characteristics of firm's origin; R&D intensity; R&D alliances, manufacturing & marketing alliances; technological innovation, and financial performance of bio-medical firms as a holistic model. A structural equation model offers a statistical method to analyze theoretical causal relationships and the levels of correlation among various variables, which allows comprehensive measurements of multiple-variable relationships and supports systematic solutions to problems (Sobel, 1982). Inter alia, the generalized structural equation model includes the generalized linear response variables that are included in logistic, Poisson,

negative-binomial, ordered, and other models (i.e., the measurements can be continuous, binary, count, categorical, and ordered), and it can estimate multilevel mixed effects (Rabe-Hesketh et al., 2004). Therefore, the model used in this study assumes that the relationship of each element is hierarchical (Skrondal and Rabe-Hesketh, 2004). The generalized structural equation model used to verify the hypotheses in this study is defined in Eq. (1) to (5) according to the conceptual framework presented in Figure 4.

$$RD_{it} = \beta_0 + \beta_1 RIV_{it} + \beta_2 CV_{it} + \beta_3 SIZE_{it} + \beta_4 AGE_{it} + \beta_5 FIV_{it} + \beta_6 INTE_{it} + \beta_7 DIV_{it} + \beta_8 PLAT_{it} + \beta_9 GOV_{it} + \varepsilon_{it} \quad \cdots\cdots \text{Eq. (1)}$$

$$ARD_{it} = \beta_0 + \beta_1 RIV_{it} + \beta_2 CV_{it} + \beta_3 RD_{it} + \beta_4 SIZE_{it} + \beta_5 AGE_{it} + \beta_6 FIV_{it} + \beta_7 INTE_{it} + \beta_8 DIV_{it} + \beta_9 PLAT_{it} + \beta_{10} GOV_{it} + \varepsilon_{it} \quad \cdots\cdots \text{Eq. (2)}$$

$$PAT_{it+1} = \beta_0 + \beta_1 RIV_{it} + \beta_2 CV_{it} + \beta_3 RD_{it} + \beta_4 ARD_{it} + \beta_5 SIZE_{it} + \beta_6 AGE_{it} + \beta_7 FIV_{it} + \beta_8 INTE_{it} + \beta_9 DIV_{it} + \beta_{10} PLAT_{it} + \beta_{11} GOV_{it} + \varepsilon_{it} \quad \cdots\cdots \text{Eq. (3)}$$

$$AMM_{it+1} = \beta_0 + \beta_1 RIV_{it} + \beta_2 CV_{it} + \beta_3 PAT_{it+1} + \beta_4 SIZE_{it} + \beta_5 AGE_{it} + \beta_6 FIV_{it} + \beta_7 INTE_{it} + \beta_8 DIV_{it} + \beta_9 PLAT_{it} + \beta_{10} GOV_{it} + \varepsilon_{it} \quad \cdots\cdots \text{Eq. (4)}$$

$$REV_{it+3} = \beta_0 + \beta_1 RIV_{it} + \beta_2 CV_{it} + \beta_3 AMM_{it+1} + \beta_4 PAT_{it+1} + \beta_5 SIZE_{it} + \beta_6 AGE_{it} + \beta_7 FIV_{it} + \beta_8 INTE_{it} + \beta_9 DIV_{it} + \beta_{10} PLAT_{it} + \beta_{11} GOV_{it} + \varepsilon_{it} \quad \cdots\cdots\cdots\cdots \text{Eq. (5)}$$

Technological innovation performance or manufacturing & marketing alliances must be considered with a time lag of one year because they are attributed to the results of R&D investment or alliance activities (Kang and Park, 2012). In addition, financial performance is considered after a time lag of two years from measurement of technological innovation performance or formation of manufacturing & marketing alliances because new technologies and products require some time to spread into the market (Qian and Li, 2003). Because the numbers of alliance and patent registrations are countable integers that include multiple zeros, in this case, the Poisson distribution or the negative-binomial distribution should be assumed (Hilbe, 2011). The Poisson distribution applies in situations in which the mean and variation are equal. In other cases, based on the assumption of a negative-binomial distribution, regression equations should be analyzed. Therefore, in the generalized structural equation model, for the dependent variables related to the number of alliances and patents, the negative-binomial distribution is assumed for a regression analysis, and for the dependent variables of R&D intensity and revenues, the generalized least square regression analysis was used. Moreover, because the distributions of R&D intensity and revenues do not show perfect bilateral symmetry but appear skewed, indicating that some companies have much larger

values than others, natural logarithmic transformation was used to reduce the impact of some exceptionally large values on the analysis results. In addition, if these values are “0”, a very small value of “0.00001” was used to prevent that these were treated as missing values in analysis.

Moreover, with regard to multicollinearity among variables, this study analyzed them through variance inflation factor (VIF). Variance inflation factor means increment of variance by multicollinearity among independent variables, which can calculate like Eq. (6).

$$VIF_j = \frac{1}{1-R_j^2}, j = 1, 2, \cdots, k \quad \text{Eq. (6)}$$

where R_j^2 is the coefficient of determination in the regression model. Generally, if the value of VIF is greater than 10, there is multicollinearity in the analytic model (Neter et al., 1985). The maximum value in the VIF test of this model is 1.66; thus, there is no multicollinearity among the variables. For this analysis, a total of 3,100 observations were used, minus 340 missing values, among 8 years of data associated with 430 firms.

3.4 Results and Discussions

The descriptive statistics and the correlation coefficients of the variables included in the analytical model are described in Table 3, and the results from the analyses of the generalized structural equation model are presented in Table 4. All positive or negative correlation coefficients, except those associated with the number of R&D alliances or patent registrations with corporate ventures, were statistically significant. Maximum log-likelihood of this model was -12267.59 and AIC (Akaike Information Criterion)[1] was 24657.19, which showed the fittest value than any other models.

[1] These statistics are used not to judge fit in absolute terms but instead to compare the fit of different models. Smaller values indicate a better model fit. The statistics of AIC is given by -2(log-likliho od)+2K(Here, K is the number of effective degrees.) (Fang, 2011). By Forbes and Zampelli (2008), it could be calculate it as follows: $AIC = -2(\frac{L}{n}) + \frac{p}{n}$ (Here, L is log-likelihood, p is the number of parameters in the model; n is the number of observations.)

Table 3. Descriptive statistics and correlation coefficients of variables in study on firm's origin

Variable	Mean	Standard deviation	RIV	CV	RD	ARD	PAT	AMM	REV	SIZE	AGE	FIV	INTE	DIV	PLAT
RIV	0.278	0.448	1.												
CV	0.052	0.222	-0.145***	1.											
RD	3.227	1.715	0.075***	0.097***	1.										
ARD	0.052	0.299	0.136***	0.012	0.097***	1.									
PAT	0.509	1.542	0.079***	0.013	0.136***	0.166***	1								
AMM	0.036	0.229	0.017	0.113***	0.140***	0.272***	0.126***.	1							
REV	7.270	2.598	-0.099***	0.299***	0.100***	0.060	0.091***	0.151***	1.						
SIZE	21.412	19.784	-0.063***	0.077***	-0.144***	0.099***	0.096**	0.055**	0.221***	1.					
AGE	8.793	5.827	0.084***	0.062***	0.145***	0.150***	0.054	0.151***	0.352***	0.256***	1.				
FIV	0.398	0.490	-0.405***	-0.190***	-0.092***	-0.080**	-0.013	-0.035*	0.021	0.092***	-0.059	1			
INTE	1.474	0.657	0.042*	0.137***	0.013	0.289***	0.195***	0.208***	0.305***	0.447***	0.252***	-0.012	1		
DIV	1.452	0.684	0.108***	-0.016	0.062	0.059**	0.071***	0.039*	0.029	-0.050**	0.104***	-0.040*	0.023	1	
PLAT	0.456	0.498	0.028	-0.129***	-0.011	0.0144	-0.024	-0.009	-0.074***	-0.051**	0.041*	-0.025	-0.041*	0.061***	1
GOV[a]	164	411	0.123***	-0.001	0.132***	0.299***	0.192***	0.158***	0.045*	0.160***	0.074***	-0.044**	0.217***	0.044**	-0.004

*** p<0.001, ** p<0.01, * p<0.05, † p<0.1

Note. [a] unit = million KRW (1 U.S. dollar = 1,068.50 KRW as of October 1, 2014)

Table 4. Analysis results of generalized structural equation model

Explanatory variable	Dependent variable				
	RD_{it}	ARD_{it}	PAT_{it+1}	AMM_{it+1}	REV_{it+3}
RIV_{it}	0.441*** (0.090)	0.509† (0.292)	0.691*** (0.158)	-0.331 (0.354)	-0.354** (0.132)
CV_{it}	0.148 (0.160)	0.483 (0.452)	0.092 (0.277)	1.604*** (0.392)	0.598** (0.229)
RD_{it}		0.361*** (0.097)	0.146*** (0.038)		
ARD_{it}			0.174† (0.083)		
PAT_{it+1}				0.056† (0.026)	0.075** (0.028)
AMM_{it+1}					0.412* (0.192)
$SIZE_{it}$	-0.031*** (0.002)	0.001 (0.007)	0.006† (0.003)	0.028*** (0.007)	0.020*** (0.003)
AGE_{it}	0.061*** (0.006)	0.014 (0.012)	-0.013 (0.011)	0.050** (0.016)	0.026*** (0.008)
FIV_{it}	0.161* (0.081)	-0.547 (0.337)	0.456** (0.145)	0.049 (0.333)	0.205† (0.118)
$INTE_{it}$	0.096 (0.059)	1.617*** (0.176)	0.360*** (0.086)	1.677*** (0.204)	0.346*** (0.086)
DIV_{it}	0.046 (0.046)	0.176 (0.156)	0.103 (0.074)	0.108 (0.178)	0.214** (0.069)
$PLAT_{it}$	-0.265*** (0.065)	-0.045 (0.229)	-0.376*** (0.114)	-0.190 (0.254)	0.305*** (0.096)
GOV_{it}	0.001*** (0.001)	0.001*** (0.001)	0.001*** (0.001)	0.001*** (0.001)	0.001 (0.001)

*** p<0.001, ** p<0.01, * p<0.05, † p<0.1

Note. Standard error of the coefficient estimate in parentheses

Maximum log-likelihood: -12267.59, Number of observations: 3,100

Looking at the relationship between the control and analysis variables, this study sees

that the size of firm had a negative relationship with its R&D intensity ($p<0.001$) and a positive relationship with technological innovation performance, manufacturing & marketing alliance, and financial performance ($p<0.1$, $p<0.001$, and $p<0.001$, respectively). This finding implies that the size of firm is inversely proportional to the amount of internal R&D investment but is directly proportional to the number of parents registered, the number of manufacturing & marketing alliances, and revenue. The age of firm has a positive relationship with all dependent variables except R&D alliance and technological innovation performance. This finding shows that firm age is directly proportional to R&D intensity, manufacturing & marketing alliance, and financial performance ($p<0.001$, $p<0.01$, and $p<0.001$, respectively). In particular, older companies have an advantage in manufacturing facilities, know-how for manufacturing, and marketing capabilities or distribution networks as accumulated since their foundation, with which they are assumed to carry out manufacturing & marketing alliance activities and earn revenues. Nevertheless, although an older firm is linked to a higher R&D intensity level, the innovation performance, as measured by patent registrations, is not guaranteed.

Moreover, the firm's origin characteristics of independent venture by entrepreneurs with career in other firm positively influences on R&D intensity, technological innovation, and financial performance ($p<0.05$, $p<0.01$, and $p<0.1$, respectively). It shows that entrepreneurs from other firm have advantage to R&D investment. They may facilitate to collect R&D investment with social capital accumulated in prior firm (Bosma et al., 2004). In addition, their business experience in other firm is favorable to commercialize their technological innovation and to achieve financial performance, because of their

accumulated commercial knowledge (Wennberg et al., 2011). The level of vertical integration gives positive effects on R&D and manufacturing & marketing alliance, technological innovation and financial performance ($p<0.001$, $p<0.001$, $p<0.001$, $p<0.001$, respectively). This implies that high vertically integrated firms have advantages on forming strategic alliance and achieving performance. The higher level of vertical integration can understandably make a various type of strategic alliances, and benefits of productivity and profitability generated from balance between vertical integration and strategic alliance ultimately positively influence on their performance (Rothaermel et al., 2006). The business diversification is only positively related to financial performance ($p<0.01$) indicating that greater business diversification leads to greater revenues. The diversification of their business portfolio disperses their business risks, contributing to their financial performance (Martin and Sayrak, 2003). The result of analysis also shows that the business in platform & service segment (that is, the firm provides platform technologies and related service along with R&D and commercialization process of therapeutic product) has a negative relationship with R&D intensity, technological innovative performance ($p<0.001$ and $p<0.001$, respectively) and a positive relationship with financial performance ($p<0.001$). These results demonstrate that platform & service-oriented firms have properties less R&D investments and technological innovation performance, but they experience an advantage in terms of creating revenue. Pisano (2006) explained bio-medical firms in platform & service segment might have different technological properties with therapeutic product oriented firms, less uncertain, interdisciplinary, and accumulated, even little technological risk as service firm. However, they run business with direct revenue stream through executing various projects in

specialized stage of value chain (Willemstein et al., 2007).

Government R&D funding has a positive relationship with R&D intensity, R&D alliance, technological innovation performance, and manufacturing & marketing alliance ($p<0.001$, $p<0.001$, $p<0.001$, and $p<0.001$, respectively), but not with financial performance. This finding indicates that government R&D funding contributes to the overall level of business activity, ranging from R&D investment, R&D alliances, and number of patents to the number of manufacturing & marketing alliances. Particularly because government R&D funding promotes manufacturing & marketing alliances, one can conclude that government R&D funding contributes, not only to technology innovation, but also to raising the commercialization capacity of the firm through collaborations.

The results confirmed that R&D intensity has a positive effect on R&D alliance and technological innovation performance ($p<0.001$ and $p<0.001$, respectively), which is consistent with the results of previous studies that confirmed the same relationships between patent holding and alliance building with R&D investments (Hall and Bagchi-Sen, 2001, 2002; Kang and Park, 2012). A series of previous studies reported that the R&D intensity levels of bio-medical firms are higher than those of any other industry (Bagchi-Sen, 2007; Deeds, 2001). Hall and Bagchi-Sen (2002) easily identified bio-medical firms in which R&D investment accounts for more than 50 percent of revenues. The results of this study can further the understanding of these findings by illustrating the background characteristics of the technology-intensive bio-medical industry.

The findings from this study showed that R&D alliance positively affected technological innovation performance ($p<0.1$), which means that the R&D alliances of

bio-medical firms stimulate their patent registrations. Because the findings show R&D intensity affects R&D alliance, and influence technological innovation performance, one can see that R&D investments, along with direct effects of R&D intensity, positive mediating effect on technological innovation performance by promote R&D alliances. Kang and Park (2012) provided evidence of the direct effects of R&D intensity on technological innovation performance in Korean biotechnology industry and also addressed the mediating effect of upstream alliance stimulation with research organizations, such as universities, on technological innovation performance. The results of this study support and complement the findings of Kang and Park (2012) because the findings show that R&D alliances with other firms and research organizations positively influence technological innovation performance.

In addition, technological innovation performance had a positive effect on financial performance and manufacturing & marketing alliance ($p<0.01$ and $p<0.1$, respectively). The fact that the number of patent registrations positively affects the amount of revenue can be interpreted in two ways. First, revenues are generated when bio-medical firms transfer their technology assets to pharmaceuticals or other bio-medical firms that are capable of commercializing those technologies. For bio-medical firms that focus on technology development, manufacturing & marketing are a difficult task, so they must realize excellent returns on their technological innovation performances and carry out technology transfers. Second, they transpire when firms commercialize their technology assets by themselves. Bio-medical firms with commercialization capacities witness their technological innovation performance directly leading to revenues. These results support the conclusions of prior studies showing that technological innovation performance exerts

a positive impact on financial performance (Hall and Bagchi-Sen, 2002; 2007).

Moreover, results showing that positive technological innovation performance results in more manufacturing & marketing alliances suggest that bio-medical firms that lack resources and capabilities for commercialization must present their technologies for commercialization through alliances with other firms with relevant manufacturing facilities or engage in alliances through which to sell their manufactured products. Therefore, this study found that manufacturing & marketing alliance has a positive impact on financial performance ($p<0.05$), which suggests that bio-medical firms that lack (or have) manufacturing & marketing capacities complement (or utilize) their abilities through alliances such that revenue is increased. Thus, this study also shows the mediating effects of patent registrations through manufacturing & marketing alliances as well as the direct effect of patent registrations and manufacturing & marketing alliances on revenue.

This study confirmed that the characteristics of bio-medical firms established by entrepreneurs from research organizations exert a positive effect on R&D intensity, R&D alliance, and technological innovation performance ($p<0.001$, $p<0.1$, and $p<0.001$, respectively). (Hypotheses 1-1, 1-2, and 1-3 are supported.) Furthermore, it showed that the characteristics of bio-medical firms established by entrepreneurs from research organizations gave mediating effect the promotion of R&D alliances by increasing R&D intensity. In addition, the results presented that it also positively mediated on patent registrations by enhancing R&D intensity and alliances. In sum, the results of this study demonstrate that the characteristics of bio-medical firms established by entrepreneurs from research organizations are relatively advantageous for achieving technological

innovation performance, and are favorable for the R&D investments and R&D alliances that confer technology intensiveness. Although this study confirmed the mediating effects that entrepreneurs from research organizations have on enhancing the financial performance of bio-medical firms through R&D intensity and alliances as well as technological innovation, the results show that these entrepreneurs are associated with a direct negative impact on it as well ($p<0.01$). To examine the effect of path coefficients more specifically, this study carried out effect decomposition, as shown in Table 5. This confirms that the property of firm's origin by entrepreneurs from research organizations has a direct effect of -0.354 and a mediating effect of 0.086 on financial performance. Thus, this study identified that firm origin has a total effect of -0.268 on financial performance.

Table 5. Effect decomposition on financial performance by firm's origin of entrepreneurs from research organizations

Effect	Path	Decomposition value	
Direct effect	RIV→REV		-0.354
Mediating effect	1) RIV→RD→PAT→REV	0.005	0.086
	2) RIV→RD→ARD→PAT→REV	0.002	
	3) RIV→RD→PAT→AMM→REV	0.001	
	4) RIV→RD→ARD→PAT→AMM→REV	0.001	
	5) RIV→ARD→PAT→REV	0.007	
	6) RIV→ARD→PAT→AMM→REV	0.002	
	7) RIV→PAT→REV	0.052	
	8) RIV→PAT→AMM→REV	0.016	
Total effect			-0.268

It supports study of Meyer (2003) that bio-medical firms established by entrepreneurs from research organizations may have a disadvantage in achieving financial performance. These results imply that bio-medical firms established by entrepreneurs from research

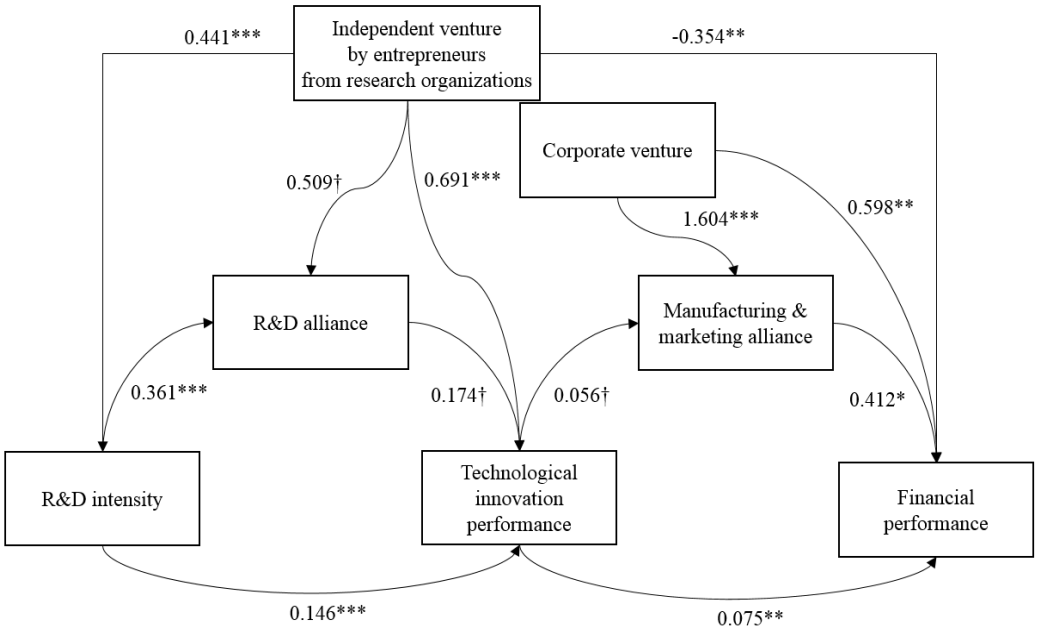
organizations enhance their revenues through their technological innovation performance, but generally offer poor capacity to commercialize their technologies that leads to revenue generation.

This study found that spin-off bio-medical firms experience a positive effect of manufacturing & marketing alliance and financial performance ($p<0.001$ and $p<0.01$, respectively). (Hypotheses 2-1 and 2-2 are supported.) That is, the characteristics of these firms wield a positive direct effect on manufacturing & marketing alliance and revenue, and mediating effect on revenue through promotion of manufacturing & marketing alliances. However, this study could not verify the indirect effects that spin-off bio-medical firms have on enhancing revenue through increasing R&D intensity, R&D alliances, and technological innovation performance. This result shows that spin-off bio-medical firms can have a business model for the commercialization of technologies created through the R&D activities of parent or other firms rather than one designed to generate revenues based on the technological innovation performance created by their R&D activities. These firms seems to have strong commercialization capacities through easy access to the resources and capabilities of their parent firms and generate revenues by making manufacturing & marketing alliances with other bio-medical firms that have with a reputation of outstanding technological innovation performance as well as by promptly commercializing the technologies of their parent firms in the market.

The results of this study differ somewhat from those by Zahra (1996) and Zahra and George (1999). While their research showed that corporate ventures have more R&D inputs and alliances in the bio-medical industry, this study failed to show that these type of companies stimulate R&D intensity or R&D alliances. This result can be interpreted in

two ways. First, spin-offs in Korean bio-medical industry are profit-oriented ventures, pursuing growth by expanding their business portfolios related to core businesses, which differs from the innovation-oriented ventures that engage in new business areas through R&D activities. Second, it is likely that corporate venture spin-offs create short-term financial performance through dependence on their parent firms rather than by generating the necessary dynamics themselves. Corley and Gioia (2004) argued that corporate ventures are likely to focus on manufacturing & marketing through the advantages offered by their parent firms rather than commit to R&D activities. Although their reliance on the culture, resources, and capabilities of parent firms imposes limitations on the R&D activities of corporate ventures, it also presents the possibility of a distinguished business model that uses the unique advantages offered by their parent firms.

The analysis results are summarized in Figure 5.



*** p<0.001, ** p<0.01, * p<0.05, † p<0.1

Figure 5. Summary of results in study on firm's origin

3.5 Sub-Conclusion

This study emphasized the characteristics of firm's origin. It has been considered important factor for firm growth at initial stage. However, there are few studies have examined the direct and mediating effects of firm's origin, on the strategies and performance of bio-medical firms throughout their value chains. Therefore, above all, this study described the factors that can affect the performances of bio-medical firms in Korea as one of latecomers in the bio-medical industry with a focus on R&D and commercialization activities as well as the characteristics of firm's origin. First, the structural relationship among R&D intensity and alliances and performances, as suggested by previous studies, was confirmed. Second, this study emphasized that the characteristics of firm's origin can be important resources and capabilities, due to the relatively high distribution of small-sized entrepreneur firms in bio-medical industry.

This study confirmed not only the positive direct and mediating effects of R&D intensity and alliances of bio-medical firms on technological innovation performance but also affirmed those of technological innovation performance as well as manufacturing & marketing alliances on financial performance. Moreover, the characteristics of bio-medical firms established by entrepreneurs from research organizations directly confer technological innovation performance advantages due to the entrepreneurs' basic science knowledge, which generates higher R&D intensity levels and more R&D alliances. In addition, the study findings confirmed that the characteristics of spin-off bio-medical firms provide an advantage in enhancing financial performance due to the easy access to the resources and capabilities of their parent firms, which increases the frequency of manufacturing & marketing alliances. The results of this study were summarized through

an explanation of a positive loop in the structural relationships among the R&D intensity levels, alliances, and performances of bio-medical firms. The technology-intensive characteristics of bio-medical firms established by entrepreneurs from research organizations allowed for technological innovation performance, but not financial performance. Conversely, spin-offs were actively pursue in alliance activities for product commercialization, but do not enthusiastically engage in R&D activities, yet enjoy high financial performance.

Based on these results, this study suggests two implications. First, bio-medical firms established by entrepreneurs from research organizations should make efforts to achieve financial performance to secure their spontaneity, despite having excellent technological resources and capabilities. According to Science and Technology Policy Institute of the Republic of Korea (2013), the average revenue of independent ventures was 7.22 billion KRW, and that of corporate ventures formed via spin-offs was 38.5 billion KRW. This implies that independent ventures are inferior to corporate ventures in terms of financial performance in the Korean context. This study also shows that independent bio-medical firms established by entrepreneurs from research organizations are deficient in terms of achieving revenue generation. This means that their business models are relatively risky.

Generally, founding of them is highly distributed in the therapeutic product-oriented segment with their innovative idea, which typically has a business model by commercializing their technologies, or directly productizing (Zucker et al., 2002; Hall and Bagchi-Sen, 2002, 2007). The results of this study show that there are difficulties associated with their business process—which Pisano (2006) described as typical *"science business"*—in the Korean bio-medical industry, despite their outstanding

technological innovation performance. The process from R&D to technology or product commercialization of therapeutic products in the bio-medical industry involves high uncertainty, requires huge R&D expenditure, and a long development period (Zucker et al., 2002). The result of this study in the context of Korean bio-medical firms established by entrepreneurs from research organizations indicated that they failed to achieve financial performance since they focused on their technology development exclusively. Therefore, these firms should make efforts to generate profits by redefining their business model to include commercialization.

In many cases, the technologies are too innovative (lack of evidence to prove the relationship between diseases and drug candidates, low reproducibility); thus, they could be difficult to commercialize (Pisano, 2006). Therefore, bio-medical firms established by entrepreneurs from research organizations should consider commercial processes in their R&D stage right from founding. Kasch and Dowling (2008) and Wennberg et al. (2011) emphasized the importance of commercialization capacity in the bio-medical industry at the initial stage, along with technological innovation capacity. Thus, bio-medical firms should foster commercial knowledge. It could be the solution for receiving managerial support in the form of financing from venture capital firms (Baum and Silverman, 2004) or policy support from incubating institutions, which provide education programs for enhancing their commercial knowledge.

Second, spin-off bio-medical firms can provide a new opportunity by reducing business risk and promoting the founding of new firms in Korea. This study found that spin-off bio-medical firms have competitive advantages because they can access the resources and capabilities of their parent companies. The bio-medical industry in the US

has abundant private investment like venture capital (Pisano, 2006). However, Korea has a bank-oriented financial system, and the bio-medical industry in Korea lacks of private investment (Whitley, 1992). Therefore, a new organizational model for the founding of firms that complements the business risk from the subsequent pressure of funds is required. Spin-off bio-medical firms can be this alternative model.

The parent companies of such firms have been mainly divided into two kinds in Korean bio-medical industry: medium-sized pharmaceutical companies and conglomerates. First, in the case of spin-offs from pharmaceutical companies, the bio-medical firms are spun-off for the diversification of the profit structure under pressure of drug price cuts. Though they may not have excellent technological capabilities in the bio-medical segment due to its cumulative property by learning (Pisano, 2006), they already have experience in the manufacturing & marketing process of chemical drugs, the know-how and facility (or capital) for drug manufacturing & marketing, and various marketing channels. Thus, they are likely to have immediate advantages in manufacturing & marketing operations than in R&D. Second, there are conglomerates called *chaebol* in the Korean industry structure (Casper, 2009). In fact, conglomerates like Samsung, LG, SK, and CJ entered the bio-medical industry by establishing spin-offs. These conglomerates selected the bio-medical industry as their new growth engine. They have different core capabilities such as information and electronic technology, chemical technology, and food technology, which means their entry to the bio-medical industry could serve as the means of related diversification and non-related diversification. Despite their various purposes, what is obvious is that they can give managerial support in the form of resources and capability like capital and consulting for their spin-offs. Their reputations are another

complementary asset. For example, based on such resources and capabilities, firm S entered the contract manufacturing organization (CMO) business segment. Firm S established a huge cell line and performed cell culture development in the upstream and recombinant process of proteins based on its high quality system. Firm S contracted and planned to expand its business to global pharmaceutical companies. Such situations imply that corporate bio-medical ventures created via spin-offs may be an alternative organizational model for reducing risk and enhancing the probability of growth at founding in the context of Korea.

However, less relevance with technological innovation performance along with poor R&D intensity and R&D alliance may be challenge of spin-off bio-medical firms in Korea. In fact, they have enough potential to change their business model into fully integration firm involving from R&D to manufacturing & marketing. In particular, Zahra (1996) argued they also can acquire excellent technologies from external organizations, thanks to their parent companies. Therefore, they should reinforce their technological innovation capacity to absorb excellent technologies in the long run (Cohen and Levinthal, 1990). Absorptive capacity is capabilities that enables firms to acquire and assimilate external knowledge with their internal knowledge through understanding and learning; transform that knowledge to create innovation performance that has synergy effects; and exploit those effects as a core competence (Zahra and George, 2002; Lichtenthaler and Lichtenthaler, 2009). This means that spin-off bio-medical firms are required the ability to assimilate, transform, and exploit the knowledge acquired from research organizations according to their strategic goals. Therefore, they need to exert themselves to enhance their technological innovation capacity in the long-term perspective.

This study has several limitations that should be taken under consideration when interpreting the results. The numbers of employees and business areas that reflect the size of firm and the level of business diversification reflect 2012 data and are specified as constants that do not change by year. Although the number of employees or business areas unlikely change year to year, the firms' growth (or decline) or changes of the firm's business strategies over time will affect the usefulness of static values. In addition, because of their significance in the bio-medical industry, use of patents as a proxy for technological innovation performances was a reasonable choice, but this measurement does not fully reflect the technological innovation in bio-medical firms. Moreover, the proxy of financial performance as solely represented by revenues leads to an incomplete picture of profitability. Therefore, subsequent work needs to show various proxies that more fully measure the technological innovation and financial performances of bio-medical firms.

Chapter 4. Business Models in Korean Bio-medical Industry

4.1 Introduction

Recently, the competitive focus among firms has shifted from simply product or technology competition to overall business model competition; this shift suggests that understanding the business model is critical to creating competitive advantages and identifying business opportunities (Casadesus-Masanell and Ricart, 2010). Regarding business concept innovation, Hamel (2000) emphasized that business concept or business model innovation is the best means of maximizing corporate value and performance in an era in which the competitive composition is rapidly changing. Although previous business model research evinced diversity at a rudimentary level, the definition and components of the business model remain ambiguous. However, previous studies had commonly, but narrowly, emphasized the bundle of strategies and profit generation as business model components (Afuah and Tucci, 2001; Afuah, 2004; Zott et al., 2011). Therefore, for industry development, further studies on business models with a strategic perspective should be required.

Previous studies investigating bio-medical industry business models showed that the vertical integration in value chains and business diversification were critically important criteria (e.g., Bigliardi et al., 2005; Willemstein et al., 2007; Konde, 2009). However, because of rapidly increasing development costs and declining productivity and profitability, cost reduction, profit generation and sustainable growth goals have been

emphasized in bio-medical firms' business models. Hence, for the federated model, it is more important that firms form value networks with a variety of organizations in the industry's value chain (March-Chordà and Yagüe-Perales, 2011). In particular, such business models are more necessary for latecomer countries in the bio-medical industry. In these countries, bio-medical firms need to consider cost reduction, profit generation and sustainable growth for survival from founding because of shortage of industrial ecosystem as yet.

In regards to bio-medical industry business models, the role of the value chain or the integration level, and the business area or the diversification level were important considerations in previous studies. In addition, studies on the value network of federated business models were insufficient. Moreover, most previous studies on business models in bio-medical industry suggested exemplary cases of certain firms and conceptualized these to propose business model types. Although those studies provided a little evidence regarding business models of bio-medical industry through qualitative analysis, the studies suggested phenomenologically revealed important characteristics and were insufficient in evincing implications. However, there are few studies to identify business model of bio-medical firms with quantitative method, considering strategies related with criteria to classify them. Therefore, this study is object to group bio-medical firms in Korea quantitatively with the following four important criteria consisted business models, emphasized in bio-medical industry: the level of vertical integration, business diversification, R&D alliance, and manufacturing & marketing alliance. In particular, this study is expected to deduce useful bio-medical industry business model implications by classifying the heterogeneous characteristics of Korean bio-medical firms into a

homogeneous group utilizing the four business model criteria with the clustering method.

This study is structured as follows: chapter 4.2 examines the business model concepts and proposes criteria to classify business model in the bio-medical industry through previous studies papers. Moreover, chapter 4.3 introduces the clustering analysis method, which is the quantification method used to deduce a business model. Chapter 4.4 discusses the analysis results, and chapter 4.5 provides implications depending on business model of Korean bio-medical firms.

4.2 Business Model and Bio-medical Industry

4.2.1 The Concept of Business Model

Because a business model determines a firm's strategy (Shafer et al., 2005; Casadesus-Masanell and Ricart, 2010) and reveals the potential competitive advantages in product and service markets (Markides and Charitou, 2004), competition among firms is becoming a competition of business models (Christensen, 2001; Casadesus-Masanell and Ricart, 2010). Moreover, a business model is a route to commercialize a firm's technology innovations (Zott et al., 2011). In addition, the business model enables technological innovation to materialize and may occasionally be created by technological innovation (Calia et al., 2007). This means that technological innovation is crucial for a firm; however, innovation cannot guarantee a firm's performance or survival (Chesbrough, 2010). Moreover, a firm needs a business model to realize not only the technology embedded in attractive products and services but also to realize the commercial potential and profitability (Doganova and Eyquem-Renault, 2009; Zott et al., 2011). Furthermore, business model innovation is required to avoid organizational inertia and heighten technological innovation (Kimberly and Bouchikhi, 1995; Chesbrough 2010; Doz and Kosonen, 2010).

Previous studies defined business models by various means. Generally a business model can be defined as a *structural template that determines the internal and external resources of a firm and provides a process for a firm's value proposition and profit generation* (Timmers, 1998; Rayport and Jaworski, 2001; Afuah and Tucci, 2001; Magretta, 2002; Johnson et al., 2008). Timmers (1998) defined a firm's business model as a structural template of interested parties in a business and their roles for product, service

and information flow. Afuah and Tucci (2001) suggested that a business model is composed of seven elements: customer value, scope of offering, pricing, profit structure, corporate activities for a value proposition, business execution capability and business sustainability. Rayport and Jaworski (2001) categorized components of a business model into value proposition, value cluster, marketspace offering, resource system and a financial model. Magretta (2002) viewed a business model as including six elements: value proposition, customer definition, internal process and competencies, external positioning, economic model and investment. Additionally, Johnson et al. (2008) determined that a business model consists of a customer value proposition, profit formula, key resources and key processes enabling the combined sharing, creating and delivering of value.

Although the business model has been broadly defined in a variety of ways, a business model commonly emphasized *the value creating and capturing mechanism through firms' strategies for managing their resources, capabilities and profit generation* (Afuah and Tucci, 2001; Afuah, 2004; Zott et al., 2011). First, a business model narrowly focuses on value creation and capture. (Chesbrough and Rosenbloom, 2002); in other words, the value proposition regarding what firms provide (Mansfield and Fourie, 2004). For the value proposition, a firm first needs to determine the business boundary in the industry value-chain and the business area (Chesbrough and Rosenbloom, 2002). A business boundary generates corporate activities for the value proposition (Afuah and Tucci, 2001). In particular, for its value proposition, a firm should strategically utilize not only its internal but also external resources and capabilities. Hamel (2000), Christensen and Rosenbloom (1995), Peppard and Rylander (2006) also emphasized that value creation

and capture in business models can manifest as extended external participants; in addition, the value network in various combinations can create business model diversity. In other words, a firm's business model serves the role of defining its boundary through cooperation with buyers, suppliers and competitors (Magretta, 2002; Mansfield and Fourie, 2004; Zott et al., 2011). This demonstrates that business models may play a role in expanding a firm's boundary to surpass a focal firm's network (Zott et al., 2011). This means that the value proposition method in accordance with a business boundary in an industry value chain and with the business area and value network composition should be included in a business model; in addition, the method can be an important criterion for classifying business models. Second, a business model reflects the value proposition through the bundling of a firm's realized strategies and provides the rationale for the specific profit structure of a firm's revenues or costs (Chesbrough and Rosenbloom, 2002; Casadesus-Masanell and Ricart, 2010; Teece, 2010). Thus, although a business model generally includes a profit model concept, this is narrowly used, similar to a profit model (Zott et al., 2011).

4.2.2 Business Model in Bio-medical Industry

Previously discussed studies on bio-medical industry business models depended on a firm's vertical integration level and business diversification level (Casper, 2000; Casper and Kettler, 2001; Fisken and Rutherford, 2002; Bigliardi et al., 2005; Burns, 2005; Nosella et al., 2006; Willemstein et al., 2007; McKelvey, 2008; Konde, 2009; Demil and Lecocq, 2010; Sabatier et al., 2010; March-Chordà and Yagüe-Perales, 2011; Suurna, 2011). First, business models in the bio-medical industry traditionally have been divided

into two models for the level of vertical integration: a model in which a firm transfers technology to pharmaceutical companies by relying on venture capital, and another model of large pharmaceutical companies based on the vertical integration of R&D, clinical tests, approval, product manufacturing and marketing (McKelvey, 2008). Burns (2005) also segmented business models in the bio-medical industry according to the value chain role and the level of vertical integration, including RIBCO (Research Intensive Bio-Pharmaceutical Company), the Technology Platform Model, NRDO (No Research, Development Only) and FIBCO (Fully Integrated Bio-Pharmaceutical Company). First, the RIBCO model is a type of firms specializing in R&D and generating profits through technological performance in basic R&D or product development processes. In such a business model, a firm conducts clinical tests on new drug candidate substance and licenses to pharmaceutical companies, then reinvests the royalty profits generated from this into R&D. Second, the technology platform model[2] refers to a type of firms that increases product efficacy in the R&D stage of biotechnology products and adds value in technology by providing platform technologies to ultimately generate profit. There have been steady efforts to standardize a series of processes related to culture, refinement and analysis, and because of such efforts, platform technologies have been developed in the bio-medical industry. Third, the NRDO model[3] is a type of firms developed solely through licensing, its entire product pipeline from the outside (other bio-medical firms

[2] In particular, recently, attempts to explore bio-marker or new drug candidate substance and offer personalized medical services using genomics, proteomics, metabolomics, and bio-informatics are detected as target therapy or personalized medicine, thus the importance of platform technologies is even more increasing (Lesko 2007).

[3] With development of genomics in these days, business activities are increasing due to “drug repositioning” which looks for other diseases for which a medicine failed by other bio-medical firm is efficacious (Rothman and Kraft 2006), however, it might not be a long-term survival strategy for bio-medical firms as NRDO model-type firms need licensing activities on a regular basis, hence some of those firms converted to RIBCO model through securing sustainable profitability (Burns, 2005).

and pharmaceutical companies). Because R&D risk reduction, sales and profit increases are critical for these bio-medical firms, this type of firms concentrates on development related to profit materialization areas instead of on initial R&D. Last, the FIBCO model is a type of firms that are traditional pharmaceutical companies conducting business activities encompassing R&D, manufacturing and marketing. In certain cases, RIBCO, Technology Platform and NRDO model-type firms convert to the FIBCO-model when their profit grows and then develop phase 3 clinical trials on their own and address approval, manufacturing and marketing (Burns, 2005; Rhyne, 2009).

Second, the business model of bio-medical industry has been classified regarding the level of business diversification. Casper (2000) classified the bio-medical industry into a therapeutic product segment and a platform & service segment. This means the platform & service segment plays a role not only in the value chain but also in different business segments utilizing developed therapeutic drugs and devices. Casper and Kettler (2001) noted in their study that Germany was able to overtake UK in the late 1990s. However, Germany fell behind the UK in the bio-medical industry's early stage because many bio-medical firms using a platform & service business model appeared in the market. The researchers also argued that traditionally, Germany has been strong in human resources relation with mechanics and electronics, which were more suitable and advantageous for a platform & service business model.

Fisken and Rutherford (2002), in their study on business model of European biotechnology firms, said that firms founded since the early 1980s in Europe are bio-medical firms concentrating on developing therapeutic products; however, firms developing the platform & service area started to appear in the late 1980s, and the hybrid

business model encompassing both therapeutic product and platform & service area appeared in the early 1990s. In particular, firms with a hybrid business model reduced investment risks and increased expected ROI, hence attracting more investment than those with a single business segment (Fisken and Rutherford, 2002). Besides, Willemstein et al. (2007), Konde (2009), Demil and Lecocq (2010) also have expanded business portfolio of bio-medical industry by adding a platform & service segment. Furthermore, Sabatier et al. (2010) and March-Chordà and Yagüe-Perales (2011) also emphasized the business model portfolio as a corporate strategy to combine markets in the bio-medical industry. They argued that bio-medical firms should secure revenue streams through related business diversification, which had high interdependency in bio-medical industry. This is caused that R&D process of bio-medicine and diagnostic kits & reagents are risky (Pisano, 2006). In this end, it also means that bio-medical firms should consider their revenues through interrelated business diversification as well as costs (Konde, 2009).

In a comprehensive perspective of both value chain integration and business diversification, Bigliardi et al. (2005), through cluster analysis, divided Italian bio-medical firms into the following three types: 1) platform & service firms, 2) RIBCO-type firms concentrating on R&D, and 3) FIBCO-type integration firms. Furthermore, Nosella et al. (2006) classified business models in Italian bio-medical firms into: 1) RIBCO-type firms concentrating on R&D, 2) NRDO-type firms commercializing technologies or products, 3) FIBCO-type integration firms, and 4) platform & service firms. Willemstein et al. (2007) sorted business models in the Dutch bio-medical industry into: 1) platform & service firms at the basic R&D stage, 2) hybrid firms with mixed platform & service firms and product firms, and 3) product firms commercializing or productizing developed

technology in accordance with a value chain. Konde (2009) divided business models in the Indian bio-medical industry into: 1) platform & service firms, 2) product firms, 3) hybrid firms, and 4) vertical integration firms in accordance with a value chain of R&D, product development, manufacturing & marketing. March-Chordà and Yagüe-Perales (2011) segmented business models in the Canadian bio-medical industry into: 1) RIPCO model traditionally concentrating on R&D and relying on private equity funds such as venture capital, 2) platform & service model with platform technologies in proteomics or bio-informatics, and 3) NRDO model in which a firm spins off from a pharmaceutical companies and rapidly materializes profit through gradual innovation. Suurna (2011) emphasized that business models in the Estonian bio-medical industry are primarily RIPCO model; in addition, the industry is evolving into more segmentation regarding technology and business. Therefore, through previous studies, bio-medical firm business models have been demonstrated as vertical integration in a value chain and as business diversification.

However, in accordance with the worsening productivity and profitability of bio-medical firms, to strengthen core competitiveness and sustain growth, a new business model for survival should be required (Pammolli et al., 2011). March-Chordà and Yagüe-Perales (2011) and Rusu et al. (2011) emphasized a federated model in which various organizations form value networks. The federated model is a business model in which each functional organization’s value chain cooperates with one another through close strategic alliances forming a network; in addition, a large portion of corporate activities is outsourced. Furthermore, there is functional differentiation from FIBCO business model, a federated model created the CRO, which is a Contract Research Organization in charge

of clinical tests and approval derived from clinical trial design and new drug approval applications, the CMO, which is a Contract Manufacturing Organization and the CSO, which is a Contract Sales Organization (Piachaud, 2005). The fact that these business models are emphasized represents reduced business risks, strengthened core competitiveness and sustained growth; acquiring complementary assets through strategic alliances in drug development is critical for a bio-medical firm's growth and survival. In particular, such business models are more necessary for latecomers of the bio-medical industry. In these countries, bio-medical firms need to consider cost reduction, competitiveness, profit generation at founding, and sustainable growth for survival for new businesses because of non-organized industrial ecosystem (March-Chordà and Yagüe-Perales, 2011). Combining all discussions, all business models discussed in the bio-medical industry are shown in Figure 6.

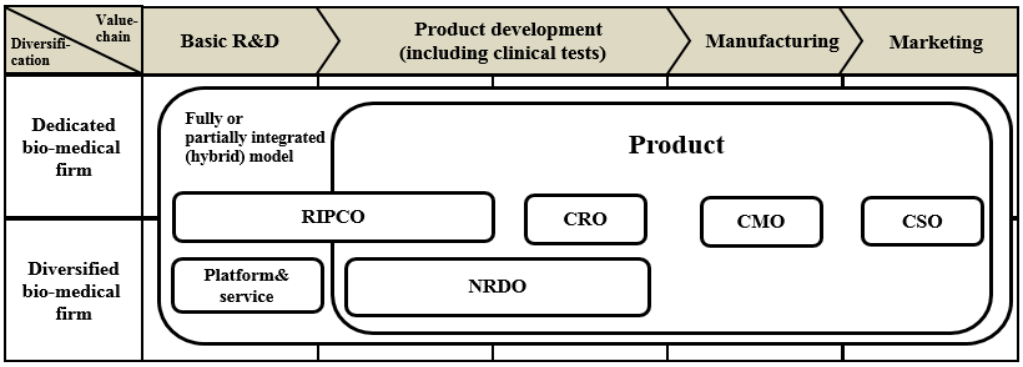


Figure 6. The business model of bio-medical firms

Previous studies failed to comprehensively consider aspects of the strategic level of vertical integration, diversification and strategic alliance. Therefore, this study consider

the federated model through strategic alliances in addition to the level of vertical integration and diversification, which are critical criteria for classifying business model of bio-medical industry. In particular, although there are various type of strategic alliances, these can be divided into both R&D and manufacturing & marketing alliances, which this study regards as the two types of strategic alliance criteria to classify all business models. Moreover, previous studies presented various business models depending on the country, because each has different industrial circumstances, and thus, a country's bio-medical industry naturally has unique type of business model. In sum, this study intends to classify business model of bio-medical firms in Korea in accordance with four criteria as shown in Figure 7.

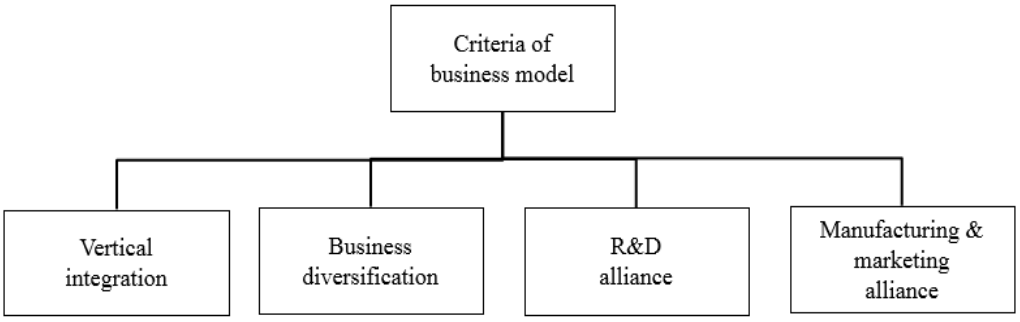


Figure 7. Classification criteria of bio-medical firm's business model

4.3 Methods

4.3.1 Data

This study used the bio venture DB of Science and Technology Policy Institute (STEPI) of the Republic of Korea (2013). Among the 756 bio-medical firms found in the research DB which suggested Chapter 3.3, the most recent data are for 2012, but 2012 has many missing values and unclear information. Thus, this study is conducted on 313 firms based on data for 2011 for analysis. Among these, although there are 6 CRO firms and 2 CMO firms in bio-medical industry of Korea, this study excluded these firms because they appear to have minimum representation in this study. Consequently, 305 firms were used in this study.

The size, age, and core business area of the target firms for analysis are shown in Table 6. There were 268 companies (87.87 %) categorized as small because they employed fewer than 50 people. The number of firms under 10 years old was 156 (51.15 %). Among the total number of firms, 203 (66.56 %) were considered therapeutic product-oriented firms and were made up of 161 bio-medicine and 42 diagnostic kits & reagents manufacturing firms. There were 102 infrastructure firms (33.44 %); 83 of them featured supporting services, and 19 offered measurement & analysis equipment.

In particular, this DB includes strategic alliance information from the Korean bio-medical industry from 2005 to 2011. This study used 139 data points on R&D collaborations, 66 data points on technology transfer, 16 data points on commissioned R&D, 8 on manufacturing alliances, and 75 on bio-medical firm marketing alliances for the analysis; in total, 304 alliance data points from 2005 to 2011.

Table 6. General characteristics of firms in study on business model

Characteristic	Number of firms	Percentage
Size (number of employees)		
Small (<50)	268	87.87
Medium (51-100)	37	12.13
Large (>100)	0	0.11
Age (years since formation)		
Young (<10)	156	51.15
Established (>10)	149	48.85
Main business area		
Bio-medicine	161	52.79
Diagnostics kits and regents	42	13.77
Supporting service	83	27.21
Measurement & analysis equipment	19	6.23

4.3.2 Analytical Method

This study adopted the hierarchical clustering method to find clusters in bio-medical industry of Korea using the level of vertical integration, business diversification and R&D and manufacturing & marketing alliance as the criteria. Hierarchical clustering, classifying homogeneous firms and differentiating groups, is that a cluster belongs to another cluster according to the distance between two clusters; however, duplication between clusters is not allowed. Overall, the hierarchy type is structured similar to a tree branch by aligning and combining the clusters. Hierarchical clustering methods vary according to the measuring distance between groups as follows: single linkage method, complete linkage method, average linkage method, centroid linkage method, median linkage method and Ward's method. This study used Ward's method, one of the methods

proposed in Bigliardi et al. (2005)'s study for hierarchical clustering. Ward's method integrates clusters by minimizing the square error of Euclidean distance between objects comprising a cluster (Ward, 1963); in addition, this is known to tend to classify the size of a cluster smaller and more evenly than other hierarchical clustering methods (Szekely and Rizzo, 2005).

Though a few bio-medical firms are recognized at home and abroad by their excellence and have functions ranging from technology development to manufacturing & marketing with active strategic alliances, most firms remain small-sized. Hence, there is great concern for data bias regarding clustering features. In such cases, other clustering methods are highly likely to divide two clusters into a group of firms with outstanding performance and another group for the remainder. Therefore, in this study, it appears reasonable to use Ward's method of grouping clusters with the highest similarity by defining the error sum of squares derived during the formation of a new cluster as the distance between two clusters (Szekely and Rizzo, 2005).

Ward's method defines the error sum of squares of objects belonging to new cluster i, which is formed when grouping two clusters, U and V as ESS_i (ESS : Error Sum of Squares), and the error sum of squares of all clusters is equivalent to Eq. (7).

$$ESS = \sum_{i=1}^{g} ESS_i \quad \cdots\cdots \text{Eq. (7)}$$

Here, ESS of cluster i is equivalent to Eq. (8), and

$$ESS_i = \sum_{j=1}^{N_i} \sum_{k=1}^{p} (X_{ijk} - \overline{X}_{ik})^2 \quad \cdots\cdots \text{Eq. (8)}$$

X_{ijk} includes N_i objects among g clusters at the current stage, and the measured value of k^{th} variable of j^{th} object in i^{th} cluster is as Eq. (9).

$$\overline{X}_{ik} = \sum_{j=1}^{N_i} X_{ijk} / N_i \quad \cdots\cdots \text{Eq. (9)}$$

(The average value of variable k in cluster i, $i = 1, 2, \cdots, g$; $j = 1, 2, \cdots, N_i$; $k = 1, 2, \cdots, p$)

The increment of ESS generated by grouping two clusters, U and V, whose size are N_1 and N_2, respectively, is equivalent to Eq. (10).

$$\begin{aligned} E(U,V) &= \sum_{i \in U \cup V} \left\| X_i - \overline{X} \right\|^2 - \left[\sum_{i \in U} \left\| X_i - \overline{X_1} \right\|^2 + \sum_{i \in V} \left\| X_i - \overline{X_2} \right\|^2 \right] \\ &= \sum_{i=1}^{2} N_i \left\| \overline{X_i} - \overline{X} \right\|^2 \\ &= \left\| \overline{X_1} - \overline{X_2} \right\|^2 / (1/N_1 + 1/N_2) \quad \cdots\cdots \text{Eq. (10)} \end{aligned}$$

Here, $\overline{X_1}$ and $\overline{X_2}$ indicates a centroid vector of cluster U and V, respectively, and $\overline{X}$ is the vector expressed as the weighted average of the two vectors is equivalent to Eq. (11).

$$\overline{X} = \frac{N_1\overline{X_1} + N_2\overline{X_2}}{N_1 + N_2} \quad \cdots\cdots \text{Eq. (11)}$$

Ward's method is the same as defining the increment $E(U,V)$ as the distance between two clusters, U and V. This means the farther the distance between cluster U and V, the larger the value of $E(U,V)$ is, and the higher the loss of information. This result differs from the centroid linkage method in that the distance between the centers of two clusters is weighted in the distance calculation.

To determine the business model types for bio-medical firms in Korea, this study conducted cluster analysis based on the following criteria: 1) *the level of vertical integration*, 2) *the level of business diversification* 3) *the level of R&D alliance and 4) manufacturing & marketing alliance*. For cluster analysis, grouping variables are classified by each criterion presented in Table 7.

Table 7. Grouping variables and codified values

Grouping variables	Operational definition
(1) Level of vertical integration	1: Basic R&D stage 2: Basic R&D and product development 3: Full integration (basic R&D, product development, manufacturing, and marketing)
(2) Level of diversification	The number of business areas
(3) Level of R&D alliances	The number of R&D alliances from 2005 to 2011
(4) Level of manufacturing & marketing alliances	The number of manufacturing & marketing alliances from 2005 to 2011

First, this study examined the distribution of each firm's business functions in a value chain to check the level of vertical integration. The value chain in the bio-medical industry can be divided into four broad stages: 1) basic R&D, 2) product development, 3)

manufacturing, and 4) marketing (Konde, 2009). Examining the data analysis results for business functions in bio-medical firms' value chains, the classification is as follows: 1) firms specialized in basic R&D, 2) firms with integrated both basic R&D and product development functions, and 3) firms in which basic R&D, product development, manufacturing and marketing functions are all integrated. Therefore, this study specifies firms with basic R&D functions as "1", firms with integrated basic R&D and product development functions as "2" and firms with basic R&D, product development, manufacturing and marketing functions all integrated as "3".

Second, this study investigated firms' business diversification. For the biotechnology industry, business areas can be divided into four types: 1) red-bio related to pharmaceutical, 2) green-bio related to food, 3) white-bio associated with the cosmetic, functional material or energy industry, and 4) platform & service related to specialized platform technology or services such as cell culture, refinement and analysis (Hermann and Patel, 2007; Science and Technology Policy Institute of the Republic of Korea, 2013). Therefore, this study used the number of business areas that bio-medical firm engaged in the four biotechnology sectors as proxy of the level of business diversification.

Third, this study examined R&D and manufacturing & marketing alliances. R&D alliances included R&D collaborations, technology transfers, and commissioned R&D; in addition, manufacturing & marketing alliances included commissioned manufacturing alliances and marketing alliances. However, strategic alliances in the Korean bio-medical industry are not as active as in developed countries as yet. Because of such data features, in the analysis based solely on 2011 data, strategic alliance characteristics are highly likely to be omitted. Thus, this study determines the level of R&D or manufacturing &

marketing alliance based on the number of strategic alliances from 2005, when data research was started, to 2011.

However, having different absolute value ranges, these variables should normalize. If these variables are used in clustering analysis without normalizing, the variable with the larger range influences more important role of classifying the objects. Therefore, this study used z-score transformation for normalizing criteria variables, which measures how far the object is from the average value using the unit of standard deviation. The Z of the z-score value is equivalent to Eq. (12).

$$Z = \frac{X - \overline{X}}{SD} \quad \cdots\cdots \text{Eq. (12)}$$

Here, $\overline{X}$ indicates the average value of X, and SD is the standard deviation of variable X.

After clustering analysis, this study confirms equality in variables among clusters, and contrast them between paired clusters. For these, this study uses Kruskal-Wallis equality test and Mann-Whitney test as its ad-hoc test, because the variables in this study did not follow the normal distribution. The Kruskal-Wallis equality test is non-parametric method for comparing equalities among groups. It is a multiple-sample generalization of the two sample Mann–Whitney rank sum test (Kruskal and Wallis 1952; Gibbons and Chakraborti, 2011). Samples of sizes n_j ($j = 1, \cdots, m$) are combined and ranked in ascending order of magnitude. Tied values are assigned the average ranks. Let R_j equivalent to Eq. (13) denote the sum of the ranks for j^{th} sample.

$$R_j = \sum_{i=1}^{n_j} R(X_{ji}) \quad \text{Eq. (13)}$$

The statistics of Kruskal-Wallis one-way analysis of variance test, H is defined in Eq. (14).

$$H = \frac{1}{S^2}\left\{\sum_{j=1}^{m}\frac{R_j^2}{n_j} - \frac{n(n+1)^2}{4}\right\} \quad \text{Eq. (14)}$$

Where $S^2 = \frac{1}{n-1}\left\{\sum_{allranks} R(X_{ji})^2 - \frac{n(n+1)^2}{4}\right\}$

The distribution of H is approximately χ^2 with $m-1$ degree of freedom.

In addition, the method of Mann-Whitney test can analyze difference between two groups by converting data into ordered scale (Gibbons and Chakraborti, 2011). There are two independent variables, X_1 and X_2. And null hypothesis that $X_1 \sim X_2$, Let n_1 denote the sample size of X_1 and n_2 the sample size of X_2. Mann-Whitney's U statistics in Eq. (15) is the number of pairs (X_{1i}, X_{2j}) such that $X_{1i} > X_{2j}$.

$$U = \sum_{i=1}^{n_1} R_{1i} - \frac{n_1(n_1+1)}{2} \quad \text{Eq. (15)}$$

The mean value m_U and standard deviation σ_U of U are equivalent to Eq.(16) and

Eq. (17).

$$m_U = \frac{n_1 + n_2}{2} \quad \text{Eq. (16)}$$

$$\sigma_U = \sqrt{\frac{n_1 \times n_2 \times (n_1 + n_2 + 1)}{12}} \quad \text{Eq. (17)}$$

Using a normal approximation, it is calculated like Eq.(18)

$$Z = \frac{U - m_U}{\sigma_U} \quad \text{Eq. (18)}$$

Then, if p-value is bigger than significant level, null hypothesis that there is no difference between two groups is adopted.

4.4 Results and Discussions

4.4.1 Grouping of Korean Bio-medical Firms

Figure 8 describes a dendrogram, which is a diagram for allocating objects subject to classification by hierarchical clustering. This dendrogram is a description from the 20th group in the hierarchy stage. The horizontal axis indicates groups and vertical axis represents dissimilarity between clusters. As shown in Figure 8, bio-medical firms in Korea can be classified into multiple numbers of clusters through statistical analysis. In Figure 8, although bio-medical firms in Korea generally can be classified into two clusters, on the basis of three clusters, those firms' clustering result appears to suggest more business model implications. In fact, there is no definitive answer regarding the optimal number of clustering because hierarchical clustering analysis is an exploratory approach (Dubes and Jain, 1980; Bigliardi et al., 2005).

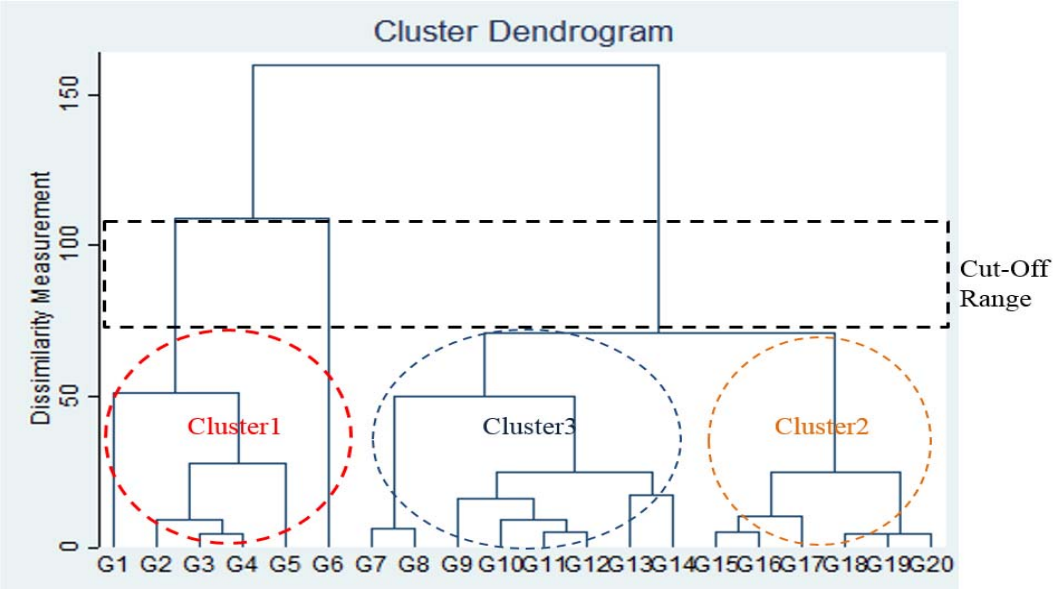


Figure 8. Dendrogram from hierarchical cluster analysis

Table 8 describes the number of bio-medical firms by cluster. Clusters 1, 2 and 3 include 82 (26.89 %), 118 (38.69 %) and 105 (34.42 %) firms, respectively. Cluster 2's size is the largest, followed by cluster 3, then cluster 1. The descriptive statistics of the criteria for firms' business model types belonging to the three groups is as shown in Table 8. First, regarding the level of vertical integration, cluster 2, cluster 1 and cluster 3 indicated 2.076, 1 and 1of average value, respectively. Second, for business diversification, cluster 1, cluster 2 and cluster 3 showed 2.183, 1.534, and 1 of average value, respectively. Third, for the level of R&D alliances, the average value of cluster 2 was 1.500 and that of cluster 1 and 3 were 0.476 and 0.048, respectively. Fourth, for the level of manufacturing & marketing alliances, the average value of cluster 2 was 0.551 and that of cluster 1 and 3 were 0.220 and 0, respectively.

In addition, this study performed the Kruskal-Wallis equality test for confirming differences in grouping variables among clusters. Its results represent significant differences in grouping variables among clusters in Table 8. They rejected the null hypothesis that median values of all groups are equal at the significance of 99 %. Thus, this study confirmed that there are differences according to each cluster in all criteria. Then, this study performed the Mann-Whitney test for contrasting in grouping variables between paired clusters as post hoc analysis of Kruskal-Wallis equality test. Table 8 shows that there are differences on criteria among all clusters except case of manufacturing & marketing alliance between cluster 1 and cluster 3.

Table 8. Descriptive statistics of grouping variables, and the results of Kruskal-Wallis and Mann-Whitney test

Statistic / Criteria	Descriptive statistic				Significant differences	Mean differences between paired clusters		
	1 (N=82)	2 (N=118)	3 (N=105)	Total	Chi-square	2 vs 1	3 vs 1	2 vs 3
The level of vertical integration	1 (0)	2.076 (-0.324)	1 (0)	1.416 (-0.562)	209.062***	1.076***	0***	1.076***
The level of business diversification	2.183 (-0.756)	1.534 (-0.724)	1 (0)	1.525 (-0.752)	92.677***	-0.649***	-1.183***	0.534***
The level of R&D alliance	0.476 (-1.080)	1.500 (-3.891)	0.048 (-0.214)	0.725 (-0.360)	11.527***	1.024**	-0.428**	1.452***
The level of manufacturing& marketing alliance	0.220 (-0.522)	0.551 (-1.430)	0 (0)	0.272 (-0.283)	9.840***	0.331**	-0.220	0.551***

*** p < 0.01, ** p < 0.05, * p < 0.1

Note. The values in parentheses is standard deviation.

Moreover, in Table 9 and Table 10, this study drilled down firm distribution according to combinations of business diversification and average number of strategic alliances according to its types as shown. Table 9 shows that there are various combinations in cluster 1, while focusing on only red area (bio-medicine and diagnostics kits & reagents area) in cluster 2, and concentrating on red or platform & service area respectively in cluster 3. Table 10 represents that there are more active both outbound and inbound strategic alliances in cluster 2 than other clusters.

Table 9. Percent distribution of combinations of business diversification in each cluster

Cluster	Combinations of business diversification												Sum
	Red (Only)	P&S (Only)	Red+ Green	Red+ White	Red+ P&S	P&S+ Green	P&S+ White	Red+ Green+ White	Red+ Green+ P&S	Red+ White+ P&S	P&S+ Green+ White	Red+ Green+ White+ P&S	
1	9.8	9.8	8.5	12.2	8.5	6.1	8.5	9.8	9.8	11	4.8	1.2	100
2	59.3	7.6	9.3	1.7	8.5	0	1.7	2.5	5.2	2.5	1.7	0	100
3	41	59	0	0	0	0	0	0	0	0	0	0	100
Total	37.7	23.3	5.9	6.2	5.6	1.6	2.6	5.9	3	3.2	2	3	100

Note. P&S is abbreviation of Platform & Service.

Table 10. Average number of strategic alliance in each cluster

Cluster	Outbound strategic alliance						Inbound strategic alliance					
	R&D alliances			Manufacturing & marketing alliances		Sum of outbound alliance	R&D alliances			Manufacturing & marketing alliances		Sum of inbound alliance
	R&D collaboration-out	Tech. transfer-out	Research commissioned-out	Manufacturing alliance-out	Marketing alliance-out		R&D collaboration-in	Tech. transfer-in	Research commissioned-in	Manufacturing alliance-in	Marketing alliance-in	
1	0.268 (51%)	0.061 (12%)	0.012 (2%)	0.012 (2%)	0.171 (33%)	0.524 (100%)	0.061 (36%)	0.061 (36%)	0.012 (7%)	0 (0%)	0.037 (22%)	0.171 (100%)
2	0.517 (39%)	0.297 (23%)	0.093 (7%)	0.034 (3%)	0.373 (28%)	1.314 (100%)	0.415 (56%)	0.169 (23%)	0.008 (1%)	0.025 (3%)	0.119 (16%)	0.736 (100%)
3	0.019 (50%)	0 (0%)	0.019 (50%)	0 (0%)	0 (0%)	0.038 (100%)	0 (0%)	0.010 (100%)	0 (0%)	0 (0%)	0 (0%)	0.01 (100%)
Total	0.279 (42%)	0.131 (20%)	0.046 (7%)	0.016 (2%)	0.190 (29%)	0.662 (100%)	0.177 (53%)	0.085 (25%)	0.007 (2%)	0.010 (3%)	0.056 (17%)	0.335 (100%)

Note. Out and In mean Outbound and Inbound strategic alliance.

First, in Table 8, cluster 1 has a relatively high level of diversification, low level of vertical integration and a middle level of R&D and manufacturing & marketing alliance compared with other clusters. This represents that cluster 1 has firms that maintain mainly basic R&D stage, and the cluster indicates a level of business diversification with an average of two or more business areas. In addition, cluster 1 had a tendency to moderately ally with other organizations for R&D and manufacturing & marketing activities. Therefore, cluster 1 can be defined as diversified firms utilizing a business diversification strategy with some strategic alliances. Table 9 shows that firms in cluster 1 are diversified through various combinations of business area combinations. Except for the combinations of platform & service with green, platform & service with green and white, red and platform & service with green and white, there is an even distribution of 8.5 % ~ 12.2 %. Moreover, Table 10 shows that firms in cluster 1 mainly play a role as a technology provider through outbound R&D collaboration. Although outbound technology transfer, inbound R&D collaboration, and inbound technology transfer exist, the strategic alliance portion is relatively trivial. Additionally, there are outbound marketing alliances, which can be interpreted as comprehensive agreements with R&D alliances such as outbound R&D collaboration. In sum, this study named cluster 1 "*Business Diversified Firms with Weak Strategic Alliance*".

Second, in Table 8, cluster 2 shows a higher level of vertical integration, R&D, and manufacturing & marketing alliances than other clusters, and a middle level of business diversification that is greater than cluster 3, but smaller than cluster 1. This implies that, although cluster 2 may have a few firms in the basic R&D stage, cluster 2 mainly includes firms with product development, manufacturing and marketing functions.

According to Table 9, firms in cluster 2 have high portion of business area related only drug development including on unique red area, which is not high business diversification. This means that firms in cluster 2 have a propensity to concenter on drug development, which is a red area. Moreover, firms that belonged to cluster 2 tend to actively utilize business strategy to improve internal capability or performance through R&D or manufacturing & marketing alliances with external organizations. As indicated by Table 10, firms in cluster 2 have characteristics to enthusiastically conduct both outbound and inbound R&D alliances through R&D collaborations and technology transfer. In addition, cluster 2 also highly forms outbound and inbound marketing alliances, although there are a few manufacturing alliances. Consequently, this study named cluster 2 "*Vertical Integrated Firms with Strong Strategic Alliance*".

Third, in Table 8, cluster 3 features a lower level of vertical integration, business diversification, R&D alliance, manufacturing & marketing alliance, compared to the other clusters. Firms in cluster 3 do not use a vertical integration strategy, business diversification strategy and strategic alliance strategy. This means firms belonging to cluster 3 are to work business with only basic R&D in a single business area. In addition, table 9 shows that firms in cluster 3 can be divided into red (41 %) and platform & service (59 %) areas. This indicates that firms in the basic R&D stage without a business diversification strategy are predominantly mainly divided in red and platform & service segment. Moreover, table 10 shows that the firms of cluster 3 rarely ally other organizations, although there are trivial R&D alliances. In this ends, this study named cluster 3 as "*Non-diversified R&D Firms*".

4.4.2 The Characteristics and Performances of Each Cluster

In this chapter, this study intends to find the characteristics and performances of each cluster. First, this study considers characteristic variables as firm's size, age, origin, business segment, the status of government R&D funding, R&D intensity, the spending time from founding to generating financial performance. Variables of size which can be defined the number of employees, age which can be defined the number of years from founding used. In addition, for firm's origin, this study scrutinized the distributions of 1) independent venture by entrepreneurs from research organization, 2) independent venture by entrepreneurs with career from other firm, and 3) corporate venture. Moreover, this study investigated duplicative summation of red and platform & service segment for finding business property of each cluster. For examining the status of government R&D funding, it also investigates total government R&D fund, the total number of government R&D projects. R&D intensity measured the value to divide R&D expenditure by the number of employees. Furthermore, this study checked up the spending time from founding to generating financial performance depending on each cluster. The number of years from founding to generating of first revenue, the number of years from founding to generating of first positive net profit used as proxies for it. Second, this study identified differences of technological innovation and financial performance among each cluster. The number of patents considered to represent technological innovation performance of each cluster (Kleinknecht et al., 2002), and revenues, operating profit, net profit used for measuring of financial performance (Qian and Li, 2003). The descriptive statistics (mean and standard deviation) of characteristics and performance variables in each cluster are described in Table 11.

The results of Kruskal-Wallis equality test in Table 11, also show that there are differences between at least one cluster and the rest two clusters in all variables except net profit. Further, the results of Mann-Whitney test between paired clusters in Table 11 represent differences among all characteristic and performance variables except net profit. (“Net profit” was not significant in the Kruskal-Wallis equality test, then excluded in discussion.)

Table 11. Descriptive statistics of characteristic and performance variables, and the results of Kruskal-Wallis and Mann-Whitney test

Statistic / Criteria	Descriptive statistic				Significant differences	Mean differences between paired clusters		
	1 (N=82)	2 (N=118)	3 (N=105)	Total	Chi-square	2 vs 1	3 vs 1	2 vs 3
Size	20.976 (-20.190)	31.797 (-16.167)	16.476 (-22.332)	23.613 (-20.867)	43.241***	10.821***	-4.500	15.320***
Age	9.768 (-3.979)	12.551 (-4.727)	7.924 (-7.646)	10.210 (-6.192)	39.620***	2.783***	-1.844	4.627***
Independent venture by entrepreneurs from research organization	0.073 (-0.262)	0.295 (-0.502)	0.474 (-0.501)	0.374 (-0.485)	30.374***	0.401***	0.422***	-0.121***
Independent venture by entrepreneurs with career from other firm	0.927 (-0.262)	0.257 (-0.439)	0.483 (-0.502)	0.525 (-0.500)	62.738***	-0.444***	-0.670***	-0.226***
Corporate venture	0 (0)	0.248 (-0.434)	0 (0)	0.085 (-0.280)	12.624***	0.248***	0	0.248***
Red segment	0.708 (-0.501)	0.890 (-0.499)	0.410 (-0.377)	0.675 (-0.475)	16.970***	0.181	-0.270***	0.288***
Platform & service segment	0.597 (-0.482)	0.272 (-0.462)	0.590 (-0.500)	0.436 (-0.498)	11.459***	-0.219***	0.019	-0.238***
Total government R&D funding	180,651 (-306.375)	434,049 (-242.996)	141,855 (-644.810)	265,331 (-472.737)	13.479***	253,398***	-38,796	292,194***
Number of government R&D projects	0.866 (-1.028)	1.246 (-1.058)	0.771 (-1.339)	0.980 (-1.184)	7.046**	0.380**	-0.095	0.475***
R&D intensity	67.891 (-91.503)	153.482 (-120.816)	76.338 (-476.090)	103.913 (-309.880)	4.283**	85.591**	8.447	77.144**
Patent	0.317 (-1.041)	0.814 (-0.899)	0.352 (-1.768)	0.521 (-1.350)	7.252**	0.497**	0.035	0.461**
Years to first revenue	1.101 (-1.614)	2.234 (-1.839)	1.135 (-1.686)	1.543 (-1.798)	51.195***	1.133***	0.034	1.098***
Years to first positive net profit	3.173 (-3.147)	3.600 (-2.774)	2.464 (-2.582)	3.148 (-2.846)	12.044***	0.427**	-0.709	1.136**
Revenue	7,096,661 (-21,100,000)	19,900,000 (-6,388,841)	2,884,126 (-27,600,000)	10,600,000 (-22,000,000)	81.411***	12,803,339***	-4,212,535**	17,015,874***
Operating profit	437,853 (-1,862,492)	1,131,939 (-903,633)	4,553 (-4,940,631)	557,216 (-3,291,769)	22.188***	694,086**	-433,300	1,127,386**
Net profit	332,629 (-1,491,234)	420,086 (-959,050)	3,494 (-4,978,336)	253,156 (-3,237,243)	9.087	87,457	-329,135	416,592

*** p < 0.01, ** p < 0.05, * p < 0.1

Note. The values in parentheses is standard deviation.

Note. The unit of “Total government R&D fund”, “Revenue”, “Operating profit”, “Net profit”: thousand KRW (1 U.S. dollar = 1,100.20 KRW as of March 4, 2015)

According to Table 11, *"Business Diversified Firms with a Weak Strategic Alliance"* in cluster 1 were the smaller and younger than firms of cluster 2. They have the highest distribution of founding by entrepreneurs with career from other firm, while they have the lowest distribution of founding by entrepreneurs from research organization among three clusters. Moreover, they distribute higher in red segment than cluster 3, and higher in platform & service segment than cluster 2 by duplicative summation of business scope among red, green, white, and platform & service. They also performed the smaller number of government R&D projects and received government R&D funding than firms of cluster 2. Furthermore, though they received government R&D support, they recorded relatively lower R&D intensity and technological innovation performance as a proxy for patents than cluster 2, whereas financial performance through revenue achieved a middle level, which indicates a much larger cluster 3 and a much smaller cluster 2. This implies that firms in cluster 1 remain poor in R&D input, creating technological innovation, though there are a few R&D alliances in Table 10; however, these firms realize financial performance through business diversification strategy. In particular, they spent the shorter time from firm founding to first revenue and positive net profit than cluster 2, as average of 1.101 and 3.173 years. This implies that business diversification in Korean bio-medical industry help to rapidly realize their revenue.

Business diversification of the bio-medical firms in Korea progresses in two directions: from therapeutic products (red segment) to other products, and vice versa. First, Korean bio-medical firms with difficulties in financing face huge drug development costs, and they strategically pursue related or unrelated business diversification as one solution for the diversification of their profit structure. For example, firm H, which had

competitiveness in new bio-medicines such as those for septicemia, stroke, and premature ejaculation, founded a division for functional cosmetics through business diversification. Firm H expanded its future business portfolio by entering the market of functional cosmetics using hyaluronic acid, which was to be produced using their technology of fermenting microorganisms. Similarly, firm O, which specialized in developing new medicines related to bones, decided to advance into the business of functional food. This division of firm O developed differentiated functional foods based on red ginseng and ginseng by using raw material that could prevent osteoporosis and effective natural ingredients for reducing inflammation and restoring cartilage. Thus, firm O created a new profit source from the functional food segment. These examples show that the bio-medical firms that developed therapeutic products in the red segment considered Plan B for their profit generation and survival through business diversification, which essentially shows that they should have a profit model from founding because of the lack of risk money such as venture capital in Korea.

Second, pharmaceutical companies and biotechnology firms with core technologies related to functional food and cosmetics try to enter the therapeutic product segment (red segment) in Korea through business diversification. Firm E, which manufactures active pharmaceutical ingredients (API), diversified its business into gene therapy products in the bio-medical segment, simultaneously producing contrast medium for the MRI and CMO segments. Facing a policy for continuous pharmaceutical price cuts, Korean pharmaceutical companies started looking for other opportunities, and they have been involved in diverse areas such as functional food, cosmetics, medical devices, and the biotechnology industry. Thus, the bio-medical segment is one of the areas that present

opportunities for Korean pharmaceutical companies.

In addition, firm C that has excellent probiotics technologies for functional food, attempted to secure growth momentum through business diversification while simultaneously increasing its market shares in the current probiotics market. Firm C conducts R&D for developing medicines for colorectal cancer, diabetes, and atopic dermatitis. Firm M focused bio-cosmetic products based on botulinum toxin that had been used for beauty from its founding; moreover, it launched a new product pipeline for protein therapeutic products with the aim of profit diversification. These cases demonstrate that biotechnology firms with core technologies related to functional food and cosmetics try to enter the bio-medical segment for finding a new growth engine.

"Vertical Integrated Firms with Strong Strategic Alliance" in cluster 2 were largest and oldest firms among three clusters in Table 11. They have higher distribution of founding by entrepreneurs from research organization than cluster 1, and the lowest distribution of founding by entrepreneurs with career from other firm, while they specially have type of firm's origin on spin-off from parent company. Moreover, they distribute higher in red segment than cluster 3, and the lowest in platform & service segment among three clusters by duplicative summation of business scope. The number of average government R&D projects or the size of government R&D funding were also much largest than any other clusters. It also recorded relatively higher R&D intensity and better patent performance than firms of other clusters. In addition, firms in cluster 2 boast absolutely excellent revenues and operating profits, though they spent the longest time from firm founding to first revenue, average 2.234 years; to first positive net profit among three clusters, average 3.6 years. This means that firms with stable R&D investment,

excellent technological innovation or financial performance exist in Korea. Furthermore, those firms effectively utilized strategic alliances for R&D and manufacturing & marketing activities, which also seems to positively influence their technological innovation and financial performance through enhanced productivity by them.

In fact, among the bio-medical firms in Korea, some therapeutic product firms have demonstrated business performance excellence as vertically integrated firms with various types of strategic alliances, although these are not large-scale models of global pharmaceutical companies. One example is firm P, which has excellent stem cell therapy technologies and products and a drug delivery system (DDS) that involves the formulation method or process for administering a medicinal compound to achieve the intended therapeutic effect in humans or animals. This bio-medical firm enabled efficient and effective treatment through the combination of stem cell and DDS technologies. Firm P created synergy by integrating the value chain of the stem cell and formulation technologies. Further, firm P continuously tried to form strategic alliances with domestic and foreign pharmaceutical companies for clinical trials and marketing. Firm P exclusively separates the clinical trial and marketing segment, although it is vertically integrated from basic R&D to manufacturing.

In addition, there are cases of fully integrated bio-medical firms that took over small and medium-sized pharmaceutical companies in Korea, while pharmaceutical companies generally took over bio-medical firms. For example, firm C took over the CRO firm S, which specialized in designing clinical trials. Firm C also took over pharmaceutical firm H, which had grown based on the active pharmaceutical ingredient (API) business and had broad foreign distribution channels. Through the vertical integration of firm C, it

could create synergistic effects in the process of new drug development and secured a favorable position in the overseas market. Similarly, firm G, which had specialized technologies and products related to antibody drugs, merged pharmaceutical firm S and firm C. Firm G made antibody drugs that were rapidly diffused through the distribution channel and marketing capabilities of pharmaceutical firm S and firm C. These cases imply that vertically integrated firms with strong strategic alliances in Korea gradually pursue synergy and process efficiency, particularly in marketing, through vertical integration strategy in the value chain.

"*Non-diversified R&D Firms"* of cluster 3 in Table 11 were the smaller and younger than firms of cluster 2. They have higher distribution of founding by entrepreneurs from research organization than cluster 1, and the middle level of distribution of founding by entrepreneurs with career from other firm among three clusters. In addition, they distribute the lowest in red segment among three clusters, and higher in platform & service segment than cluster 2 by duplicative sum of business scope. They also performed the smaller number of government R&D projects and received government R&D funding than firms of cluster 2. R&D intensity and technological innovation through patents were the smaller than cluster 2. Moreover, these firms have the lowest financial performance as proxies for revenues among three clusters. These imply that they have difficulty realizing financial performance as yet, though they had business model that spent shorter time from firm founding to first revenue and first positive net profit than firms of cluster 2 as average of 1.135 and 2.464 years. This implies that there are infant firms in Korean bio-medical industry.

The firms in Cluster 3 represent the business model of bio-medical firms that

performed only basic R&D in a single business segment in the red segment or the platform & service segment without active strategic alliances. Their businesses are currently immature. Further, they are not successful in generating financial performance compared to the firms in cluster 1, although they are similar in terms of average R&D intensity and total number of patents. This implies that they need to secure profits for their spontaneity. However, it is not easy to overcome the initial difficulties associated with founding a firm in the bio-medical industry because of the longer R&D period and the higher R&D expenditure compared to other industries and the deficiency of private investment in Korea (Whitley, 1992). Therefore, internal growth strategies and government support are required for the growth of the firms in Cluster 3.

4.5 Sub-Conclusion

The science-based, technology-intensive characteristics and high business risk in clinical trials, approval, manufacturing and marketing in the bio-medical industry require a variety of strategies for bio-medical firms. In particular, the business model of entrepreneurial firms as bundle of strategies is critical because strategic choice dominates the performance and the survival to identify opportunities. Paradoxically, this property implies that the business model reflects firms' competitive advantage by strategically choices to orchestrate their resources and capabilities, considering their contextual business circumstances. Thus, this study's objective was to identify the business models of bio-medical firms of Korea and to suggest implications for industry development.

Previous studies on bio-medical industry business models have been classified by the level of vertical integration and business diversification. In addition, recently the federated model emphasized formation of a value network such as strategic alliances to prevent a reduction in productivity and profitability and to sustain growth of firm. Thus, this study quantitatively classified bio-medical firms in Korea using a clustering analysis method that utilized the following criteria: the level of vertical integration, business diversification, R&D and manufacturing & marketing alliances.

Consequently, bio-medical firms in Korea are classified into the following three clusters: 1) business diversified Firms with weak strategic alliance, 2) vertical integrated firms with strong strategic alliance, and 3) non-diversified R&D firms. First, business diversified firms with weak strategic alliance in cluster 1 have relatively better financial performance than cluster 3 through the use of a business diversification strategy; however, these firms still lacked investment in R&D and technological innovation than cluster 2,

despite their R&D alliance efforts. Second, vertical integrated firms with strong strategic alliance in cluster 2 notably indicated a higher level of financial performance as well as R&D intensity and technological innovation than any other clusters, leveraging vertical integration and alliance strategies. Third, non-diversified R&D firms in cluster 3 featured a lower financial performance than any other clusters, though R&D intensity and technological innovation performance as proxy of patent were similar to cluster 1.

Based on these results, this study suggests three implications. First, vertical integrated firms with strong strategic alliance are the type of successful business group of Korean bio-medical industry. Nonetheless, this study suggests that they should consider cost and benefit between level of vertical integration and strategic alliance for their growth in the future. Defining the firm's scope on the industry's value chain, maintaining a core competitive advantage are significant tasks in a corporate-level strategy (Hamel and Prahalad, 1990). If a firm's internal capability for various functions in a value chain is insufficient, its performance can be aggravated, then a firm's productivity and profitability may deteriorate because of the dispersion of its core capability (Gilley and Rasheed, 2000). This strategy enables both backward vertical integration to upstream activities such as basic R&D, raw material or intermediate goods and forward vertical integration to downstream activities such as product development, manufacturing and marketing (Harrigan, 1985; Lafontaine and Slade, 2007). Firms should decide which activities it will conduct internally or externally (Pisano, 1991). That is, Korean bio-medical firm needs to consider that different institutional arrangements; market vs. firm, accompany different costs. If vertical integration in a value chain increases the benefit rather than the cost, they may use a vertical integration strategy. However, in contrast case,

they should reduce their costs by effectively through strategic alliances for R&D and manufacturing & marketing. Therefore, for sustainable growth of these firms, they need to understand their core internal capability and exert efforts to determine the vertical integration level of the value chain or the corresponding strategic alliance scope.

Second, business diversification strategy relatively be fast route to make a revenue for Korean bio-medical firms that should consider profit model from founding, and it may be opportunity for incumbents like pharmaceutical and biotechnology firms with core technologies related to functional food and cosmetic. The result of this study showed that Korean bio-medical firms diversified into other business segment like food and cosmetic for securing profit structure because they spent long time and huge cost for R&D and commercialization. On the other hand, pharmaceutical companies and biotechnology firms with core technologies related to functional food and cosmetic try to enter promising bio-medical segment for profit diversification. It implies that they are object to expand their profit stream through business diversification strategy, regardless of different business diversification paths. However, they also should consider their resources and capabilities, and the costs caused by business diversification such as coordination costs or influence costs as well as the profit structure changed by business diversification (Milgrom and Robert, 1990).[4] Though business diversification strategy has the potential advantage of economy of scope and risk diversification (Palich et al., 2000; Villalonga, 2004), profit from the source that increases value (or benefit) must exceed cost (Milgrom

[4] A diversification strategy accompanies two types of additional costs: coordination costs and influence costs. Coordination cost is the cost of coordination to minimize conflicts and to maximize value (synergy) between each business according to the number of interrelated businesses, business size and business type. Influence cost is the cost incurred by inefficiency because entrepreneurs or entrepreneurial team influences capital and resource allocation and selects the second best plan through political maneuvers.

and Robert, 1990). Therefore, they should consider various aspects of their resources and capabilities and the costs-benefits derived from business diversification.

Third, there are immature infant firms in the Korean bio-medical industry currently. This study suggests that they should make efforts to consider opportunities for commercialization to achieve initial growth in the bio-medical industry, although they are currently infant firms (Kasch and Dowling, 2008). By securing profit by commercializing their technologies and providing services for basic R&D at the initial stage, they can evolve to diversified firms or partially and fully integrated firms. In particular, the distribution of bio-medical firms, including those in the platform & service segment, is a little high relatively compared to the distribution that includes the firms in the therapeutic product segment. The platform & service segment has advantages that can rapidly secure profit compared to the case of the therapeutic segment because of lower R&D risk and expenditure (Pisano, 2006; Chiaroni et al., 2009) and direct relations to revenues through the execution of various projects in specialized areas of value chain (Willemstein et al., 2007). This implies that they may find it easier to secure initial profit generation, which indicates the possibility for the growth of Korean bio-medical firms in cluster 3.

Finally, this study has a limitation regarding the clustering method. Although this study identified the business model for bio-medical firms in Korea through the quantitative clustering method, a variety of methodological efforts are required. This study was analyzed using hierarchical clustering based on Ward's method as one of the methods recommended by Bigliardi et al. (2005). However, there are various distance measurement criteria and calculation methods in hierarchical clustering. Therefore, to enhance validity, it is necessary to compare a variety of methods in the future.

Chapter 5. The Factors of Korean Bio-medical Firms for Survival[5]

5.1 Introduction

The development process of biotechnology is technology-intensive (Coriat et al., 2003), and the distribution of small-sized entrepreneurial bio-medical firms face higher than other industries (OECD, 2014). Thus, bio-medical firms face many challenges ranging from basic R&D to commercialization, i.e., moving a technology or product to market (Pisano, 2006). In particular, compared with pioneers in the bio-medical industry such as the US, UK, and Germany, Korea as one of latecomers to the bio-medical industry, where the industrial ecosystem has not yet developed, face more difficult problems and thus need strategies to help ensure their survival at the firm or national level (Thorsteinsdóttir et al., 2006; Casper, 2009; Zhang et al., 2011).

A firm's survival has been considered to be based on its performance of business activities (Hopenhayn, 1992), which is critical for economic growth (Schmitz, 1989; Audretsch, 1991). Particularly, given the high level of business risk in latecomers of bio-medical industry, it may serve as a sufficient condition to outperform the global competition and maintain and increase national economic growth (Klepper, 2002; Pisano, 2006). Few studies, however, examine the survival factors for firms in bio-medical industry. Additionally, studies on bio-medical industry mainly focused advanced countries like US, UK, and Germany. Further, national differences in sectoral- and national-

[5] The study is currently under revision and resubmit process in Asian Business & Management (9 June 2015).The title of the submitted paper is "The Factors of Biotechnology Firms for Survival: A Study of Korean Biotechnology Firms".

innovation system may result in different survival rates compared with pioneers (Malerba, 2002). Therefore, studies on considering on context of Korean is necessary.

Previous studies have shown firm size, age (Mata and Portugal, 1994; Das and Srinivasan, 1997), business diversification (Cottrell and Nault, 2004), technology innovativeness such as R&D intensity, patents and new products (Cefis and Marsili, 2005; 2006), and industrial growth potential measured as the entry and exit rate (Honjo, 2000) as important factors for firm survival. In addition, scholars on bio-medical industry have emphasized that they must recognize constraints on resources and capabilities and should connect with external organizations to help prevent firm failure (Zahra, 1996; Baum et al., 2000; Baum and Silverman, 2004). However, there are few studies on firm survival with these integrated view in bio-medical industry. Therefore, this study suggests an integrated perspective that examines both internal factors (the microscopic perspective) and external factors (the mesoscopic perspective) affecting firms' survival in the bio-medical industry.

Important internal factors for the survival of bio-medical firms include the firm's origin (independent firms or corporate ventures) (Cooper, 1985; Zahra, 1996; Zahra and George, 1999) and the business sub-sector, i.e., the therapeutic product area and platform & service area (Prevezer, 2001; Casper and Kettler, 2001 and Willemstein et al., 2007) at the time of the firm's founding. Bio-medical firms should also make an effort to recognize their environmental conditions to prevent business risks from industrial transitions (Teece, 1996), identify business opportunities (Powell et al., 1999; Alvarez and Barney, 2001) and obtain complementary resources and capabilities to gain a competitive advantage (Baum et al., 2000; George et al., 2002; Qian and Li, 2003; Baum and

Silverman, 2004). In terms of external factors, bio-medical firms should engage in strategic cooperation with the government and other stakeholders such as universities, hospitals, government-funded research institutes, and other bio-medical or pharmaceutical firms in the bio-medical industry.

The rest of this paper is structured into four sections. Chapter 5.2 provides the theoretical background and hypotheses, by discussing the perspective of this study and the internal and external factors affecting the survival of bio-medical firms, from which hypotheses can be deduced. Chapter 5.3 presents the data, analysis model, and variables, while chapter 5.4 presents the analysis results and discussion. Chapter 5.5 finds the implications of the study based on the results.

5.2 Theories and Hypotheses

This study search for internal factors inherited from founding; 1) *origins from other firm*, 2) *business property in platform & service segment*, and external factors as firm's proactive behaviors for complementary assets and against their business risk; 1) *government R&D funding*, 2) *strategic alliance*. This study contributes to finding survival factors and discussing their implications from an integrated perspective, considering internal and external factors in firm survival in the context of Korea. On the other hand, these integrated perspective can also allow to investigate survival factors of focal firm which connect other organizations in Figure 9 (Baum et al., 2000; Baum and Silverman, 2004).

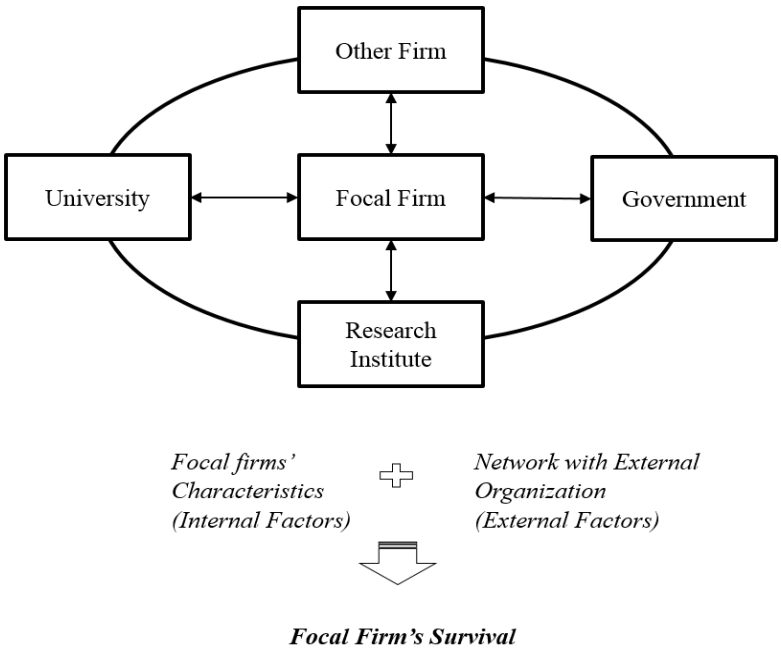


Figure 9. The integrated view for finding survival factors

This study describes why these factors should be figured significantly in bio-medical firms' survival based on the resource-based view and strategic choice theory. It assume that survival factors may have different benefits or costs as resources and capabilities and that each firm can proactively select survival factors that suite their contexts. First, the resource-based view argues that the difference in the resources and capabilities of firms determines their survival and growth (Barney, 1991). It is based on the assumption that a firm is a unique aggregate of tangible and intangible resources and capabilities. From the benefits stemming from specific resources and capabilities, a firm achieves a short-term performance, and when this performance is internalized as organizational capacity that cannot be easily transacted, the firm can realize sustainable growth based on its long-term advantages (Wade and Hulland, 2004).

Second, strategic choice theory, emphasizes that firms can actively select against environmental change to grow and survive (Child, 1972; Kochan et al., 1984). This theory originated in resistance to population ecology theory, which explored the principle of industrial evolutionary thinking (Barney, 2001). In population ecology theory, the survival and exit of an organization is mostly affected by environmental factors, and each individual organization or organizational group fights to secure resources and capabilities (Hannan and Freeman, 1977). Hannan and Freeman (1986) explained the survival and exit of an organization on the basis of environmental selection: there is a one-to-one relationship between the organizational form that represents the technology, structure, and goal of an organization, and the environmental niche that describes its environmental goodness of fit. If an organization fails to find its appropriate environmental niches, it

will naturally die out. In its most extreme perspective, population ecology theory suggested that firms could not change, that strategic choice was not possible, and that populations of firms was the only legitimate outcome of industrial evolution (Hrebiniak and Joyce, 1985).

Population ecology theory, however, leans too heavily on environmentalism and thus underestimates the possibility of proactive responses and strategic choices by firms (Astley and Van de Ven, 1983). Strategic choice theory emphasizes that the firms' strategies should recognize the exercise of choices by decision makers (Peng and Heath, 1996; Pfeffer and Salancik, 2003). Therefore, strategic choice theory can represent firms' proactivity in their own contexts and circumstances (Child, 1997; Sharma, 2000). In this ends, it contributes that firm boundaries may also be decided by the selections of decision makers in relation to external organizations as industrial environments (Peng and Heath, 1996).

5.2.1 Origins from Other Firm

Scholars in the bio-medical industry such as Zahra (1996) and Zucker and Darby (1997) have highlighted the competitive advantages that entrepreneurs from research organizations, such as universities, hospitals, and government-funded research institutes, can have gain in terms of knowledge. This is because biotechnology R&D is based on basic science, which can be learned through the performance of tacit knowledge. Slaughter and Rhoades (2004) called this idea "academic capitalism". In addition, entrepreneurs' knowledge is a cornerstone for identifying business opportunities. Thus, the initial resources and capabilities inherited by entrepreneurs from a research

organization may play a key role in the survival of bio-medical firms (Aspelund et al., 2005). Although entrepreneurs from research organizations have business opportunities that can commercialize their knowledge base, however, their different entrepreneurial propensities and managerial capabilities have led to inconsistent results for financial performance and survival (Clarysse and Moray, 2004; Vallas and Kleinman, 2008).

On the other hand, some studies have shown consistent results regarding the advantages for the survival of entrepreneurial firms that either have entrepreneurs with experience in other companies or are spin-offs from parent companies (Baden-Fuller, 1989; Deeds and Hill, 1999; Sorenson and Audia, 2000; Shane and Cable, 2002; Wennberg et al., 2011). First, entrepreneurs that have experience working in other companies generally establish independent ventures in the management unit, which provides them with superior management capabilities. Therefore, these firms can more actively respond to the risks posed by industrial characteristics and economic circumstances, as well as management risks (Baden-Fuller, 1989). Deeds and Hill (1999) emphasized that entrepreneurs with background knowledge or experience in the bio-medical industry could better manage relationships with employee and improve performance. Sorenson and Audia (2000) and Shane and Cable (2002) claimed that prior experience in other firm generally guaranteed outstanding contract skills and a reputation for external funding. Hsu et al. (2009) also demonstrated that prior experience facilitate venture capital investment. Wennberg et al. (2011) argued that, for firms' financial performance and survival, the commercial knowledge acquired from work experience in other companies is more important than the academic knowledge obtained through research experience at universities. This implies that managerial knowledge and

capabilities acquired through prior firm experience are important for the survival of bio-medical firms. Therefore, this study verifies the following hypothesis:

H1-1. Bio-medical firms that were established by entrepreneurs with work experience in other companies have lower hazard rates for their survival.

Second, corporate ventures spun off from parent companies have a longer survival period than independent ventures (Buenstorf, 2007). Buenstorf (2007) argued that the survival rate of corporate ventures may be better than that of other venture types. Zahra (1996) and Zahra and George (1999) showed the advantages of corporate ventures regarding resources and capabilities for R&D and product manufacturing in the bio-medical industry. In these cases, the resources and capabilities that corporate ventures can acquire from their parent companies, such as funding, human resources, technologies, manufacturing and marketing capabilities, and reputation, may play an important role in their survival. Arregle et al. (2013) also highlighted the positive effect of resource support from a parent company on new firms' growth and survival. In addition, Wilson et al. (2013) showed that family firms displayed superior performance to their counterparts because they experienced less agency problems due to the superior alignment behind the firm's common goal and more efficient business management. Lumpkin and Brigham (2011) and Breton and Miller (2011) also argued that corporate ventures can experience the multi-temporality of achieving their goals, with a long-term perspective that is consequently advantageous for their survival. All of this suggests that advantages in resources, capabilities, and managerial efficiency stemming from the parent company are

important for the survival of bio-medical firm. In sum, bio-medical firms that were either established by entrepreneurs with work experience in other companies or spun off from parent companies have a higher possibility of survival. Therefore, this study verifies the following hypothesis:

H1-2. Bio-medical firms spun-off from parent companies have lower hazard rates for their survival.

5.2.2 Business Property in Platform & Service Segment

In general, biotechnology has the characteristics of scientific uncertainty, complexity with multiple disciplines, and cumulativeness to learn from many failures (Pisano, 2006; Carayannopoulos and Auster, 2010). In addition, biotechnology products are required to meet strict regulations because they target human beings, which can be another obstacle to the firm survival (Hermans and Kauranen, 2005). These factors pose challenges in biotechnology R&D. Not all types of bio-medical firms, however, necessarily face the same R&D challenges. Willemstein et al. (2007) and Chiaroni et al. (2009) argued that bio-medical firms can be divided into two categories: 1) therapeutic product-oriented firms, which provide intermediate materials and finished products related to bio medicine, companion diagnostic kits & reagents; and 2) platform & services firms involving on platform technology like bio-informatics software, and bio-chip, and services related to cell culturing, synthesis and refinement, gene and cell analysis, the supply of experiment animals for preclinical, cell banking, for basic R&D stage, further including contract research organizations (CRO), contract manufacturing organizations (CMO). In particular,

firms in platform & service segment were born in standardization process of technology and process that require the most resources in terms of time and cost in bio-medical industry (Fisken and Rutherford, 2002). Bio-medical firms had exerted steady efforts for it, and firms with expertise in platform technologies for basic R&D and services needed in specific stages of value chain, began appearing in the bio-medical industry (Amir-Aslani and Negassi, 2006).

Compared to therapeutic product-oriented firms, platform & service bio-medical firms may have relatively higher advantages for their survival. This is because the technological and financial risk of platform & service firms is lower than that of therapeutic product-oriented firms (Casper, 2000). The reasons are as follows. First, compared to therapeutic product-oriented biotechnology, biotechnology in platform & service segment may have lower technological intensiveness due to its service characteristics. It may also require greater technological capabilities related to mechanical or electronic mechanisms, which involve less risk than the mechanisms of biotechnology (Pisano, 2006; Chiaroni et al., 2009). They also operate in a specialized area of the value chain (Burns, 2005). Thus, they can shift the burden on resources and capabilities from R&D to new products (Fisken and Rutherford, 2002). In addition, due to lower uncertainty in R&D and higher productivity in their specialized areas, platform & service firms may face less funding pressure, whereas therapeutic product-oriented firms require greater R&D investment (Prevezer, 2001). Second, the business model of platform & service firms is directly related to revenues because they execute various projects in specialized area of the value chain, whereas therapeutic product-oriented firms execute one or two projects with high business risk from basic R&D to the commercialization stage (Willemstein et al., 2007).

Together, this implies that platform & service firms are more likely to survive than therapeutic product-oriented firms. Therefore, this study verifies the following hypothesis:

H2. Bio-medical firms in platform & service segment have lower hazard rates for their survival.

5.2.3 Government R&D Funding

The bio-medical industry is considered to be one of the industries with high possibility of market failure due to difficulties in R&D and commercialization (Martin and Scott, 2000). Guellec and Van Pottelsberghe De La Potterie (2003) explained why government R&D funding in this industry are justified: imperfect appropriability and risks. Technology itself is in nature a public good because abundant basic science knowledge is required in biotechnology (Coriat et al., 2003), and it hinders the appropriability of technology (Pisano, 2006; Guthrie and Durand, 2008). With widespread knowledge, the profit that a company obtains through research and development becomes less than the social profit; hence, the appropriate level of R&D activities required in the society has not occurred in the industry, which means imperfect appropriability causes market failure (Arrow, 1962). In addition, biotechnology development has fundamental uncertainty and risks in the R&D process, which is increased by the long development period that includes clinical test and approval. For these reasons, investors' investment in the bio-medical industry has decreased, and it is detrimental to the growth of the bio-medical industry, which requires stable funding (Romijn and Albu, 2002). Therefore, government R&D funding in the bio-

medical industry are a critical institutional complementary measure that can mitigate the market failure caused by imperfect appropriability and risks (Pisano, 2006).

However, previous studies found that government R&D funding are not granted at random (Busom, 2000; Blanes and Busom, 2004; Shane, 2009). Busom (2000) argued that a firm's size is proportionate to its size of R&D or willingness (effort) for R&D. A firm's size is a decisive factor in receiving government R&D funding. In addition, David et al. (2000), Blanes and Busom (2004), and Heijs and Herrera (2004) highlighted that a firm's size could overcome its financial restrictions. Moreover, in accordance with the principle of "Picking the Winner", government R&D funding inevitably concentrate on firms with excellent R&D capability or performance. Shane (2009) found that the policy decision method frequently used by policymakers to select a "good firm" for R&D funding is selecting a firm with excellent technological innovation performance. Previous studies describe that the reasons for selecting a firm with excellent technological innovation performance are a reduction of the crowding effect (Shane, 2009), a decreased failure rate of government-sponsored R&D projects (Stigliz and Wallsten, 2000) and inducing external investment through excellent technological innovation performance (Takalo and Tanayama, 2010).

Generally, previous studies, government R&D funding generally had a positive effect on technological innovation performance (Branstetter and Sakakibara, 1998; Czarnitzki and Licht, 2006; Bérubé and Mohnen, 2009; Cantner and Kösters, 2012; Kang and Park, 2012). Branstetter and Sakakibara (1998) reported that firms participating in an R&D consortium in Japan had increased patent performance. Czarnitzki and Licht (2006) on German manufacturers described that a firm with government R&D funding had better

patent achievement than those without subsidies. The survey of Canadian manufacturers in Bérubé and Mohnen (2009) found that firms who are given both tax benefits and government R&D funding directly generated more technological innovation performance, such as new product development, compared to those who received tax benefits only. Cantner and Kösters (2012) analyzed the effect of government R&D funding in entrepreneurial firm in East Germany and confirmed that the number of patents increased more in firms to which government R&D funding was granted. In addition, Kang and Park (2012) on Korean biotechnology firms proved that government R&D subsidies have a positive impact on patent performance.

These results indicate that government R&D funding may underpin the survival of bio-medical firms to a certain extent, enhancing their technological innovation performance (Banbury and Mitchell, 1995; Christensen et al., 1998; Cefis and Marsili, 2006; Buddelmeyer et al., 2010). Banbury and Mitchell (1995) found that the number of new products positively affect firms' survival in the cardiac pacemaker industry. Christensen et al. (1998) also demonstrated that firms' technology innovation enhanced the probability of their survival in the disk drive industry. Cefis and Marsili (2006) argued that technological innovation performance could increase the possibility of firms' survival and that its effect increased over time based on the Community Innovation Survey in the Netherlands. Buddelmeyer et al. (2010) found the positive relationship between product innovation and firms' survival using data from Australian companies. All of this implies that government R&D funding promotes technological innovation performance, which ultimately has a positive influence on firms' survival. Therefore, this study verifies the following hypothesis:

H3. Bio-medical firms received government R&D funding have lower hazard rates for their survival.

5.2.4 Strategic Alliance

Bio-medical firms generally play a role in commercializing the basic research results of research organizations and transferring them to pharmaceutical companies (Pisano, 2006; Bianchi et al., 2011). This has allowed bio-medical firms establish a variety of alliance networks to commercialize the basic research results of research organizations and carry out technology development, manufacturing, marketing, and investment with other bio-medical firms and pharmaceutical companies (Baum et al., 2000). Alliance networks may be valuable, because they offer opportunities by acquiring and learning of resources and capabilities from external organizations (Anand and Khanna, 2000). Small-sized entrepreneurial firms, in particular, should strive to acquire complementary assets through strategic alliances with various external organizations because they lack the resources and capabilities to hold their own against competitors in the rapidly changing industrial environment (Eisenhardt and Schoonhoven, 1996; Coombs and Bierly, 2006).

Previous studies show that a strategic alliance as one of firm's strategies can increase the possibility of firm's survival rate through the acquisition of complementary R&D and manufacturing and marketing assets (Baum et al., 2000; Cooke, 2001; George et al., 2001; Oliver, 2001; Rothaermel, 2001; Ariño, 2003; Audretsch and Feldman, 2003; Baum and Silverman, 2004; Delmar and Shane, 2004; Rothaermel and Deeds, 2004; 2006; Tsai and Erickson, 2006; Raz and Gloor, 2007). Ariño (2003) showed that the strategic

alliance positively influenced firm survival using the data of Spanish firms. Delmar and Shane (2004) conducted research analyzing the survival factors of Swedish firms and concluded that the ability to overcome the weak point in a social relationship through the establishment of relationships with external stakeholders, i.e., strategic alliances, is an important factor for the survival of a firm. Raz and Gloor (2007) studied the Israeli software industry, proved that building strategic alliances is important for the survival of a firm.

This result can also be applied to the bio-medical industry. Previous studies have demonstrated that if bio-medical firms have sufficient alliance management capability or absorptive capacity, their technological innovation performance or financial performance can benefit from a strategic alliance, which ultimately positively influence on firm survival (George et al., 2001; Rothaermel, 2001; Audretsch and Feldman, 2003; Rothaermel and Deeds, 2004; 2006). George et al. (2001) emphasized strategic alliances to downstream expand their market-share and make more profit, enhancing their probability of survival. In particular, Baum et al. (2000), Baum and Silverman (2004) and Tsai and Erickson (2006) emphasized that strategic alliances count in regard to the growth and survival of a biotechnology firm in its initial stages. These heighten the possibility of survival via performances created by strategic alliances among bio-medical firms. Furthermore, through an analysis at the country level, Cooke (2001) noted that the survival rate of bio-medical firms in the UK was lower than that of firms in the US because the strategic alliances of the UK bio-medical firms were not active. Oliver (2001) analyzed the strategic alliances of bio-medical firms in the US and concluded that bio-medical firms with a lower number of strategic alliances had a lower possibility of

survival. Together, these results imply that strategic alliances can have a positive effect on the survival of bio-medical firms. Therefore, this study verifies the following hypothesis:

H4. Bio-medical firms with strategic alliances have lower hazard rates for their survival.

The research model are summarized in Figure 10.

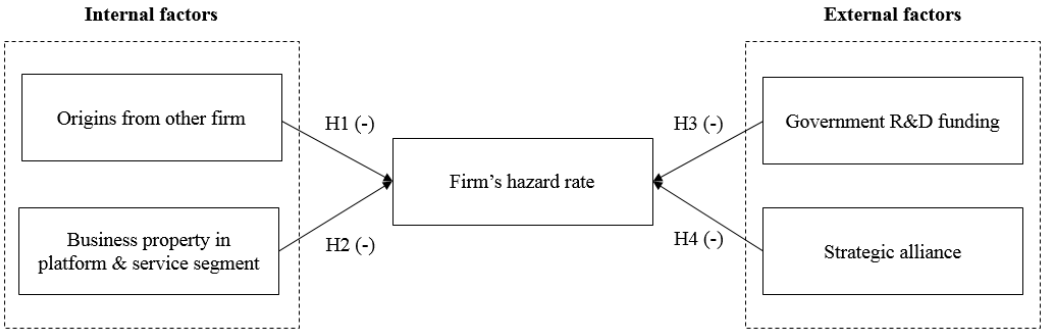


Figure 10. Study hypotheses in study on survival

5.3 Methods

5.3.1 Data

Among 756 therapeutic product-oriented or platform & service firms, for analysis in the Korean bio-medical industry, 610 firms were used, excluding 134 firms that might harm the robustness of the analysis, due to a lot of missing values and 8 firms that only perform product development and manufacturing service for codification of variable on the level of vertical integration. Moreover, this study includes M&A events as cases of a firm's exit. In the case of M&As, the focus is on the creation of synergy between the acquirer and the target and on the payback for the target, and there are a few M&A events for the backdoor listing of the acquirer as a minority. Although M&As for backdoor listing are one reason for the exit of bio-medical firms in Korea, this motivation is miniscule. Therefore, this study assumes that M&A events are meant for creating synergy between the acquirer and the target and for payback of the target; thus, four firms that conducted a takeover for backdoor listing were eliminated from the analysis. In addition, the target data of this study contains many censored data. For this study, totally 3,792 data used.

The distribution of bio-medical firms for each business area is presented in Table 12. The business areas are divided into the pharmaceutical product area, which deals with bio-medicine and diagnostic kits & reagents, and the platform & service area, which produces services for supporting technology development or measurement & analysis equipment. Counting the most representative business area only, the therapeutic product area accounted for 64.43 % and the platform & service area accounted for 35.57 %. To be specific, bio-medicine and supporting service areas represented higher levels, at 53.12 % and 25.08 %, respectively, while diagnostic kits & reagents, measurement & analysis

equipment occupied 11.31 % and 10.49 %, respectively.

Table 12. General characteristics of firms in study on survival

Characteristic	Number of firms	Percentage
Size (number of employees)		
Small (<50)	434	71.15
Medium (51-100)	96	15.74
Large (>100)	80	13.11
Age (years since formation)		
Young (<10)	570	93.44
Established (>10)	40	6.56
Main business area		
Bio-medicine	324	53.12
Diagnostics kits and reagents	69	11.31
Supporting service	153	25.08
Measurement & analysis equipment	64	10.49

5.3.2 Analytical Method

For survival analysis, the Cox proportional hazards model is mainly used (Fisher and Lin, 1999). Although this model is known as a robust estimation method in survival analysis, actual events about exits, such as bankruptcy and M&A, should reach an appropriate size during the analysis period. Due to this problem, in this study, the Cox hazard model with stepwise time-varying covariates was used for survival analysis, as an extension of the Cox proportional hazards model. In the Cox proportional hazards model with survival period (T) and elapsed time (t), an object dies when $t > T$. If the death probability of an object is $f(t)$, regarding a certain short elapsed time (Δt), the cumulative mortality

function is $F(t) = \Pr(T \le t)$, and the survival probability of the object is $S(t) = 1 - F(t) = \Pr(T > t)$. If the number of initial objects is n_0, the number of objects that survived at this point is calculated by multiplying the number of initial objects by $S(t)$. Therefore, the number of objects that die during the period of Δt is $n_o f(t)$. In sum, the probability, $h(t)$ which represents the number of objects that died among those that survived at point t, is a hazard function and given by Eq. (19).

$$h(t) = \lim_{\Delta t \to 0} \frac{\Pr(t + \Delta t > T \mid T > t)}{\Delta t} = \frac{f(t)}{S(t)} \quad \text{Eq. (19)}$$

The cumulative hazard function is $H(t) = \int_0^t h(u)du$

The Cox proportional hazards model is a non-parametric model, assuming that a hazard function for an individual that is presented according to its unique characteristics is proportional to a baseline hazard function, as described in Eq. (20). In this equation, $h(t)$ is a hazard function for an individual where time (t), individual firm (j), and covariate (x_j), and $h_0(t)$ is a baseline hazard function at time (t), which represents the value of the hazard function, where all of the values of covariates (x_j) equal 0. A function of covariate vector is generally assumed in the form of an exponential function. In this way, the Cox model can analyze whether the changes in these covariates bring about proportional changes in the hazard rate within the model. In this sense, the Cox model is called a proportional hazard model.

$$h_j(t) = h_0(t)\exp(\beta_0 + x_j\beta_x) \quad \cdots\cdots \text{Eq. (20)}$$

If the covariate (x_j) is not a variable of time, $h_j(t)$ has a value proportional to $h_0(t)$ in Eq.(20), where the Cox proportional hazards model can be applied. This study, however, applies the value of covariates that change according to time to acquire actual exit events. In previous studies that explore the factors influencing firm survival, variables for all factors are generally assumed to be covariates. This study aims to find the factors for survival in the bio-medical industry and thus uses 1) origins from other firm, 2) business property in platform & service segment, 3) government R&D funding, and 4) strategic alliance as independent variables and the firm size, age, R&D intensity, independent venture by entrepreneurs with career in research organization or not, the level of vertical integration, and the level of business diversification, and industrial growth potential as control variables, all of which have been largely utilized in previous studies.

The origins from other firm is revealed resources and capabilities of the entrepreneur and entrepreneurial team (Colombo and Grilli, 2005). The firm's origins of bio-medical firms are categorized into two types: 1) independent ventures established by entrepreneurs from research organizations, such as universities, hospitals, and government-funded research institutes, or from other firms, such as bio-medical or pharmaceutical companies; and 2) corporate ventures established in the form of affiliates by parent companies to generate new profits or reduce business risks (Zahra, 1996; Zahra and George, 1999; Baum et al., 2000). In this regard, this study analyzes whether the

work experience of entrepreneurs at other firm and an affiliate of a parent company is a covariate that represents the characteristics of origins from other firm.

Bio-medical firms can be classified into two types: 1) therapeutic product-oriented firms that produce bio-medicine and diagnostic kits & reagents, and 2) platform & service firms that provide platform technology and support service (Willemstein et al., 2007; Chiaroni et al., 2009). Platform & service firms include in both firms that develop platform technology such as bioinformatics or micro electro mechanical systems (MEMS) and firms that provide service for support their basic R&D, product development, manufacturing, and marketing processes in value chain. In this study, whether or not platform & service firms is used as a covariate.

Previous studies on government R&D funding have considered two indicators: 1) whether a firm is receiving government R&D funding and 2) the amount of government R&D funding (Feldman and Kelley, 2006; González and Pazó, 2008; Kang and Park, 2012). Although both of these indicators have been used in previous studies, it is presumable that the amount of funding actually received is more closely related to the survival of a firm. Therefore, this study uses the log-transformed ratio of total amount of government R&D funding provided for each firm through the government R&D support projects in a given year as a proxy of government R&D funding. In this case, a very small value of “0.00001” was used when these values were “0” to ensure these values would not be excluded from analysis as missing values.

The strategic alliances of bio-medical firms can be categorized into two categories based on their strategic alliance motivation: 1) upstream alliance (R&D alliances), and 2) downstream alliance (manufacturing & marketing alliance) (Gulati, 1995; Kale et al.,

2002; Oxley and Sampson, 2004). To verify the effects of these types of strategic alliances, previous studies have analyzed both the outcome of having a strategic alliance or not, and the number of strategic alliances (Oxley, 1999; Lin et al., 2012). In this study, the total number of strategic alliances in the pertinent year is used as a proxy of alliance effects. This assumes that cooperation is more closely related to the survival of a firm based on the premise that larger strategic alliances lead to the availability of more resources and capabilities from external organizations (Baum et al., 2000). Additionally, this study examines the effects of strategic alliance according to motivation, because it expects to differently work on firm survival (Rothaermel and Deeds, 2004).

Firm's size, age, R&D intensity, independent venture by entrepreneurs with career in research organization or not, the level of vertical integration, the levels of business diversification, and industrial growth are used as control variables. Previous studies have argued that the size and age of a firm have a positive relationship with its survival in terms of correspondence to circumstances by their resources accumulated and capabilities experienced (Evans, 1987; Dunne et al., 1988; Phillips and Kirchhoff, 1989; Audretsch, 1991). The size of a firm is represented by the number of employees and the age of a firm is calculated by subtracting the year of foundation from the pertinent year. In addition, higher R&D intensity can enhance a firm's market value and provides a positive signal to the market, which aids fundraising (Baum and Silverman, 2004). Nonetheless, there also are research result that excessive R&D investment negatively affects firms' cash flows, which may lead to firm failure (Gilchrist and Himmelberg, 1995). Generally, the R&D intensity of a firm uses the value calculated by dividing the R&D expenditure by the amount of revenues, or the number of employees that represents the size of the firm (Lin

et al., 2006). This study used the value calculated by dividing the R&D expenditure by the amount of revenues. However, it takes a substantial amount of time for a bio-medical firm to generate revenues, and thus, there are multiple zero values. In this context, each “0” value was replaced with a very small value of “0.00001”, so that these values would not be excluded from analysis as missing values.

Additionally, this study uses control variable of whether the bio-medical firms is independent venture by entrepreneurs from research organization or not. Brüderl et al. (1992) emphasize that the research and work experience, and industrial-specific experience may give effect to firm’s survival among various properties firm’s origin. In Korea, there are also distinctive portion of firm founding by them (Science and Technology Policy Institute of Korea, 2013). Thus, this study consider the property of firm’s origin by entrepreneurs from research organization as control variable, despite its inconsistent results for survival (Clarysse and Moray, 2004; Vallas and Kleinman, 2008; Wennberg et al., 2011).

Moreover, for the level of vertical integration, this study checked up the distribution of each firm’s business functions in a value chain. Cader and Leatherman (2011) argued that the level of vertical integration gave positive impact to firm’s survival in US small business, because of supply more value to their customer and expanding market position. The operational function of value chain in the bio-medical industry can be divided into four stages of basic R&D, product development, manufacturing, and marketing (Konde, 2009). This study operationally defines that firms with only basic R&D function are “1”, firms with basic R&D and product development are “2”, the firms with all of basic R&D, product development, manufacturing and marketing functions are “3”. In addition, for the

level of business diversification, this study examined engaged business areas. Firms engaged in various business areas are more likely to survive than those engaged in a single business area, since they can diversify the risks of uncertainty in the market they are entering (Klepper and Simons, 2000). However, firms that engage in a single business area are more likely to survive than those engaged in diversified business areas in the late entry (Bayus and Agarwal, 2007). Business diversification are measured as the number of business areas in bio-medicine, diagnostic kits & reagents, supporting services, and measurement & analysis equipment.

Lastly, there is generally a positive relationship between the rate of entry in an industry and the innovation performance of a firm (Winter, 1984; Geroski, 1995; Aghion et al., 2009), which may gradually influence on firm's survival (Cefis and Marsili, 2006). It attributes that the characteristics of technological regime in the industry can be indirectly inferred from the rate of industrial growth rate (Honjo, 2000). The industry growth as the proxy, calculated by dividing the difference between the number of entry firms and the number of exit firms by the number of existing firms in the pertinent year (Honjo, 2000).

The variables and operational definition are described in Table 13.

Table 13. Definition of variables in study on survival

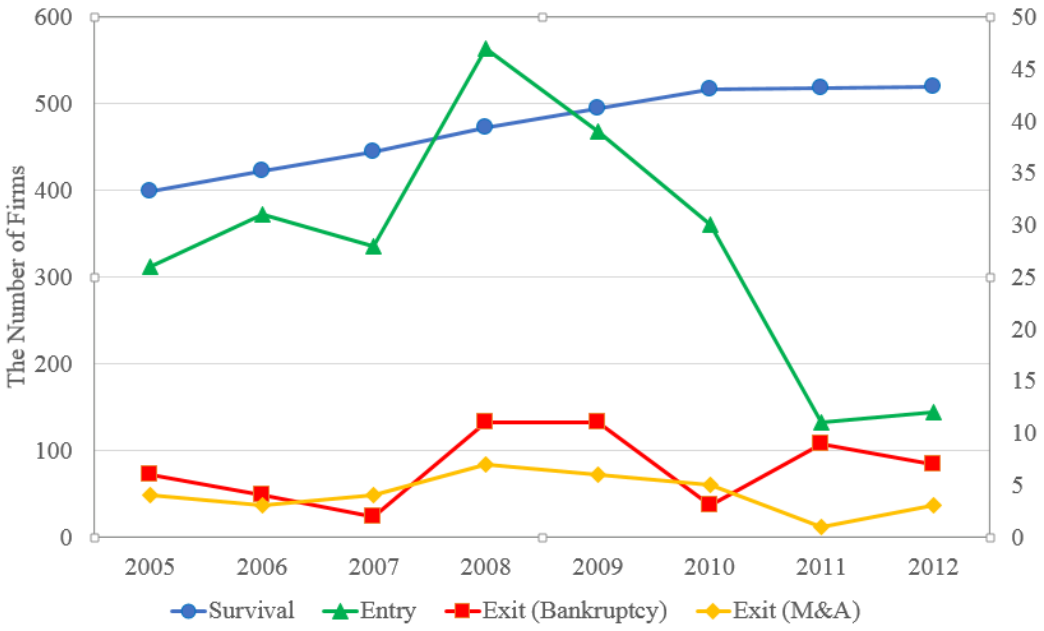
Abbreviation of variable	Variable	Definition
FIV	Independent venture established by entrepreneurs with career of other firm	1 if the firm established by entrepreneurs work experience at companies, 0 otherwise
CV	Corporate venture	1 if the firm spun-off from a parent firm, 0 otherwise
PLAT	Platform & service segment	1 if there are platform & service firm, 0 otherwise
GOV	Government R&D support	Log-transformed ratio of total amount of R&D funding supported by the government
ALLI	Total alliance	Number of strategic alliances
ARD	R&D alliance	Number of R&D alliances
AMM	Manufacturing & marketing alliance	Number of manufacturing & marketing alliances
SIZE	Firm size	Number of employees
AGE	Firm age	Number of years since founding
RD	R&D intensity	Log-transformed ratio of R&D expenses to revenues
RIV	Independent venture established by researchers and scientists	1 if the entrepreneur had career in research organizations, 0 otherwise
INTE	The level of vertical integration	1 if the firm is in basic R&D stage of value chain 2 if the firm is in basic R&D and product development of value chain 3 if the firm is a full-integrated firm (involving basic R&D, product development, manufacturing, and marketing of value chain)
DIV	The level of business diversification	Number of business areas in which the firm is engaged
GROW	Industry growth	The value to divide the difference between the number of entry firms and that of exit by the number of existing firms in pertinent year

Nonetheless, this study examined multicollinearity among the variables. Previous studies argued that private R&D intensity was enhanced by government R&D funding

(Buisseret et al., 1995; Hsu et al., 2009; Kang and Park, 2012) or promoted strategic alliances by increasing absorptive capacity and by providing higher market value (Griliches, 1981; Mowery et al., 1996; Caloghirou et al., 2004). Therefore, this study examined the multicollinearity among the variables using VIFs. The highest VIF among the variables in all the research models is 1.973, which means the model has goodness of fit, assuming the cut-off to be below 10 for the multiple regression models (Neter et al., 1985).

5.4 Results and Discussions

Figure 11 illustrates the distribution of entry / exit (bankruptcy) / exit (M&A) / survival firms. In Korea, around 30 firms were established from 2005 to 2007, and the number of new firms was outstanding, especially in 2008 and 2009, when it reached 47 and 39, respectively. However, the number since 2008 has decreased to a record 30 in 2010, 11 in 2011, and 12 in 2012. In addition, firm exits were caused more by bankruptcy than by M&A, except in 2007 and 2010. When it comes to the total of firm exits caused by bankruptcy and M&A during the analysis period, the number of exited firms due to bankruptcy was 53 (62 %) and due to M&A was 33 (38 %). This result shows a stark difference from the Canadian bio-medical industry, where 36 % of exited firms were bankrupt and 64 % had undergone M&A, from 1996 to 2010 (Moustakbal, 2014). This clearly demonstrates the situation of the Korean bio-medical industry, in which M&As are not actively conducted as yet, than advanced country of bio-medical industry like Canada.



Year	2005	2006	2007	2008	2009	2010	2011	2012	Total
Entry	26	31	28	47	39	30	11	12	224
Exit (Bankruptcy)	6	4	2	11	11	3	9	7	53
Exit (M&A)	4	3	4	7	6	5	1	3	33
Survival	398	422	444	473	495	517	518	520	

Figure 11. Distribution of entry / exit (bankruptcy) / exit (M&A) / survival firms
(Left: entry / exit (bankruptcy) / exit (M&A) firms;
Right: survival firms;
Unit: the number of firms)

The basic statistics and correlation coefficients of the variables included in the analysis model are presented in Table 14. The results of analyzing the Cox hazard model with stepwise time varying covariates are presented in Table 15.

Table 14. Descriptive statistics and correlation coefficients of variables in study on survival

Variable	Mean	Standard deviation	FIV	CV	PLAT	GOV	ALLI	ARD	AMM	SIZE	AGE	RD	RIV	INTE	DIV
FIV	0.324	0.468	1												
CV	0.055	0.228	-0.169***	1											
PLAT	0.434	0.496	-0.007	-0.136***	1										
GOV	5.336	3.156	0.086***	-0.049**	-0.016	1									
ALLI	0.146	0.640	-0.017	0.048***	-0.002	0.128***	1								
ARD	0.059	0.327	-0.015	0.024	0.031*	0.092***	0.850***	1							
AMM	0.086	0.397	-0.015	0.057***	-0.029*	0.130***	0.901***	0.537***	1						
SIZE	37.696	58.829	0.010	0.295***	-0.024	0.076***	0.189***	0.165***	0.167***	1					
AGE	8.518	5.410	-0.001	0.036*	0.018	-0.016	0.193***	0.203***	0.141***	0.395***	1				
RD	3.847	2.346	0.159***	-0.061***	0.016	0.371***	0.067***	0.050***	0.067***	0.033*	-0.040**	1			
RIV	0.304	0.460	-0.459***	-0.160***	-0.001	0.094***	0.066***	0.055***	0.061***	-0.079***	0.023	0.022	1		
INTE	1.368	0.625	0.055***	0.170***	-0.056***	0.107***	0.180***	0.142***	0.171***	0.779***	0.324***	0.053***	-0.075***	1	
DIV	1.395	0.643	0.040**	-0.022	0.062***	0.153***	0.083***	0.091***	0.058***	0.035*	0.102***	0.164***	0.054***	0.001**	1
GROW	0.032	0.022	-0.012	-0.007	-0.010	0.007	0.004	0.011	-0.003	0.032*	-0.252***	0.112***	0.014	0.041	0.020

*** p<0.001, ** p<0.01, * p<0.05, † p<0.1

Table 15. Analysis results of Cox hazard model with stepwise time-varying covariates

	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
FIV		-0.751***	-0.747***	-0.668**	-0.694*
		(0.179)	(0.179)	(0.223)	(0.324)
CV		0.677***	0.696***	-2.333*	2.648***
		(0.211)	(0.211)	(1.016)	(0.285)
PLAT		-0.541***	-0.528***	-0.465**	-1.786***
		(0.130)	(0.130)	(0.145)	(0.362)
GOV		-0.059***	-0.060***	-0.115***	-0.036**
		(0.010)	(0.010)	(0.021)	(0.013)
ALLI		0.156*			
		(0.065)			
ARD			-0.113	0.966	-0.245
			(0.264)	(0.726)	(0.334)
AMM			0.315*	-2.290*	0.457**
			(0.155)	(1.053)	(0.125)
SIZE	-0.027***	-0.023***	-0.024***	-0.006***	-0.061***
	(0.003)	(0.003)	(0.003)	(0.001)	(0.005)
AGE	-0.173***	-0.189***	-0.191***	-0.100***	-0.549***
	(0.024)	(0.025)	(0.025)	(0.029)	(0.064)
RD	-0.187***	-0.153***	-0.153***	-0.653***	-0.004**
	(0.015)	(0.016)	(0.016)	(0.142)	(0.001)
RIV	0.387**	0.295*	0.289*	0.315*	0.155
	(0.114)	(0.129)	(0.129)	(0.154)	(0.258)
INTE	1.214***	1.061***	1.074***	-2.081***	4.340***
	(0.142)	(0.142)	(0.142)	(0.404)	(0.300)
DIV	-0.349**	-0.306**	-0.299**	-0.202**	-0.195
	(0.112)	(0.116)	(0.116)	(0.093)	(0.230)
GROW	-4.354	-5.712*	-5.713*	-2.245	-7.832***
	(2.750)	(2.834)	(2.831)	(3.574)	(2.226)
N	3,792	3,792	3,792	3,792	3,792
Event	351	351	351	228	123
Likelihood Ratio	509.838	613.580	614.878	599.749	614.500
Wald-χ^2	153.288***	433.900***	433.168***	123.330***	375.249***

*** p<0.001, ** p<0.01, * p<0.05, † p<0.1

Note. MODEL 1: Basic model; MODEL 2, 3: Full model;
MODEL 4: Full model with dependent variable of bankruptcy;
MODEL 5: Full model with dependent variable of M&A

MODEL 1 in Table 15. is a basic model that conducted an analysis by inserting control variables only, while MODEL 2 is a full model that considered both independent and control variables. Looking at the control variables in MODEL 2, firm size ($p<0.001$), age ($p<0.001$), R&D intensity ($p<0.001$) and the level of business diversification ($p<0.01$) the growth rate of industry ($p<0.05$) had negative impacts on the exits of bio-medical firms. However, the property of firm's origin by entrepreneur had career in research organizations ($p<0.05$) and the level of vertical integration ($p<0.001$) had positive impacts on their exits. This means that a larger and older firm has a higher possibility of survival. This result supports existing studies that argue that the size and age of a firm are important factors for its survival (Mata et al., 1995; Das and Srinivasan, 1997). In addition, R&D intensity also positively affect firm survival, showing the industrial property of technology intensiveness (Hall and Bagchi-Sen, 2001; 2002). Moreover, a higher level of business diversification in a firm leads to a lower hazard of exit. This implies that a bio-medical firm engaged in various areas of business is more likely to survive, due to the reduction of business risks. This result supports a number of studies that argued that a firm engaged in various business areas has a higher chance of survival (Klepper and Simons, 2000), and contradicts a few studies that concluded that a firm engaging in a single business area is more likely to survive (Bayus and Agarwal, 2007). Furthermore, the growth rate of the industry positively affect firm survival. It support the result of previous studies that the entry rate in industry positively influence on innovation performance of a firm, which ultimately can enhance their possibility of survival (Aghion et al., 2009; Cefis and Marsili, 2006; Honjo, 2000). On the other hand, the property of firm's origin by entrepreneur from research organizations negatively affect firm survival.

Though tacit knowledge about basic science by entrepreneurs from research organization can be a cornerstone for creating or identifying business opportunities, the result of this study shows that entrepreneurs from research organization are disadvantage for firm's survival. In addition, the level of vertical integration also unexpectedly gave negative effect on firm survival.

The bio-medical firms that were established by entrepreneurs with work experience in companies had a positive effect on the survival of a firm, while, spin-offs from parent companies had a negative effect on it (Hypothesis 1-1 is supported; Hypothesis 1-2 is not supported.). In MODEL 2, the characteristics of a firm's origin which had entrepreneurs with work experience at other firms had a negative relationship with the hazard rate ($p<0.001$) and the characteristics of a firm's origin that were spun off from parent companies had a positive relationship with the hazard rate ($p<0.001$). The result on hypothesis 1-1 implies that the commercial knowledge of entrepreneurs increase the survival probability of bio-medical firms. This result supports the study by Wennberg et al. (2011) that argued that the commercial knowledge of entrepreneurs are important for the performance and survival of a firm. However, the result on hypothesis 1-2 cannot confirm that there are competitive advantages on resources and capabilities, resulted from their parent company, of spin-offs for survival. This result contradict studies by Buenstorf (2007) and Arregle et al. (2013).

The business property of platform & service bio-medical firms had a positive effect on the survival of a firm as well. (Hypothesis 2 is supported.) In MODEL 2, platform & service bio-medical firms had a negative relationship with the hazard rate ($p<0.001$). This means that there are advantages of platform & service bio-medical firms for survival than

that of therapeutic product-oriented bio-medical firms. The high uncertainty of bio-medical R&D and business, and huge R&D expenditures, make therapeutic product-oriented bio-medical firms less likely to survive than platform & service bio-medical firms. Casper and Kettler (2001) found that the bio-medical industry in Germany could overtake that of the UK, stating that "Germany has a higher distribution of platform & service bio-medical firms". Casper and Kettler (2001) argued that latecomers could have rapid growth by intensively nurturing the platform & service segment, since they have better chances of survival, which is also supported by the results of this study.

Government R&D funding also had a positive effect on the survival of a firm. (Hypothesis 3 is supported.) In MODEL 2, the government R&D funding for a bio-medical firm had a negative relationship with its hazard rate ($p<0.001$). This implies that government R&D funding is crucial to the survival of a bio-medical firm. This result also supports the study by Lyles et al. (2004) that emphasized the impact of government support on firm survival. In addition, the positive effect of government R&D funding on firm survival can be explained in that government R&D funding positively contributes to the creation of competitive technological innovation performance of a bio-medical firm, which ultimately positively affects its survival.

Strategic alliance had a negative impact on the firm survival (Hypothesis 4 is not supported.) In MODEL 2, the strategic alliance of a bio-medical firm had a positive relationship with its hazard rate ($p<0.05$). This implies that strategic alliance is an important factor of firm exit. This result contradicts previous findings, which show that strategic alliances improve the chances of firm survival, by complementing the resources and capabilities of a bio-medical firm and providing advantages in terms of dealing with

institutional challenges (Cooke, 2001; Oliver, 2001; Tsai and Erickson, 2006). In MODEL 3, this study additionally investigated the effect of strategic alliance according to motivation for it, of which could divide R&D alliance with Manufacturing & Marketing alliance. This study found that R&D alliance does not have a significant relationship with the hazard rate of firm exit, while manufacturing & marketing alliance also had a negative relationship with its hazard rate ($p<0.05$). It shows that manufacturing & marketing alliance positively influence on bio-medical firm's exit. Overall effect of strategic alliance also may result from manufacturing & marketing alliance.

MODEL 4 and 5 in Table 15 are the result of analyzing firm survival, deduced by examining bankruptcy and M&A, respectively. In the case of firms that exited after bankruptcy, the firm's origin by entrepreneurs with career in other firm, business property in platform & service segment, government R&D funding, firm size, age, R&D intensity, the level of vertical integration, the level of business diversification had a negative impact on their hazard ratio ($p<0.01$, $p<0.01$, $p<0.001$, $p<0.001$, $p<0.001$, $p<0.001$, $p<0.001$, and $p<0.01$, respectively), while the firm's origin by entrepreneurs from research organization had a positive impact on their hazard ratio ($p<0.05$). However, spin-offs from parent company and manufacturing & marketing alliance had a negative effect on their hazard ratio, contrary to when bankruptcy and M&A were all considered for firm exit ($p<0.05$, $p<0.05$, respectively). In the case of exited firms due to M&A, the firm's origin by entrepreneurs with career in other firm, business property of platform & service firm, government R&D funding, firm size, age, R&D intensity, and lastly the growth rate of industry had a negative effect on their hazard ratio ($p<0.05$, $p<0.001$, $p<0.01$, $p<0.001$, $p<0.001$, $p<0.01$, and $p<0.001$, respectively), while the level of vertical integration had a

positive impact on their hazard ratio ($p<0.001$). However, in the case that a bio-medical firm is forced to exit because of M&A, spin-offs from parent company, and manufacturing & marketing alliance had a positive effect on their hazard ratio ($p<0.001$, $p<0.05$, respectively).

In MODEL 3, the overall result considered both bankruptcy and M&A as factors of firm exit, showed that spin-offs from parent company and manufacturing & marketing alliance had a negative impact on firm's survival. It could be interpreted as what is more affected by firm exit, because of M&A. Consequently, this study found that the property of firm's origin by spin-off from parent company and manufacturing & marketing alliance help to decrease the hazard of bankruptcy and activate M&A. First, the result of firm's origin by spin-off from parent company reflect that spin-offs from parent company have competitive advantage by easier access to resources and capabilities from their parent company than their counterparts, which can be interpret to help them to prevent bankruptcy and activate M&A events. Second, the result of manufacturing & marketing alliance also can serves to prevent bankruptcy and activate M&A events. The complementary assets acquired through manufacturing & marketing alliances improve their financial performance and enhancing their market value, ultimately forbid their bankruptcy (Kale et al., 2002). It also can promote M&A events by being providing acquirer with real information about potentials of target and by enhancing target's reputation (Reuer and Ragozzino, 2008). M&A entails relatively larger opportunity costs and risks than those of strategic alliance (Wang and Zajac, 2007). Therefore, acquirer that intends to takeover needs to investigate real value of the target through their experiences on target. Accordingly, the acquirer firstly intends to contract manufacturing & marketing

alliance that has relatively low opportunity costs and risks (Porrini, 2004; Zaheer et al., 2010). Furthermore, repetitive strategic alliances of firms can give a positive signal to market, enhancing their reputations (Pangarkar, 2003, Houston, 2003). Success of repetitive strategic alliance improve firm's reliability, and gradually value. In these ends, strategic alliance is catalyst activating M&A events.

5.5 Sub-Conclusion

Since the bio-medical industry is expected to be a future growth engine by countries all around the world, a number of studies have been conducted on growth of bio-medical industry. However, due to the industrial properties resulted from technology-intensiveness and high distribution of small-sized entrepreneurial firms, it faces many challenges, and can be more difficult to run successfully for latecomers to the industry such as Korea than for countries with a developed industrial ecosystem such as the US, UK, and Germany. This study have emphasized 1) origins from other firm; firms established by entrepreneurs with career from other firm, or spun-off from parent company, 2) business property from platform & service segment as internal factors, and 1) government R&D funding, 2) strategic alliance as external factors for survival of bio-medical firms. Few studies have discussed the survival of bio-medical firms with integrated perspectives between internal and external factors. Therefore, this study contributes to the findings on internal and external survival factors for bio-medical firms.

This study searched for entry, exit, and survival situations in bio-medical firms of Korea. It showed that firm exit due to bankruptcy is more active than exit due to M&A. This is different from the bio-medical industries of advanced countries, such as Canada (Moustakbal, 2014), where firm exit due to M&A is more active than exit due to bankruptcy. In addition, a result of this study, which used the Cox hazard model with stepwise time varying covariates, demonstrates that the properties of firm's origin by entrepreneurs with career in other firm, the business property in platform & service segment, and government R&D funding all have a positive impact on the survival of bio-medical firms. Moreover, this study founded two facts by classifying the reason of firm

exit into both bankruptcy and M&A. The firm's origin by spin-off from parent company and manufacturing & marketing alliance contribute to prevent bankruptcy and promote M&A. Therefore, this study also found that both the property of firm's origin by spin-off from parent company, and manufacturing & marketing alliance may be important survival factors for business progress.

These results present five implications. First, the industrial structure of a virtuous circle should be formed for M&A in the bio-medical industry of Korea. On average, bankruptcy is more common than M&A in exits during the period of this study. This shows that the Korean bio-medical industry was less mature than that in advanced countries such as the US and Canada. After bio-medical firms with promising technologies and knowledge accept an investment, the investors should withdraw them through IPO and M&A. The bio-medical industry in advanced countries have such a virtuous cycle (Pisano, 2006). However, in the case of the bio-medical industry of Korea which is a latecomer in the bio-medical industry, firms are required to make an effort to activate M&A.

Second, firms established by entrepreneurs with career in other firms and those spun-off from a parent company provide opportunistic elements for firm's survival of bio-medical industry of Korea. In Korea, the number of new firms established by entrepreneurs with careers in other companies is much higher than that of new firms founded by entrepreneurs from research organizations (Science and Technology Policy Institute of the Republic of Korea, 2013). These findings indicate that the founding of new firms by research organizations in Korea (which is a latecomer) may be more difficult than in advanced countries like the US because of differences in the national

institutional framework such as the labor or financial system (Casper and Kettler, 2001). However, this study presents hope for bio-medical firms in Korea by providing a positive signal for preventing bankruptcy. More than half of the entrepreneurs of bio-medical firms involved in initial public offerings (IPO) are entrepreneurs with career in other firms in Korea. In research of Hanguk-Kyungje Press, which is a Korean newspaper, on the work history of entrepreneurs in Korean bio-medical firms listed from 2010 to 2014, 17 entrepreneurs among 26 companies had experience working in other firms in Korea. This evidence implies that the managerial superiority of such bio-medical firms may be their strength for surviving in the context of Korea.

Bio-medical firms that were spun-off from parent company avoided bankruptcy and promoted M&A. This finding implies that founding new firms spun-off from parent company is favorable for business progress in the context of Korea. Entrepreneurship in the bio-medical industry should keep in mind the management of risk resulting from technological and business uncertainty (Pisano, 2006). Resources and capabilities from the parent company provide competitive advantage for the spin-offs. They can overcome restrictions because of business risk at the initial stage of firm founding, ultimately preventing bankruptcy. Further, they are likely to be attractive to other firms that intend to take over them by achieving excellent financial performance and ensuring their spontaneity. In the cases of Korea, spin-offs also are often taken over by their parent company. For example, SK merged with firm I and firm B, subsidiary firms that were originally spun-off from it to strengthen its synergy in R&D and commercialization. In another case, Green Cross spun off firm P as a type of affiliation specialized in medicines made from vaccines, placentas, diagnostic reagents. Firm P was later taken over by Green

Cross. This means that parent companies are a kind of incubating organization for spin-offs in the Korean context. This finding implies that spin-off bio-medical firms may be an alternative organizational model in Korea, which has medium-sized pharmaceutical companies and conglomerates (the well-known *chaebol*) (Whitley, 1992; Casper, 2009; Science and Technology Policy Institute of the Republic of Korea, 2013).

Third, business entry in the platform & service segment could be another opportunity for firm's survival in Korean bio-medical. Recently, the federated business model—forming value networks with a variety of organizations in the value chain—is on the rise for enhancing the productivity, profitability, and sustainable growth of bio-medical firms (March-Chordà and Yagüe-Perales, 2011). The business model of platform & service firms may be attractive for latecomers in the bio-medical industry such as Korea, since the bio-medical firms can concentrate on specialized area of value chain without high risks from basic R&D to commercialization. In addition, the ICT industry has traditionally played an important role in economic growth with globally competitiveness in Korea (Avgerou, 2003). Thus, another alternative for the platform & service firms is biotechnology fused with ICT, which can promote the growth of the bio-medical industry in Korea. Therefore, this study suggests that remarkable attention needs to be paid to the growth of the biotechnology segment fused with ICT.

Fourth, Korean bio-medical firms make efforts to receive government R&D funding for their survival, and the sustainable R&D support of the government is also required for the growth of Korea's bio-medical industry. Lim (2009) and Casper (2009) emphasized that the remarkable growth of the Korean bio-medical industry can be attributed to intensive government support. The government in Korea gradually has reinforced

investment in the five fields of drug research, stem cell, brain research, genome study, and establishment of medical infrastructure (Ministry of Science, ICT and Future Planning and Biotech Policy Research Center of the Republic of Korea, 2014). In particular, government R&D funding seems to play a key role in the growth and survival of bio-medical firms because Korea has a bank-oriented financial system (Whitley, 1992) and an immature private investment like venture capital (Casper, 2009). This means that sustainable government R&D funding may be a solution to the lack of private investment such as venture capital in government-led latecomers such as Korea, in contrast to the situation in advanced countries like the US (Wright et al., 2004). Paradoxically, this also means that Korea also needs to make an effort to grow the venture capital industry.

Fifth, manufacturing & marketing alliances need to be promoted further for the survival of bio-medical firms in Korea. The results of this study show that manufacturing & marketing alliances decrease the hazard of firm exit because of bankruptcy and increases the number of firm exits because of M&A. This indicates that the manufacturing & marketing alliances of bio-medical firms are more important than R&D alliances for their survival. Thus, this study shows that the chances of survival depend on the activities for promoting financial performance. Outbound or inbound manufacturing & marketing alliances may constitute an alternative solution for this. For example, some bio-medical firms in Korea gained revenue through contract manufacturing for clinical trials in Korea. The period of distribution is critical for bio-medical products that use raw materials such as cells because of concerns related to the impairment or transformation of materials (Thiel, 2004). Therefore, foreign bio-medical firms contract with Korean bio-medical firms for manufacturing, and they supply their products for clinical trials in many

cases. Some firms contracted with a foreign sales agency to export their bio-medical products and expanded their distribution channel. Other Korean bio-medical firms acquired exclusive sales rights to new bio-medicine and diagnostics products in the domestic market. These findings mean that the promotion of business activation through manufacturing & marketing alliances is important for the survival of Korean bio-medical firms.

Finally, this study has limitations that the number of employees and business areas were treated as a constant, as of 2012, due to the lack of data. The change in the number of employees and business areas might be insignificant, in that the age of firms is young on average, but these values can change according to the growth (or decline) and strategy of a firm. Therefore, this study need to complement data in future studies. Further, the effect on private investments, such as venture capital, has not been considered for the survival of bio-medical firms in Korea. Pisano (2006) suggested the role of venture capital for the US bio-medical industry. Though, in Korea, private investment like venture capital is weaker than public (government) investment (Casper, 2009), there are definitely effect of private investment, which need to be considered in the future research.

Chapter 6. Overall Conclusion

6.1 Summary of Results

As the age of bio-economy draws near, all countries—global pioneers and latecomers to the bio-medical industry alike—are making preparations. However, there are various challenges for science-based businesses in each country that affect the growth of the bio-medical industry. This industry requires sustainable public and private investment as well as internal and external growth strategies. In particular, the bio-medical industry in Korea, which is a blooming latecomer in this field, has a high distribution of small businesses. Moreover, the growth of the Korean bio-medical industry has been well-led by the government so far, as the private investment has not been sufficient. This implies that it is necessary for Korean bio-medical firms to secure spontaneity more proactively. In addition, there are unique national advantages in Korean bio-medical industry for its growth, such as connectivity bio-medical technologies with developed ICT and conglomerate-oriented industrial structure. Such context of the Korean bio-medical industry describes the need for strategic entrepreneurship to consider the nature of the firm's origin, the acquisition of internal and external complementary resources and capabilities, and strategic management simultaneously in order to ensure performance. Therefore, through three studies on firm origin, business model, and survival, this dissertation argued that strategic entrepreneurship is desperately required for the growth of Korean bio-medical firms.

The first study of this dissertation examined the differences in strategies and performances depending on the firm's origin and the characteristics of the entrepreneur or

entrepreneurial team with regard to the strategic management of resources and capabilities, are critical in terms of strategic entrepreneurship inputs. The second study identified the types of business model of Korean bio-medical firms and compared their characteristics and performance as a result of strategic entrepreneurship, which is considered as the bundle of strategies for generating profits wherein entrepreneurs or entrepreneur firms proactively select their contextual circumstances. The third study recognized the limitations of prior studies that concentrated on short-term performance, particularly in the bio-medical industry, and tried to identify the survival factors of firms from a long-term perspective. Together, the three studies offer several findings.

The first study in chapter 3 examined the impact of the characteristics of independent and corporate venture on strategies and performance. First, this study structured the relationships among R&D intensity, R&D alliances, manufacturing & marketing alliances, technological innovation, and financial performance. Subsequently, it investigated the impact that the origin of the two types of firms had on their strategies and performances. The results revealed structured relations among R&D intensity, R&D alliances, and manufacturing & marketing alliance, technological innovation, and financial performance, as was expected. Moreover, bio-medical firms established by entrepreneurs from research organizations were found to have a positive influence on the firms' R&D intensity, R&D alliance, and technological innovation performance (which represent technology-intensive characteristics), confirming their direct and moderating effects, although they were insufficient to create financial performance. In the case of spin-offs from parent company, the firms' origin positively affected manufacturing & marketing alliances as well as financial performance, indicating that they could run differentiated business

activities, thanks to the parent companies' resources and capabilities.

The second study in chapter 4 identified business model, examined characteristics, and performance of firms clustered by the critical criteria of vertical integration, business diversification, R&D, and manufacturing & marketing alliances. This study identified three types of business models in the Korean bio-medical industry: 1) diversified firms with weak strategic alliances, 2) vertical integrated firms with strong strategic alliances, and 3) non-diversified R&D firms. The cluster of vertical integrated firms with strong strategic alliances included most of the bio-medical firms in Korea, followed by the cluster of non-diversified R&D firms, and diversified firms with weak strategic alliances. Diversified firms with weak strategic alliances had the highest level of business diversification and some R&D and manufacturing & marketing alliances, which represented the middle level of financial performance as a proxy of revenue through business diversification strategy among the three clusters, although they had a much lower level of R&D intensity and technological innovation performance compared to cluster 2. Vertical integrated firms with strong strategic alliances had the highest level of vertical integration, R&D, and manufacturing & marketing alliances, including the highest R&D intensity as well as the best technological innovation and financial performance among the three clusters. Non-diversified R&D firms were characterized by little vertical integration and business diversification, with a few strategic alliances. They had the lowest financial performance among the three clusters, although they had some R&D intensity and technological performance.

The third study in chapter 5 examined the status of survival and exits in the Korean bio-medical industry and identified that the incidence of bankruptcy among firm exits

was superior to that of M&A in the industry. Further, this study intended to find the unique internal and external survival factors of the bio-medical industry in Korea. The properties of origin from other firms involving entrepreneurs with careers in other firms and spin-offs from a parent company, and the business property in platform & service segment were considered as internal factors from a microscopic view, while the government R&D funding and strategic alliance were considered as external factors from a mesoscopic view. This study found that the properties of firm's origin involving entrepreneurs with careers in other firms have a positive effect on firm survival, especially in preventing bankruptcy. The firm's origin via a spin-off from a parent company prevented bankruptcy and promoted M&A events, although it was a negative signal for the survival of Korean bio-medical firms in general. Bio-medical firms in the platform & service segment and those that received government R&D funding had superior probability of survival compared to their counterparts in terms of preventing bankruptcy in the Korean bio-medical industry. Contrary to expectations, strategic alliance had a negatively effect on the survival of bio-medical firms. Through additional analyses, this study found that manufacturing & marketing alliance has a positive effect on survival; further, it prevents bankruptcy and promotes M&A.

Table 16 presents the summary of the results of the three studies in this dissertation. This dissertation presents comprehensive results in terms of identifying the business model and the performances of Korean bio-medical firms depending on the type of firm's origin and growth strategies. First, in terms of the type of firm's origin, independent bio-medical ventures established by entrepreneurs from research organizations appear to have business models with a high level of vertical integration and strong strategic alliances

(including R&D alliance as well as manufacturing & marketing alliance), or they have business models that are non-diversified and with only basic R&D functions. They have improved technological innovation performance but weakened financial performance; thus, they are vulnerable to bankruptcy. Independent bio-medical ventures established by entrepreneurs with careers in other firm appear to have business models with a high level of business diversification and weak strategic alliances, or they have business model that are non-diversified and with only a basic R&D function. They strengthen on improving both technological innovation and financial performance; therefore, they are superior in terms of preventing bankruptcy. In addition, corporate bio-medical ventures that are spin-offs appear to have business model with high levels of vertical integration and strong strategic alliances. They have excellent financial performance; further, they have properties that prevent bankruptcy and promote M&A events. Second, based on type of internal growth strategies, the vertical integration strategy—which mainly appears in firms that have business model with high level of vertical integration and strong strategic alliances—enhances technological innovation and financial performance, prevents bankruptcy, and promotes M&A events. The business diversification strategy, which mainly appears in firms that have business model with a high level of business diversification and weak strategic alliances, improves financial performance and prevents bankruptcy. The business entry strategy in the platform & service segment—which mainly appears in firms with business model that have a high level of business diversification and weak strategic alliances or are non-diversified with only basic R&D function—cannot improve technological innovation performance. However, this strategy is superior in terms of financial performance, and it prevents bankruptcy. Third, according

to type of external growth strategies, government R&D funding, which is high in firms that have business models with a high level of vertical integration and strong strategic alliances, improves only technological innovation performance, not financial performance; it also prevents bankruptcy. In addition, R&D alliance strategy, which mainly appears in firms with business models with a high level of vertical integration and strong strategic alliances, enhances the technological innovation performance. Moreover, it indirectly promotes financial performance by mediating it, but it does not have a significant relationship with the firm's survival. Finally, manufacturing & marketing alliance, which mainly appears in firms with business model with a high level of vertical integration and strong strategic alliances, enhances financial performance only; further, it can prevent bankruptcy and promote M&A events.

Table 16. Overall summarization through results of three studies

Strategic entrepreneurship \ Business model and Performance			Business model			Performance				
			Business diversification with weak strategic alliance	Vertical integration with strong strategic alliance	Non-diversified R&D firm	Technological innovation performance	Financial performance	Survival	*Bankruptcy*	*M&A*
Firm's origin	Independent venture	Establishing by entrepreneur from research organization	Low	Middle	High	Positive	Negative	Negative	Promoting	Not significant
		Establishing by entrepreneur with career from other firm	High	Low	Middle	Positive	Positive	Positive	Preventing	Preventing
	Corporate venture	Spun-off from parent company	Low	High	Low	Not significant	Positive	Negative	Preventing	Promoting
Firm's growth strategies	Internal growth strategies	Vertical integration	Low	High	Low	Positive	Positive	Negative	Preventing	Promoting
		Business diversification	High	Middle	Low	Not significant	Positive	Positive	Preventing	Not significant
		Business entry in platform & service	High	Low	High	Negative	Positive	Positive	Preventing	Preventing
	External growth strategies	Government R&D funding	Low	High	Low	Positive	Not significant	Positive	Preventing	Preventing
		R&D alliance	Middle	High	Low	Positive	(Indirect positive)	Not significant	Not significant	Not significant
		Manufacturing & marketing alliance	Low	High	Low	N/A	Positive	Positive	Preventing	Promoting

6.2 Managerial and Policy Implications

This dissertation focused on entrepreneurship in the Korean bio-medical industry and emphasized the need for strategic entrepreneurship for the growth of this industry because of the science-based nature of the industry and the necessity of strategies in Korean context such as the high distribution of small businesses, the developed ICT industry, and conglomerate-oriented industry structure. Previous studies identified the properties of firm's origin in entrepreneurship (particularly spin-offs from conglomerates in Korea), human resources, or R&D intensity as the internal growth factors, while connection with research organizations such as universities, hospitals, government-funded research institutes, pharmaceutical companies, or the government are underlined as external growth factors with regard to the growth of Korean bio-medical firms. Few previous studies comprehensively considered these factors in the viewpoint of the type of firm's origin and growth strategies. Thus, this dissertation attempted to observe the type of firm's origin and the internal and external growth strategies simultaneously and to present a comprehensive result. Further, strategic entrepreneurship highlighted the role of resources and capabilities as inputs, the role of resources and capabilities coordination (orchestration) as process, and the outcomes of created and captured value through them. This dissertation performed studies focused on firm's origin, business model, survival of Korean bio-medical firms along with input-process-outcome model of strategic entrepreneurship, comprehensively considering on factors relation with firm's origin and growth strategies. Therefore, this dissertation contributes to the identification of managerial and policy implications about the firm's origin as input, the business model as the process, and survival as the outcome of strategic entrepreneurship for the Korean bio-

medical industry.

The first study in chapter 3 found that independent ventures established by entrepreneurs from research organizations had competitive advantages in terms of the intent to secure superior technological capability, while the competitive advantage of corporate ventures in terms of commercial capability was derived from the managerial support (in terms of resources and capabilities) from their parent company. The results showed that there are difficulties associated with the business process in the Korean bio-medical industry, despite the firms' excellent technological innovation performance. Therefore, independent ventures founded by entrepreneurs from research organizations should make efforts to generate financial performance to ensure their spontaneity, based on the business model for generating profit and fostering commercial knowledge. Additionally, this study found that corporate ventures created via spin-offs could gain new opportunity by reducing business risk at founding because of the lack of risk money in the context of Korea. Parent companies such as pharmaceutical companies and conglomerates—which have abundant resources and capabilities—may play a key role as incubating organizations for entrepreneurial bio-medical firms in Korea. On the other hand, this study suggested that corporate ventures must gradually strengthen their technological capability in order to have technological advantages and to absorb excellent external technologies from the long-term perspective.

The second study in chapter 4 identified the three business models in the Korean bio-medical industry and reported the growth potential and concerns about firms in three business models. First, vertical integrated firms with strong strategic alliance are currently the most mature business groups in the Korean bio-medical industry. Nonetheless, for

their growth, they should consider balance in terms of level of vertical integration as internal growth strategy and strategic alliance as external growth strategy, acknowledging their core competence. High level of vertical integration could disperse their core resources and capabilities, although it might lead to more efficient processes and effective outcomes. Currently, Korean bio-medical firms exploit strategic alliances to avoid the disadvantages associated with vertical integration. Second, diversified firms with weak strategic alliances could serve as a fast route to revenue in the Korean bio-medical industry. This study explained that these firms aimed to decrease the cost of coordinating their business activities by efficiently integrating each process and increasing their profits through the business diversification strategy. This business model particularly seems to be required for Korean bio-medical firms in the therapeutic product segment to concerning profit at the founding because of the lack of risk money such as venture capital. In addition, the findings implied that the bio-medical segment is one of the areas of opportunities for Korean pharmaceutical companies and biotechnology firms with core technologies related to functional food and cosmetics. However, they should also consider their internal business capability and costs such as coordination cost or influence cost stemming from business diversification. Third, there are some immature, or infant firms that are non-diversified and are in the basic R&D stage of value chain in the Korean bio-medical industry. These firms should make efforts to exploit opportunities of commercialization for initial growth. By securing profits by commercializing their technologies and providing services for basic R&D at the initial stage, they can achieve business progress. Fortunately, there are some bio-medical firms have entered the platform & service segment, which has the possibility for the growth of non-diversified

R&D firms, because of the ease of generating initial profits.

The third study in chapter 5 presented implications for survival in Korean bio-medical industry. First, it showed that firm exits resulted most commonly from bankruptcy rather than M&A, presenting a significant challenge that Korea (which is a latecomer to the bio-medical industry) should solve; in contrast, more firm exits resulted from M&As in advanced countries. Second, the property of the firm's origin involving entrepreneurs with career in other firm or spin-offs provides opportunistic elements for survival of the bio-medical industry in Korea. In the context of Korea, the number of new firms were established by entrepreneurs with career in other firm was much higher than that of other types of firm's origin. Thus, the managerial superiority of these bio-medical firms may be their strength in terms of survival. Spin-off bio-medical firms are the alternative organizational model in Korea, whose parent companies are medium-sized pharmaceutical companies and conglomerates. Third, business entry in the platform & service segment is another opportunity for their survival in the Korean bio-medical industry. In particular, platform & service firms are associated with a promising business model that reduces business risk and enhances financial performance through the formation of value networks. Moreover, this study suggested a viable alternative for growth in the biotechnology segment fused with ICT because Korea has a well-developed ICT industry (Avgerou, 2003). Fourth, Korean bio-medical firms make efforts to receive government R&D support for their survival, and sustainable R&D support from the government is also required for the survival of Korean bio-medical firms. This study particularly emphasized sustainable government R&D funding as a solution for the lack of private investment such as venture capital in government-led latecomers like Korea,

compared to the situation in advanced countries like the US (Wright et al., 2004). Fifth, this study argued that more manufacturing & marketing alliances are required for the survival of firms in the Korean bio-medical industry. This study showed that outbound or inbound manufacturing & marketing alliance, which directly ensures financial performance, could be an alternative solution for survival.

In sum, this dissertation provides managerial and policy implications for the Korean bio-medical industry according to the type of firm's origin and growth strategies. First, the firm's origin as input in strategic entrepreneurship in the Korean bio-medical industry could be novel resources and capabilities; further, it could sway strategic activities, performances, and further survival of the firm. Independent bio-medical ventures established by entrepreneurs from research organizations, those established by entrepreneurs with career in other firm, and corporate bio-medical ventures have different competitive advantages in terms of basic science knowledge, commercial knowledge and capabilities, and managerial support in the form of resources and capabilities from the parent company, respectively. Based on their different competitive advantages, they have different strategic activities and performances. Independent bio-medical ventures established by entrepreneurs from research organizations are classified into two distinctive groups: mature firms and immature, or infant firms. However, overall, they have a positive influence on technological innovation performance but a weak impact on generating financial performance; ultimately, they are likely to face bankruptcy. This overall result seems to be more prominent in the case of infant firms compared to mature firms. On the other hand, if infant firms make efforts to generate profits by innovating their business model based on commercialization (e.g., by commercializing their

technologies, providing support services for R&D and commercialization and fostering commercial knowledge), they would have enough growth potential in the Korean bio-medical industry.

Independent bio-medical ventures established by entrepreneurs with career in other firm have excellent technological innovation and financial performance through commercial knowledge and capabilities such as commercializing their technologies and business diversification; thus, they are able to prevent bankruptcy, ultimately. In Korea, where this is the most common type of firm's origin (Science and Technology Policy Institute of the Republic of Korea, 2013), this may be an advantage, providing excellent commercial knowledge and capabilities for the growth of bio-medical firms. Corporate bio-medical ventures that spun-off from parent company are also favorable to their growth. In the bio-medical industry in Korea, which has high technological and business risks, they are an alternative solution. They could play a role in incubating organizations, providing managerial consulting support and funding, etc. for their spin-off bio-medical firms. However, their technological competitiveness seems to be deficient; they need to strengthen their technological capability gradually in the long-term perspective.

Second, in the context of strategic entrepreneurship, internal growth strategies through vertical integration, business diversification, and business entry in the platform & service segment, and external growth strategies through government R&D funding and strategic alliance are important for the growth and survival of Korean bio-medical firms. Most mature bio-medical firms in Korea that have the highest technological innovation and financial performance are characterized by a high level of vertical integration and strong strategic alliances. Additionally, in the context of Korea, which is deficient in risk money

at the initial stage of founding, it is natural that Korean bio-medical firms would consider plan B to secure profit; bio-medical firms have tried to enter the food and cosmetic segment to expand their profit stream through the business diversification strategy. Moreover, bio-medical firms, which have been diversified from pharmaceutical companies and other biotechnology firms such as food and cosmetic, can serve as new engines of their growth. The business entry strategy in the platform & service segment is favorable to the growth of Korean bio-medical firms because it reduces business risk and rapidly achieves financial performance. In particular, this dissertation expects that the Korean bio-medical industry may have strength in the segment of biotechnology fused with ICT because of the well-developed ICT industry.

Further, Korean bio-medical firms actively work to connect with external organizations for their growth and survival. Above all, Korean bio-medical firms make efforts to receive government R&D funding. It is the cornerstone for the survival of bio-medical firms at the initial stage of founding in the context of Korea, which is lacks private investment. Public funding should induce private investment. However, this is difficult in the Korean bio-medical industry because of the long product development period and uncertain returns on investment. Thus, the government should subsidize for their business progress like R&D and commercialization until the firms can achieve sufficient growth to be attractive private investment. Finally, strategic alliances with other organizations such universities, hospitals, government-funded institutes, other bio-medical firms and pharmaceutical firms for R&D and manufacturing & marketing should be promoted in the Korean bio-medical industry. This dissertation found that R&D alliance has a positive influence on technological innovation performance and an indirect

influence on financial performance, although the effect of R&D alliance on survival was not confirmed. Further, manufacturing & marketing alliances were found to have a positive influence on financial performance and survival. Thus, Korean bio-medical firms should progress their own businesses through strategic alliance, depending on its motivation.

Recently, some Korean bio-medical firms have been challenging the global market with excellent technologies, products, and facilities. For example, firm V established by an entrepreneur from a university has successfully completed the phase 2 clinical trial to evaluate the safety and effectiveness of its candidate medicine for painful diabetic neuropathy compared to the placebo (control group) in 13 hospitals in different states, including Northwestern hospital and four hospitals in Korea, for 100 patients with painful diabetic neuropathy. Furthermore, the phase 3 clinical trial has been approved by the FDA. Similarly, firm S established by an entrepreneur from a university was certified by FDA the certificate its herpes virus (HSV) diagnosis kit based on real-time multiple molecular diagnosis technology. This is the first time that a domestic molecular diagnosis product acquired FDA approval. In addition, firm S, which is a subsidiary of a conglomerate, has been successfully operating its CMO business. They have signed a CMO contract for the 30,000-liter factory currently in operation and for a 150,000-liter second factory that will be built soon. Firm S also signed a long-term supply contract for biopharmaceutical ingredients with Merck, a global pharmaceutical company. These cases describe that there are possibility for growth of Korean bio-medical firms. Above all, Korean bio-medical firms should progress their business with entrepreneurial proactivity, and strategic management in their business that can transform their competitive resources and

capabilities into visible growth. This dissertation argued that "*strategic entrepreneurship"* is required for growth of Korean bio-medical industry based on the challenges and opportunities in both "*science business*", and "*Korean context*". Through results of this dissertation that three studies on strategic entrepreneurship in Korean bio-medical industry, they can worthily be used on decision process of Korean bio-medical firms and government policy makers.

6.3 Limitations and Future Research

Despite this dissertation's implications and contributions, there are some limitations that open avenues for future research. First, this dissertation was based on the complete enumeration of all the items in a collection of bio-medical firms in Korea. The STEPI data was used in this dissertation. Initially, the target firms were listed according to the biotechnology firms introduced in "Guide to Biotechnology Companies in Korea" published by the Korea Biotechnology Industry Organization in 2012. Subsequently, the bio-medical firms involved in government R&D projects were added using the database (DB) of the National Science & Technology Information Service. In addition, lists of target firms were added, referring to prior reports and lists of firms that participated in the conventions and exhibitions of the bio-medical industry, such as Bio-Korea. Along with this method for collecting data, the STEPI data provided a total of 2,441 target firms in operation from 1992 to 2012. Further, the biotechnology firms that specialized only in overseas import and distribution operations as well as foreign corporations were excluded. The final sample had 1,504 target firms. However, in the process of data integration about financial, patent, strategic alliance, government R&D funding, etc., over 200 target firms were excluded because of the lack of information. Therefore, it might be a greater number of bio-medical firms in Korean bio-medical industry. This was the result of the limitations on investigating venture-type and small-sized firms.

Second, this dissertation used proxies for firm's origin to measure the characteristics of the entrepreneurs and entrepreneurial firms. Generally, prior studies used the survey method for this purpose. This method has the advantage of including various criteria that can be quantified through questions, such as motivation of founding, leadership, and

technological and managerial capability. However, the STEPI data only involved information about the properties of firm's origin that was based on objectively observable data. Since small-sized bio-medical firms are highly distributed in Korea, their response rate through survey may be generally very low. Therefore, the STEPI data involved only information about the firm's origin to examine the career of entrepreneurs and the history of entrepreneurial firms from the DB of the Korean Enterprise Data. Nonetheless, the descriptions of the properties of entrepreneurs and entrepreneurial firms used in this study have clear limitations, compared to the survey method that includes various criteria. Therefore, future studies should include the survey method in parallel.

Third, although this dissertation described a variety of strategic alliance types and discussed their effects, it did not consider the strength of these alliances. The number of alliances was used as a proxy to examine the effects of strategic alliances on performances and survival. The size and the strength of alliances are important in nurturing firm's performance and surviving (De Man, 2005; Lee and Cavusgil, 2006). However, this dissertation could not consider their strength because of the limitation of the data. The strategic alliance data of STEPI was collected through a search of news items on various strategic alliance contracts reported by the Korea Biotechnology Industry Organization and the Biotech Policy Research Center. Though it has the limitation of depending on news searches, the strategic alliance DB seems to be close to complete enumeration, in that the news of two organizations is very comprehensive, and bio-medical firms actively announce media outlets. Nonetheless, it did not provide information about the strength of strategic alliances. Therefore, future studies would need a design of data collection that considers the strength of strategic alliances.

Fourth, this dissertation provided insufficient information about the object variables of technological innovation performance by using limited variables in Chapters 3 and 4. These studies measured patents as a proxy for technological innovation performance; the critical role of patents as a form of technological innovation performance in the bio-medical industry makes this a reasonable metric. Nonetheless, patents cannot completely reflect technological innovation performance in bio-medical firms. Kleinknecht et al. (2002) pointed out that proxies such as R&D intensity, patent quantity or quality, and new product announcements were available measurements of technological innovation performance. In addition, Cefis and Marsili (2005) described the different effects that product innovation and process innovation among technological innovation performances have on survival. Therefore, future work should use a variety of proxies that measure technological innovation performance in bio-medical firms more fully.

Fifth, this dissertation provided insufficient information about some variables in Chapters 3, 4, and 5 because of data restrictions. The variables of the numbers of employees and business areas that reflect the size of the firm and the level of business diversification are based on 2012 data and are specified as constants that do not change by year. Although the number of employees or business areas is unlikely to change annually, the firms' growth (or decline) or changes in business diversification strategies over time would affect the usefulness of the static values. Therefore, future studies would require supplementary data.

Sixth, this dissertation has a limitation regarding the clustering method in Chapter 4. Although the study identified the bio-medical firms' business models in Korea through a quantitatively clustering method, it is required a variety of methodologies for enhancing

validity of analysis. This dissertation used hierarchical clustering analysis with Ward's method. However, there are various distance measurement criteria and calculation methods. Therefore, to verify the validity and credibility analysis results future studies should compare a variety of clustering methods.

Seventh, the study in Chapter 5 is limited in that it did not account for the effects of private investment on firm survival. Many scholars, such as Lerner (1994), Gompers and Lerner (2001), Baum and Silverman (2004), and Pisano (2006) have emphasized the role of private investment like venture capital in the US. In particular, previous studies by Cooke (2001), Casper and Kettler (2001), and Prevezer (2001) pointed out that latecomers in the bio-medical industry should preferentially activate private investment. Though Korea practically lack of private investment, such as venture capital, compare to public (government) investments in the bio-medical industry (Casper, 2009), private investment in Korean bio-medical industry obviously exists. Therefore, if private investment as an external factor for firm survival is considered in future research, it may provide richer implications for public and private funding.

This dissertation hopes that these limitations will be solved through future studies. Solving these limitations will further help to grow Korean bio-medical firms, and enrich the managerial and policy implications for them.

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Abstract (Korean)

제약산업과 더불어 바이오의약산업은 전세계적으로 국가의 신성장동력으로 주목받고 있다. 다가올 바이오경제의 기대 속에 세계 각국은 바이오경제를 대비하기 위하여 준비하고 있다. 이러한 기대에도 불구하고 바이오의약기업의 발전은 바이오기술 고유의 특성으로부터 야기되는 연구개발에서부터 상업화에 이르기까지의 다양한 도전들이 존재한다. 이에 대하여 바이오의약기업은 내부적으로 연구개발집중적이면서 위험관리에 힘써야 하며 투자자, 정부, 대학, 병원, 타기업 등의 외부 이해관계자들과의 보완적 관계를 중요하게 고려해야 한다. 더욱이 바이오의약산업 후발국의 기업들은 글로벌 경쟁이나 산업생태계의 미흡으로 인해 선진국에 비해 기업성장에 더 많은 어려움을 겪는다. 그렇다고 후발국들이 산업혁신시스템이나 국가혁신시스템의 상이함으로 인해서 무조건 선진국의 전략을 모방해서도 안 된다. 그러므로 후발국의 바이오의약기업들은 반드시 그들의 성장을 위한 고유한 전략을 가져야만 한다.

본 논문은 바이오의약산업의 후발국 중의 하나인 한국의 바이오의약산업에 초점을 맞추고 있다. 한국의 바이오의약산업은 아직까지 소기업의 비중이 높고, 정부주도적으로 발전해온 특성을 갖는다. 또한 한국은 ICT 산업의 발달로 인한 바이오의약산업과의 연계성과 대기업 중심의 산업구조로 인한 독특한 발전이 기대된다. 이러한 한국 바이오의약산업의 특성은 창업부터 각 기업들의 고유한 경쟁우위와 성장전략을 고려하는 “전략적 기업가정신”이 필요하다는 것을 이야기 한다. 그 중에서도 특히, 본 논문은 전략적 기업가정신의 투입요

소로써 창업자나 창업팀의 특성, 프로세스로써 비즈니스 모델, 장기적 결과로써 기업생존에 대해 살펴보았다. 각 연구들을 위하여, 본 논문은 “한국의 바이오경제의 미래를 위한 국가전략”을 수립하기 위해 2013년도에 수집된 과학기술정책연구원의 바이오벤처 데이터베이스를 사용하였다.

제 3장의 첫번째 연구는 창업자나 창업팀의 특성이 한국 바이오의약기업의 전략과 성과에 미치는 차이점에 주목하였다. 특히, 연구조직에서의 경험을 가진 창업자와 모기업으로부터 스핀오프된 창업기업의 특성에 주목하였다. 이 연구는 연구조직에서의 경험을 가진 창업자에 의해 설립된 바이오의약기업이 더 높은 연구개발집중도와 더 많은 연구개발제휴의 특성을 보여주었고, 나아가 특허를 통해 살펴본 기술혁신성과 역시 우수하여 이들의 기술집중적인 기업특성을 발견할 수 있었다. 본 연구를 통하여 높은 연구개발집중도와 많은 연구개발제휴가 기술혁신성과에 미치는 직간접적인 효과를 확인할 수 있었고, 추가적으로 재무성과에 미치는 부정적인 효과를 확인하였다. 이러한 결과는 연구조직에서의 경험을 가진 창업자에 의해 설립된 독립기업이 아직까지 재무성과 창출에는 미흡하다는 것을 보여주었으며, 기업의 성장을 위하여 기술혁신뿐만 아니라 이들이 기술 상업화나 비즈니스 모델의 혁신을 통해 재무성과를 창출할 수 있도록 힘써야 한다는 것을 보여주었다. 특히 이를 위해, 상업화 능력을 고양하기 위한 기업가 또는 기업의 자체적인 노력과 경영지원을 위한 정책적 노력이 필요하다는 함의점을 주었다. 반면, 모기업으로부터 스핀오프된 바이오의약기업은 모기업으로부터의 자원과 능력의 지원으로 인해 생산 및 마케팅 제휴가 활발하였고 나아가 재무성과의 창출에도 긍정적인 영향을 주었다.

스핀오프된 기업의 모기업은 제약기업과 대기업으로 분류할 수 있었으며, 제약기업의 생산과 판매의 이점, 대기업 자본의 이점이 스핀오프된 기업의 차별화된 비즈니스 모델을 가능케 하였음을 확인하였다. 이러한 창업유형은 특히, 벤처캐피탈과 같은 모험자본이 부족한 한국적 상황에서 하나의 대안적 창업모델이 될 수 있음을 시사하였다. 덧붙여 장기적으로 이들이 성장하기 위해서 기술능력 제고가 필요하다는 함의점을 발견할 수 있었다.

제 4장의 두번째 연구는 한국의 바이오기업들의 비즈니스 모델의 유형을 확인하고 그들의 특성과 성과를 비교하고자 하였다. 비록 비즈니스 모델에 대한 정의가 다양하지만 비즈니스 모델은 수익창출을 위한 기업전략의 꾸러미로 협의적으로 정의될 수 있다. 따라서 본 연구에서는 기존의 문헌들에서 제공하는 기업의 가치사슬, 사업다각화, 연구개발제휴, 생산 및 마케팅 제휴의 정도를 비즈니스 모델 분류의 기준으로 고려하였으며, 클러스터링 방법을 통한 분석결과 한국의 바이오의약기업을 1) 강한 전략적 제휴를 가진 가치사슬 통합군, 2) 약한 전략적 제휴를 가진 사업다각화군, 3) 비다각화 R&D 기업군의 3가지 유형으로 분류할 수 있었다. 그 중에서 한국의 바이오의약산업에서 가장 경쟁우위에 있는 기업군은 강한 전략적 제휴를 가진 가치사슬 통합군이었다. 이들은 평균적으로 제품개발 이상의 가치사슬 통합도를 보였으며 활발하고 다양한 목적과 형태의 전략적 제휴를 보여주었으며, 기술혁신성과와 재무성과에서 타기업군에 비해 월등히 우수하였다. 둘째, 약한 전략적 제휴를 가진 사업다각화군은 평균적으로 두 분야 이상의 사업다각화도를 가지고 있었으며 연구개발과 마케팅을 위해 전략적 제휴를 활용하고 있었다. 이들은 상대적으로 연

구개발투자와 기술혁신성과에 취약하였지만 사업다각화를 통한 시장접근성 확보로 인하여 재무성과의 창출 측면에서 비교적 우수하였다. 이것은 모험자본이 부족하여 사업다각화를 통해 창업부터 수익을 고려해야 하는 한국 바이오의약기업의 특성을 잘 보여주고 있으며, 한편으로 제약기업들과 의약외 식품, 화장품 등의 타바이오기업들에게 바이오의약산업의 또 다른 성장경로가 될 수 있다는 것을 보여주었다. 마지막으로 비다각화 R&D 기업군은 한국 바이오의약산업에서 아직 사업초기 기업들의 존재를 보여주었다. 이들은 기초연구단계에서 단일한 사업영역을 가지고 있었으며 아직까지 전략적 제휴에도 취약했다. 특히, 이들은 연구개발강도나 기술혁신성과의 측면에서 약한 전략적 제휴를 가진 사업다각화군과 유사했지만 재무성과의 창출은 더 취약했다. 따라서 이들의 성장을 위한 전략과 정책적 지원이 더욱 절실하다고 보여진다.

제 5장의 세번째 연구는 장기적 성과의 차원에서 한국 바이오의약기업의 생존에 미치는 요소들에 주목하였다. 이 연구는 기업의 내적 특성으로써 기업경력을 가진 창업자와 모기업으로부터 스핀오프된 기업의 창업특성, 즉, 타기업으로부터의 창업특성과 플랫폼 & 서비스 분야의 특성을 고려하였으며, 환경에 대한 기업의 적극적인 전략적 선택을 강조하며 외적 특성으로써 정부의 연구개발 지원과 전략적 제휴를 고려하였다. 이러한 통합적인 관점으로부터 기업경력을 가진 창업자에 의한 창업특성, 플랫폼 & 서비스 분야의 특성, 정부의 연구개발 지원이 생존에 미치는 긍정적인 영향을 확인할 수 있었다. 하지만 예상과는 다르게 모기업으로부터 스핀오프된 기업의 창업특성과 전략적 제휴가 기업의 생존에 미치는 효과는 부정적이었다. 또한 전략적 제휴의 동기에

따라 생존에 미치는 영향을 분석해 본 결과 R&D 제휴가 기업생존에 미치는 유의미한 효과를 발견할 수 없었으며, 단지 생산 및 마케팅 제휴가 미치는 긍정적인 효과를 확인할 수 있었다. 추가적인 연구를 통하여 한국의 기업퇴출이 파산과 M&A에 의해 이루어지고 있으며, 파산이 M&A의 경우보다 많은 특성을 확인하였다. 특히 M&A의 경우, 대부분 성과가 좋은 피인수기업의 인수를 통해 인수기업과 피인수기업 두 기업간 시너지를 창출하고, 나아가 피인수기업에게는 투자회수의 기회를 주는 목적이었다. 하지만 인수기업이 성과가 좋지 않은 피인수기업을 통해 우회상장하려는 목적을 가지고 M&A 하는 경우도 소수 존재하였다. 따라서 본 연구에서는 우회상장을 위한 소수의 M&A 사례를 제거하고 시너지 창출 및 투자회수의 목적을 위한 M&A 사례를 분석대상에 포함하였다. 이와 같은 추가연구를 통하여 모기업으로부터 스핀오프된 기업의 창업특성과 생산 및 마케팅 제휴가 파산을 막을 뿐만 아니라 M&A를 촉진하는 효과도 있음을 발견하였다. 따라서 이 연구를 통하여 타기업으로부터의 창업특성과 플랫폼 & 서비스 분야에서의 비즈니스가 한국 바이오의약기업들의 생존률을 높여 줄 수 있는 기회요소가 될 수 있다는 것을 알 수 있었으며, 지속적인 정부의 연구개발 지원과 생산 및 마케팅 제휴를 통한 수익확보가 기업의 생존을 위해 필요하다는 함의점을 발견할 수 있었다.

요약하자면, 본 논문은 한국 바이오의약기업의 성장을 위하여 창업특성과 성장전략을 고려한 전략적 기업가정신이 필요하다는 것을 창업특성, 비즈니스 모델, 생존에 관한 연구를 통하여 보여주고 있으며, 각각의 창업특성과 성장전략이 비즈니스 모델의 구성과 성과에 미치는 영향을 통해 이에 따른 경영적,

정책적 함의점을 제시한다. 최근 몇몇의 한국 바이오의약기업들이 글로벌 시장에서 선전하고 있는 가운데, 각 기업의 창업특성에 따른 경쟁우위와 그것에 대한 적극적인 활용 및 도전, 한국적 상황에서 그들의 성장전략에 대한 본 논문의 함의점들은 한국 바이오의약기업의 성장을 더욱 가시화 시킬 수 있을 것이라고 기대한다.

주요어 : 전략적 기업가정신, 창업특성, 비즈니스 모델, 생존, 바이오의약기업

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