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The Innovative Performance Determinants in Biotechnology Industry's Joint Ventures

: Joint Ventures from 1976 to 2013

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Abstract

The Innovative Performance Determinants in Biotechnology Industry's Joint Ventures

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The main objective of this paper is to develop and empirically examine the determinants of formation and innovative performance in biotechnology industry's joint ventures measured by number of patents application. Author conducts empirical studies through negative binomial method to test the hypotheses from all biotechnology's joint venture cases. The combination of two unique characteristics of biotechnology's industry (long product development cycle, high R&D investment, low success rate) and joint venture (risky, uncertain, and high failure rate) questions the factors that drive the

establishment and innovative performance. So far, there has been no study questioning the appropriate quantitative measurement for innovative performance in the biotechnology's joint venture. This study brings together two bodies of literature. First, we will examine the factors that contribute to establishing joint venture and second, we seek to identify the factors that enhance or impede innovative performance in established joint venture in biotechnology industry. We argue that technology transfer, parent's business relatedness and prior alliance experience will have positive influence on the innovative performance, which is measured with number of patent count. These hypotheses will be tested using SDC Platinum, DataStream, and the USPTO. The sample covers 1023 joint ventures, which are all the biotechnology's joint venture established from 1976 to 2013. Amongst them, 699 successfully established joint ventures and 99 joint ventures issued patents to measure the innovative performance.

Keywords: Innovative Performance; Joint Venture; Biotechnology Industry, Patent
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Chapter 1. Introduction

1.1 Biotechnology Industry

The biotechnology industry is one of the most competitive and knowledge-intensive sectors in the economy. It is a highly volatile and unpredictable sector due to the scientifically intensive operations of companies that reside in this industry. Biotechnology has been on the rise since 1950s when genetics research first began to make significant process; however, it was not until mid-1970s that biotechnology became sufficiently advanced to allow the commercial development with the main goal of enhancing the quality of human life. Because the process of developing biotech products is very capital intensive with long research and development and approval cycles, many biotechnology companies partner with large firms to complete product development. As shown in Figure 1, for every 5,000 to 10,000 compounds discovered, only one of them makes it to the approval by the Food and Drug Administration (FDA), the primary regulatory of the biotechnology industry. It takes about ten to fifteen years to develop a single medicine from the time it is discovered to when it is available for treating patients. The average cost to research and develop each successful drug is estimated to be $800 million to $1 billion. Nonetheless, the investment in R&D continues to rise while the number of new drug approval fails to keep pace (Figure 2). Further, the patents of blockbusters have been expiring since the mid-2000s, bringing the crisis in the market status, financial stress, and R&D investment reduction (Figure 3). The patent expiry of several major blockbuster

drugs is worth $103 billion between 2009 and 2013 (DTIC Global Life Science and Healthcare Industry analysis of Global Generic, Cygnus).

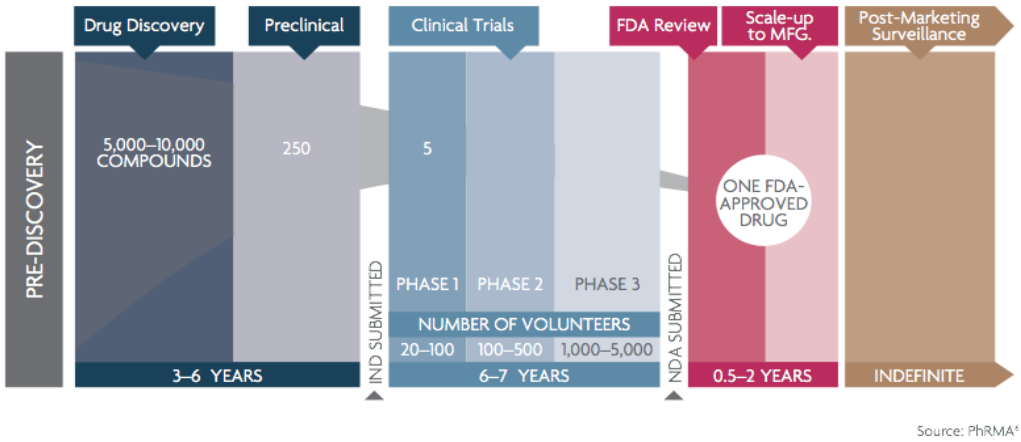


Figure 1. Product Life Cycle

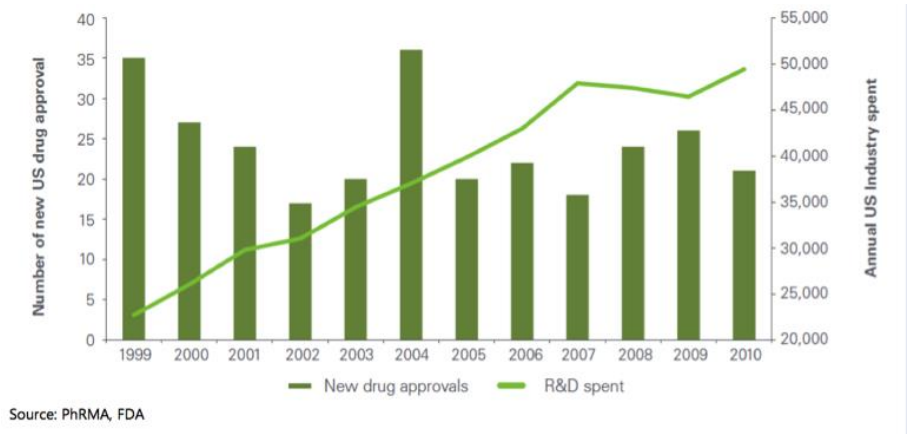


Figure 2. Growth Limits: R&D investment vs. Drug Approval

To deal with this problem, biotechnology industry tries to collaborate, partner, M&A to maximize the R&D efficiency. For example, Merck's sales were about 242 billion dollars in 2007 and 480 billion dollars in 2011, which increased the average by 18.7% annually. Merck has high R&D input ration to sales, compared to that of the other global pharmaceutical companies, which was more than that of 20%. However, even with the increase of the sales in 2011, the R&D input decreased to 17.6% (Table 1). This phenomenon also recurred in other global pharmaceutical companies as Pfizer, Novartis, etc. As a result, these companies decided to partner with academics and biotech companies for the purpose of developing novel drugs.

Therefore, to cope with this volatile, changing market and the new technological opportunities, companies are more prone to "open innovation". Traditionally, new business development processes and the marketing of new products took place within the company's boundaries which is defined as "closed innovation" (Chesbrough, 2003). On the contrary, due to the technological change and global competition, it has forced firms to search for external sources of knowledge through a wide variety of alliances (Hagedoorn and Osborn, 2002). Thus, the R&D process that was once performed in house is now organized through a network of technological alliances in order to reap the benefits of complementary skills and fast product development (Rothaermel and Deeds, 2004; Colombo et al. 2006). Since biotechnology is a field where all the relevant capabilities are rarely found under a single organization roof (Powell and Brantley, 1992),

participants cooperate to make up for their lack of internal capabilities (Powell, 1996). Moreover in biotechnology, significant resource and speed demands of patent races and commercialization motivate biotechnology firms to seek out partnership with other organization (Powell et al., 1996).

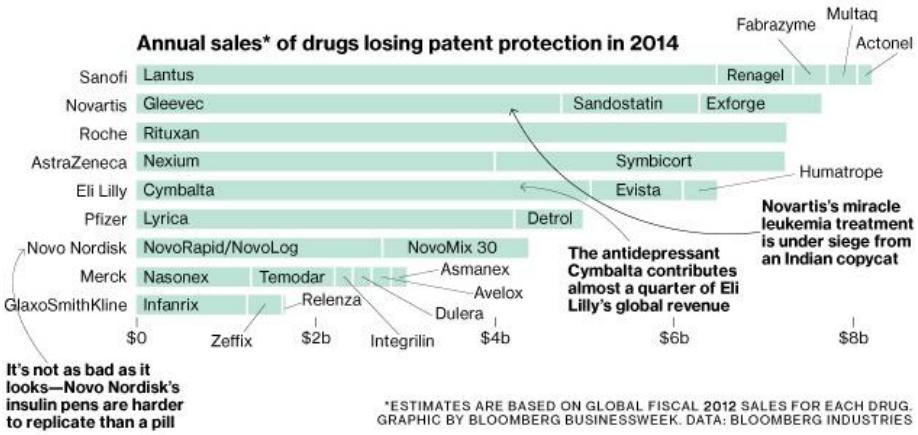


Figure 3. Annual sales of drugs losing patent protection in 2014

Table 1. Global Pharmaceutical R&D input, sales, net profit

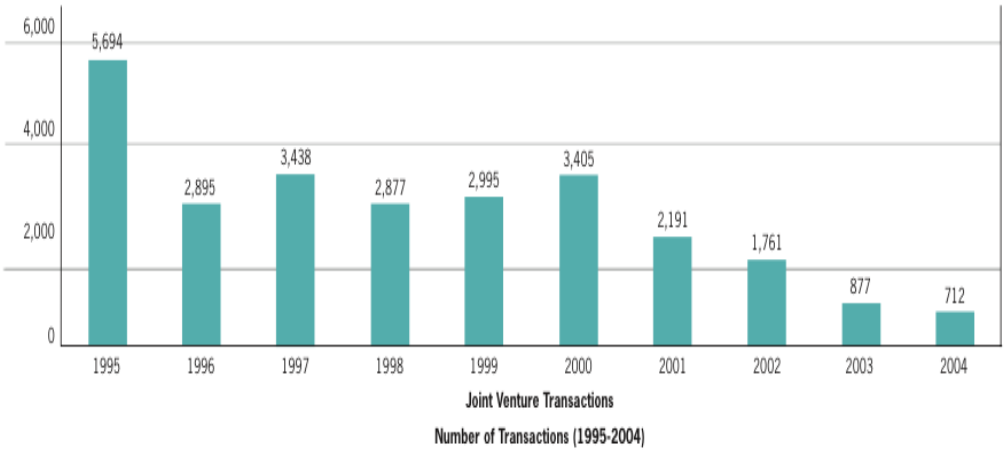
Company	Categories	2007	2008	2009	2010	2011
Pfizer	R&D input ratio	**16.7%**	**16.5%**	**15.7%**	**14%**	**13.5%**
	Sales	48,418	48,296	50,559	67,057	67,425
	Net Profit	8,144	8,104	8,635	8,257	10,009
	R&D input	8,089	8,104	8,635	8,257	9,112
Novartis	R&D input ratio	**16.9%**	**17.4%**	**16.9%**	**17.9%**	**16.4%**
	Sales	38,072	41,459	44,267	50,624	58,566
	Net Profit	11,946	8,159	8,400	9,794	9,113
	R&D input	6,430	7,217	7,469	9,070	9,583
Merck	R&D input ratio	**20.2%**	**20.1%**	**20.5%**	**23.9%**	**17,6%**
	Sales	24,198	23,850	27,428	45,987	48,047
	Net Profit	3,275	7,808	12,901	861	6,272
	R&D input	4,882	4,805	5,613	10,991	8,467
Sanofi-Aventis	R&D input ratio	**16.2%**	**16.6%**	**15.6%**	**14%**	**14.4%**
	Sales	38.454	40,550	40,866	42,939	46,491
	Net Profit	7,215	5,664	7,342	7,253	7,927
	R&D input	6,219	6,729	6,390	6,032	6,699

1.2 Joint Venture

While there are many different types of alliances that are "voluntary initiated cooperative agreement between firms" (Gulati 1999), this study focuses on joint ventures in biotechnology industries. Joint ventures are defined as "partnership in which two or more firms create a separate entity to carry out a productive economic activity and take an active role in its strategic decision making" (Harrigan, 1986). A joint venture is more formal than a contractual alliance that involves more commitment from the partners because they take an equity stake. Because joint ventures are organizationally interdependent, they have complex organizations and are difficult to manage. Therefore, companies tend to engage in such organizational modes if they see a long-term perspective and wide-ranging benefits (Hagedoorn, 1993).

Many Joint Ventures were formed during the 1980s and 1990s driven by regulatory barriers that restricted foreign ownership. To invest in some emerging markets, it was often necessary to have a local partner. Even in developed markets, restrictions on foreign ownership in certain industries encouraged joint ventures or strategic alliances instead of cross-border mergers and acquisitions. However, many of these barriers have been relaxed or eliminated, the corporate demand for joint ventures has also diminished (Turowski, 2005). This is depicted in Figure 4 that the peak year of joint venture formation activity was 1995, and since then its transactions have significantly decreased.

In addition, joint ventures have high failure rate compared to the other organizational mode. The predominant explanation for the high failure rate of young organizations is that their members have to learn new roles and routines at a time when the resources were scarce and stretched to the limit (Stinchcombe, 1965; Hannan & Freeman 1984). Since these factors take time to develop, new organizations such as newly established joint ventures tend to fail at higher rates than that of the older ones, the established firms (Singh and Lumsden, 1990).



Source: SDC Platinum

Figure 4. Joint Venture Activity: From 1995 to 2004

Technological joint ventures can be critical on high-technology industries due to the dynamic rate of technological development, product complexity, and the high cost of

product R&D (Teece, 1986). Hence, it is important to acknowledge that joint ventures are particularly prevalent in technology-intensive industries (Mowery et al. 1998). Among the various types of alliances, joint ventures are more likely to be in situations where alliance partners are faced with greater ambiguity, since a clear and well-specified contract is difficult and costly (Williamson, 1985). In sum, given that ambiguity and uncertainty exist high in technology-intensive situations (Mody, 1993; Pisano, Russo, and Teece, 1988), joint ventures tend to be a preferred choice (Anand & Khanna 2000).

1.3 Joint Ventures in the Biotechnology Industry

Biotechnology is a very difficult industry to define, drawing from fields such as protein, chemistry, molecular biology, and genomics. Biotechnology is not an industry per se but a collection of technologies that may be applied to many industries: medicine, agriculture, chemicals, veterinary science and waste disposal (Oliver, 2000). One of the universal characteristics of those firms involved in biotechnology is the extensive use of collaborative agreements, including joint ventures. This is due to the rapid changes in the underlying science and technologies of the industry.

Hence, biotechnology represents an industry and a field of technologies that spans many other types of businesses. Biotechnology is the most research-intensive industry and relies on a dense network of collaborative arrangements to access commercially valuable scientific knowledge and complementary commercial assets. (Richards and De Carolis, 2003).

1.4 Research Questions

The purpose of this research is to develop and empirically examine the determinant factors of innovative performance in biotechnology's joint venture measured by the number of patent applications. This study brings together two bodies of literature that have thus far been largely disjoint. First, we will examine the variables that contribute to facilitating the establishment of joint venture, whereas the second seeks to identify the factors that enhance or impede innovative performance in established joint venture in biotechnology industry.

A large literature addresses the issue of performance assessment, without offering much resolution. There has been a long history of struggling with the measurement of the innovative performance. Many previous studies use R&D inputs, patent counts, patent citations or counts of new product announcements as an indicator of the innovative performance. So far, numerous studies have been published that show how the patent has been used as an indicator of innovative performance in joint venture and biotechnology industry separately; however, there is no study regarding whether it can be the appropriate measurement in the biotechnology industry's joint venture. Throughout this study, the author investigates the determinants of innovative performance in biotechnology industry's joint venture measured by the number of patent application that is new and successfully established joint ventures issued. In essence, the author investigates whether the alliance between one or more participants transferring

technology, the parent company to the new established joint venture, produces a greater innovative performance output. Second, the author explores whether the parent company and the joint venture, if in the same industry, produce a greater degree of innovation output. Lastly, the author looks at the higher degree of innovative performance output resulting from the accumulated past experiences from alliance with other companies.

For information collection of joint venture activities, the author has used the SDC Platinum (Securities Data Company's online databases of financial transactions) from Thompson Financials provided by the LEREPS (University Research Centre in Toulouse, France). The sample covers 1023 joint ventures over the 1976.01.01 to 2013.12.31 period. The database provides information on the basic contractual terms in each alliance including heterogeneity, brief deal description, geographical origin of firms, the date of signing, number of parents and other elements that explicate the type of alliance (joint venture, R&D, licensing, manufacturing marketing, etc.).

The rest of this paper is organized as the following: Section 2 introduces related literature that reviews the topic of how technology transfer, degree of direct competitor, degree of previous alliance experience partners influence the innovative performance. Section 3 provides the methodology and explains the datasets used in this study. Section 4 discusses the results from the analysis and their possible causes or reasons. Finally, this paper ends with the conclusion and further study in Section 5.

Chapter 2. Literature Review

2.1 Patents as Innovative Performance

In a vast amount of economics literature, R&D input, sales, and patent are used as indicators of innovative performance. Amongst these, raw patent counts are generally accepted as one of the most appropriate indicators that enable researchers to compare the innovative performance of companies in terms of new technologies, processes and products (Archibugi, 1992; Acs and Audretsch, 1989; Aspden 1983; Bresman et al. 1999; Cantwell and Hodson, 1991; Cohen and Levin, 1989; Dosi, 1988; Freeman and Soete, 1997; Griliches, 1998; Napolitano and Sirilli, 1990; Patel and Pavitt, 1995; Pavitt, 1988). Even Arundel & Kabla, 1998 and Mansfield, 1986, which the authors are somewhat critical of the overall use of patents as a performance indicator, admit that patents can be an appropriate indicator in the context of many high-tech sectors.

While a simple patent count may not capture the difference between certain patents and not being a perfect measure of a firm's intellectual output, it is a widely accepted measure for innovation output (Griliches, 1990; Trajtenberg, 1990). Specifically in the biotechnology industry, the volume of patenting is shown to be an important dimension of intellectual capital (Smith-doerr et al. 1999). Patents not only represent measurement of technological novelty and innovation (Griliches, 1990) but also have a significant impact on a firm's operations; therefore, they may also serve as a measure of firm

performance (Scherer & Ross, 1990; Zaheer & Bell, 2005)

Despite their downsides of the measurement of innovation (Grant and Baden-Fuller, 1995), patents captured some of the firm's technological knowledge (Almeida, 1996; Liebeskind et al., 1996). Even though not all the knowledge contained in patents produced new products, some of these patents became an essential source of revenue when other firms licensed or purchased them, especially significant in the biotechnology's industry.

2.2 Technology Transfer

Technology Transfer has acknowledged that a substantial transfer of technology regardless whether tacit or explicit technology will positively leads to a higher potentials of innovation performance (Guan et al., 2006; Kotabe et al., 2007), enhances the competitive advantage (Liao and Hu, 2007; Rodriquez and Rodriquez, 2005), and advances the organizational learning effectiveness (Inkpen, 2000; Inkpen and Dinur, 1998).

Joint venture depends on the know-how or technology that cannot be easily codified and requires intimate human contract for exchange for the venture partners to appropriate firm-specific competitive advantages (Hamel et al. 1989). Porter and Fuller (1985) argue that joint venture involving technology transfer fails mostly because of opportunistic behavior that induces unexpected leaks of replicable firm-specific assets. Thus, a joint venture with a transfer of technology requires human contract in order to learn the know-how, which is not easily transferrable; hence, joint ventures involving technology transfer fail. Furthermore, the transfer of technology normally leads to asymmetric possession of information, and partners face difficulties in understanding what is transferred and how much is to be expected in return (Teece, 1980). Therefore,

Hypothesis 1. Joint Ventures are more likely to have higher performance when partners involve technology transfer in biotechnology industry.

2.3 Business Relatedness

Partner-to-partner business relatedness refers to the extent to which the parent companies in a joint venture are in a similar business. Higher levels of business relatedness allow firms to scrutinize with greater confidence the credibility of their partners' contributions and any opportunistic behavior (Alchian and Demsetz, 1972; Merchant and Schendel, 2000). Moreover, similarities in the business activities of the parent and the joint venture lead to economies of scale and scope by increasing learning opportunities and reducing production cost. Given similar strategic objectives and similar resource bases, a partner in similar business can identify and then assimilate another partner's know-how (Cohen and Levinthal, 1990).

Partners from similar industry or business area will lead firms to recognize similar interest in collaborating; thus they may have similar value chains and norms of behavior (Richards and De Carolis, 2003). Also, Kotabe and Swan, 1995 states that horizontal linkages among cooperating firms produce more innovative products. This is because knowledge misappropriation may be lessened due to the understanding and commonalities of the partner. Thus,

Hypothesis 2. Biotechnology's Joint Venture with at least one parent's business industry of same 283 SIC code is more likely to have higher innovative performance.

2.4 Prior Alliance Experience

Experience is defined by Merriam-Webster (2010) as 'practical knowledge, skill, or practice derived from direct observation of or participation in events or in a particular activity'. It is then reasonable to accept that if partners can implement any of this knowledge or skill from a previous encounter, then the potential of success will increase. By dealing with many alliance partners, firms learn how to manage partners from routines, systems, and the atmosphere of the relationship (Gadde, 2004).

Past or current relationships between the partners can be very influential, and through this insights can be gained such as knowing their strengths and weaknesses, greater understanding of skills and routines, having in-depth knowledge such as the firms' strategy, structure and operations. As the duration of interaction between the partners' increases, so does the likelihood of making the right partner selection. Finding partners with joint venture can be very useful, due to steep learning curve of the joint venture. It is expected that experiences and know-hows can be gained that are transferable to the future alliance.

Parent's prior alliance experience greatly influences the innovative performance of joint venture in biotechnology industry. To be specific, Sampson, 2007 emphasized that prior alliance experience positively influences the alliance patenting and increases innovative performance output afterward. It not only reduces adverse selection problems

in alliance formation, but also enhances communication and coordination. Moreover, there are better collaborative opportunities by signaling that they are attractive partners. Therefore,

Hypothesis 3. The degree of previous alliance experience is positively related to the greater degree of innovative performance in biotechnology's joint venture.

Chapter 3. Methodology

3.1 Sample Design

The study of joint ventures pose major difficulties in that it is not easy to fully capture the behavioral variables of joint venture activities because of their complexity and multidimensionality (Parkhe, 1993). This paper focuses joint ventures in biotechnology industry, limiting the SIC code to 283, regardless of the industrial origins of the parent firms. Within SIC code 283, there are 2833, 2834, 2835, and 2836 section which are medicinal chemicals and botanical products, pharmaceutical preparations, in vitro and in vivo diagnostic substances, and biological products, respectively except the diagnostic substances, (Table 2). Also we selected joint venture that was established from January 1976 and observed them through December 2013; thus, the period of observation was lengthy. Joint ventures that failed to establish after their initial announcements were excluded to determine the factors of innovative performance.

Table 2. Industry Distribution

Industry Code	Industry Definition: Chemical and Allied Products (28), Drugs (283)	Number of Observations
2833	Medicinal Chemicals and Botanical Products – (1) manufacturing bulk organic and inorganic medicinal chemicals and their derivatives and (2) processing (grading, grinding, and milling) bulk botanical drugs and herbs.	73
2834	Pharmaceutical Preparations – manufacturing, fabricating, or processing drugs in pharmaceutical preparations for human or veterinary use.	342
2835	In Vitro and In Vivo diagnostic substances – manufacturing in vitro and in vivo diagnostic substances, whether or not packaged for retail sale. These materials are chemical, biological, or radioactive substances used in diagnosing or monitoring the state of human or veterinary health by identifying and measuring normal or abnormal constituents of body fluids or tissues.	65
2836	Biological products, except diagnostic substances – the production of bacterial and virus vaccines, toxoids, and analogous products (such as allergenic extracts), serums, plasmas, and other blood derivatives for human or veterinary use, other than in vitro and in vivo diagnostic substances. Production of microbiological products for other uses and manufacturing in vitro and in vivo diagnostic substances are classified in Industry 2835.	220

3.2 Data collection

The sample set for this study consisted of panel data on the alliance and patenting activities in the biotechnology industry. Alliance data is retrieved from the Securities Database Corporation (SDC) Database on Joint Ventures and Alliances. Information on this database covers all types of alliances and is compiled from publicly available sources, including SEC filings, industry and trade journals, and news reports. This dataset is one of the most comprehensive sources of alliance information, and is the only source available for large-scale empirical studies on alliances (Anand and Khanna, 2000 and Sampson, 2004). Furthermore, strategic alliances within the field of biotechnology have taken a number of different forms, including collaborative R&D, licensing agreements and marketing or distribution agreements. The patent data for this research was drawn from the United States Patent and Trademark Office (USPTO) database, which is a comprehensive and publicly available database of US patents. Each year the USPTO issues over 150,000 patents to companies and individuals worldwide, and the patent database is viewed in the literature as both a common knowledge domain and an arena of technological competition for knowledge-intensive firms (Lin and Chen, 2005). We focused on patents collected in the United States because it represents the largest market for the biotechnology industry. Therefore, the firms generally patent in the United States before other countries (Albert et al., 1991 and Rothaermel and Boeker, 2008). Lastly, we collected data on firm size, sales and R&D expenses from the DataStream Thomson Financial database.

Our sample provides information on the basic contractual terms in each alliance including heterogeneity in alliance type (joint venture, R&D, licensing, manufacturing marketing, etc.), brief deal description, geographical origin of firms, the date of signing, number of parents. As shown in Table 3, in total of 1023 samples, letter of intent, completed/signed, pending, renegotiated, rumor, seeking to form, and terminated are included; however, not all 1023 samples were established successfully. Only 699 firms were successfully established and which categorized as the completed/signed and terminated which we used in this study. Terminated alliance was included because it implies that the alliance was once created. Amongst 699, joint venture is established and only 99 firms issued patent for us to measure the patent raw count.

Table 3. Joint Venture Formation Status: From 1976 to 2013

Status	Number of Cases	Percentage
Completed/Signed	653	63.8%
Terminated	46	4.5%
Letter of Intent	39	3.8%
Pending	280	27.4%
Rumor	2	0.2%
Seeking to form	2	0.2%
Renegotiated	1	0.1%
Total	1023	100

3.3 Definitions of Variables

3.3.1 Dependent Variables

Status of Joint Venture To identify the variables affecting the establishment of joint venture. Amongst total intentions and completions of joint ventures, 68% succeeded in completing and signing the joint venture which classified as 1 in the status, whereas classified as 0 if the samples had letter of intent, rumor, seeking to form but failed to do so. Table 4 depicts the definition of variables used in the equation as the following:

$$status = \beta_0 + \beta_1 X_{tt} + \beta_2 X_{b.rel} + \beta_3 X_{n.prct} + \beta_4 X_{mkt} + \beta_5 X_{lcs} + \beta_6 X_{mnf} + \beta_7 X_{cba} + \beta_8 X_{cbp} \quad \text{Eq. (1)}$$

Innovative Performance Here we focus our attention on patents, tracking only patents of joint ventures issued after the alliance was formed to determine the factors that influence innovative performance. We argue that if the output of the R&D is measurable by patent indicators, then patents, which are assigned to the joint ventures, should be good measurements of the innovative output resulting from the joint venture. This is because it is necessary that all the inventors involved make some contribution to the final invention to obtain a patent (Kim and Song, 2007).

Based on the prior studies, we assume that the average duration of an alliance is three years (Lavie and Miller, 2008), with two years dedicated to application of the patent before it was granted. In this case, the survival selection bias should be very small because the termination of joint ventures within the first 3 years is extremely rare. In addition, prior research has shown that, in high-technology industries, organizational memory depreciates rapidly, and the knowledge accessed from outside the firm may lose significant value within the approximation of five years (Argote, 1999). This study thus employs the number of patents granted in the period of t_i to t_i+5 as the factor of the firm's novelty creation, where t_i is the year that the joint venture was announced.

$$t5patent = \beta_0 + \beta_1 X_{tt} + \beta_2 X_{b.rel} + \beta_3 X_{p.exp} + \beta_4 X_{emp} + \beta_5 X_{mnf} + \beta_6 X_{age} \quad \text{Eq. (2)}$$

Table 4. Definition of Variables

Establishment of Joint Venture			**Innovative Performance of Joint Venture**		
Dependent Variables					
status	status of joint venture	establishment of joint venture (completed/signed & terminated) classified as '1' whereas other classified as '0'	t5patent	number of patent	Total number of patents joint venture issued within five years
Independent Variables					
tt	technology transfer	one or more than one participants transferred their core proprietary technology to the newly established joint venture	tt	technology transfer	one or more than one participants transferred their core proprietary technology to the newly established joint venture
b.rel	business relatedness	at least one of the participant's primary SIC code of 283 was classified as '1', whereas if none, classified as '0	b.rel	business relatedness	at least one of the participant's primary SIC code of 283 was classified as '1', whereas if none, classified as '0
n.prct	number of participants	total number of participants involved in the alliance from two to six	p.exp	prior alliance experience	classified as the number of previous collaboration
Control Variables					
mnf	manufacturing	'1' if the alliance is a manufacturing agreement	age	firm age	age from the joint venture was established
lcs	licensing	'1' if the alliance is a licensing agreement	emp	employee	number of participant's employee when the joint venture was established
mkt	marketing	'1' if the alliance is a marketing agreement	mnf	manufacturing	'1' if the alliance is a marketing agreement
cba	crossborder alliance	joint venture is formed multi-nationality			
cbp	cross border participant	where participants with different countries come together to form joint venture			

3.3.2 **Independent Variables**

Technology Transfer Alliance in which one participant transfer technology to another participant or to alliance

Business Relatedness Joint venture classified as having business relatedness with its parents when at least one parent has SIC Primary code of 283. If none, classified as unrelated.

Number of Parents Total number of participants involved in the alliance. In our database, minimum two to maximum six participants were involved.

Cross Border Alliance Joint Venture when alliance was formed cross-border.

3.3.3 **Control Variables**

Firm Age Firm age alters the organizational context in which innovation is produced. While a number of scholars assert that organizational competence improves over time (Hannan and Freeman, 1984; March, 1991), aging has also been seen as an impediment to effective innovation due to organizational inertia (Barron et al., 1994). On these grounds, this study considers the relationship between firm age and innovative performance, employing firm age as our control variable.

3.4 Statistical Method

Drawing from the absorptive capacity perspective, this study intends to explore the relationship between the biotechnology's joint venture and innovative performance, moderated by technology transfer, business relatedness, and prior alliance experience. The dependent variable in this study, the number of patents granted to the established joint venture is a countable variable, and takes only non-negative integer values. Prior studies asserted that the Poisson regression approach provides a natural baseline model for such data (Gilsing et al., 2008; Nooteboom et al., 2007). In our case, however, Poisson regression is not appropriate because of over-dispersion (Luo and Deng, 2009), and the underlying assumption of the Poisson model of equality of the mean and variance of the event count is thus likely to be violated, leading to inefficient Poisson estimates. Consequently, this study utilizes negative binomial regression to overcome the problem of over-dispersion (Luo and Deng, 2009; Wuyts et al., 2004). Wuyts et al. (2004) claims that the negative binomial regression model overcomes the problem of over-dispersion, and is an appropriate specification for the countable characteristic of the dependent variable, as well as the relatively large number of zeros, which is a natural outcome of the counting process.

As noted, the distribution of patents is highly skewed, with a preponderance of zeros and small values. Furthermore, patent citations data is count data that is measured in integers.

Chapter 4. Empirical Results

4.1 Data Analysis

Biotechnology joint venture's establishment history dates back to 1976. However until 1980s, biotechnology developed their product in-house, which resulted low rates of strategic alliance, including formation of joint venture. The establishment of joint ventures in biotechnology started to grow from the early 1990s and reached its peak in 1994; however, since then, it has been downhill. Also the failure rate of establishing joint venture has been continuously increasing (Figure 5). Moreover, biotechnology joint venture was established mostly in the United States and China, as demonstrated in the 225 and 144 cases. Also Europe and Asia showed a high rate of establishment of joint venture, compared to that of the other continents. (Figure 6)

From the correlation table presented in Table 5, it shows that the presence of technology transfer negatively impacts the patent applications issued within five years, while the participants' related industry and prior experience, number of employees, and firm age positively influence the patent applications issued within five years.

Table 5. Correlation (n=699)

Variables	1	2	3	4	5	6	7
1. t5.pt	1	-0.18586	0.052975	0.161395	0.177927	0.008394	0.003194
2. tt.yn	-0.18586	1	-0.16551	-0.10493	-0.08067	-0.07214	0.181037
3. mnf	0.052975	-0.16551	1	-0.05644	-0.09468	0.245701	-0.28041
4. rel.ind	0.161395	-0.10493	-0.05644	1	0.025078	-0.1701	-0.15916
5. p.exp	0.177927	-0.08067	-0.09468	0.025078	1	0.13477	-0.25585
6. emp	0.008394	-0.07214	0.245701	-0.1701	0.13477	1	-0.3395
7.age	0.003194	0.181037	-0.28041	-0.15916	-0.25585	-0.3395	1

Table 6. Descriptive Analysis

Variable	n	Mean	S.D.	Median	Min	Max	Skew	Kurtosis
t5.appn	62	28.758	66.165	8	0	354	3.491	12.083
tt.yn	699	0.243	0.429	0	0	1	1.195	-0.574
mnf	699	0.622	0.485	1	0	1	-0.5035	-1.749
rel.ind	699	0.740	0.439	1	0	1	-1.090	-0.814
lcs	699	0.0558	0.230	0	0	1	3.862	12.936
mkt	699	0.322	0.468	0	0	1	0.761	-1.423
p.exp	99	46.192	165.444	7	0	1448	6.883	51.894
emp	63	30716.03	47563.82	15490	88	254199	2.556	7.363
firm.age.q	99	18.010	6.561	19	1	37	-0.593	0.297

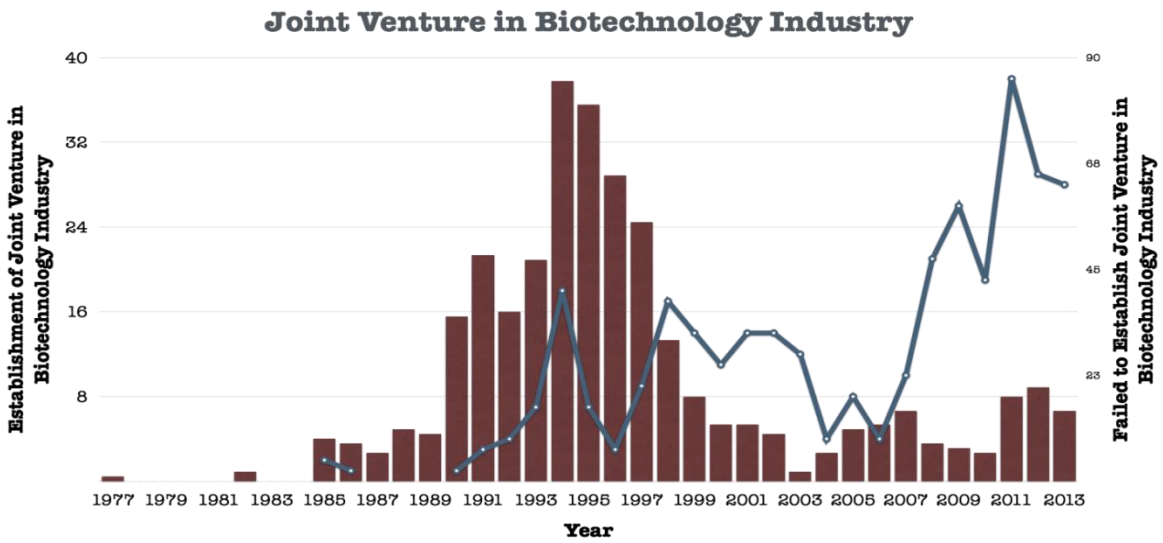


Figure 5. Joint Venture Formation and Failure in Biotechnology Industry

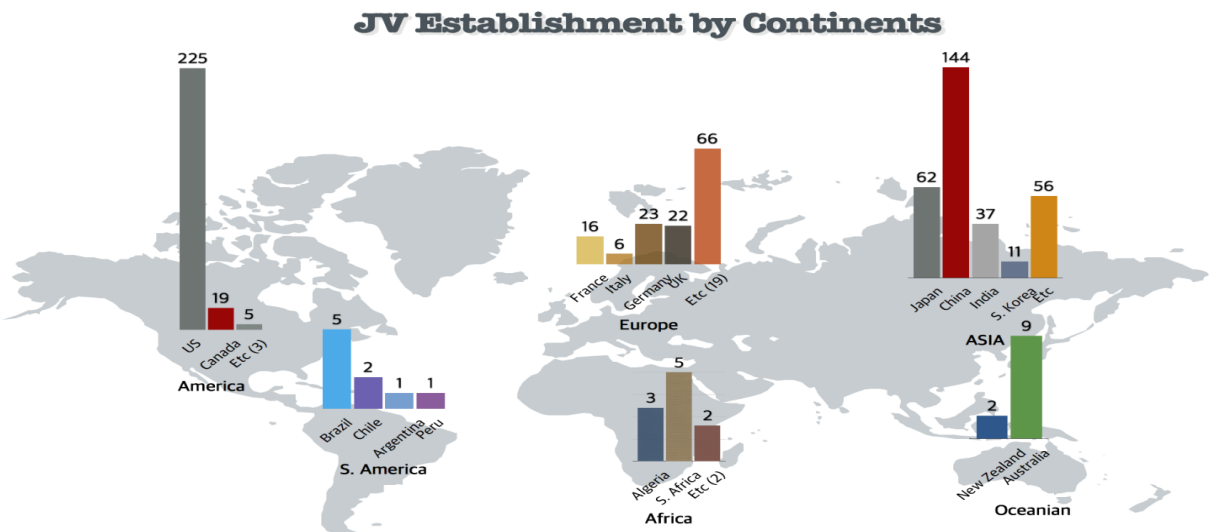


Figure 6. Joint Venture Formation by Continents

4.2 Establishment of Biotechnology Joint Venture

From 1976 to 2013, a total number of 1023 joint ventures cases were observed to identify the features that make the firms succeed in establishing joint ventures. Amongst total intentions and completions of joint ventures, 68% succeeded in completing and signing the joint venture, whereas others had intention to form but failed; the letter of intent is 39, pending is 280, rumor and seeking to form is 2 each. From negative binomial model, transfer of technology, cross border alliance, and marketing agreement positively contributed to the establishment of biotechnology's joint venture, whereas parents' business relatedness, cross border participant, and number of participants negatively influenced the establishment of biotechnology's joint venture (Table 7).

Table 7. Establishment of Joint Venture

Variable	N.B. GLM
Observation	n=1024
tt.yn	0.528 (0.124)***
rel.ind	-0.333 (0.110)***
n.prct	-0.141 (0.130)***
cba	0.524 (0.233)**
cbp	-0.227 (0.100)**
mkt	0.575 (0.108)***
lcs	0.043 (0.231)
mnf	-0.127 (0.091)
(Intercept)	0.779 (0.135)***
	AIC: 1202.8
	-2LogL: -570.1780

Significant levels: ***p<0.01; **p<0.05; *p<0.1

4.3 Determinants of Innovative Performance in Biotechnology's Joint Venture

To determine the factors that influence the innovation output measured by the number of patents, we performed negative binomial model. Amongst 699 joint ventures established from 1976 to 2013, only 99 joint ventures issued patent and joint venture that issued patents in the first five years is 39 joint ventures. This number of patent application may seem low. Nevertheless, compared to the worldwide patent application by field of technology; it is shown as very high percentage. However, through the generalized Tobit test (Table 8) which rho value is bigger than 0.1 we can conclude that this sample has no sampling bias, and that we consider only patent raw count that is bigger than zero. By evaluating 27 cases, it could be analyzed that when parents' businesses are related, parent's prior alliance experience, firm age, and manufacturing agreement have a positive impact on the innovation output (Table 9). Surprisingly, technology transfer has a negative impact on the innovation output.

Table 8. Generalized Tobit Test

Variable	Probit Part (Obs: 39)
p.exp	0.168 (0.120)
emp	-0.035 (0.112)
(Intercept)	0.380 (0.969)
Variable	**Probit Part (Obs: 27)**
tt.yn	-63.221 (34.613)*
rel.ind	40.494 (32.745)
p.exp	29.996 (22.266)
age	10.116 (3.731)***
mnf	83.886 (41.168)**
emp	-0.917 (8.429)
(intercept)	-244.742 (165.994)
σ	73.453 (10.075)**
ρ	-0.012 (3.024)

Significant levels: ***p<0.01; **p<0.05; *p<0.1. This table shows the results of the generalized Tobit model, which is used to investigate the determinants of the innovative performance in biotechnology's joint venture, where the dependent variable is t5: patent granted within 5 years. Rho is a test statistic for the error term: high Rho indicates the presence of a significant selection effect, which means the generalized Tobit model should be used rather than standard Tobit.

Table 9. Determinants of Innovative Performance in Biotechnology's Joint Venture

Variable	N.B. GLM
Observation	**n=27**
tt.yn	**-1.438 (0.486)*** **
rel.ind	**0.828 (0.464)***
p.exp	**0.670 (0.173)*** **
age	**0.210 (0.054)*** **
mnf	**2.050 (0.591)*** **
emp	**-0.159 (0.106)**
(intercept)	**-1.803 (1.490)**
	AIC:255.1
	-2LogL: -239.097

Significant levels: ***p<0.01; **p<0.05; *p<0.1

Chapter 5. Discussion

Through this study, we investigated two research questions: 1) determinants that influence the establishment and 2) innovative performance of biotechnology joint venture from the first formation biotechnology joint venture up to 2013. However, due to the high failure rate of joint venture and long product development cycle and high investment cost of biotechnology, measuring raw patent count as an indicator of innovative performance is questionable. In fact, the number of patents per se does not necessarily indicate the technological and economic value of the patent portfolio. This is an issue that deserves further investigation, including a deeper analysis of the technologies involved and their impact on the value chain of the company.

The research sought to solve the given problem statements, which are when joint venture is likely to be formed and the determinants of innovative performance in biotechnology's joint venture by looking back into the first establishment of joint venture from year of 1976 to 2013.

5.1 Variables of Establishment of Joint Venture

Factors that attract the formation of joint venture in biotechnology industry was investigated. Presence of technology transfer, cross border alliance, and marketing agreement positively affect the successful establishment of its joint venture.

Technology Transfer has to acknowledge that a substantial transfer of technology regardless whether tacit or explicit technology will positively lead to a higher potentials of innovation capabilities in in establishing biotechnology's joint venture. Also, when two parents come together, they are more likely to achieve their objectives (Garcia-Canal et al., 2003). In sum, when a biotechnology chooses its partner, technology transfer may seem as a very attractive factor for having their own core proprietary technology; however, in terms of innovative performance, it hinders the performance as we have conducted and analyzed in the second research questions.

Cross border alliance promotes the establishment of joint venture because of the attractiveness of newly formed joint venture in multiple markets. Also, it creates economies of scales and critical mass, reduce risks,

learn new skills and technologies, and facilitate effective resource sharing (Bleeke & Ernst, 1993; Harrigan, 1988; Slocum & Lei, 1992; Yip, 1992). Although nationality alone cannot fully capture cultural values, national boundaries delineate the legal, political, and social environments within which organizations and workers operate (Ronen & Shenkar, 1985), hence, forming a joint venture is favorable.

We found that marketing agreements have more relationships with the formation of joint ventures than that of the manufacturing agreements. This finding can be explained by the nature of the biotechnology industry. Joint venture partners may agree to discover and develop a new product, and then at some point market that product together, but separate the manufacturing (Arora and Gambardella, 1990; Daly, 1985). Thus, marketing agreement may seem attractive in establishment of biotechnology joint venture.

In contrast, participants' business relatedness, higher number of participants and cross border participants negatively impact the establishment of joint venture. Business relatedness seems unfavorable in joint venture

probably because a company tends to form joint venture when they lack internal capabilities. However in reality, this is driving force of innovative performances. Thus, when looking for innovation, parent should see for related business industry. Also, a greater number of participants involved in joint venture formation negatively triggers the establishment due to possible problems of communication and decision making conflicts. Therefore, a smaller number of participants' involvement is recommended. Lastly, cross border participants hinder due to cultural differences in communication and business practices.

5.2 Determinants of Innovative Performance

In the second part of the research question, three hypotheses were testified with negative binomial regression model to identify the determinants of innovative performance measured by number of patent. In our study, *H2* and *H3* were proven to be successful while *H1* was rejected (Table 10).

Table 10. Summary of Results

Hypotheses	Result
H1. Joint Ventures are more likely to have higher innovative performance when partners involve technology transfer in biotechnology industry.	Not Supported
H2. Biotechnology's Joint Venture with at least one parent's business industry of same 283 SIC code is more likely to have higher innovative performance.	Supported
H3. The degree of previous alliance experience is positively related to the greater degree of innovative performance in biotechnology's joint venture.	Supported

H1 was, *Joint Ventures are more likely to have higher performance when partners involve technology transfer in biotechnology industry*. Based on the result, joint venture involved in technology transfer negatively affects the innovative performance. Despite the fact that transfer of technology may bring tacit knowledge to the newly formed joint venture, Porter and Fuller (1985) argue that joint venture involving technology transfer fails mostly

because of opportunistic behavior that induces unexpected leaks of replicable firm-specific assets. Also, a well-recognized problem area within a joint partnership of high technology firms is that much of the technological capability is not easily transferrable from one partner to another. This occurs simply because the successful implementation and operationalization of most technologies depend a great extent on the built-up experiences and expertise of critical personnel such as key scientists, engineers, equipment operators, suppliers, and the like. Much general knowledge is explicit in nature, easily documentable and retrievable through formal written media. The ways in which interdependent technologies are "fine-tuned" to work effectively within a complex system, however, are much more tacit or "sticky" in nature, relying on the overall experiences, skills, and understandings that have been learned over time and internalized, perhaps even subconsciously, by those who actually "work" the system (Nonaka and Takeuchi, 1994; Hippel, 1994)

H2 is *Biotechnology's Joint Venture with at least one parent's business industry of same 283 SIC code is more likely to have higher innovative performance* was the second hypotheses. The result indicates that *H2* is plausible. It can conclude that when similar businesses come together,

less control is needed, reduces production cost, requires low level of knowledge transfer, and increases learning opportunity which in return increases the innovative performance. However, it is notable that the business relatedness does not significantly impact the innovative formation nor as did in the formation of joint venture in biotechnology's industry. Lastly, with the H3 which is *The degree of previous alliance experience is positively related to the greater degree of innovative performance in biotechnology's joint venture,* was also proven to be true. . The result showed great impact of how a parent's experience they had in previous years shows the performance in this joint venture. It is because it reduces adverse problems and enhances communication and coordination learnt from the prior experience. Therefore, by the grouped analyses, the study has delivered the important factors that contribute to the formation and to the innovative performance of joint venture in biotechnology.

In order to address the question, in-depth survey was carried out to understand and help broaden knowledge within the joint venture in biotechnology industry. The uniqueness of the biotechnology's joint venture is that intellectual property (IP) ownership is not always necessary to create a

competitive advantage in biopharmaceutical industries. Joint ventures aim to generate value in progressive products along the drug development process by licensing them out to pharmaceutical or top tier biotechnology companies or take them straight through to commercialization or form additional joint venture for a specific purpose such as one product with another partner. However, the high cost of commercialization makes it unlikely that any new, small firm can succeed on its own and thus the initial research and innovation developed by the smaller firms is transferred to their larger counterparts in most of the partnerships (Segers, 2013).

5.3 Limitation and Further Study

This study sought to fill the gap of measurement of innovative performance in biotechnology's joint venture. Due to special characteristics of joint venture compared to those of other strategic alliances and biotechnology industry in other industries, measuring raw patent count as innovative performance is insufficient. In order to solve this limitation, more appropriate measurable indicators should be proposed to accurately measure the performance in this industry. In order to do so, more variables such as sales, R&D input, employee numbers, or patent citations, etc. must be provided and applied to the methodology. Despite the fact that the database we used, SDC Platinum, is the world's foremost financial transaction database, obtaining joint venture's basic company information was difficult. Hence, there is a need to examine the nature, quality, and duration of biotechnology's joint ventures in theorizing about their effect on a firm's innovative performance.

By acknowledging the importance of formation of joint venture in biotechnology in facilitating the innovative performance, the government should also fully recognize and understand the difference of joint venture in

biotechnology to support and increase its formation and provide joint venture's information to the researchers to maximize its innovative performance. Moreover, primary purpose of joint venture is not focused in the ownership of patent like the other joint venture should be recognized. Corresponding to Hypothesis 2, despite the fact that governments strive for creative economy by creating partnerships among variety of industries, governments should foster biotechnology's joint venture to partner with related business first and then with others, accordingly. Also, for Hypothesis 3, we can derive that companies seeking for innovative performance should engage in establishing more joint ventures due to the existence of learning curve.

This research has emphasized the determinant factors that contribute to the formation of joint venture in biotechnology and to the innovative performance by measuring raw patent count as an indicator. Thus, this research has only provided one measurable aspect of innovative performance; using the patent. For future research, further examination with effort and dedication with other measurable variables of indicators is necessary for it

will contribute to not only biotechnology industry, but also the world as a whole.

Appendix 1. Motivations for Joint-Venture Formation

A. Internal Uses
1. Cost and risk sharing (uncertainty reduction)
2. Obtain resources where there is no market
3. Obtain financing to supplement firm's debt capacity
4. Share outputs of large minimum efficient scale plants
    a. Avoid wasteful duplication of facilities
    b. Utilize by-products, processes
    c. Shared brands, distribution channels, wide product lines, and so forth
5. Intelligence: obtain window or new technologies and customers
    a. Superior information exchange
    b. Technological personnel interactions
6. Innovative managerial practices
    a. Superior management systems
    b. Improved communications among SBUs
7. Retain entrepreneurial employees

B. Competitive uses (strengthen current strategic positions)
1. Influence industry structure's evolution
    a. Pioneer development of new industries
    b. Reduce competitive volatility
    c. Rationalize mature industries
2. Preempt competitors ("first-mover" advantages)
    a. Gain rapid access to better customers
    b. Capacity expansion or vertical integration
    c. Acquisition of advantageous terms, resources
    d. Coalition with best partners
3. Defensive response to blurring industry boundaries and globalization
    a. Ease political tensions (overcome trade barriers)
    b. Gain access to global networks
4. Creation of more effective competitors
    a. Hybrids possessing owners' strengths
    b. Fewer, more efficient firms
    c. Buffer dissimilar partners

C. Strategic uses (augment strategic position)
1. Creation and exploitation of synergies
2. Technology transfer
3. Diversification
    a. Toehold entry into new markets, products, or skills
    b. Rationalization of investment
    c. Leverage-related owners' skills for new us

Chapter 6. Bibliography

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국문 초록

본 연구에서는 바이오산업의 합작회사의 혁신역량 결정요인에 대해서 탐구하였다. 바이오산업은 높은 R&D 투자비율에 비해서 긴 제품개발주기와 낮은 투자성공률을 가지고 있다. 이러한 산업 불확실성을 극복하기 위해서 많은 기업들이 합작회사를 설립하고 있지만 실패하는 경우가 많다. 선행연구에서 바이오산업의 합작회사 혁신역량에 미치는 요인에 대해서 질적 연구 중심으로 수행되었지만 이에 대한 정량적인 연구는 없었다.

연구에서는 SDC Platinum 데이터를 바탕으로 1976년부터 2013년 사이에 설립된 바이오산업의 모든 합작회사들을 대상으로 하고 있다. 합작회사의 설립단계에서 어떠한 변수들이 성공적인 설립에 영향을 미치는 지 분석한 후에 이들 설립된 회사들의 혁신역량 결정요인을 분석하였다. 또한 핵심역량은 합작회사 설립 후 5년간 출원한 특허를 가지고 측정하였다. 총 1,023개의 바이오산업 합작회사 중에서 성공적으로 설립된 합작회사 699개이며 이들 회사 중 설립 후 5년간 특허를 출원한 기업은 99개이다.

연구결과, 기업설립 시점에서 모 회사로부터 기술이전을 받는 경우와 다국적 합작회사인 경우, 그리고 마케팅 목적의 합작회사일 경우들은 합작회사의 설립에 긍정적인 영향을 미치는 것으로 확인된다. 반대로 합작회사와 모 회사와의 산업분류가 동일한 경우와 합작회사의 모회사가 많은 경우, 국외(Cross border) 참여자일수록 부정적인 영향을 미치고 있었다. 혁신관점에서는 모회사로부터 기술이전을 받을수록 부정적인 영향을 미치고 있으며 모 회사가 합작경험이 많을수록 그리고 모 회사와 합작회사의 산업분류가 같을수록 합작회사의 혁신역량에 긍정적인 영향을 미치는 것을 확인하였다.