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Relationship between R&D co-development and knowledge creation-The moderating role of licensing behavior

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Abstract

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For the pharmaceutical industry, where the acquisition of external knowledge is very important in knowledge creation, this study investigated the moderating effect of the utilization of licensing, a unilateral relationship, on the knowledge creation of R&D co-development, a bilateral relationship. The results showed that pharmaceutical firms that properly utilize external knowledge through licensing contracts had larger knowledge creation compared to firms that only utilize R&D co-development with large organizational learning effects and risks. The study was carried out using licensing contracts, R&D co-development, and the data of new FDA-approved medicines targeting the top 100 global pharmaceutical companies for the past 20 years (1995 to 2015). Licensing contracts showed slightly significant moderating effects in the correlation of R&D co-development and knowledge creation

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TABLE OF CONTENTS

Introduction

Nowadays, companies in the high-tech industry not only generate knowledge internally but also proactive receive the same from external sources. Companies absorb knowledge of diverse subjects from various avenues such as mergers and acquisitions (M&As), alliances, licensing, and joint ventures (JV).

Remaining innovative by relying only on internal knowledge creation has become very challenging, especially for the knowledge-intensive industry. The pharmaceutical industry is a typical example. As the terms of patents on some of the best selling drugs that generated huge revenue in the past have expired, active utilization of external knowledge has emerged as the most critical factor in the innovation and growth practices of pharmaceutical companies with regard to the development of new medicines. The pharmaceutical industry is, arguably, the leading industry in which markets for technology have rapidly grown and are actively utilized (Arora and Gambardella, 2010).

According to most research findings until now, there is a greater likelihood of the avoidance of absorption of external knowledge as R&D productivity increases or when the production functions become more complementary with R&D, as is the case in the

high-tech industry. On the contrary, recent research results show that if such a high-tech industry's internal R&D productivity declines, the marginal value of downstream assets that have a close, complementary relationship with the existing R&D also decreases. Therefore, this leads to the promotion of external knowledge absorption (Ceccagnoli et al., 2010).

First, there is a need to clearly define licensing and joint development because these terms have different connotations in every industry. For instance, for some, the meaning of licensing is limited to the extent that a licensee is allowed to produce goods in his or her area by purchasing the patent given for mere technologies. Further, joint development refers to autonomously producing, and later combining, each component (for example, a fuselage) of a product that comprises several components, rather than jointly conducting research on a product (the Airbus case). However, especially in an academic sense, licensing denotes an activity where a licensor transfers technology to a licensee in lieu of licensing fee, and joint development refers to an activity that creates knowledge through joint R&D, not just by combining parts (Leone et al., 2012). Furthermore, licensing has theoretical significance because it is the most efficient means to absorb external knowledge in terms of time and R&D costs. This is because a licensee, apart from receiving technology, can have the fastest and the easiest access to a licensor's knowledge.

An R&D alliance is one of the representative external knowledge

acquisition methods in alliances, which is the most important element in alliance execution, and at the same time, it is the most commonly used measure in gaining external knowledge. Companies considering external knowledge acquisition are at the crossroads between licensing and R&D alliance since weaknesses could exceed strengths, as mergers and acquisitions for knowledge acquisition could entail significant integration problems along the process. An R&D alliance can promote exposure to and absorption of a variety of external knowledge by companies, ultimately helping to achieve a high level of innovative results (Lin et al., 2012). Among various theories, such R&D alliances can be best explained by the RBV and TC theories. The RBV theory refers to companies seeking strategic partnerships through an R&D alliance to share insufficient resources, and the TC theory suggests that companies choose strategic partnerships to minimize transaction costs. Although there are many kinds of R&D alliances, we defined an R&D alliance as joint development or joint R&D that constitutes the most significant constituent of alliance execution.

R&D alliances and licensing are the most commonly executed alliance types, especially in the knowledge-intensive industry. According to SDC platinum, R&D alliances account for more than 70% of several alliance measures, and many research results portray the positive relationship between R&D alliances and R&D performance as an empirical relationship. Ahuja (2000) suggested that R&D alliances “serve as sources of resources and

information," and that R&D alliance activities have a positive relationship with a company's patent and innovative activities. Moreover, Baum et al. (2000) verified that the more R&D alliances biotech venture companies have formed, the more innovative results they have produced. As for licensing, many research findings empirically supported that it has a positive effect on R&D performance (Fosfuri, 2006; Leone et al., 2012).

Many studies also suggest that licensing can improve innovation speed and, furthermore, eventually enhance companies' absorptive capacity as well. On the negative side, however, there are research results that if companies depend too much on licensing, their ability to develop new products may be impeded later on because causal ambiguity in independent new product development may hamper learning (Mulotte et al., 2013).

Existing studies have analyzed the large positive impact of joint R&D development on knowledge productivity from a variety of perspectives. However, according to a REDCap report, a wide variety of relationships, in addition to the commonly used joint development, are being used for external knowledge acquisition. In particular, in recent years, the use of licensing agreements is growing exponentially; this is because it is impractical for R&D divisions at multinational pharmaceutical companies to conduct research in all areas, as new drugs continue to become increasingly segmented and specialized. In the face of the rising number of joint R&D research projects and licensing agreements,

existing studies show clear limitations by not reflecting this reality. In addition, theoretically, high-tech corporations acquire external knowledge using several methods simultaneously; however, by analyzing the relation between one of the methods and research productivity, existing studies demonstrate a large gap in their assumptions. Thus, the existing studies demonstrate the significant logical weakness of pharmaceutical companies that overlook intermediate stage licensing by hypothesizing R&D co-development scenarios that occur within the context of joint knowledge creation to be 0 or 1.

My research topic originated from the following academic interest, that is, the root of my interest can be found in the following research question: given the reality that licensing agreements are used in conjunction with joint R&D to acquire external knowledge, what impact would utilizing these two methods as separate theoretical elements have on research productivity?

Literature Review

A great deal of research has proven the strong correlation between joint R&D and research productivity. Several theories exist as to why the mutual relationship joint R&D has a strong correlation with productivity, compared with other forms of external knowledge acquisition. The most well-known study is

by Roathmelar et al., who state that social capital is an important driver. Joint R&D, which is partnership-based rather than contract-based, requires a relatively high level of trust, given the long time period required to develop new drugs. Joint R&D requires the exchange of technology, knowledge, and R&D manpower over this long period of time; therefore, in the absence of a high level of trust, it will inevitably fail. In addition, countless examples exist where, despite a high level of effort and the many hours spent, joint R&D relationships are terminated because of lack of a certain level of trust, and as a result, critical manpower and hours are wasted. Therefore, while the achievements of successful joint R&D may be large, given the high level of risk associated with it, a high level of trust is required.

Other research indicates that the ongoing learning from joint R&D is a key driver to producing positive research productivity. Rather than being a one-way learning environment, joint R&D allows for two-way, in-depth learning, permitting parties to learn from each other. Therefore, a correspondingly high level of learning is required for joint R&D success. Joint R&D that lacks a high level of learning faces a relatively high risk of failure.

As seen above, R&D alliance has many positive effects on innovation performance in terms of R&D productivity. However, we also need to consider its many challenges. Information asymmetries, opportunistic behaviors, and/or even knowledge

leakage could occur. Many companies have tried to minimize the side effects by narrowing the scope of either equity-based alliances or R&D, but doing so has inherent challenges. They have been suffering from knowledge outflow rather than inflow, and while controlling the leakage, they have not been able to maximize the impact of their R&D alliance. Furthermore, research indicates that for companies with a stronger centrality of alliance networks, business performance is more likely to be swayed by the ratio of outflow rather than that of inflow. In other words, it should be remembered that R&D alliances aimed at external knowledge acquisition could boomerang on technology-led companies and cause them serious damage. For global pharmaceutical companies, R&D alliances could be a golden egg laying goose but should be approached with caution (RKD thesis citation).

In view of the above, accepting external technologies through licensing could be a better alternative for companies to combat information leakage. However, in the initial stage, accepting external knowledge could give rise to strong opposition from employees. This is called NIH (Not Invented Here) syndrome, signifying a phenomenon of opposing external knowledge, not created internally. A cooperative creation of knowledge through R&D alliances could become more active if licensing can eliminate the disagreeable sense of using external knowledge. Nonetheless, it is true that licensing has less effect on a company's R&D productivity or learning than R&D alliances.

The results from existing research ascertained that the knowledge gained from acquisition and that from licensing complement each other. Although the existing research did not go any further than showing that both knowledge acquisitive behaviors are helpful in increasing R&D productivity, the significance of this study lies in the fact that the acquisition of external knowledge through various methods, not just one method, can be conducive to organizations' innovation. This study has substantiated that a joint adoption of the two measures does not impede the efficiency of knowledge acquisition by other methods. By extending the preliminary research of J. Walter, the findings of this research proved that knowledge acquired from alliances and licensing is complementary. This study also provides the reasoning that problems in alliances can be solved by undergoing a one-time licensing process.

Despite the observed facts, there were no studies that conveyed the relationship between licensing and alliances. Recent empirical studies that involved a context analysis of the messages from the CEOs of those companies that are actively absorbing external knowledge proved that among the many modes, licensing and R&D alliances display the maximum similarity of purpose. It was quite surprising that there had been no significant research aiming to substantiate the relationship between these two modes, which can be compared to the two sides of the same coin. That provided me the starting point of my research.

My research has maily three theoretical contributions. At first, it is not independent, but dependent and simultaneous action. Studies on alliances have mostly been carried out focusing either on their formation or on execution. In particular, research on formation has focused on what characteristics can increase the likelihood of alliance formation with others. An underlying assumption of the research on R&D alliance formation is that if companies chose the policy of alliance to absorb external knowledge, their considerations would boil down to whether they opt for R&D alliance or not. According to actual cases and various theses, however, companies consider R&D alliance, licensing, and acquisition concurrently when absorbing external knowledge. In particular, mergers and acquisitions require extremely careful judgment because of numerous integration and financial problems. Hence, there is no choice but to consider licensing and R&D alliances simultaneously. However, the research so far has addressed these two measures in parallel aspects. In reality, companies do not exclusively choose only one of these measures. Most companies adequately and simultaneously utilize both measures. Therefore, existing studies that postulate that companies can use either of the two measures independently to acquire external knowledge represent inadequate research.

As such, licensing and R&D alliances are among the primary methods in gaining access to external knowledge. Nonetheless,

the studies so far have focused on the respective factors that determine each behavior. That is, they saw them as a two independent behaviors. However, companies' external knowledge acquisition behaviors do not consider licensing and R&D alliances to be mutually exclusive. By establishing that the knowledge gained from licensing and the knowledge acquired from M&As are complementary, Ceccagnoli et al. (2008) proved wrong the preconception that utilizing various methods to acquire external knowledge may hamper R&D productivity. Further, Yang et al. (2011) confirmed that alliance partners are more likely to become a target for M&As, and that acquiring one's existing alliance partner is more effective than acquiring a completely new acquisition target. While independent studies on acquisition and alliances have been integrated, it is quite surprising that there has been no research revealing the relationship between licensing and alliances. The significance of this research lies in its conduct of an empirical analysis of the relationship between the two representative behaviors of companies' external knowledge acquisition.

Second, it contributes in that indirect experience, not direct experience, can bring about a positive effect. There have been many research results so far that highlight the positive effect of experiences on R&D alliances, thereby reflecting a positive influence on R&D performance. However, this thesis has significance in that the first step has been initiated toward clarifying the hitherto independent relationship between licensing

and R&D alliances by demonstrating that licensing, not R&D alliance experience, can indirectly have a positive influence on R&D performance.

Finally, it contributes in that minimizing the negative effects of R&D alliances. Although many research findings have highlighted only the positive effects (knowledge acquisition) of R&D alliances, recent research results show that there are as many negative effects as positive ones. However, measures to minimize such negative effects have not been specifically addressed. By showing that the negative effects of R&D alliances can be offset if collaboration in the form of licensing is utilized, this thesis has a meaningful contribution in that it can provide managerial implications beyond a theoretical paper.

Based on this rationale, research has been conducted to establish the relationship between strategic alliances and acquisition, which are, in effect, the most widely used in companies' expansion strategies. A recent research indicates that alliance partners have a higher probability of becoming the target for M&As, and that if the partners who had a strategic alliance experience were merged and acquired, the M&As had a greater likelihood of being successful. In other words, strategic alliances and M&As are not independent options, rather they can be simultaneously utilized by companies at any time. Further, other research showed that companies' utilization of various methods lead to increase in knowledge production by proving that licensing and M&A would

serve as mutual substitutes or become complementary to each other with regard to knowledge absorption.

Theory and Hypothesis

Social capital theory

R&D alliances are characterized by many problems; hence, without a high level of trust, they could rather bring forth side effects. Therefore, trust building should come first through licensing, a lower level of knowledge acquisition; following this, R&D alliances, a higher level, should be sought. Progression in that order presents a higher probability of success.

Social capital theory suggests that the amount of knowledge that two companies can acquire differs based on their social capital with respective partners. Social capital can be largely comprised of social interaction, relationship quality, and partner network ties. Among others, social interaction symbolizes the depth of an information relationship between two organizations (Larson, 1992; Nahapiet & Ghoshal, 1998; Fey & Birkinshaw, 2005). Relationship quality represents a theory that the trust and reciprocity between two organizations determines the ambience and intensity of their amicable relationship (Dyer & Singh, 1998; Ring & Van de Ven, 1992; Fey & Birkinshaw, 2005).

Both the inflow and outflow of knowledge occur frequently in a partnering-based (not contract-based) relationship like R&D alliances. As the purpose of these relationships is knowledge creation and sharing of expertise, higher level of achievements are possible because companies can comprehend not only their counterparts' technologies but also their underlying tacit knowledge and cultures. The extent of knowledge that can be absorbed depends on each company's absorptive capacity and the passion with which companies collaborate with each other, and more (Cohen & Levinthal, 1990; Hamel, 1991; Inkpen, 1992; Lane & Lubatkin, 1998; Fey & Birkinshaw, 2005). Since R&D alliances are not a zero-sum game, in which one side's gain of knowledge is balanced by the other side's corresponding deficiency, they have a win-win structure that can generate a higher level of knowledge acquisition if a stronger level of trust and knowledge is established (Fey & Birkinshaw, 2005). As such, companies that want to acquire external knowledge through R&D alliances need a much higher level of trust relationship and understanding of counterpart companies, compared with the case where they acquire external knowledge through licensing, that is, a contract-based action.

Repeated interaction can have a greater impact on relationship formation and trust building, and its influence is stronger when in partnership than in contracting. There are various reasons as to why a higher level of knowledge acquisition occurs in a partnering relationship, where a stronger trust is built, rather

than in a contracting one (Rothaermel et al., 2009). Rothaermel et al. (2009) reasoned that a higher level of knowledge acquisition occurs since a higher level of trust relationship can provide an opportunity to organizations to access the networks of their counterpart companies.

The occurrence of these problems can be explained by social capital theory. Network relations may enhance the social capital of a company by making it easier to access information, technical expertise, and financial support. However, these relationships may simultaneously lead to social liability (by reducing the possibilities to relate to companies outside the network, risk of spillover, and high coordination costs of network relations). In general, R&D relationships are not very tightly knit; hence, leading to problems relating to lack of information and opportunism.

Organizational learning theory

Companies, as the main agents of behavior with "bounded rationality," act based on their experience and accumulated knowledge (Levinthal & March, 1993; Yang et al., 2011). Many studies on M&As have proved that companies' decisions on M&As are dependent upon the accumulated knowledge from their experiences (Haleblian, Kim, & Rajagopalan, 2006; Hitt, Harrison, & Ireland, 2001; Levinthal & March, 1993; Vermeulen & Barkema,

2001; Zollo & Reuer, 2010; Yang et al., 2011). Although many studies have discussed the influence of alliances and M&As on companies' experiences, decision making, and ultimately on their business performance, there was little research on the impact that the experience and knowledge accumulated from two different fields might have on other fields.

In reality, however, there is a high propensity that many organizations would take over companies with whom they have established relations through their existing alliance, rather than the companies they do not know at all. In other words, the experiences from alliances and the resulting network relationships have an inevitable influence on the decision making concerning M&A (Lin et al., 2009; Yang et al., 2011). Nonetheless, regarding companies' M&A decision making and related outcomes, the existing academic studies are characterized by a major logical flaw of viewing the behaviors two different companies in complete isolation and observing them in a mutually exclusive scenario.

By employing the behavioral learning theory, Yang et al. (2011) proved that experience gained from alliances and a firm's relative network position wield a significant impact on M&A decision making in future and elicit better outcomes. Yang et al. (2011) were able to persuasively explain about some companies' acquisition decisions and post-acquisition performance, which had been explained using financial theories earlier, by integrating the

individual factors related to alliance, acquisition, and learning research.

Yang et al. observed that companies that formed a relationship through alliance would be more aware of important information with which they could precisely evaluate counterpart companies. This would exert a more positive influence on their M&A decision making. This is because with regard to the M&As of high-tech companies, determining the intrinsic hidden worth of companies is far more important than calculating the value, which can be financially determined (Dussauge, Garrette, & Mitchell, 2000). Several studies have already explained the link between M&A and favorable outcome because M&A of companies that were alliance partners may provide better information and, consequently, reduce uncertainty in seeking, evaluating, and even consolidating M&A targets (Porrini, 2004; Yang et al., 2011).

A very limited number of studies have shown that experiences from companies' different fields can spread to, and eventually exert a positive effect on other fields. Until now, there have been only a few studies focusing on the methods through which accumulated experience and knowledge can spread and the influence they have (Zollo & Reuer, 2010; Yang et al., 2011). This study has significance in that this is the first study that linked licensing and R&D alliance among other activities of companies.

Technology acquisition through collaboration is essential in the high-tech industry. However, it is certainly the most complex and risky activity among lots of alliance types that two firms that have completely different knowledge characteristics jointly create new knowledge through cooperative research development. As mentioned above, R&D alliances are fraught with risks. Research and development does not go as smoothly as expected due to opportunistic behaviors and a limited understanding of each other's technologies, and there are numerous difficulties in absorbing newly created knowledge. These reasons explain why many firms that had not been familiar with external technology acquisition imprudently tried to acquire technologies through R&D alliance from the beginning but met with repeated failures. Several studies suggest that the experience effect or knowledge spillover caused by licensing was less detrimental (Fey & Birkinshaw, 2005; Yang et al., 2011). Licensing is undoubtedly an effective method for external technology acquisition, but effects of knowledge acquisition will be insignificant in the long run since licensing reflects a unilateral acceptance of existing technologies. It remains a fact, however, that licensing has fewer side effects. In this regard, for the companies that aggressively acquire external technologies, licensing will be useful as a middle step before concluding an R&D alliance.

Hypothesis 1. There is a positive relationship between the level of using R&D co-development and knowledge creation.

Absorptive capacity theory

Absorptive capacity is generally developed through continuous funding of, and engaging in, R&D over time (Cohen and Levinthal, 1990; Rothaermel and Alexandre, 2009).

"It requires a substantial research capability to understand, interpret, and to appraise knowledge that has been placed upon the shelf – whether basic or applied. The cost of maintaining this capability [in terms of R&D dollars] is high" (Rosenberg, 1990; Rothaermel and Alexandre, 2009).

Absorptive capacity includes a capability to search and evaluate existing technologies in the market and to appraise their exact value, as well as to properly absorb technologies as one's own (Mowery, 1983; Cohen and Levinthal, 1990; Helfat, 1994; Rothaermel and Alexandre, 2009). Therefore, absorptive capacity enables companies to correctly appraise the value of external knowledge and to selectively absorb the knowledge useful for them, and in the end, it can be highly conducive to a firm's knowledge acquisition (Arora and Gambardella, 1994; Rothaermel and Alexandre, 2009). As such, absorptive capacity can be divided into two components: the ability to adequately search and evaluate technology outside of a company and the ability to effectively accumulate and utilize it. If emphasis is placed only on

one of these abilities, a firm may face serious challenges in conducting knowledge acquisition activities.

Rothaermel and Alexandre (2009) suggested that there are two separate abilities in terms of a firm's knowledge acquisition behavior: the ability to adequately search for, evaluate, and acquire external knowledge and the ability to internally generate knowledge on its own. They also pointed out the balance and ambidexterity between these two abilities.

When a firm possesses an adequate level of absorptive capacity, it tends to not only be more sensitive to opportunities that present themselves in their technological environments, but also be more proactive in exploiting those opportunities by combining internal and external sources of knowledge (Cohen and Levinthal 1990; Rothaermel and Alexandre, 2009).

In the pharmaceutical industry, it is quite important for global pharmaceutical companies to be able to continuously search for information about a wide variety of new drug candidate substances that are developed by small scale biotech firms all over the world. It is equally critical for them to explore the chemical components that can be beneficial to research and development. If they identify appropriate technologies, they can absorb external knowledge through licensing.

Absorptive capacity in searching and applying external knowledge can be enhanced through licensing. Consequently, outcomes from R&D alliance, in which knowledge is jointly developed, can be eventually maximized.

According to a research result, accepting licensing and acquisition at the same time has a mutually complementary effect in research productivity. Although there are many studies concerning the positive influence each of these two actions has on research productivity, in reality, companies perform not just one action, but two actions simultaneously. There are limitations associated with the existing studies that analyzed the effects of a single action only. According to empirical research findings, accepting external knowledge by using the two measures simultaneously results in further enhancing the research productivity created by one measure. Furthermore, the positive effect of licensing can get more pronounced when the companies that accept knowledge possess more scientific technologies (that is, when they have knowledge with strong basic technologies).

We believe that the complementary effects of research productivity can be much bigger if R&D alliance, rather than the acquisition that has integration problems, is utilized in lieu of licensing. We interpret this finding as suggesting that licensing leads to spillovers and learning while avoiding integration problems. Therefore, licensing benefits from the scientific capabilities of the buyer since they typically enhance *absorptive*

capacity and facilitate knowledge flows. R&D alliance has a higher correlation than licensing with respect to R&D performance. Hence, the companies that have gone through the middle phase called licensing, without directly opting for a joint R&D formation, have a higher probability of pursuing alliance formation with each other.

Hypothesis 2. The level of using licensing moderated the positive relationship between the level of using R&D co-development and knowledge creation.

Data & Method

Sample

I used joint Venture & alliance data in SDC Platinium as R&D co-developmen and licensing data. SDC Platinum is one of the representative database in the field of M&A and alliance, which draws all kinds of data from formal public news to informal information only flew in Bloomberg terminal. I select global top 100 pharmaceteutical campanies in terms of sales in 2012 as sample data. It is relatively small size of data sample enough to conduct reliable regression analysis. But, pharmaceteutical industry has been operated by almost top 100 global companies and others are mostly local companies which do not have their

own research capability, but only import drugs or make generic drug using expired patent. Also, they were not captured global database such as SDC platinum because they play mostly in their country, or even their regional district. This fact that my research has relatively small size sample data is one of the most challenging and weakest point in this research. I used simple regression analysis. I encountered some empirical problems in that under 50 firms showed very low number of r&d co-development or licensing behavior, which are mostly 0 or at most 3 Sampson(2007) used negative binominal analysis to solve this kind of empirical problems . The other difficulty which I encountered conducting empirical analysis is that some samples which showed 0 or 1 in terms of R&D codelopmentor licensing showed hundreds of transaction in terms of FDA approval. It might be due to that SDC platinum didn't collect proper data. So, I extracted 24 sample to conduct a reasonable empirical analysis, which concluded total number of 76 data sample.

SDC Platinum's Joint Venture & Alliance database was used to collect R&D co-development and licensing data. SDC Platinum is the most representative alliance-related database, which not only captures not only a variety of officially announced merger and acquisition (M&A) and alliance data, but also unofficial announcements shared in the news or via the Bloomberg terminals. The sample was selected to include the top 100 pharmaceutical companies based on 2012 sales. The sample size was slightly small for credible regression analysis; however, the

pharmaceutical industry is concentrated largely in the top 100 companies, and companies further down in rank are mostly local companies rather than global ones. Many of these are not even identified in the SDC Platinum database, and the few that are identified do not have a sufficient number of R&D co-development or licensing agreements to produce a meaningful sample to conduct regression analysis. This posed the biggest challenge, as well as limitation, for this study's empirical analysis. The study used a simple regression model as its statistical methodology. The biggest challenge faced using the simple linear regression was that companies in the bottom 50 increasingly had very simple recorded incidences of R&D co-development or licensing agreements, such as 0 or 1. Sampson (2007) used a negative binominal model to overcome such challenges. This research, however, used simple linear regression. Some of the companies with 0 or 1 R&D co-development or licensing samples still had hundreds of FDA approvals; this was likely due to the fact that the SDC Platinum database did not have accurate data. Therefore, I used a general regression analysis excluding 24 samples, which were inconsistent among the 100 samples.

Independent variable

Among the numerous alliance data, only R&D co-development and licensing data were extracted, and cross licensing, which is

generally used to avoid patent lawsuits rather than for general external knowledge acquisition, were excluded from the sample. Most pharmaceutical companies showed patterns of using R&D co-development as the standard, and using licensing as ancillary for external knowledge acquisition. In reality, however, companies do not specify the two in external communications or in the news; therefore most of the data show the two methods as being used together. This is why, despite selecting a time span of 20 years, pure R&D co-development and licensing samples barely exceed a few hundred, and the top 100 companies by sales provided samples less than several dozen. Thus, presenting challenges in conducting credible empirical analysis.

I extracted cross licensing data because firms generally use cross licensing contract to avoid patent litigations. Most of pharmaceteutical firms mainly use R&D co-deveopment and use licensing contract as supplemental method for the purpose of acquiring external knowledge. But practically many firms didn't give accurate information to public between R&D co-development and licensing in the past times. Generally, they just use the trem "R&D alliance". Even though they give accurate information, news company or database company did not discern between these two methods in the past time. It is because that licensing was not used broadly and it was not that recognized as a independent method to acquire external knowledge. So although we collected dataset for 20 years, we did not collect enough data sample. Most company which ranked under 50 recorded at most

0 or 1 in terms of licensing deals. It is very challenging when I conducted empirical analysis, but I could not solve this problem.

Dependent variable

The dependent variable was the number of FDA approvals of the top 100 pharmaceutical companies. FDA approval could be confirmed through the FDA's Orange Book list. The Orange Book list catalogs FDA-approved new drugs, and the recent change to hosting the Orange Book data online allows the data to be collected more readily. Existing research sometimes uses a R&D alliance's output, such as number of patents, as the dependent variable, but since FDA approvals and whether a product can be released are more meaningful than the number of patents, the number of FDA approvals was used as the dependent variable. Furthermore, because the Orange Book requires the patents for all listed new drugs that earned FDA approvals to be listed in the same way, using the number of FDA approvals as the sole dependent variable was determined as a way to avoid any theoretical weakness.

I used the number of FDA approval which global top 100 pharmaceutical have obtained as dependent variable. I could check out the number of FDA approval on website of FDA, which so called "Orange book". Organge book was originally orange color covered book which FDA listed all drugs that FDA had approved. They recently uploaded all the dataset on website, so

we can collect data just logging in. Some prior research used the number of patent as dependent variable. But specifically in pharmaceutical industy, the importance of FDA approval is much stronger than the importance of getting patent because new drugs consist of many related patents. It does mean that just patent itself doesn't work at all. Also FDA policy require all pharma firms to upload related patents when they apply new drugs approval. These facts made me think using FDA approval as a dependent variable is proper and has not any logical problems.

Control variable

It is assumed that research and development activities of a pharmaceutical firm take place over a long period of time. In addition, such firms are capable of investing significantly large amounts on R&D, consequently exhibiting high organizational learning ability and high absorptive capacity. Accordingly, these companies will not be able to accurately measure the positive effects of licensing on R&D co-development. Hence, in this context, the age and size of each pharmaceutical firm were chosen as the control variables. While there may be suggestions that aside from these control variables, the number of patents and number of FDA approvals should rightfully be considered as control variables, the process of data collection revealed that once

the size and age of the firm are controlled, the other control variables are almost insignificant in their influence. Meanwhile, the age of the firm was measured by the date of establishment as posted on the website of each firm, or if any of the firms were acquired, the age of the company was measured from the date of acquisition. While the data for measuring size may vary, this study used the average of the annual revenues for the past three years.

Result

Insert Table 1.

Insert Figure 1.

As shown in Table 1, there is a correlation between R&D co-development and FDA approvals with licensing as a moderator. The firm size, a control variable, demonstrated a strong correlation with FDA approvals as well. R&D co-development, a dependent variable, did not exhibit a strong correlation with FDA approvals. Licensing, a moderator variable, showed a relatively strong correlation with the independent variable FDA approvals. To sum up, the moderator variable (licensing), the control variables (age and size of the pharmaceutical firms), the independent variable (R&D

co-development), and the dependent variable (FDA approvals) showed highly significant correlations.

As shown in Figure 1, it was found that licensing, which was measured as a moderator, had a significant moderating effect between R&D co-development and FDA approvals, which was the knowledge generation variable

Conclusion

This study explored the effects of external knowledge acquisition —specifically, in the pharmaceutical industry—where the ability to generate knowledge through R&D is crucial for sustainable and optimal financial performance. In contrast with the past where internal knowledge generation was the norm, the current industry practice is to collaborate with an external partner to broaden the parameters of acquired external knowledge and maximize its impact.

In particular, R&D co-development is currently the most common form of this collaboration, where the two parties jointly develop new medicine. However, R&D co-development is largely about two firms—with most of the time very different organizational and research cultures—collaborating over time to create products and this can have negative performance and production implications. For instance, such partnership may result in

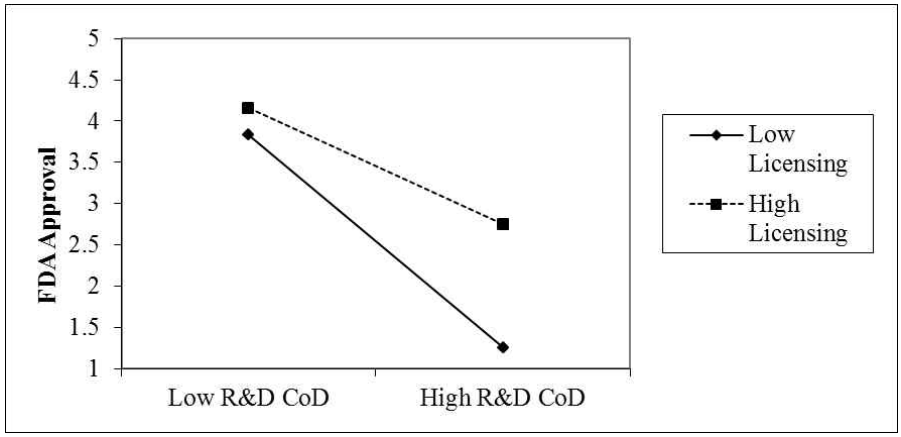
opportunistic behavior, lack of commitment, and even lack of trust—because of the fear of knowledge leakage—prompting one party not to fully disclose the knowledge they possess. For instance, R&D co-development which aimed to produce maximum results at half the cost were most often inefficient and frequently ended with both partners filing lawsuits against each other over issues of technology leak or patent ownership.

In contrast, licensing contracts whereby one party provides information to the other are free from such issues. It can be argued that from the perspective of organizational learning, the effects are weaker than R&D co-development, where effects are more innovative; however, this does not make joint learning the best course of action. In this regard, it was hypothesized that the appropriate utilization of licensing by firms will result in better performance in terms of knowledge creation, compared to firms that only utilize R&D co-development in obtaining external knowledge; the empirical study supported this hypothesis as well.

Table 1.

	(1)	(2)	(3)	(4)
	fda1	fda1	fda1	fda1
lnage	1.22	2.17	1.67	3.91
	(0.21)	(0.38)	(0.31)	(0.74)
size	18.48***	8.42	7.37	7.57
	(4.26)	(1.16)	(1.40)	(1.12)
codevelopment		1.85+		-1.00
		(1.72)		(-0.83)
licensing			5.30**	0.45
			(3.31)	(0.20)
c.codevelopment#c.licensing				0.29**
				(2.84)
_cons	-122.11**	-60.71	-52.77	-55.01
	(-2.88)	(-1.10)	(-1.17)	(-1.08)
N	76	76	76	76
R^2	0.200	0.232	0.306	0.380
adj. R^2	0.178	0.200	0.277	0.335
F	9.14	7.25	10.58	8.56
Log.Like	-385.00	-383.46	-379.61	-375.35
Degree of Freedom	2.00	3.00	3.00	5.00

Figure 1.


FDA Approval
5
4.5
4
3.5
3
2.5
2
1.5
1
Low R&D CoD
High R&D CoD
Low Licensing
High Licensing

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국문초록

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외부지식습득이 지식창출에 있어서 매우 중요한 제약산업에 있어서 일방적인 관계인 라이센싱 계약의 적절한 이용이 쌍방적인 관계인 공동연구개발이 지식창출에 얼마나 조절효과를 미치는지 연구해보았다. 연구결과, 조직학습 효과는 높지만 그만큼 위험성도 큰 공동연구개발만을 활용하는 제약회사보다 상황에 따라 적절히 라이센싱 계약을 통하여 외부지식 습득을 활용하는 제약회사가 더 큰 지식창출을 해 내는 것으로 밝혀졌다. 세계 １００대 제약회사가 1995-2015년까지 20년 동안 맺은 라이센싱계약과 공동연구개발 그리고 FDA에서 허가받은 신약 데이터를 기초로 연구를 수행하였으며 라이센싱 계약은 공동연구개발이 지식창출에 미치는 상관관계에 있어서 미약하게나마 유의미한 조절효과를 보여주었다.

주요단어: 공동연구개발, 라이센싱, 학습효과, 제약산업, 지식습
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