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Ph.D. Dissertation of Business Administration

Latecomer Firm's Technological Learning Strategies for Creative Imitation, Innovation, and International Licensing-out

창조적 모방, 혁신 및 국제 라이선싱 아웃을 위한
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Latecomer firm's technological learning strategies for creative imitation, innovation, and international licensing-out

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이 논문을 경영학박사 학위논문으로 제출함

2021년 5월

서울대학교 대학원

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ABSTRACT

Drawing on latecomer firms (LCFs)' technological learning and catch-up model, open innovation literature, resource and capabilities-based perspective, and organizational identity literature, this paper examines how the heterogeneity of LCFs' technological learning strategies affects their creative imitation, innovation and international out-licensing at the firm-level. In Study 1, I examine how accumulated internal R&D investment and foreign technology in-licensing experience independently and interactively affect creative imitation by LCFs. I showed that either accumulated internal R&D investment or foreign technology in-licensing experience has a positive impact on the development of creative imitation by LCFs. However, I found that a simultaneous increase in accumulated internal R&D investment and foreign technology in-licensing experience leads to less creative imitation outcomes, implying the existence of an internal tension between these two learning modes. Study 2 proves how accumulated internal R&D investment, foreign technology in-licensing experience, and creative imitation experience independently and interactively influence LCFs' innovation. I showed that LCFs' accumulated internal R&D investment and creative imitation experience have a positive impact on their innovation, respectively. However, I found that LCFs' creative imitation experience weakens the positive relationship between accumulated internal R&D investment and innovation, implying the paradoxical effect of LCFs' creative imitation strategy on their innovation. The effect of foreign technology in-licensing experience on the innovation of LCFs was not statistically significant in both the case of the independent effect and the case of the interaction effect with accumulated internal R&D investment. In Study 3, I examine how accumulated internal R&D investment, foreign technology in-licensing experience, and international joint R&D experience affect

LCFs' international technology out-licensing. While accumulated internal R&D investment has a positive impact on LCFs' international technology out-licensing, international joint R&D experience showed no significant effect. However, the effect of foreign technology in-licensing experience was rather complicated. Not considering the interaction with accumulated internal R&D investment, foreign technology in-licensing experience negatively affect LCFs' international out-licensing. However, considering the interaction with accumulated internal R&D investment, foreign technology in-licensing experience positively affects LCFs' international technology out-licensing independently while the interaction term of foreign technology in-licensing experience and accumulated internal R&D investment negatively affects LCFs' international out-licensing. The empirical analysis was conducted based on the panel dataset of 66 listed LCFs of the Korean pharmaceutical industry over 21 years (1999 ~ 2019). The empirical results of this paper provide important implications for establishing efficient catch-up strategies for LCFs by showing the complex and subtle causal relationship inherent in the innovation creation mechanism of LCFs.

Key Words: Latecomer firms' innovation, Catch-up, Technological learning, Technology licensing, Creative imitation, Korean Pharmaceutical industry

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OVERALL INTRODUCTION

In the 21st century, where the external environment changes rapidly, innovation is considered an essential strategy for securing and maintaining a sustainable competitive advantage for firms. In reality, however, inter-firm imitation strategies are still prevalent among firms in terms of products, technologies, resource configuration, management practices, etc. (Ethiraj & Zhu, 2008; Kim 1997, 1998; Li & Kozhikode, 2008; Lieberman & Asaba, 2006; Luo, Sun, & Wang, 2011; Posen, Lee, & Yi, 2013; Posen & Martignoni, 2018; Posen, Yi, & Lee, 2020; Shenkar, 2010; Wang, Wu, Pechmann, & Wang, 2019).

While imitation is meaningful as a viable means to enter the industry, it is generally considered a bad strategy that can negatively affect a firm's profitability and competitive advantage in the long run (e.g. Posen et al., 2013). However, scholars who have studied imitation strategies, including Levitt (1966), argue that under certain conditions or circumstances, imitation strategies can be effective strategies to enable firms to achieve and sustain high returns and business growth based on lower investment costs and risk compared to innovation strategies. From imitation-based learning, firm can minimize organizational searching costs (e.g., Katz & Shapiro, 1985), reduce uncertainty and risk in the process of R&D projects (e.g., Bikhchandani et al., 1998) and absorb newly-invented external knowledge efficiently (e.g, Cohen & Levinthal, 1990; Di Guardo & Harrigan, 2016).

In this paper, I probe latecomer firms (LCFs)' technological learning strategy for creative imitation, innovation and international technology out-licensing. In particular, I focus on the positive and negative impacts of LCFs' rapid success through imitation of technology on the creation of innovative outcomes. LCFs from emerging or newly industrialized economies are often regarded as lacking technological and innovative capabilities compared to firms in developed countries (Kim, 1997; Mathews, 2002). Kim (1997; 1999) suggested that the catch-up process of LCFs follows a sequential path: duplicative imitation – creative imitation – innovation. Based on this sequential learning model of LCFs, several case studies on technological catch-ups of LCFs in the context of various countries and industries have been continued. However, there is a limit to the generalization of this model, since empirical verification based on quantitative research methodology has been hardly performed in extant literature. In addition, compared to the studies that applied this model to explain phenomenon, studies that discover or disprove the overlooked causal relationships in the model were very insufficient. The purpose of this study is to empirically verify the determinants affecting creative imitation, innovation, and international technology out-licensing of LCFs based on Kim (1997, 1999)'s technology learning model for LCFs through quantitative research methods. This study aims to discover mechanisms that have been overlooked and to disprove the arguments in the existing model. Research hypotheses were established based on Kim (1997, 1999)'s technological learning model of LCFs, resources and capabilities-based perspective, open innovation literature and organizational identity literature.

The empirical verification of the research hypothesis was conducted through analysis of listed firms in the Korean pharmaceutical industry. Korean pharmaceutical firms are typical LCFs. Some Korean pharmaceutical firms have evolved sequentially from duplicative imitator to creative imitator and from creative imitator to innovator since the 1960s. To test the hypotheses, I constructed a panel dataset on LCFs of the Korean pharmaceutical industry for 21 years (1999~2019).

STUDY 1.

LATECOMER'S TECHNOLOGICAL LEARNING STRATEGY FOR CREATIVE IMITATION: EVIDENCE FROM THE KOREAN PHARMACEUTICAL INDUSTRY

ABSTRACT

This paper examines how accumulated internal R&D investment and foreign technology in-licensing experience independently and interactively affect creative imitation by latecomer firms. Based on data of 61 listed Korean pharmaceutical firms over 19 years (1999 ~ 2017), I showed that either accumulated internal R&D investment or foreign technology in-licensing experience has a positive impact on the development of creative imitation by latecomer firms. However, I found that a simultaneous increase in accumulated internal R&D investment and foreign technology in-licensing experience leads to less creative imitation outcomes, implying the existence of an internal tension between these two learning modes.

Key Words: Creative imitation, Technology in-licensing, Latecomer firms, Pharmaceutical industry

1. INTRODUCTION

Latecomer firms (LCFs) from emerging or newly industrialized economies are often regarded as lacking technological and innovative capabilities compared to firms in developed countries (Kim, 1997; Mathews, 2002). However, numerous studies have provided strong evidence that these LCFs can successfully catch up or compete with global industry leaders not, telecommunication device only in medium- or low-tech industries, but also in high-tech industries such as electronics, biopharmaceuticals s, and automobiles (Chittoor, Sarkar, Ray, & Aulakh, 2009; Kale & Little, 2007; Li & Kozhikode, 2008; Luo, Sun, & Wang, 2011; Miao, Song, Lee, & Jin, 2018; Park & Ji, 2020; Wang, Wu, Pechmann, & Wang, 2019).

How is such catch-up possible for LCFs? Do they transform themselves from imitators to innovators? The conceptual model of technological learning of LCFs proposed by Kim (1997; 1999) has spurred copious related research. He suggested that the catch-up process of LCFs follows a sequential path: duplicative imitation – creative imitation – innovation, highlighting creative imitation as a transitional phase in which a duplicative imitator may transform into an innovator. Creative imitation entails generating imitative products with new performance features; it differs fundamentally from duplicative imitation, in which mature technology is simply imitated through reverse engineering (Kim & Nelson, 2000; Lee, 2005). Becoming a creative imitator requires considerable effort, technological learning, and investment in internal R&D activities to create the foundation for innovation. Presenting several case studies on Korean firms, Kim (1999) suggested substantial internal R&D investment and foreign technology in-licensing as critical determinants for LCFs to engage successfully in creative imitation. The importance of these two determinants has been examined in subsequent case studies (e.g., Kale & Little, 2007; Li & Kozhikode, 2008; Luo et al., 2011), but there are few quantitative empirical studies based on generalizable research hypotheses and backed by statistical analysis.

The purpose of this empirical study is to verify the effects of accumulated internal R&D investment and foreign technology in-licensing experience of LCFs on the outcomes of creative imitation at the firm level. I also investigated how foreign technology in-licensing experience and accumulated internal R&D investment interactively affect creative imitation in LCFs by positing competing hypotheses.

To test these hypotheses, I constructed a unique panel dataset of 61 listed Korean pharmaceutical firms for 19 years (1999 ~ 2017). The results show that both accumulated internal R&D investment and foreign technology in-licensing experience have a positive impact on the development of creative imitation in LCFs, as suggested in the existing literature (e.g., Kim, 1997; 1999). However, a simultaneous increase in accumulated internal R&D investment and foreign technology in-licensing experience leads to less creative imitation outcomes. These results imply that an internal tension exists between the two learning modes: internal R&D and external foreign technology in-licensing. Therefore, LCFs should choose their mode of learning carefully at different stages of the technological catch-up process.

2. THEORY AND HYPOTHESES

2.1. Technological learning strategy of LCFs in the early stage of catch-up

“All organizations are learning systems. They learn as they develop, produce, and market technologies and products" (Kim, 1998: 508). As most LCFs are far behind industry leaders in terms of technological and innovative capabilities in the early stage of catch-up (Fan, 2006; Kim, 1997), they enter an industry by imitation of external foreign technologies or products from developed countries (Chung & Lee, 2015; Kale & Little, 2007; Luo et al., 2011). In the process of imitation, the transformation of the original product's characteristics and the addition of creative ideas may vary depending on their strategic orientation or intent (Kale & Little, 2007; Kim, 1997; Kim & Nelson, 2000; Schnaars, 1994; Ulhoi, 2012; Wang et al., 2019).

Duplicative imitation refers to the development of copies of original products, such as straightforward knock-offs or clones whose patents or copyrights have expired (Kim, 1997; Raustiala & Sprigman, 2012; Schnaars, 1994). A product developed through duplicative imitation has the same or very similar characteristics to those of the original product, but the selling price is much lower. While LCFs can gain a temporary competitive price advantage through duplicative imitation, this competitive advantage is difficult to sustain in the long run (Kim & Nelson, 2000).

In contrast, creative imitation requires a more complex and difficult development process involving not blindly imitating the original products or technologies of innovators, but creatively reorganizing or recombining them to meet the needs of new customer segments or to enter new markets or sectors (Kim, 1997; Lee & Zhou, 2012; Wang et al., 2019). Creative imitation requires learning through internal R&D to overtake the original product developers (Giachetti, Lampel, & Li Pira, 2017; Posen & Martignoni, 2018; Shenkar, 2010). LCFs that successfully engage in creative imitation can enhance firm performance efficiently by improving original innovative products or technologies with relatively little development and low experimentation costs than developers of the originals (Lieberman & Montgomery, 1988; Shenkar, 2010). LCFs in major Asian countries such as Korea, China, and India have engaged in creative imitation as a strategy to secure a competitive advantage over industry leaders from Western developed countries (Wang et al., 2019).

In an investigation of South Korea's automobile industry, Kim (1997) suggested that LCFs follow the aforementioned sequential path from duplicative imitation to creative imitation, and then to innovation. The technological trajectory of firms in developed countries consists of three phases: a fluid (or turbulent) period following the emergence of radical innovation, a transition period in which a dominant design emerges, and a mature period followed by incremental or process innovation (Utterback & Abernathy, 1975; Xu & Li, 2014). For LCFs in the early stage of catch-up, technology evolves in the reverse direction of the technological trajectory of original firms from developed countries through international technology transfer (Jin & von Zedtwitz, 2008; Lee, Bae, & Choi, 1988). The evolution is as follows. LCFs begin by reverse engineering foreign mature technologies and engaging in duplicative imitation. To become creative imitators, they must allocate firm resources not only to in-licensing of foreign technologies, but also to internal R&D (Fan, 2006; Forbes & Wield, 20086; Li & Kozhikode, 2008). In the following sections, I describe how these two learning modes, namely, internal R&D and international technology in-licensing, affect LCFs' creative imitation performance both independently and interactively.

2.2. Internal R&D investment, foreign technology in-licensing, and creative imitation

Creative imitation requires recombination of imitators' own distinctive and innovative knowledge with imitated aspects of the incumbent's original technologies or products. To execute the knowledge recombination process, LCFs must engage in internal R&D activities (Chang, Kim, Song & Lee, 2020; Kim, 1999). The purpose of such R&D activities is to create new knowledge, technologies, and products, exploiting knowledge existing within and outside the firm. Through accumulated internal R&D investment, LCFs can secure tangible strategic assets such as R&D staff, R&D equipment, and financial resources indispensable to implementation of internal R&D processes.

Several studies have emphasized the importance of steady and continuous engagement in internal R&D activities for firms to secure intangible assets, including tacit knowledge, innovation capabilities, and flexible organizational routines, all of which are critical to overcoming the uncertainties, failures, and changes that arise in the process of new technology or product development (e.g., Li & Kozhikode, 2008). Internal R&D investment is also crucial for building absorptive capacity, which is defined as firms' ability to acquire, assimilate, transform, and exploit the external knowledge necessary to adapt to external technological innovation (Cohen & Levinthal, 1990; Zahra & George, 2002). Though LCFs may initially increase their absorptive capacity by imitation, they must continuously update their abilities until they can "absorb" the latest, state-of-the-art, sophisticated external technologies (Kim, 1997; Sohn, Chang, & Song, 2009). Therefore, I hypothesize that:

H1*: Accumulated internal R&D investment of a latecomer firm has a positive relationship with its creative imitation.*

While firms “make” their own knowledge and technologies through internal R&D activities, they can also “buy” knowledge and technologies from outside the company (e.g., Veugelers & Cassiman, 1999). Foreign technology in-licensing is a substitution mechanism for internal R&D activities in terms of acquiring knowledge and technologies (Atuahene-Gima & Patterson, 1993; Kim, 1999; Laursen & Salter, 2006; Veugelers & Cassiman, 1999). Creative imitation begins with imitation of the latest innovative, cutting-edge original external technologies (Lee & Zhou, 2012; Wang et al., 2019). In-licensing of foreign innovators' original technologies, which have established technological standards after competition between technological alternatives within the industry, but have not yet entered the maturity stage, allows LCFs to imitate them in the market for technology (Bianchi & Lejarraga, 2016; Kim, 1999; Laursen & Salter, 2006; Sikimic, Chiesa, Frattini, & Scalera, 2016). In-licensing of technologies allows LCFs to secure technologies that are distant from their internal technological path, or those that are difficult to be developed based on their internal knowledge base or technical competencies (e.g., Rigby & Zook, 2002).

In addition, foreign technology in-licensing enables firms to secure geographically distant knowledge developed by innovative foreign firms, universities, and research institutes efficiently (e.g., Laursen & Salter, 2006). For this reason, Kim (1999) suggested the transfer of foreign technology through in-licensing as the major mode of imitative learning for creative imitation in LCFs. LCFs typically conduct product development and production activities in countries with low levels of technological, and innovation capabilities in their industries (Hobday, 1998). It is therefore important for LCFs to learn from the technologies of foreign innovators to overcome this lack of country-level capabilities (Guo, Gao, & Chen, 2013; Kim, 1999). In the global market for technologies, LCFs can utilize in-licensed innovative external knowledge within the firm that is difficult to secure in the domestic technology market and technologies that are "sticky" in more innovative regions or industrial clusters in foreign countries (Arora & Fosfuri, 2003; Asheim & Isaksen, 2002; Bianchi et al., 2016; Kim, 1998; Sikimic et al., 2016). Therefore, I hypothesize that:

> ***H2****: Experience with foreign technology in-licensing of a latecomer firm has a positive relationship with its creative imitation.*

2.3. The moderating effect of foreign technology in-licensing experience

In-licensing may serve as a mechanism complementary to firms' internal R&D activities in terms of creating innovative knowledge (e.g., Cassiman & Veugelers, 2006; Ceccagnoli, Higgins, & Palermo, 2014; Laursen & Salter, 2006; Laursen, Leone, & Torrisi, 2010; Veugelers & Cassiman, 1999). Through intensive investment in technology licensing, firms can secure access to a huge amount of external technology, which can potentially be utilized as a helpful knowledge resource for internal R&D. LCFs can create unique technological ideas by combining the knowledge and technologies resulting from internal R&D activities with the knowledge and know-how acquired from external foreign licensors (e.g., Fleming & Sorenson, 2004; Higgins & Rodriguez, 2006; Kim, 1997; Tsai & Wang, 2008). In other words, in the process of developing new knowledge and ideas for creative imitation, synergy effects can occur when LCFs concurrently engage in internal R&D investment and foreign technology in-licensing. Therefore, I hypothesize that:

***H3a**: The positive relationship between a latecomer firm's accumulated internal R&D investment and its creative imitation is strengthened as its foreign technology in-licensing experience increases.*

On the other hand, habitual in-licensing of foreign technologies may weaken the incentives for internal R&D teams to strive to learn. For LCFs to become creative imitators and move beyond duplicative imitation, their intensity of effort to learn is more important than their current knowledge base (Kim, 1997; 1999). Due to the lack of internal technological capabilities in LCFs and their restricted rights to licensed technology as defined in licensing contracts, internal R&D teams may have difficulty in controlling licensed technologies from foreign licensors (Walter, 2012). They tend to rely on the licensors to solve problems arising from the exploitation of licensed technology (Lowe & Taylor, 1998; 1999). This can lead to internal R&D teams losing their learning momentum and becoming too dependent on the technologies of external foreign licensors (Atuahene-Gima, 1993; Atuahene-Gima & Patterson, 1993; Enkel, Gassmann, & Chesbrough, 2009; Lichtenthaler & Lichtenthaler, 2009; Lowe & Taylor, 1998; Walter, 2012).

Organizations learn through accumulated experience, repetition of certain behaviors, and adjusting of existing routines based on the interpretation of past experiences (e.g., Levitt & March, 1988). These adapted routines form the new foundation for current and future behaviors and processes within organizations. As LCFs accumulate foreign technology in-licensing experience, routines may be established in their R&D units that lead them to rely on foreign technology licensors to solve technical problems. These routines may weaken their motivation and appetite for voluntary learning, thus hindering their in-depth understanding of imitated knowledge and stifling development of novel knowledge for creative imitation. Even if the tangible and intangible resources essential for internal R&D activities are secured through accumulation of knowledge via adequate internal R&D investment, the productivity of the internal R&D team in terms of creative imitation will decrease if their motivation for learning weakens. Thus, I hypothesize that:

> ***H3b****: The positive relationship between a latecomer firm's accumulated internal R&D investment and its creative imitation is weakened as its foreign technology in-licensing experience increases.*

Hence, I propose two competing hypotheses regarding the effect of the interaction between accumulated internal R&D investment and foreign technology in-licensing experience. Our research model is illustrated in Figure 1.

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Insert Figure 1 about here

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3. EMPIRICAL SETTING AND METHOD

3.1. Empirical Context and Data

In the pharmaceutical industry, original drugs, incrementally-modified drugs, and generics correspond to innovation, creative imitation, and duplicative imitation, respectively (Kale & Little, 2007). Original drugs are new medicines based on a new chemical entity (NCE) with a new structure (Kale & Little, 2007). Original drugs are developed through discovery, pre-clinical research, and clinical studies, and are guaranteed intellectual property rights for a certain period of time by a patent. Incrementally-modified drugs (often known as "me-too" drugs) are medicines that have similar compounds and efficacy to original drugs, but the properties and types of the latter have been changed to produce an effective product (Ha, Choi, Kim, Chung, & Lee, 2011). Generic drugs are medicines created to be the same as already marketed original drugs in terms of dosage form, safety, strength, route of administration, quality, performance characteristics, and intended use (Kale & Little, 2007).

I conducted empirical analyses within the context of the Korean pharmaceutical industry. In the 1960s and 1970s, Korean pharmaceutical firms entered the pharmaceutical industry by technology imitation. Korean pharmaceutical firms reverse-engineered or in-licensed original drugs invented by industry leaders of advanced countries and regions such as the US, Japan, and the EU to manufacture and sell generic drugs in the Korean domestic market. Since the 1990s, some Korean pharmaceutical firms have developed incrementally-modified drugs and original drugs based on their own capabilities.

I tested our hypotheses by constructing a panel dataset of 61 Korean pharmaceutical firms for a period of 19 years (1999 ~ 2017), firms listed on the Korea Stock Exchange as of February 28, 2018. Information on licensing contracts of and product development in Korean pharmaceutical firms was collected using the TS-2000 (a reputable web-based database of Korean firms' business information managed by the Korea Listed Companies Association), Korea Pharmaceutical Industry R&D White Papers published by the Korea Drug Research Association, Korea Pharmaceutical Company Directory Books published by the Korea Health Industry Development Institute, Korea Pharmaceutical Data books published by the Korea Pharmaceutical and Bio-Pharma Manufacturers Association, company websites, and press releases. Financial and other business information of sample firms was collected from DART (a reputable web-based database of Korean companies' business and financial information managed by the Financial Supervisory Service of the Korean government) and KIND (a reliable web-based database of Korean companies' disclosed information managed by the Korea Stock Exchange).

On the Korea Stock Exchange, 122 listed firms were coded as belonging to the pharmaceutical manufacturing industry during the study period. I categorized these 122 listed companies as general pharmaceutical companies, animal pharmaceuticals specialists, raw material specialists, medical device specialists, and therapy specialists. To secure information from sample firms suitable for our research, I selected only general pharmaceutical companies. Due to data availability issues, information for only 61 sample firms was used for hypothesis testing. Our final sample therefore consists of 771 firm-year observations.

3.2. Variables

Dependent variable. To observe LCFs' creative imitation at the firm level, I calculated the number of incrementally-modified drugs developed by a focal firm in a given year.

Independent variables. I measured the extent of accumulated internal R&D investment in LCFs by calculating the natural logarithm of their total R&D expenditure in the 5-year window before a given observation year. In the pharmaceutical industry, long-term R&D investment must occur for LCFs to succeed in developing incrementally-modified drugs or new original drugs (Kale & Little, 2007). According to the 2019 Korea Pharmaceutical Industry R&D White Paper, on average, 5 years of R&D activities are required for Korean pharmaceutical companies to develop one incrementally-modified drug (the dependent variable). To measure LCFs' foreign technology in-licensing experience, I calculated the total number of publicly-disclosed international in-licensing contracts signed by a focal firm within the 5-year window before a given observation year. I used 5-year windows following the approach of Sikimic et al. (2016), which assumes that recent in-licensing experience is more relevant to firms' innovative activities than is experience from the distant past.

Control variables. I controlled for several firm-level factors that may impact creative imitation outcomes in LCFs. I controlled for domestic technology in-licensing experience and international joint R&D experience, which may significantly confound the effect of foreign technology in-licensing experience and accumulated internal R&D investment on the creative imitation. Domestic technology licensing-in experience was calculated by the total number of publicly-disclosed domestic technology licensing-in contracts signed by a focal firm within the 5-year window before a given observation year. International joint R&D experience was measured by determining the number of cases in which LCFs had conducted joint research or development projects for R&D purposes with external overseas organizations such as foreign pharmaceutical companies, bio-ventures, specialized research institutes, or universities within the 5-year window before a given observation year. To take different patenting strategies into account, I also controlled for the number of patents filed by a focal firm within the 5-year window before a given observation year (Wu et al., 2019). Additionally, firm size was controlled by determining the total revenue of a focal firm in a given observation year (using a natural logarithm form). To measure firm age, I subtracted the year of establishment of a focal firm from the focal observation year. Since LCFs with more financial slack resources can initiate more projects, albeit with a higher risk of failure, I controlled for slack resources, measured as the logarithm of the ratio of total current liabilities to total current assets in a given observation year. Firms with better performance can also allocate more financial resources to innovation activities. I therefore controlled for firm performance, measured by return on assets—the ratio of total income divided by total assets in a given observation year (Wu et al., 2019). To consider the orientation toward technological learning of LCFs (Kim, 1997), I also controlled for firms' innovation experience, duplicative imitation experience, and creative imitation experience. Innovation experience was measured by the number of new original drugs developed by a focal firm. Duplicative imitation experience was calculated by the total number of generic drugs developed by the firm. Creative imitation experience was measured by the total number of incrementally-modified drugs developed by the firm. These three experience-related variables were calculated using a 5-year window before the focal observation year. Lastly, I accounted for year-specific unobserved heterogeneity by including year dummies in the regression models.

3.3. Method

As our dependent variable is a count variable, which has a positive integer value, I can employ a panel Poisson or negative binomial regression model to test our hypotheses

(Wooldridge, 2013). The results of the likelihood ratio (LR) test in Model 5, the full model of this study, show that I can conclude the dependent variable of this study is not over-dispersed, while the results of the LR test in other models suggest I cannot reach such a conclusion. Therefore, the results are reported based on a panel Poisson regression model, which is appropriate for testing of the full model (Wooldridge, 2013). As the LR test indicated that inter-panel heterogeneity did not exist in the full model, I introduced the GEE (Generalized Estimating Equation) population-averaged model into the analysis (Wooldridge, 2013). To take into account time-lag effects, all explanatory variables were lagged by 1 year.

4. RESULTS

4.1. Results of Hypothesis Testing

Table 1 presents the descriptive statistics of the variables and shows the correlations between them. The correlation matrix indicates no troubling collinearity among the variables, except for that between firm size and accumulated internal R&D investment. To ensure that the results of this study were not affected by multicollinearity, I calculated the variance inflation factors (VIFs) associated with the model covariates. VIFs of firm size and accumulated internal R&D investment were 4.88 and 4.82, respectively, and all other VIFs were below 3, suggesting that there is no significant bias in the estimated models resulting from a multicollinearity problem.

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Insert Table 1 about here

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Table 2 presents the results of the GEE population-averaged regression analyses from Model 1 to Model 5. Model 1 is the base model, which shows the effects of control variables only. In Models 2 and 3, I added accumulated internal R&D investment and foreign technology in-licensing experience, respectively. In Model 4, these two main effects were added to the base model. The explanatory power of Model 1 increased significantly with the addition of the main independent variables. In Model 5, I tested the previous models adding the interaction term.

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Insert Table 2 about here

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In Hypothesis 1, I predicted a positive relationship between accumulated internal R&D investment and creative imitation in a given LCF. In Models 2, 4, and 5, the coefficients of accumulated internal R&D investment are consistently positive and significant ($p < 0.001$), suggesting that accumulated internal R&D investment is essential for LCFs to develop creative imitation. This result supports Hypothesis 1.

Hypothesis 2 proposed a positive relationship between foreign technology in-licensing experience and creative imitation in a given LCF. The coefficients of foreign technology in-licensing experience are not statistically significant in Models 3 and 4, but they are significant in Model 5 ($p < 0.01$), thus supporting Hypothesis 2.

The interaction term in Model 5 is significant with a negative sign ($p < 0.01$), supporting Hypothesis 3b (but not Hypothesis 3a). Figure 2 shows a moderating effect of LCFs' foreign technology in-licensing experience, which means LCFs' foreign technology in-licensing experience weakens the positive effect of their accumulated internal R&D investment on their creative imitation. I elaborate further on this result in the following section.

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Insert Figure 2 about here

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4.2. Robustness Check

To verify that the results were not an artifact of the statistical specification, I present the findings from different regression models for count data, including the random-effects Poisson model, conditional fixed-effects Poisson model, negative binomial GEE population-averaged model, random-effects negative binomial model, and conditional fixed-effects negative binomial model, in Table 3. Except for the conditional fixed-effects Poisson and negative binomial models, the results consistently support our hypotheses. While the fixed-effects models have the advantage of utilizing within-group variation for a given firm to control for unobserved firm heterogeneity, use of the conditional fixed-effects Poisson and negative binomial models necessitates dropping of 29 firms that lack experience of creative imitation over time, out of 61 panels in this study. Thus, no hypotheses except Hypothesis 1 were statistically supported in the conditional fixed-effects models due to the loss of degrees of freedom caused by the dropout of 29 firms.

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Insert Table 3 about here

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6. DISCUSSION AND CONCLUSION

Imitation has been regarded as a strategic choice inferior to innovation (Posen, Lee, & Yi, 2013). However, for LCFs in the early stage of catch-up, creative imitation can be a more effective competitive strategy than innovation. Based on the technology learning model of LCFs proposed by Kim (1997;1999), this study contributes to the extant literature on technological catch-up by LCFs, which was previously mostly based on case studies or computational modeling, by empirically verifying the explanatory factors involved in developing creative imitation in LCFs.

Kim (1999) argued that in order for LCFs to become creative imitators instead of duplicative imitators, they must engage in a substantial amount of internal R&D investment and in-licensing of the latest foreign technologies. The results of our study show that accumulated internal R&D investment and foreign technology in-licensing experience have a positive impact on the development of creative imitation in LCFs, as suggested in the existing case research. However, experience with foreign technology in-licensing in LCFs can mitigate the positive impact of accumulated internal R&D investment on creative imitation, acting as a 'double-edged sword' and ultimately having a negative effect on creative imitation in LCFs. This causal relationship has been overlooked in research and case studies based on existing theories; our analyses revealed that a more complex and subtle mechanism is at work between the technology learning of LCFs and the development of creative imitation.

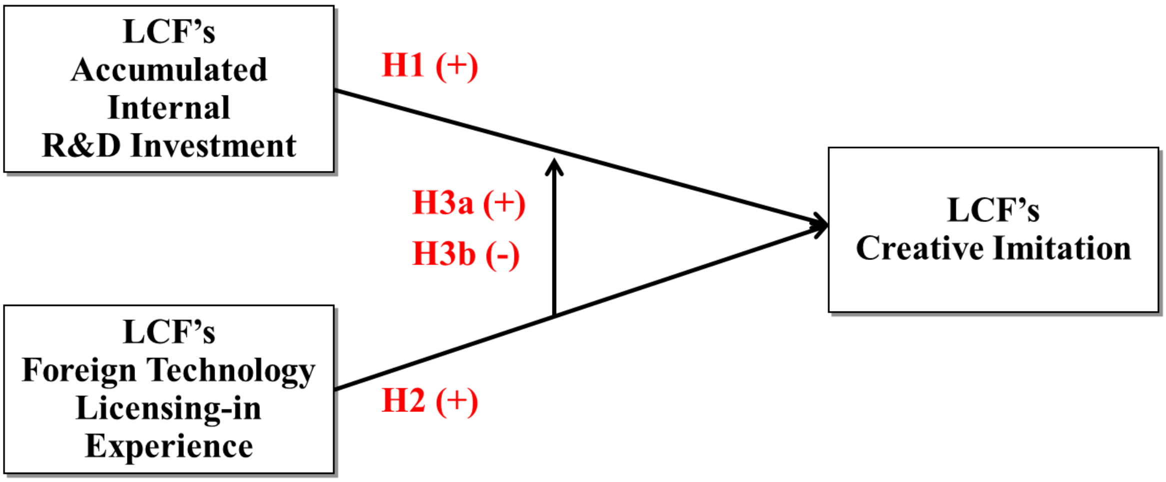
This study also provides practical implications for managers and R&D teams of LCFs pursuing catch-up with industry leaders. To become creative imitators, LCFs in the early stage of catch-up must implement a technology strategy that properly balances internal R&D investment and in-licensing of superior foreign technologies based on their limited internal tangible and intangible resources. However, excessive reliance on foreign technology in-licensing to avoid uncertainty and minimize the risk of failure inherent in internal R&D investment can act as an obstacle to development of the novel ideas essential for creative imitation. Therefore, a wise creative imitation strategy for managers and R&D staff of LCFs is to engage actively in their own R&D activities based on internal R&D investment, while at the same time selectively in-licensing foreign innovative technologies that are difficult to develop through in-house R&D.

This study is not without limitations. Firstly, generalization of the empirical analysis results is limited because I used one industry of one country as an empirical context for this research. Since the operational definition of creative imitation is inevitably different for each industry, it is inherently difficult to include LCFs of several industries in a single empirical study. However, it would be feasible and meaningful to expand the context of research on the creative imitation mechanism in LCFs to multiple countries within the same industry. If I can compare and analyze Korean pharmaceutical firms with LCFs in the pharmaceutical industry in other countries (e.g., India) that have successfully performed the catch-up process (e.g., Kale & Little, 2007; Ray & Ray, 2021), the empirical results should be more generalizable.

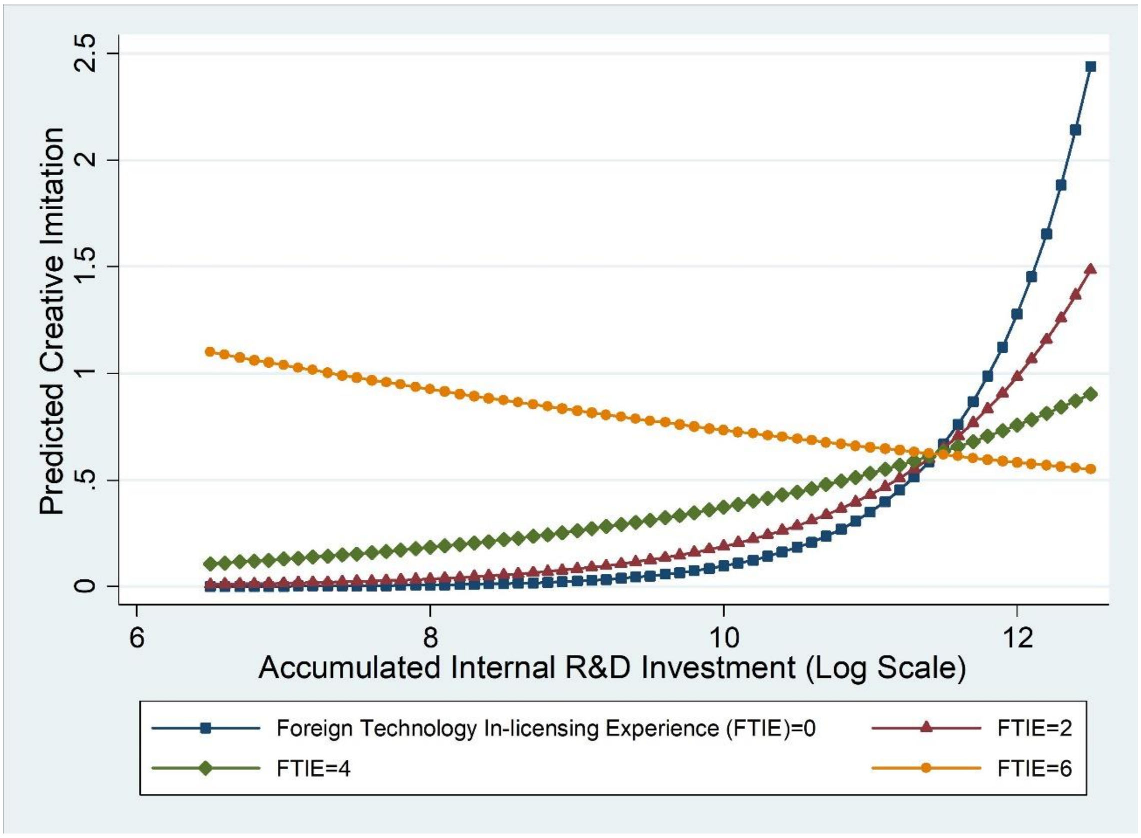
This paper only investigated the sequential process proposed by Kim (1997; 1999): duplicative imitation – creative imitation – innovation, in which LCFs transform from duplicative imitators to creative imitators before maturing into innovators. However, as previously noted, some creative imitators cannot successfully evolve into innovators. Future empirical researchers need to verify the impact of internal R&D investment and foreign technology in-licensing on the innovation performance of LCFs. In particular, it would be very interesting to reveal similarities and differences in the effects that foreign technology in-licensing experience has on creative imitation and innovation outcomes in LCFs.

Foreign technology in-licensing experience in LCFs may also affect their foreign technology out-licensing performance. By accumulating experience through foreign technology in-licensing, firms can acquire complementary knowledge and know-how regarding market intelligence of foreign technologies, foreign partner selection, monitoring of international technology transfer, and valuation and negotiation of foreign intellectual property (Lichtenthaler & Lichtenthaler, 2009; Sikimic et al., 2016). Even if foreign technology in-licensing and out-licensing are executed in opposite ways, buying and selling technology based on international licensing contracts involve similar tasks and processes. Based on the arguments of preceding studies, an empirical study examining whether foreign technology in-licensing experience in LCFs can improve their foreign technology out-licensing performance would be very interesting.

[Figure 1] Research Model



[Figure 2] Moderation effect of LCFs' foreign technology in-licensing experience



[Table 1] Descriptive statistics and correlations (N = 771)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Creative imitation	1												
2. Accumulated internal R&D investment (log scale)	0.253*	1											
3. Foreign technology in-licensing experience	0.094*	0.299*	1										
4. Domestic in-licensing experience	-0.021	0.118*	0.114*	1									
5. International joint R&D experience	0.056	0.416*	0.129*	0.036	1								
6. Number of patents filed	0.245*	0.650*	0.168*	0.042	0.651*	1							
7. Firm size (log scale)	0.223*	0.857*	0.380*	0.145*	0.340*	0.564*	1						
8. Firm age	-0.011	0.367*	0.189*	0.128*	0.065	0.126*	0.442*	1					
9. Slack resources (log scale)	-0.048	-0.098*	-0.021	-0.062	-0.089*	-0.119*	-0.179*	-0.151*	1				
10. Firm performance	0.032	0.182*	0.068	-0.007	0.032	0.086*	0.218*	0.053	0.170*	1			
11. Innovation experience	0.129*	0.460*	0.327*	0.009	0.313*	0.335*	0.502*	0.303*	-0.166*	0.051	1		
12. Duplicative imitation experience	0.137*	0.112*	0.113*	0.165*	0.002	0.163*	0.201*	0.112*	-0.231*	-0.038	0.046	1	
13. Creative imitation experience	0.269*	0.419*	0.122*	-0.099*	0.194*	0.409*	0.335*	-0.004	0.014	0.032	0.184*	0.244*	1
Mean	0.099	9.618	0.516	0.344	0.230	16.954	11.461	46.586	5.512	0.034	0.411	62.251	0.368
SD	0.368	1.560	0.949	0.707	0.813	23.998	1.022	19.276	0.639	0.151	0.833	32.054	0.966
Min	0	4.954	0	0	0	0	7.493	1	3.638	2.039	0	1	0
Max	4	13.282	6	6	8	180	14.087	119	8.127	2.842	5	213	9

* $p < 0.05$

[Table 2] Result of Panel Poisson GEE population-averaged model

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-11.419***	-10.284**	-10.643***	-10.199*	-11.305***
	(2.859)	(3.045)	(2.910)	(3.472)	(3.197)
Domestic in-licensing experience	-0.118	-0.026	-0.154	-0.053	-0.047
	(0.193)	(0.182)	(0.198)	(0.185)	(0.190)
International joint R&D experience	-0.465*	-0.465*	-0.493*	-0.483*	-0.464*
	(0.207)	(0.190)	(0.211)	(0.192)	(0.183)
Number of patents filed	0.008	-0.007	0.009	-0.006	-0.006
	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)
Firm size (log scale)	0.871***	-0.047	0.801***	-0.118	-0.100
	(0.239)	(0.360)	(0.244)	(0.364)	(0.360)
Firm age	-0.038**	-0.047***	-0.039***	-0.048***	-0.044***
	(0.012)	(0.013)	(0.012)	(0.013)	(0.012)
Slack resources (log scale)	-0.088	-0.242	-0.102	-0.251	-0.235
	(0.230)	(0.251)	(0.230)	(0.249)	(0.248)
Firm performance	-0.287	-0.547	-0.250	-0.524	-0.484
	(0.868)	(0.948)	(0.885)	(0.971)	(0.933)
Innovation experience	0.272†	0.117	0.273†	0.116	0.110
	(0.155)	(0.163)	(0.158)	(0.165)	(0.160)
Duplicative imitation experience	0.008	0.011*	0.008†	0.011*	0.008
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Creative imitation experience	-0.045	-0.192†	-0.041	-0.189 †	-0.123
	(0.099)	(0.105)	(0.098)	(0.105)	(0.101)
Accumulated internal R&D investment		1.180***		1.185**	1.294***
(log scale)		(0.333)		(0.333)	(0.339)
Foreign technology in-licensing experience			0.130	0.113	2.688**
			(0.114)	(0.112)	(0.987)
Accumulated internal R&D investment ×					-0.235**
Foreign technology in-licensing experience					(0.091)
Year dummy	Included	Included	Included	Included	Included
Wald chi-squared	75.15***	75.11***	75.79***	75.09**	88.69**
N	786	771	786	771	771

Standard errors are in parentheses. † $p < 0.1$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

[Table 3] Result of other regression models for count data (full models)

Variables	Poisson			Negative Binomial		
	GEE PA	Random Effects	Conditional Fixed Effects	GEE PA	Random Effects	Conditional Fixed Effects
Constant	-11.305*** (3.197)	-11.351*** (3.014)	-	-11.713*** (3.497)	-9.129** (3.205)	-12.739† (7.345)
Domestic in-licensing experience	-0.047 (0.190)	-0.067 (0.193)	0.431 (0.343)	-0.032 (0.208)	-0.036 (0.194)	0.403 (0.345)
International joint R&D experience	-0.464* (0.183)	-0.425* (0.168)	-0.391† (0.215)	-0.427* (0.194)	-0.424* (0.175)	-0.437† (0.228)
Number of patents filed	-0.006 (0.007)	-0.005 (0.007)	-0.029* (0.012)	-0.005 (0.008)	-0.006 (0.007)	-0.026* (0.011)
Firm size (log scale)	-0.100 (0.360)	-0.113 (0.335)	-0.271 (0.886)	-0.116 (0.387)	-0.079 (0.354)	0.143 (0.873)
Firm age	-0.044*** (0.012)	-0.041*** (0.011)	0.030 (0.086)	-0.042*** (0.013)	-0.045*** (0.011)	-0.050 (0.051)
Slack resources (log scale)	-0.235 (0.248)	-0.214 (0.233)	-0.352 (0.409)	-0.159 (0.269)	-0.305 (0.251)	-0.674 (0.457)
Firm performance	-0.484 (0.933)	-0.365 (0.859)	-1.194 (2.110)	-0.462 (1.016)	-0.366 (0.950)	-1.303 (2.470)
Innovation experience	0.110 (0.160)	0.131 (0.152)	0.166 (0.189)	0.135 (0.175)	0.188 (0.157)	0.273 (0.162)
Duplicative imitation experience	0.008 (0.005)	0.006 (0.005)	0.016† (0.009)	0.007 (0.006)	0.007 (0.005)	0.018† (0.009)
Creative imitation experience	-0.123 (0.101)	-0.051 (0.095)	-0.590*** (0.139)	-0.084 (0.120)	-0.057 (0.101)	-0.610*** (0.159)
Accumulated internal R&D investment (log scale)	1.294*** (0.339)	1.284*** (0.321)	1.206† (0.689)	1.295*** (0.370)	1.281*** (0.334)	1.639** (0.619)
Foreign technology in-licensing experience	2.688** (0.987)	3.200*** (0.864)	0.612 (1.268)	3.026** (1.040)	2.290*** (0.934)	1.008 (1.554)
Accumulated internal R&D investment x Foreign technology in-licensing experience	-0.235** (0.091)	-0.281*** (0.080)	-0.026 (0.119)	-0.264** (0.097)	-0.260** (0.086)	-0.059 (0.143)
Year dummy	Included	Included	Excluded	Included	Included	Excluded
Log-likelihood	n/a	-201.627	-131.165	n/a	-201.627	-128.955
Wald chi-squared	88.69***	113.86***	29.19**	64.49***	113.86**	29.11**
N	771	771	399	771	771	399

Standard errors are in parentheses. † $p < 0.1$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

STUDY 2.

IS TECHNOLOGY IMITATION REALLY HELPFUL FOR LATECOMER’S INNOVATION? :EVIDENCE FROM THE KOREAN PHARMACEUTICAL INDUSTRY

ABSTRACT

Drawing on the technological learning model of latecomer firm (LCFs) and the literature on LCFs' catch-up, this paper examines how accumulated internal R&D investment, foreign technology in-licensing experience, and creative imitation experience independently and interactively affect innovation by LCFs. I showed that LCFs' accumulated internal R&D investment and creative imitation experience have a positive impact on their innovation, respectively. However, I found that LCFs' creative imitation experience weakens the positive relationship between accumulated internal R&D investment and innovation, implying the paradoxical effect of LCFs' creative imitation strategy on their innovation. The effect of foreign technology in-licensing experience on the innovation of LCFs was not statistically significant in both the case of the independent effect and the case of the interaction effect with accumulated internal R&D investment. Hypothesis testing was performed based on the GEE (Generalized Estimating Equation) population averaged regression model using data of 66 Korean pharmaceutical firms over 21 years (1999 ~ 2019).

Key Words: Latecomer firms' innovation, Creative imitation strategy, Technology licensing, Technological catch-up, Pharmaceutical industry

1. INTRODUCTION

Inter-firm imitation strategies are widespread in terms of technologies, products, business models, and management practices (Ethiraj and Zhu, 2008; Giachetti, Lampel and Li Pira, 2017; Lieberman and Asaba, 2006; Posen, Lee and Yi, 2013; Posen and Martignoni, 2018; Posen, Yi and Lee, 2020; Shenkar, 2010). For latecomer firms (LCFs) in the early stage of catch-up, imitating the technologies or products of industry leaders is an indispensable strategy to survive in fierce competition (Chang, Kim, Song and Lee, 2020; Kim, 1997; Luo, Sun and Wang, 2011). However, only LCFs that have transformed from technology imitators to innovators have a chance to catch up with or leapfrog industry leaders in the long run (Kale and Little, 2006; Kim, 1997; Li and Kozhikode, 2008; Luo et al., 2011).

Is technology imitation one of the driving forces of LCFs' innovation? Or does it hinder their innovation? Based on the technological learning model of LCFs proposed by Kim (1997, 1999), I empirically investigate how LCFs' technology imitation experience affect their innovation. Kim (1999) suggested that LCFs' technological catch-up process follows a sequential path: duplicative imitation – creative imitation – innovation. After building initial knowledge base by duplicative imitation of industry leader's mature technologies, LCFs conduct substantial internal R&D activities and in-licensing of standardized foreign latest technologies to develop creative imitation technologies or products (Kale and Little, 2006; Kim, 1999). Kim (1999) argued that LCFs having experience in creative imitation activities may generate innovation by learning from large-scale internal R&D investments, in-licensing of foreign emerging technologies, joint R&D activities with foreign industry leaders, hiring foreign engineers, etc. Based on this sequential evolutionary model, several case studies have suggested the positive aspects of technology imitation for LCFs' innovation by investigating extraordinary LCFs that have evolved from imitators to innovators (e.g. Kale and Little, 2006; Luo et al., 2011; Zhang, Shi, Liu and Wu, 2021), but studies elucidating the explanatory factors of LCFs' innovation based on generalizable hypothesis testing are still very limited.

The purpose of this study is to fill this theoretical gap. I investigate the impact of accumulated internal R&D investment and technology imitation experience, such as foreign technology in-licensing experience and creative imitation experience, on the innovation outcome of LCFs. First, I conduct a hypotheses testing on the independent effects of LCFs' accumulated internal R&D investment, foreign technology in-licensing experience and creative imitation experience on their innovation. Then, to clarify the complex and subtle interaction between these explanatory factors, I explore how the impact of LCFs' accumulated internal R&D investments on their innovation differ depending on the degree of foreign technology in-licensing experience and creative imitation experience, respectively. To test our hypotheses, I constructed a 21-year (1999 to 2019) panel dataset of 66 Korean pharmaceutical firms listed on the Korean stock market, which are typical LCFs. The results of the analysis based on GEE (Generalized Estimating Equation) population-averaged regression model show why LCFs uncritically following the sequential evolutionary path suggested Kim(1997) do not easily succeed in creating innovation in the real world (Luo et al., 2011).

The remainder of the paper is structured as follows. In Section 2, I develop a set of hypotheses for the empirical analysis. Section 3 presents the specific research methods and describes the databases I used for our empirical analysis. Finally, I show the results of our empirical tests and conclude with some discussion points in sections 4 and 5, respectively.

2. THEORY AND HYPOTHESES

2.1. LCFs' technological learning strategies in the early stage of catch-up and innovation

"Latecomer firms start not from the powerful position of an IBM, but from the resource-meager position of isolated firms seeking some connection with the technological and business mainstream (Mathew, 2002: 471)." LCFs enter the industry later than incumbents. They imitate industry leaders' knowledge and technologies as they lack strategic assets such as technology or global market access at the beginning of their entry (Mathews, 2002, 2006, 2017). They ultimately aim to catch up with the global leaders or innovators in the industry (Miao, Song, Lee and Jin, 2018; Ray, Ray and Kumar, 2017). LCFs is an appropriate concept to describe the competitive strategies of firms in emerging economies such as India, China and ASEAN countries or newly-industrialized countries such as Korea, Taiwan, Brazil and Mexico (e.g. Chung and Lee, 2015; Figueiredo, 2007; Lee and Yoon, 2015; Malerba and Lee, 2020; Park and Ji, 2020).

LCFs' technology imitation strategy may have a positive impact on LCFs' innovation (Kim, 1997; Forbes and Wield, 2006; Ulhoi, 2012). Kim (1997) suggests that LCFs should follow the sequential evolutionary path from duplicative imitation to creative imitation, and then innovation. Duplicative imitation refers to the development of copies of original products, such as straightforward knock-offs or clones, based on the reverse engineering of mature technologies whose patents or copyrights have expired (Kim, 1997; Raustiala and Sprigman, 2012; Schnaars, 1994). Creative imitation means not blindly imitating the original products or technologies of innovators, but creatively reorganizing or recombining them (Kim, 1997; Wang, Wu, Pechmann, & Wang, 2019). Creative imitators source (or imitate) valuable external technologies mainly by in-licensing. They conduct substantive internal R&D activities based on imitated technologies to meet the needs of new customer segments or to enter new markets or sectors (Kim, 1997; Lee and Zhou, 2012; Posen and Martignoni, 2018; Shenkar, 2010; Wang et al., 2019). From creative imitation experience, LCFs can learn the essential characteristics and operating principles of original technologies or products deeply and secure flexible routines for innovation within the organization (Li and Kozhikode, 2008; Wu, Harrigan, Ang and Wu, 2019). However, recent literature reveals the complexity of the impact of technology imitation strategies. The degree of positive impact of technological imitation on technological innovation may vary depending on the intensity of competition a firm faces (Moreira, Klueter and Tasseli, 2020; Sikimic, Chiesa, Frattini and Scalera, 2016). Excessive technology imitation even prevents firms from pursuing radical innovation (Wu et al., 2019).

To evolve from imitators to “real” innovators, LCFs have no choice but to create knowledge or emerging technologies that do not yet exist in the industry through large-scale internal R&D investment with a high risk of failure (Kim, 1999). Through accumulation of internal R&D investment, LCFs can secure tangible strategic assets such as R&D staffs, R&D equipment, financial resources and intangible strategic assets such as tacit knowledge, innovation capabilities and flexible organizational routines. These strategic assets are critical to overcome the uncertainties, failures and changes that may arise in the process of new technology or product development (Li and Kozhikode, 2008). Internal R&D investment is also important in building absorptive capacities defined as the ability of a firm to acquire, assimilate, transform, and exploit the external knowledge (Cohen and Levinthal, 1990; Zahra and George 2002). LCFs can form its initial absorptive capacities through imitation, but in order to continue to "absorb" the latest advanced and sophisticated external technologies, the absorptive capacities must be updated through a significant amount of internal R&D activities. (Chang et al., 2020; Kim, 1997; Sohn, Chang and Song, 2009). Therefore, as a baseline hypothesis, I hypothesize that:

H1: Accumulated internal R&D investment of a latecomer firm has a positive relationship with its innovation.

2.2. Foreign technology in-licensing, creative imitation experience and LCF's innovation

As the lifecycle of innovation is shortened due to the rapid change in the technology paradigm and the acceleration of convergence between technology domains, it is becoming increasingly difficult for firms to acquire sufficient knowledge necessary for innovation only through internal R&D activities (Enkel, Gassmann and Chesbrough, 2009). Therefore, acquiring diverse knowledge developed outside the firm is considered an important success factor to enhance innovation outcome at the firm level.

Firms can source a variety of up-to-date knowledge and technology alternatives through technology imitation without the burden of uncertainty and failure associated with internal R&D investments (Laursen and Salter, 2006; Levitt, 1966; Wu et al., 2019). In terms of strategic external knowledge acquisition modes, technology imitation can be defined and measured as technology in-licensing. As in-licensing agreements allow firms to legally "buy" knowledge and technologies in the market for technology (Arora and Fosfuri, 2003), firms can substitute some of their internal R&D activities with in-licensing transactions (Bianchi and Lejarraga, 2016; Bianchi, Frattini, Lejarraga and Di Minin, 2014; Sikimic et al., 2015; Veugelers and Cassiman, 1999). For LCFs, which lack technological and innovation capabilities compared to industry leaders, in-licensing of externally developed technologies may be more important as a strategic alternative to internal R&D (Kim, 1999).

LCFs' home countries, classified as emerging economies or newly industrialized countries, have lower industrial, technological and innovation capabilities than developed countries (Hobday, 1998; Lee, Bae and Choi, 1988; Malerba and Lee, 2020). Therefore, learning knowledge and technologies from foreign innovators is strategically important for LCFs to create innovation (Guo, Gao and Chen, 2013; Kim, 1999). Through executing in-licensing of foreign technologies, LCFs can efficiently source the latest innovative knowledge that is difficult to acquire in the domestic market for technology or embedded in more innovative regions or industrial clusters abroad (Arora and Fosfuri, 2003; Asheim and Isaksen, 2002; Kim, 1999). Li-Ying and Wang (2015) showed that Chinese firms that in-licensed foreign technologies outperformed Chinese firms that in-licensed domestic technologies in terms of innovation outcome. Based on this reasoning, I hypothesize that:

H2a: Experience with foreign technology in-licensing of a latecomer firm has a positive relationship with its innovation.

However, for in-licensed technologies to positively influence licensee's innovation, it must be assumed that the licensee has a sufficient level of tacit knowledge within the organization

(Nonaka and Takeuchi, 1995; Lyles and Salk, 1996). Most LCFs lack tacit knowledge compared to industry leaders (Kim, 1997). As technology in-licensing is inefficient in transferring the licensor's tacit knowledge (Chung and Lee, 2015; Liefner, Si and Schäfer, 2019), technology in-licensing may not help LCFs innovate independently.

As LCFs accumulate foreign technology in-licensing experience, it is likely that organizational routines for technology imitation will be established inside them (Levinthal and March, 1993; Levitt and March, 1988; Nelson and Winter, 1982). LCFs with these routines may have an organizational inertia that habitually tries to imitate and exploit existing technologies in the industry, not creating their own novel solutions (Wu et al., 2019). Even when LCFs trying to innovate, this inertia can make it difficult to create radically innovative solutions by making the LCFs stick to the technological trajectory already established in the industry (Wu et al., 2019). Therefore, I hypothesize that:

H2b: Experience with foreign technology in-licensing of a latecomer firm has a negative relationship with its innovation.

Technological imitation can be defined and measured in a broader sense than technology in-licensing. At each stage of evolutionary path – duplicative imitation, creative imitation, innovation, there is a significant difference in the way LCFs acquire, share, and utilize knowledge in the process of developing, producing, and marketing their technologies or products. (Kim, 1998; Luo et al., 2011). Li and Kozhikode (2008) suggested that LCFs at the stage of creative imitation go through emulation learning process. Emulation learning requires significant effort and considerable time to learn, and allows firms to understand and flexibly transform the underlying nature and principles of what they imitate (Li and Kozhikode, 2008). Therefore, LCFs that actively carry out creative imitation may have a flexible routine within the organization, which is indispensable for overcoming uncertainties and risks of failure during designing, developing, marketing innovative technologies or products. For LCFs that lack the abilities or capabilities for innovation, flexible routine gained through creative imitation experience may play a more important role as a determinant for innovation. Therefore, I hypothesize that:

H3: Experience with creative imitation of a latecomer firm has a positive relationship with its innovation.

2.3. The moderating role of foreign technology in-licensing and creative imitation experience

As a means of generating innovative knowledge, Technology in-licensing can complement a company's internal R&D activities (e.g. Cassiman and Veugelers, 2006; Ceccagnoli, Higgins and Palermo, 2014; Laursen and Salter, 2006; Laursen, Leone and Torrisi, 2010; Veugelers and Cassiman, 1999). Technology in-licensing allows firms to accumulate diverse external knowledge which can be utilized as complementary knowledge resources during the process of internal R&D (Ceccagnoli, Higgins and Palermo, 2014). LCFs can create novel and valuable technological ideas by combining the knowledge and technologies invented in internal R&D activities with the knowledge and technologies developed by external foreign licensors (Fleming and Sorenson, 2004; Higgins and Rodriguez, 2006; Kim, 1997; Tsai and Wang, 2008). In other words, in the process of developing innovation, LCFs can gain synergy effects by concurrently conducting internal R&D activities and foreign technology in-licensing. Therefore, I hypothesize that:

H4a. The positive relationship between a latecomer firm's accumulated internal R&D investment and its innovation is strengthened as its foreign technology in-licensing experience increases.

On the other hand, repeated in-licensing of foreign technologies may undermine the incentives of LCFs' internal R&D teams to strive to learn. Kim (1997, 1999) argues that in terms of absorptive capacities, LCFs' dynamic learning effort is more important than the static level of their knowledge base to become an innovator. LCFs' internal R&D teams have difficulty in controlling the in-licensed technologies from foreign innovators due to the lack of internal technological capabilities and restricted rights to the in-licensed technologies (Walter, 2012). When technological problems arise while using the in-licensed technologies, LCFs' internal R&D teams may rely on the technology licensors to solve the issues (Lowe and Taylor, 1998, 1999). This can lead to LCFs' internal R&D teams losing the motivation to learn desperately and becoming too dependent on the external foreign licensors' tacit knowledge or know-how (Atuahene-Gima, 1993; Atuahene-Gima and Patterson, 1993; Enkel, Gassmann and Chesbrough, 2009; Lowe and Taylor, 1998; Walter, 2012).

Repeated experience of foreign technology in-licensing can form routines in LCFs'

R&D departments that are technically dependent on foreign licensors (e.g. Levitt and March, 1988). These routines will act as an organizational mechanism to weaken the motivation for voluntary learning of the LCFs' R&D teams, which hinders their in-depth understanding of imitated knowledge and creation of novel ideas and knowledge. Even if the tangible and intangible resources for internal R&D activities are acquired through the accumulation of internal R&D investments, the suppressed learning motivation of LCFs' internal R&D teams will reduce the productivity of LCFs' internal R&D investments in terms of innovation at the firm level. Thus, I hypothesize that:

H4b: The positive relationship between a latecomer firm's accumulated internal R&D investment and its innovation is weakened as its foreign technology in-licensing experience increases.

In terms of firm's abilities for innovative activities, the more firms' internal R&D resources are invested in the development of creative imitation products and technologies, the less firms' internal R&D resources that can be directly invested to the development of innovation (Chang et al., 2020). For LCFs whose R&D investment resources are scarce compared to industry leaders, this trade-off issue of the allocation of internal R&D resources will critically affect LCFs' innovation outcome.

As argued above, even if LCFs have enough internal R&D investment resources, it is very difficult for them to innovate unless their R&D teams, who are executing internal R&D activities, have strong motivation for innovation (Kim, 1997, 1998, 1999). Kim (1999) argues that in order for LCF's internal R&D teams to succeed in innovation, they must learn much harder and be able to tolerate failures in R&D activities than when trying to develop creative imitation. However, based on the 'Learning by doing' mechanism, the more creative imitation experiences LCFs accumulate, the more their R&D teams will have the know-how and abilities to develop creative imitation efficiently. The internal R&D teams, who have acquired these creative imitation capabilities, are likely to be motivated to exploit internal R&D resources for creative imitation that can be developed relatively easily and successfully, rather than for innovation that requires more advanced problem solving efforts and higher risk taking. Thus, I hypothesize that:

H5: The positive effect between a latecomer firm's accumulated internal R&D investment and its innovation is weakened as its creative imitation experience increases.

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Insert Figure 1 about here

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3. EMPIRICAL SETTING AND METHOD

3.1. Empirical Context and Data

In the pharmaceutical industry, original drugs, incrementally-modified drugs, and generics correspond to innovation, creative imitation, and duplicative imitation, respectively (Kale and Little, 2007). Original drugs are new medicines based on a new chemical entity (NCE) with a new structure (Kale and Little, 2007). Original drugs are developed through discovery, pre-clinical research, and clinical studies, and are guaranteed intellectual property rights for a certain period of time by a patent. Incrementally-modified drugs (often known as "me-too" drugs) are medicines that have similar compounds and efficacy to original drugs, but the properties and types of the latter have been changed to produce an effective product (Ha, Choi, Kim, Chung and Lee, 2011). Generic drugs are medicines created to be the same as already marketed original drugs in terms of dosage form, safety, strength, route of administration, quality, performance characteristics, and intended use (Kale and Little, 2007).

I conducted empirical analyses within the context of the Korean pharmaceutical industry. In the 1960s and 1970s, Korean pharmaceutical firms entered the pharmaceutical industry by technology imitation. Korean pharmaceutical firms reverse-engineered or in-licensed original drugs invented by industry leaders of advanced countries and regions such as the US, Japan, and the EU to manufacture and sell generic drugs in the Korean domestic market. Since the 1990s, some Korean pharmaceutical firms have developed incrementally-modified drugs and original drugs based on their own capabilities.

I tested our hypotheses by constructing a panel dataset of 66 Korean pharmaceutical firms for a period of 21 years (1999 ~ 2019), firms listed on the Korea Stock Exchange as of December 31, 2020. Information on licensing contracts of and product development in Korean pharmaceutical firms was collected using the TS-2000 (a reputable web-based database of Korean firms' business information managed by the Korea Listed Companies Association), Korea Pharmaceutical Industry R&D White Papers published by the Korea Drug Research Association, Korea Pharmaceutical Company Directory Books published by the Korea Health Industry Development Institute, Korea Pharmaceutical Data books published by the Korea Pharmaceutical and Bio-Pharma Manufacturers Association, company websites, and press releases. Financial and other business information of sample firms was collected from DART (a reputable web-based database of Korean companies' business and financial information managed by the Financial Supervisory Service of the Korean government) and KIND (a reliable web-based database of Korean companies' disclosed information managed by the Korea Stock Exchange).

On the Korea Stock Exchange, 148 listed firms were coded as belonging to the pharmaceutical manufacturing industry during the study period. I categorized these 148 listed companies as general pharmaceutical companies, animal pharmaceuticals specialists, raw material specialists, medical device specialists, and therapy specialists. To secure information from sample firms suitable for our research, I selected only general pharmaceutical companies. Due to data availability issues, information for only 66 sample firms was used for hypothesis testing.

3.2. Variables & Method

Dependent variable. To observe the level of LCFs' innovation at the firm-level, I calculated the number of new original drugs developed by the focal firm in a given year.

Independent variable. I measured the extent of accumulated internal R&D investment in LCFs by calculating the natural logarithm of their total R&D expenditure in the 5-year window before a given observation year. In the pharmaceutical industry, long-term R&D investments must occur for LCFs to succeed in developing incrementally modified drugs or new original drugs (Kale and Little, 2007). According to the 2019 Korea Pharmaceutical

Industry R&D White Paper, on average, 5~10 years of R&D activities are required for Korean pharmaceutical companies to develop one original drug (the dependent variable). To measure LCFs' foreign technology in-licensing experience, I calculated the total number of publicly-disclosed international in-licensing contracts signed by a focal firm within the 5-year window before a given observation year. I use 5-year windows following the approach of Sikimic et al. (2016), which assumes that recent in-licensing experience is more relevant to firms' innovative activities than is experience from the distant past. I measured LCF's creative imitation experience by calculating the total number of incrementally modified drugs developed by a focal firm within the 5-year window before a given observation year.

Control variable. I controlled for several firm level factors that may impact on innovation outcomes in LCF's. I controlled for domestic technology in-licensing experience and international joint R&D experience, which may significantly confound the effect of accumulated internal R&D investment, foreign technology in-licensing experience and creative imitation experience on the innovation. Domestic technology in-licensing experience was calculated by the total number of publicly-disclosed domestic technology in-licensing contracts signed by a focal firm within 5-year window before a given observation year. International joint R&D experience was measured by determining the number of cases in which LCFs had conducted joint research or development projects for R&D purposes with external overseas organizations such as foreign pharmaceutical companies, bio-ventures, specialized research institutes, or universities within the 5-year window before a given observation year. To take different patenting strategies into account, I also controlled for the number of patents filed by a focal firm within the 5-year window before a given observation year (Wu et al., 2019). Additionally, firm size was controlled by determining the total revenue of a focal firm in a given observation year (using a natural logarithm form). To measure firm age, I subtracted the year of establishment of a focal firm from the focal observation year. Since LCFs with more financial slack resources can initiate more projects, albeit with a higher risk of failure, I controlled for slack resources, measured as the logarithm of the ratio of total current liabilities to total current assets in a given observation year. Firms with better performance can also allocate more financial resources to innovation activities. I therefore controlled for firm performance, measured by return on assets—the ratio of total income divided by total assets in a given observation year (Wu et al., 2019). To consider the orientation toward technological learning of LCFs (Kim, 1997), I also controlled for LCFs' innovation experience and duplicative imitation experience. Innovation experience was measured by the number of new original drugs developed by a focal firm. Duplicative imitation experience was calculated by the total number of generic drugs developed by the firm. These two experience-related variables were calculated using a 5-year window before the focal observation year. Lastly, I accounted for year-specific unobserved heterogeneity by including year dummies in the regression models.

3.3. Method

As our dependent variable is a count variable, which has a positive integer value, I can employ a panel Poisson or negative binomial regression model to test our hypotheses (Wooldridge, 2013). As the results of the likelihood ratio (LR) test in all models (Model 1 to Model 10) show that I can conclude the dependent variable of this study is not over-dispersed, the results are reported based on a panel Poisson regression model (Wooldridge, 2013). As the LR test indicated that inter-panel heterogeneity did not exist in all model, I introduced the GEE (Generalized Estimating Equation) population-averaged model into the analysis (Wooldridge, 2013). To take into account time-lag effects, all explanatory variables were lagged by 1 year.

4. RESULTS

4.1. Results of Hypothesis Testing

Table 1 presents the descriptive statistics of the variables and shows the correlations between them. The correlation matrix indicates no troubling collinearity among the variables, except for that between firm size and accumulated internal R&D investment. To ensure that the results of this study were not affected by multicollinearity, I calculated the variance inflation factors (VIFs) associated with the model covariates. VIFs of firm size and accumulated internal R&D investment were 4.88 and 4.82, respectively, and all other VIFs were below 3, suggesting that there is no significant bias in the estimated models resulting from a multicollinearity problem.

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Insert Table 1 about here

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Table 2 presents the results of the GEE population-averaged regression analyses from through Model 1 to Model 10. Model 1 is the base model, which shows the effects of control variables only. In Models 2, 3 and 4, I added accumulated internal R&D investment, foreign technology in-licensing experience and creative imitation experience, respectively. In Model

5, accumulated internal R&D investment and foreign technology in-licensing experience were inserted into the base model. In Model 6, I added accumulated internal R&D investment and creative imitation experience to the base model. In Model 7, all of the these main effects are added to the base model. The explanatory power of Model 1 increased significantly with the addition of the main independent variables.

In Model 8, I tested the model adding the interaction term of accumulated internal R&D investment and foreign technology in-licensing experience to Model 7. In Model 9, I added the interaction term of accumulated internal R&D investment and creative imitation experience to Model 7. Model 10, as the full model of this study, tested all of explanatory variables including these interaction terms.

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Insert Table 2 about here

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In Hypothesis 1, I predicted a positive relationship between accumulated internal R&D investment and innovation in a given LCF. In all models, the coefficients of accumulated internal R&D investment are consistently positive and significant ($p < 0.01$), suggesting that accumulated internal R&D investment is essential for LCFs to develop innovation. This result supports Hypothesis 1. Hypothesis 2a and 2b proposed positive and negative relationships between foreign technology in-licensing experience and innovation in a given LCF, respectively. The coefficients of foreign technology in-licensing experience are not statistically significant in all models. Thus, Hypothesis 2a and 2b are not statistically supported. Hypothesis 3 proposed a positive relationship between creative imitation experience and innovation in a given LCF. The coefficients of creative imitation experience are not statistically significant in Models 4, 6 ,7 and 8, but they are significant in Model 9 and 10 ($p < 0.01$), thus partially supporting Hypothesis 3.

The interaction terms of accumulated internal R&D investment and foreign technology in-licensing experience in Model 8 and 10 are not statistically significant. Thus, neither Hypothesis 2a and 2b are statistically supported. The interaction terms of accumulated internal R&D investment and creative imitation experience in Model 9 and 10 are significant with a negative sign ($p < 0.01$), supporting Hypothesis 5. Figure 2 shows a moderating effect of LCFs' creative imitation experience, which means LCFs' creative imitation experience weakens the positive effect of their accumulated internal R&D investment on innovation. I will further elaborate on these results in the following section.

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Insert Figure 2 about here

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4.2. Robustness Check

To verify that the results were not an artifact of the statistical specification, I present the findings from different regression models for count data, including the random-effects Poisson model, conditional fixed-effects Poisson model, negative binomial GEE population-averaged model, random-effects negative binomial model, and conditional fixed-effects negative binomial model, in Table 3. The results of hypotheses testing based on the proposed models except for the conditional fixed-effects Poisson and conditional fixed-effects negative binomial model were consistent with the results of the analytical model in this study, the Poisson GEE population averaged model. The reason why the results of the fixed effect models are not consistent with the results of other analytical models is presumed to be due to the serious loss of degrees of freedom caused by the dropout of panels in the analysis process. While the fixed-effects models have the advantage of utilizing within-group variation for a given firm to control for unobserved firm heterogeneity, use of the conditional fixed-effects Poisson and conditional fixed-effects negative binomial models necessitates dropping of 37 firms that lack experience of innovation over time, out of 66 panels in this study.

Interestingly, the fixed effect models showed statistically significant test results for hypotheses 2a, 2b, 4a and 4b, which were not statistically supported in the test results based on other analytical models. In Table3, the coefficients of foreign technology in-licensing experience of the results based on the conditional fixed-effects Poisson and conditional fixed-effects negative binomial model are statistically significant with a negative sign ($p < 0.1$), thus slightly supporting Hypothesis 2b. The interaction terms of accumulated internal R&D investment and foreign technology in-licensing in the results based on the same analytical models are significant with a positive sign ($p < 0.1$), supporting Hypothesis 4a. However, the research results were reported based on the hypothesis test results of the Poisson GEE population averaged model most suitable for the analysis of this study.

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Insert Table 3 about here

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5. DISCUSSION AND CONCLUSION

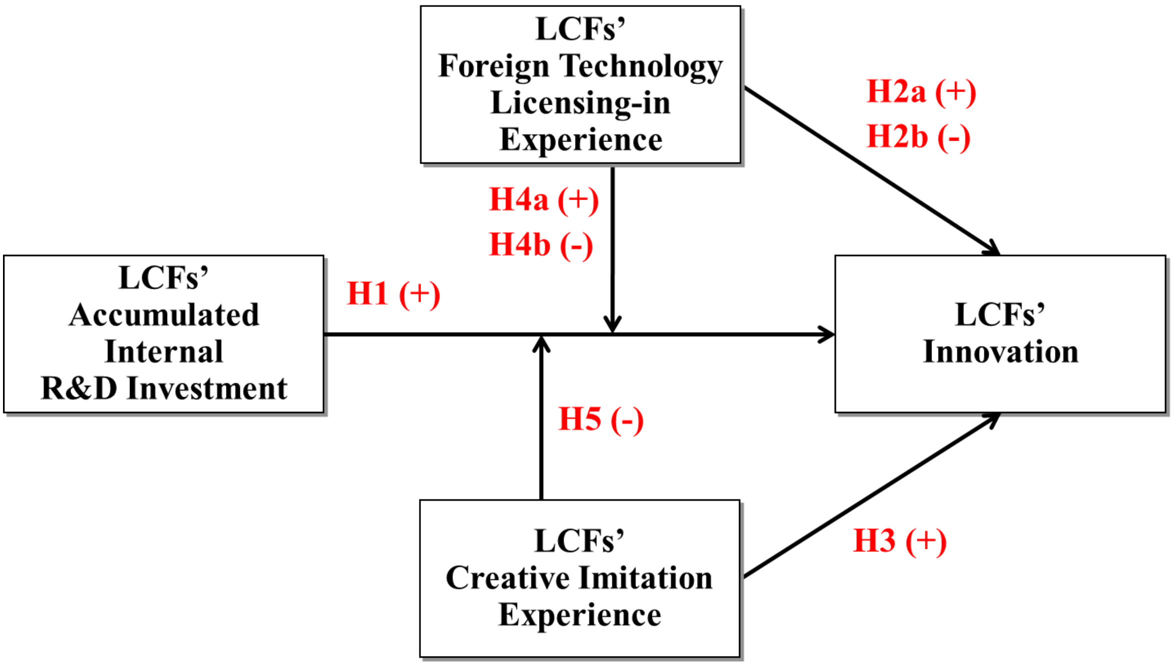
LCFs technologically catch up with industry leaders by imitating their technologies and conducting internal R&D (Chang et al., 2020; Sohn et al., 2009; Song and Lee, 2014). However, most LCFs are struggling to expand their internal R&D activities because they lack internal resources and capabilities and are vulnerable to the risk of investment failure. Moreover, as the technological gap between industry leaders and LCFs narrows, industry leaders are increasingly reluctant to transfer their innovative technologies to the LCFs (Li-Ying and Wang, 2015). Considering that industry leaders continue to strive for innovation (Jiang, Tan and Thursby, 2011), there is a growing likelihood that LCFs will lag behind and fall into a continuous catch-up trap (Zhang et al., 2021). In this study, I tried to empirically investigate the effects of LCFs' accumulated internal R&D investment and technology imitation experience on their innovation to derive their optimal technology learning strategy to increase the innovation potential and escape from the catch-up trap at the firm-level. The results show that LCFs' accumulated internal R&D investment and creative imitation experience have a positive effect on their innovation. However, as LCFs' creative imitation experience increases, the positive impact of accumulated internal R&D investment on innovation is weakened. This is because LCFs' creative imitative strategy can decentralize their internal resources that should be focused on creating innovation, and weaken the incentives of their internal R&D staffs to pursue innovation. Meanwhile, foreign technology licensing experience neither significantly affects LCF's innovation nor significantly moderates the relationship between their accumulated internal R&D investment and innovation.

This study contributes to the literature on innovation and catch-up strategies of LCFs in the following ways. First, I conducted statistical verification by establishing generalizable hypotheses about the explanatory factors of LCFs' innovation that have been derived from case studies in the existing literature. Second, I found the paradoxical effects of creative imitation experience on LCFs' innovation. This discovery allows us to gain a deeper understanding of why LCFs are hard to innovate even if they conduct intensive R&D investment in parallel with the efforts of creative imitation. Excessive creative imitation strategy can be an obstacle for firms within the imitator group to move to the innovator group (Caves and Porter, 1977; Lee, 2003) even though creative imitation may contribute to increasing diversity within an industry (e.g. Posen et al., 2013; Posen and Martigoni, 2018). Third, I found there is a complex mechanism between foreign technology in-licensing experience and LCFs' innovation, making clear causal analysis difficult. This indicates that despite management scholars' arguments that technology in-licensing can complement or substitute for internal R&D activities in the innovation creation process, LCFs must boldly invest in internal R&D in order to succeed in innovation without indiscriminately relying on foreign technology in-licensing.

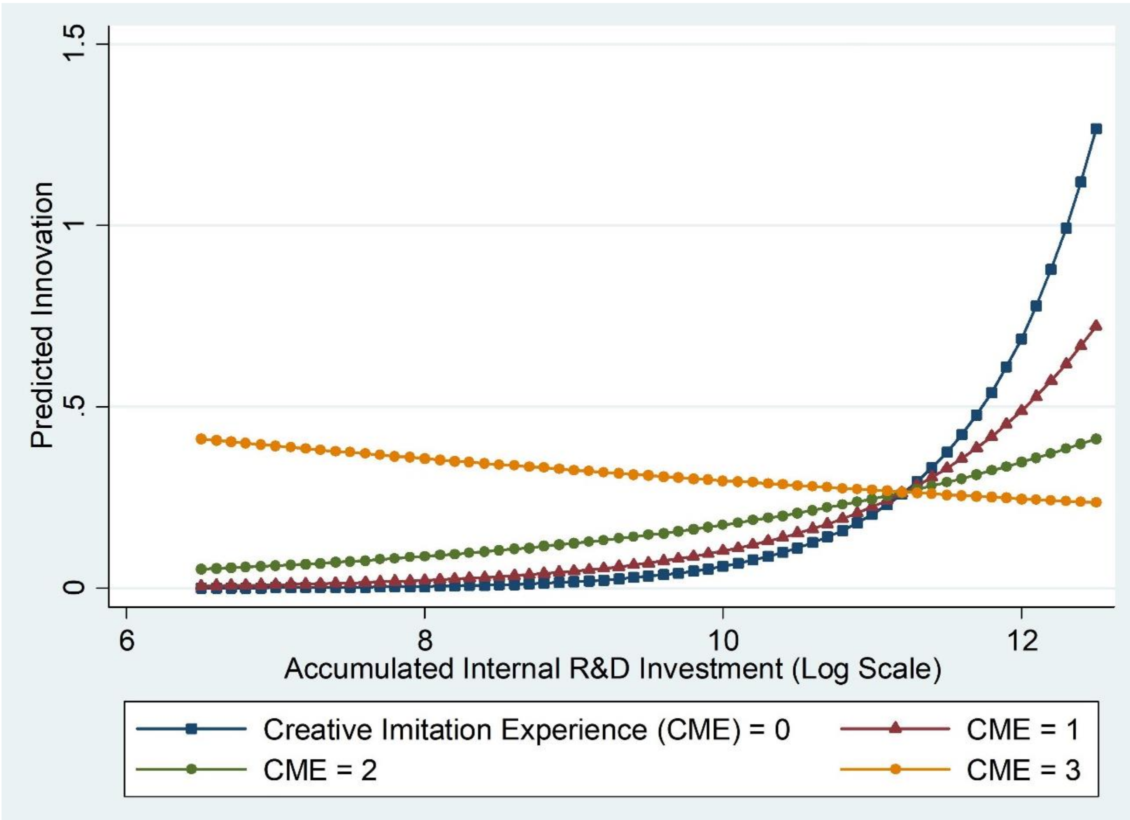
This study also has practical implications for LCF's managers and R&D staff as follows. Creative imitation strategies are attractive strategic options for LCFs because they enable LCFs' stable revenue generation in the short term and help LCFs build flexible routines for innovation in the long run. However, since repetitive creative imitation can act as a mechanism for internal R&D staffs to neglect risk-taking and intensive efforts for innovation, managers of LCFs should selectively implement creative imitation strategies. In addition, according to the agency theory, managers have an incentive to seek external technology imitation (e.g. technology in-licensing) with less investment risk rather than internal R&D investments with high risk and uncertainty in order to preserve their positions and wages (e.g. Balkin, Markman and Gomez Mejia, 2000; Baysinger, Kosnik and Turk, 1991; Coff, 2003). Managers of LCFs are more likely to prefer technology imitation over internal R&D. The results of this study implicitly suggest that LCFs should activate internal R&D investment by solving their potential agent problem with regard to their technological learning strategies.

This study has several limitations, and these limitations should be resolved in future studies. First, I found no significant results in this study on the impact of foreign technology in-licensing experience on LCFs' innovation. Empirically verifying the research hypothesis that accumulation of external technology in-licensing may undermine firm's R&D staff's motivation for innovation will theoretically contribute to clarifying the innovation mechanism of LCFs. In addition to foreign technology in-licensing, LCFs in the late stage of catch-up, source external knowledge through international joint R&D, hiring engineers, and foreign direct investment, etc. (e.g. Mathews, 2006, 2018; Almeida, Song and Grant, 2003; Song, Almeida and Wu, 2003; Sun, Peng, Ren and Yan; 2012; Nicholson and Salaber, 2013). Foreign technology in-licensing may influence the innovation of LCFs through interactions with these other knowledge sourcing modes accompanied by tacit knowledge transfer, so follow-up research on this issue seems to be necessary. Second, I used one country as an empirical context for research. It would be empirically and theoretically meaningful to expand the context of this research to multiple countries such as India, which have successfully performed the catch-up process in the pharmaceutical industry so far (Kale and Little, 2007; Ray and Ray, 2021). Third, I did not separate the types of innovation in this study. Existing literature on firm's innovation suggests that the optimal learning strategy for a firm may differ depending on the type of innovation the firm pursues. For example, Wu et al. (2019) showed that technology imitation and internal R&D investments have different impacts on firm's incremental and radical innovations. Laursen and Salter (2006) argued that while it is beneficial for firms to have a wide range of knowledge in various fields to create incremental innovation, in-depth knowledge in a specific field is better to create radical innovation. Therefore, in future research, it seems necessary to classify the innovation types of LCFs to derive the optimal technological learning strategies for each innovation type.

[Figure 1] Research model



[Figure 2] Moderation effect of LCFs' creative imitation experience



[Table 1] Descriptive statistics and correlations (N=832)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Innovation	1												
2. Accumulated internal R&D investment (log scale)	0.227*	1											
3. Foreign technology in-licensing experience	0.168*	0.299*	1										
4. Creative imitation experience	0.032	0.419*	0.122*	1									
5. Domestic technology in-licensing experience	0.024	0.118*	0.114*	-0.099*	1								
6. International joint R&D experience	0.184*	0.416*	0.129*	0.184*	0.036	1							
7. Number of patents filed	0.169*	0.650*	0.168*	0.409*	0.042	0.651*	1						
8. Firm size (log scale)	0.245*	0.857*	0.380*	0.335*	0.145*	0.334*	0.564*	1					
9. Firm age	0.164*	0.367*	0.189*	-0.004	0.128*	0.065	0.126*	0.442*	1				
10. Slack resources (log scale)	-0.076*	-0.098*	-0.021*	0.014	-0.062	-0.089*	-0.119*	-0.179*	-0.151*	1			
11. Firm performance	0.169*	0.182*	0.068	0.032	-0.007	0.032	0.086*	0.218*	0.053	0.170*	1		
12. Innovation experience	0.217*	0.460*	0.327*	0.184*	0.009	0.313*	0.335*	0.502*	0.303*	-0.166*	0.051	1	
13. Duplicative imitation experience	0.051	0.112*	0.113*	0.244*	0.165*	0.002	0.163*	0.201*	0.112*	-0.231*	-0.038	0.046	1
Mean	0.071	9.618	0.516	0.368	0.344	0.230	16.954	11.461	46.586	5.512	0.034	0.411	62.250
SD	0.302	1.560	0.949	0.966	0.707	0.813	23.998	1.022	19.276	0.639	0.151	0.833	32.054
Min	0	4.954	0	0	0	0	0	7.493	1	3.638	-2.039	0	1
Max	3	13.282	6	9	6	8	180	14.087	119	8.127	2.842	5	213

* $p < 0.05$

[Table 2] Result of Panel Poisson GEE population-averaged model

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Constant	-12.568***	-9.964**	-12.307***	-12.609***	-10.141**	-10.053**	-10.207**	-9.005**	-11.049**	-9.550**
	(3.196)	(3.231)	(3.340)	(3.222)	(3.381)	(3.261)	(3.408)	(3.573)	(3.347)	(3.504)
Domestic in-licensing experience	-0.072	-0.085	-0.081	-0.078	-0.080	-0.098	-0.093	-0.129	-0.115	-0.169
	(0.188)	(0.193)	(0.192)	(0.189)	(0.196)	(0.194)	(0.197)	(0.201)	(0.201)	(0.208)
International joint R&D experience	0.297†	0.232	0.295†	0.285†	0.233	0.213	0.214	0.246†	0. 237	0.285†
	(0.156)	(0.151)	(0.156)	(0.158)	(0.151)	(0.154)	(0.154)	(0.159)	(0.151)	(0.156)
Number of patents filed	-0.009	-0.024*	-0.009	-0.008	-0.025**	-0.023*	-0.024*	-0.025**	-0.020†	-0.022*
	(0.008)	(0.010)	(0.008)	(0.008)	(0.010)	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)
Firm size	0.948***	-0.059	0.922***	0.948***	-0.050	-0.086	-0.079	-0.131	-0.032	0.812
(Log scale)	(0.253)	(0.439)	(0.273)	(0.255)	(0.442)	(0.446)	(0.426)	(0.453)	(0.442)	(0.444)
Firm age	0.018*	0.015	0.019*	0.015†	0.015	0.013	0.013	0.013	0.011	0.010
	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Slack resource	-0.382	-0.514	-0.381	-0.372	-0.517†	-0.499	-0.501	-0.493	-0.568†	-0.570†
	(0.316)	(0.313)	(0.317)	(0.321)	(0.315)	(0.321)	(0.322)	(0.322)	(0.326)	(0.324)
Firm performance	1.070**	0.986**	1.078**	1.030**	0.979**	0.917*	0.913*	0.950*	0.792**	0.820*
	(0.378)	(0.383)	(0.380)	(0.384)	(0.385)	(0.392)	(0.393)	(0.395)	(0.395)	(0.396)
Innovation	0.021	-0.027	0.114	0.012	-0.022	-0.038	-0.033	-0.022	-0.039	-0.023
experience	(0.152)	(0.151)	(0.156)	(0.157)	(0.151)	(0.156)	(0.156)	(0.160)	(0.154)	(0.156)
Duplicative imitation experience	-0.001	-0.002	-0.001	-0.000	-0.002	-0.001	-0.001	-0.001	0.001	0.002
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Accumulated internal R&D investment		1.117**			1.130**	1.155**	1.166**	1.115*	1.216**	1.171**
		(0.429)			(0.435)	(0.441)	(0.447)	(0.444)	(0.456)	(0.450)
Foreign technology in-licensing experience			0.031		-0.021		-0.018	-1.881	-0.008	-2.316
			(0.127)		(0.128)		(0.129)	(1.707)	(0.125)	(1.728)
Creative imitation experience				0.088		-0.146	-0.145	-0.172	4.843**	5.101**
				(0.194)		(0.188)	(0.188)	(0.196)	(1.703)	(1.674)
Accumulated internal R&D investment x Foreign technology in-licensing experience								0.167		0.207
								(0.151)		(0.153)
Accumulated internal R&D investment x Creative imitation expeperience									-0.433**	-0.459**
									(0.156)	(0.154)
Year dummy	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Wald Chi-square	68.46***	74.25***	68.91***	66.64***	73.86***	71.34	71.02***	72.36***	80.53***	84.46***
N	832	786	832	832	786	786	786	786	786	786

Standard errors are in parentheses. † $p < 0.1$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

[Table 3] Result of other regression models for count data (full models)

Variables	Poisson			Negative binomial		
	GEE PA	**Random Effects**	**Conditional Fixed Effects**	**GEE PA**	**Random Effects**	**Conditional Fixed Effects**
Constant	-9.550**	-9.559**	-	-9.628*	-5.582	16.422†
	(3.504)	(3.459)		(3.796)	(3.421)	(9.563)
Domestic tech. in-licensing experience	-0.169	-0.170	-0.001	-0.205	-0.193	0.009
	(0.208)	(0.208)	(0.271)	(0.237)	(0.210)	(0.276)
International joint R&D experience	0.285†	0.289†	0.042	0.267	0.253†	0.033
	(0.156)	(0.154)	(0.194)	(0.175)	(0.145)	(0.197)
Number of patents filed	-0.022*	-0.022*	-0.008	-0.020†	0.000	-0.008
	(0.010)	(0.010)	(0.015)	(0.011)	(0.008)	(0.015)
Firm size	0.812	-0.108	-1.296	-0.047	0.256	-1.336
(Log scale)	(0.444)	(0.437)	(0.961)	(0.473)	(0.381)	(0.957)
Firm age	0.010	0.010	-0.012	0.011	0.011	-0.028
	(0.010)	(0.010)	(0.089)	(0.010)	(0.010)	(0.089)
Slack resource	-0.570†	-0.574†	0.235	-0.592†	-0.449	0.146
	(0.324)	(0.320)	(0.487)	(0.353)	(0.311)	(0.542)
Firm performance	0.820*	0.815*	0.821†	0.812	0.808*	0.828†
	(0.396)	(0.397)	(0.462)	(0.551)	(0.316)	(2.466)
Innovation	-0.023	-0.006	-0.383*	-0.020	0.145	-0.396*
experience	(0.156)	(0.153)	(0.194)	(0.173)	(0.150)	(0.199)
Duplicative imitation experience	0.002	0.002	0.002	0.002	-0.000	0.001
	(0.006)	(0.006)	(0.009)	(0.006)	(0.006)	(0.009)
Accumulated internal R&D investment	1.171**	1.177**	0.322	1.112*	0.345	0.405
	(0.450)	(0.444)	(0.723)	(0.470)	(0.290)	(0.715)
Foreign technology in-licensing experience	-2.316	-2.321	-4.507†	-2.231	-1.475	-4.548†
	(1.728)	(1.712)	(2.486)	(1.886)	(1.504)	(2.530)
Creative imitation experience	5.101**	5.063**	0.763	4.814**	5.474***	0.730
	(1.674)	(1.650)	(2.229)	(1.864)	(1.697)	(2.231)
Accumulated internal R&D investment ×Foreign technology in-licensing experience	0.207	0.207	0.407†	0.199	0.149	0.411†
	(0.153)	(0.152)	(0.225)	(0.167)	(0.133)	(0.228)
Accumulated internal R&D investment ×Creative imitation experience	-0.459**	-0.454**	-0.115	-0.430*	-0.498***	-0.111
	(0.154)	(0.152)	(0.189)	(0.171)	(0.156)	(0.190)
Year dummy	Included	Included	*Excluded*	Included	*Excluded*	Excluded
Log-likelihood	n/a	-155.472	-102.124	n/a	-167.140	-102.072
Wald Chi-square	84.46***	88.11***	23.52†	65.55***	82.90**	23.13**
N	786	786	291	786	786	291

Standard errors are in parentheses. † $p < 0.1$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

STUDY 3.

LATECOMER'S TECHNOLOGICAL LEARNING STRATEGY FOR INTERNATIONAL OUT-LICENSING :EVIDENCE FROM THE KOREAN PHARMACEUTICAL INDUSTRY

ABSTRACT

Drawing on latecomer firm (LCF)s' technological learning framework, resource and capabilities perspective and organizational identity literature, this paper examines how accumulated internal R&D investment, foreign technology licensing-in experience, and international joint R&D experience affect international technology licensing-out by LCFs. While accumulated internal R&D investment has a positive impact on LCFs' international licensing-out, international joint R&D experience is proved no significant effect. However, the effect of foreign technology licensing-in experience was rather complicated. Not considering the interaction with accumulated internal R&D investment, foreign technology licensing-in experience negatively affect LCFs' international licensing-out. However, considering the interaction with accumulated internal R&D investment, foreign technology licensing-in experience positively affects international technology licensing-out independently while negatively affects international licensing-out interactively. The empirical analysis was conducted based on the panel dataset of 66 listed latecomer firms of Korean pharmaceutical industry over 21 years (1999 ~ 2019) using panel Poisson regression model.

Key Words: Latecomer's innovation, Catch-up, Technology licensing, Open innovation, Pharmaceutical industry

1. INTRODUCTION

Due to the rapid change in the technology paradigm, the importance of an open innovation strategy is being emphasized as a corporate innovation strategy (Enkel, Gassmann, & Chesbrough, 2009). As MNCs and global industry leaders face the limits of technological innovation through internal R&D, international technology licensing-out opportunities have also increased for LCFs (Liefner, Si, & Schäfer, 2019; Zhang, Shi, Liu, & Wu, 2021). However, the existing literature on the innovation and technological catch-up mechanism of LCFs has shown little interest in clarifying the determinants for international technology licensing out of LCFs.

This paper aims to fill this theoretical gap. Based on the technological learning framework of LCFs, resource and capabilities-based perspectives, and the literature on organizational identity, I investigate the explanatory factors that affect LCFs' overseas technology licensing-out. In order for LCFs to catch up with industry leaders, they must combine technology imitation and technological innovation strategies (Chang, Kim, Song, & Lee, 2020; Sohn, Chang, & Song, 2009). Based on the existing literature on LCFs' technological strategies, I classified technology learning modes of LCFs into foreign technology licensing-in, internal R&D, and international joint R&D (Zhang et al., 2021). I empirically analyzed LCF's heterogeneity of technological strategies on their international licensing-out at the firm level.

First, I conduct a hypothesis test on the independent effects of LCFs' accumulated internal R&D investment, foreign technology licensing-in experience, and international joint R&D experience on their international technology licensing-out. Then, to clarify the complex and subtle relationship between foreign technology licensing-in experience and

LCFs' international technology licensing-out, I explore how the impact of accumulated internal R&D investments on LCFs' international technology licensing-out differs depending on the degree of foreign technology licensing-in experience.

To test these hypotheses, I constructed a 21-year (1999 to 2019) panel dataset of 66 LCFs of the Korean pharmaceutical industry, listed on the Korean stock market. Since the 1960s, Korean pharmaceutical firms have copied US, EU and Japan-based industry leaders' original products or technologies by reverse engineering or OEM and sold duplicative imitation products in the domestic market. But from the 1990s, some of them have successfully developed creative imitation products based on licensing-in of industry leader's original technologies and substantive internal R&D activities. In the 2000s, a few players have even achieved indigenous innovations by their own capabilities and licensed-out them internationally. Therefore, the Korean pharmaceutical industry is an appropriate context for testing the hypotheses of this study.

The remainder of the paper is structured as follows. In Section 2, I summarize theoretical backgrounds of this study. In Section 3, I develop a set of hypotheses for the empirical analysis. Section 4 presents the specific research methods and describes the databases I used for our empirical analysis. Finally, I show the results of our empirical tests and conclude with some discussion points in sections 5 and 6, respectively.

2. THEORETICAL BACKGROUND

2.1. Latecomer firms' technological learning strategies, innovation, and international licensing-out

LCFs enter the industry later than incumbents. Their late entry timing is not because of strategic choice but because of historical necessities (Hobday, 1998; Mathews, 2002). They imitate industry leaders' knowledge and technologies as they lack strategic assets such as technology or global market access at the beginning of their entry (Mathews, 2002, 2006, 2017; Luo et al., 2011). They ultimately aim to catch up with the global leaders or innovators in the industry (Chang, Kim, Song, & Lee, 2020, Lee & Yoon, 2015; Malerba & Lee, 2020, Miao, Song, Lee, & Jin, 2018; Ray, Ray, & Kumar, 2017).

LCFs overcome the weakness of resource shortage by imitating the technology of industry leaders through reverse engineering, license-in, OEM, ODM, etc. in the early stages of entering the industry (Figueiredo, 2007; Mathews, 2002; Min, Kim, and Song, 2017). Kim (1997) suggests that LCFs follow the sequential path from duplicative imitation to creative imitation, and then innovation. The technology trajectory of developed countries consists of three phases: a fluid (or turbulent) period following the emergence of radical innovation, a transition period in which dominant design emerges, and a mature period followed by incremental or process innovation (Utterback &Abernathy, 1975; Xu & Li, 2014). LCFs in the early stage of catch-up make technological evolution in the reverse direction of the technology trajectory of developed countries based on international technology transfer (Jin & von Zedtwitz 2008; Lee, Bae, & Choi 1988). LCFs firstly execute reverse engineering of foreign mature technologies to develop duplicative imitation. To evolve from duplicative imitator to creative imitator, however, LCFs need to allocate firm resources not only to in-licensing of foreign technologies but also to internal R&D activities (Guo, Gao, & Chen, 2013; Fan, 2006; Forbes & Wield, 2006; Li & Kozhikode, 2008). If successful, some of these creative imitators may succeed to develop innovative new technologies in the fluid period with the potential to become a technology leader (Kale &

Little 2007; Kim, 1997; Kim & Seong, 2010; Luo, Sun, & Wang, 2011; Park & Ji, 2020). Kale & Little (2007) studied the evolution of technological and R&D capabilities through imitation of LCFs in the Indian pharmaceutical industry. Indian pharmaceutical companies have secured basic knowledge and technical capabilities related to organic chemistry, synthesis, etc., which are the basis for drug development and manufacturing through reverse engineering. Since then, they have secured intermediate-level technical and R&D capabilities through the development of generic drugs or improved new drugs of original drugs whose patents have expired, and based on this, they were able to develop advanced R&D capabilities necessary for the development of original drugs.

As LCFs become more technologically capable, innovative, and international, they diversify their modes of external foreign knowledge sourcing to international joint R&D, hiring foreign engineers and foreign direct investment such as minority equity investment, establishment of wholly-owned subsidiary and cross-border M&A (e.g. Shan & Song, 1997; Almeida, Song, & Grant, 2003; Song, Almeida, & Wu, 2003; Fu, Pietrobelli, & Soete, 2011; Deng, 2009; Sun, Peng, Ren, & Yan; 2012; Nicholson & Salaber, 2013). In his technology trajectory model, Kim (1999) explained LCFs that have evolved into an innovator can license out their own developed technologies and products internationally, but did not elucidate the detailed mechanism for this phenomenon.

2.2. Organizational identity, routines, and latecomer firms' technological learning

Organizational identity refers to the understanding, social codes, beliefs, or definitions that members of an organization have about "who we are as an organization" (Ravasi, Tripsas,

& Langley, 2020). There are two main types of organizational identity. First, organizational identity can be defined as the attributes of an organization that members perceive as central, enduring and distinctive (Albert & Whetten, 1985; Ravasi & Phillips, 2011). Examples include such expressions of organizational identity: "a ground-breaking marketer", "an industry founder" (Corley & Gioia, 2004) or "a professional organization (Dutton & Dukerich, 1991)". Second, organizational identity can be formulated as the product market or industry to which the organization belongs (Tripsas, 2009). For example, it refers to defining organizational identity in the form of "digital photography companies" (Tripsas, 2009).

Organizational identity is established based on not only the perception of internal members of the organization, but also the perception of external stakeholders such as customers, competitors, suppliers, institutional investors, mass media, and government agencies (Gioia, Schultz, & Corley, 2000). External stakeholders recognize an organization by including it in certain categories with specific attributes based on the organization's perceived identity or image, and expect the organization to behave in accordance with the categories (Hsu & Hannan 2005, Pólos, Hannan, & Caroll, 2002, Tripsas, 2009). If an organization acts in accordance with the rules and attributes of its category, it can obtain legitimacy from external stakeholders (Hsu & Hannan 2005, Pólos et al. 2002). As a result of these domain consensus with external stakeholders, organizations establish their organizational identity consisting of an image of the organization's role or social code (Gioia, Price, Hamilton, & Thomas, 2010; Song & Yoon, 2010; Ravasi et al., 2020).

Organizational identity is closely related to organizational routines. Routines are the abilities (capabilities) and decision-making rules that the organization needs to perform a task or activity, and are formed within the organization through the accumulation of experience (Nelson & Winter, 1982). Organizational identity creates common expectations of organization's members about the appropriate actions the organization should take (Navis & Glynn, 2011; Tripsas, 2009). These expectations have a significant impact on the formation of routines that guide or coordinate the behavior of members in the organization (Altman & Tripsas, 2015). Kogut & Zander (1996) argued that the identity of an organization can be determined by the knowledge acquired, developed, or accumulated through the implementation of certain tasks, or by routines, which are repositories of such knowledge. In other words, organizational identity and routines influence each other and function as a mechanism to define the characteristics and direction of the organization's future behaviors (Ravasi et al., 2020).

Organizational identity can be a mechanism for organizational unity, but conversely, it can lead to conflict between members. Organization's behaviors that are not consistent with its identity is not justified and leads to discord within the organization (Kraatz & Zajac, 1996; Tripsas, 2009). If an organization does not act in accordance with the rules and attributes of its category, the organization causes confusion to external stakeholders and is difficult to obtain legitimacy and support from them (Benner, 2007; Zuckerman, 1999; Zuckerman, Kim, Ukanwa, & Rittman, 2003). In order for an organization to effectively achieve organizational change or strategic change, it must deliberately change its identity (Ravasi & Phillips, 2011; Gioia, Patvardhan, Hamilton, & Corley, 2013). For example, a non-profit organization seeking a transition to a for-profit organization must create a new identity that the organization wants to recognize to its members and external stakeholders (Altman & Tripsas, 2015; Gioia & Thomas, 1996). Organizations can also secure flexibility to respond to rapidly changing external environments through strategic management of organizational identity (Gioia et al, 2000).

When LCFs repeatedly imitate leading companies' products and technologies, knowledge or know-how necessary for imitation will be learned within the organization, thereby establishing firm-specific routines for imitation. Routines influence organizations' short-term decision-making (Levinthal & March, 1993). The LCFs who have established the routine of imitation will embed a path-dependent tendency toward imitation, that is, an organizational inertia toward imitation (Hannan & Freeman, 1984). Firms that have an organizational inertia for imitation tend to continue to imitate even though internal and external factors increase the need to create their own innovations, and they have difficulty performing the activities necessary to create innovation. Based on the theory of organizational identity, the imitation routine can have a significant effect on the formation of organizational identity in LCFs. Internal members and external stakeholders of a LCF with an imitation routine will recognize its identity as a "follower" or "technology imitator". Accordingly, LCFs can secure legitimacy from internal members and external stakeholders for the behaviors of acquiring knowledge through reverse engineering and technology licensing-in, as well as developing duplicative or creative imitation products. On the other hand, the behavior of LCFs to develop innovative technologies and products through enormous internal R&D investments, or to license them out in the market for technology (Arora, 2003), faces difficulties in securing such legitimacy. In order for a LCF to be recognized as an innovative company by internal members and external stakeholders, it is necessary to reduce the identity of a "technology imitator" and rebuild the identity of a "technology innovator" through accumulation of experience directly related to technology innovation, such as international joint R&D with innovators or leaders in the industry.

3. THEORY AND HYPOTHESES

3.1. Latecomer firm's accumulated internal R&D investment and international technology licensing-out

Licensing-out is a direct consequence of a firm's innovative technologies or products (Grindley & Teece, 1997; Hill, 1992; Lin, 2011; Mottner & Johnson, 2000; Teece, 1986). This is because technologies or products that is difficult to grant intellectual property rights such as patents are difficult to trade through licensing due to market failure. In order for LCFs to license out internationally, it is essential to carry out internal R&D activities for the development of novel technologies or products that can be licensed out.

Internal R&D investment is also indispensable to securing the knowledge and capabilities required for innovation at the firm level. LCFs generally depend on technology imitation such as reverse engineering or licensing-in of external knowledge and technologies. However, LCFs aiming to evolve from imitators to innovators must internally have adequate absorptive capacities, innovation capabilities and tacit knowledge (Kim, 1997). Internal R&D investment is critical for building firm's absorptive capacity (e.g., Cohen & Levinthal, 1990), defined as firms ability to acquire, assimilate, transform, and exploit external knowledge which is necessary to adapt to radical technological change and generate new knowledge. Through vigorous internal R&D activities, LCFs can also secure internal and external latest and new knowledge useful to create new ideas for innovative technologies, creative imitation products and innovation products, which can be licensed out to foreign licensees (Fan, 2008; Kim, 1997, 1998). In addition, LCFs can acquire innovation capabilities and tacit knowledge indispensable to overcome the uncertainties, failures and changes that arise in their on-going R&D projects through the accumulation of internal R&D investments. Hence I hypothesize that:

H1: Accumulated internal R&D investment of a latecomer firm has a positive relationship with its international technology licensing-out.

3.2. Latecomer firm's foreign technology licensing-in experience and international technology licensing-out

Firm's licensing-in and licensing-out of technologies are fundamentally different in terms of motivation and activities required. In case of licensing-in, it is critical to identify suitable technology in the market for technology, whereas licensing-out process requires searching for profitable market opportunities for the firm's own technologies (Lichtenthaler, 2011).

However, in terms of the process of contracts, buying and selling technology based on licensing contracts require the execution of common tasks even if they are executed in the opposite way (Bianchi, Frattini, Lejarraga, & Minin, 2014; Bianchi & Lejarraga, 2016, Lichtenthaler & Lichtenthaler, 2009; Sikimic, Chiesa, Frattini, & Scalera, 2016). The process of licensing-in and licensing-out requires various complementary activities such as market intelligence, licensing partner selection, monitoring of technology transfer and contract, valuation of intellectual properties, etc. (Lichtenthaler & Lichtenthaler, 2009; Sikimic et al. 2016). For this reason, firms that frequently conduct technology licensing transactions are structured so that license-in and license-out transactions are managed by the same organizational unit (Jacobides & Winter, 2005). This is because employees in charge of licensing transactions can experience both the positions of technology buyers and sellers, and accumulate the complementary capabilities necessary for the efficient completion of licensing transactions (Bidault and Fischer, 1994). As most LCFs have little experience with overseas technology licensing-out, foreign technology licensing-in experience is an important strategic means for LCFs to acquire the complementary capabilities required for their potential international technology licensing-out. LCFs dependent on international licensing-in as their mode of technology imitation can build critical complementary capabilities to perform the process of international technology licensing-out in improved ways.

While potential international licensors seek foreign market opportunities to sell their own technologies, potential international licensees must identify and source technologies that meets their technical needs (Arora, Fosfuri, & Gambardella, 2001a, 2001b; Gans & Stern, 2003). Through foreign technology licensing-in experience, LCFs can build a social network for technology transactions and cooperation with foreign firms, research institutes, and universities (e.g., Mathews, 2006; Ray, Ray, & Kumar, 2017). Through these networks, LCFs may have the opportunity to obtain information on potential foreign technology licensing-out or to promote the value and marketability of their own products and technologies (Chung & Lee, 2015). Such information may be more useful for LCFs' potential international licensing-out as most of them lack international social networks compared to global industry leaders or multinational companies. In particular, if a LCF repeatedly conducts licensing-in transactions with certain foreign partners over a long period of time, trust can be formed in the relationship with the partners, which can be a driving force for LCFs to license out their technologies to the partners (Doz, Olk, & Ring, 2000;

Ness & Haugland, 2005).[1] Based on these logic, I hypothesize that:

H2a: Foreign technology licensing-in experience of a latecomer firm has a positive relationship with its international technology licensing-out.

Organizational identity theory and literature suggests that LCFs' foreign technology licensing-in experience can affect their international technology licensing-out in the opposite direction to the prediction based on the resource and capabilities-based perspective. Most LCFs, who enter the industry later than incumbents and grow by relying on technology imitation rather than innovation, will have the identity of a "follower" or "technology imitator" within their organization. Due to their bounded rationality and information asymmetry, organization's external stakeholders such as customers, competitors,

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[1] For example, Yuhan Corporation of Korea, a LCF in the pharmaceutical industry, in-licensed technologies and products from Gilead, a global leading bio-pharmaceutical company in the United States, for about six years. Through this relationship, a trust was established between these two companies. In 2017, Gilead invited Yuhan's management to its headquarters in San Francisco, USA, and at this time, Yuhan's management had an opportunity to introduce its own new drug pipelines to Gilead's management. Among Yuhan Corporation's various pipelines, Gilead showed interest in a new drug candidate for non-alcoholic fatty liver disease (NASH), which is in the early stages of development of a new substance, and decided to in-license it eight months after the meeting based on mutual trust. "Since Gilead showed strong faith, we almost skipped technical due diligence and signed a contract. This means that the trust relationship the two companies have built up over a long period of time works," Yuhan's vice president said in an interview. – *Excerpted from Dong-A Business Review (April, 2019)*

institutional investors, mass media, and regulatory agencies will also categorize the identity or image of LCFs as a “follower” or “technology imitator”. Potential technology buyers or licensees in the international market for technology are likely not to expect innovation or technological excellence in technologies or products developed by LCFs categorized as a “technology imitator”. The more active LCFs are in foreign technology licensing-in, the stronger their identity or image as a "follower" or "technology imitator". Therefore, it is difficult to obtain legitimacy from overseas potential technology buyers when LCFs who are actively engaged in foreign technology licensing-in attempt international licensing-out of their own innovative products or technologies. Hence I hypothesize that:

H2b: Foreign technology licensing-in experience of a latecomer firm has a negative relationship with its international technology licensing-out.

3.3. Latecomer firm’s international joint R&D experience and international technology licensing-out

The rapid technological progress and convergence in the 21 century knowledge-based economy require firms to build and maintain expertise in multiple technology domains (e.g. Grant, 1996). LCFs often execute R&D projects and develop innovative technologies and products jointly with foreign firms, research institutes, universities to overcome the lack of internal technologies and competencies inside the firm and their home country (Liefner, Si, & Schäfer, 2019; Mathews, 2002, 2006, 2017; Ray, Ray, & Kumar, 2017; Zhang, Shi, Liu, & Wu, 2021). Especially, LCFs acquire the opportunities to learn tacit knowledge and technological know-how from foreign R&D partners, which is critical to solve complex problems that arise from their internal R&D projects. Because most of LCFs lack internal tacit knowledge and know-how in the early stage of catch-up, sourcing tacit knowledge and know-how from external sources would be quite critical for enhancing internal innovation potential and success of international licensing-out based on their own novel technologies and products.

Similar to the case of foreign technology licensing-in, LCFs can acquire complementary capabilities such as foreign market intelligence, foreign R&D partner selection, monitoring of international technology transfer and contract, valuation of intellectual properties through international joint R&D projects. These capabilities can be used for the process of international technology licensing-out (Lichtenthaler & Lichtenthaler, 2009; Sikimic et al., 2016). Compared to technology licensing transactions, joint R&D is characterized by uncertainty in the outcome of the project, and complex ownership of the outcome (e.g. Frishammar, Ericsson, & Patel, 2015). LCFs will be able to secure the capabilities to manage more complex contracts and technology transfers than technology licensing transactions through joint R&D projects. In addition, LCFs can make social ties with foreign partners of joint R&D projects collect critical information of potential international technology licensing-out opportunities from them (Chung & Lee, 2015; Mathews, 2006; Ray, Ray, & Kumar, 2017).

From the perspective of organizational identity, as LCFs accumulate joint R&D experiences with overseas innovative partners, their organizational identity as "followers" or "technology imitators" may weaken in the international technology market. Routines formed through the accumulation of international joint R&D experience will be able to create a new organizational identity such as “international R&D collaborator” within the LCFs. In other words, these routines can create an image of a company that is active in R&D and innovation creation even though it is a “technology imitator”. This change in organizational identity or image can bring about a change in the category of LCFs perceived by their potential customers. Potential foreign technology customers may subdivide the category of “technology imitator” into “technology imitator pursuing innovation” and “technology imitator not pursuing innovation”. Then they can regard LCFs with many international joint R&D experience as belonging to the former category, and those that do not belong to the latter category. Therefore, when LCFs strategically conduct overseas joint R&D projects frequently, it will be easier to secure legitimacy for their attempts to license out their products and technologies in the international technology market.

H3: International joint R&D experience of a latecomer firm has a positive relationship with its international technology licensing-out.

3.4. The moderating role of foreign technology licensing-in experience

Licensing-in can complement a firm’s internal R&D activities in terms of creating innovative technologies and products which can be licensed out internationally (e.g. Cassiman & Veugelers, 2006; Ceccagnoli, Higgins, & Palermo, 2014; Laursen & Salter, 2006; Laursen, Leone, & Torrisi, 2010; Veugelers & Cassiman, 1999). Innovation can be enhanced by recombining distant knowledge (Schumpeter, 1934; Sorenson & Fleming, 2004; Nerkar & Roberts, 2004; Fleming & Sorenson, 2004). Foreign technology licensing-in experience allows firms to accumulate geographically or technologically distant knowledge, which can be utilized as a potential complementary knowledge resource for internal R&D. LCFs can create unique knowledge and ideas by combining the knowledge and technologies invented in internal R&D activities with the knowledge and technologies developed by foreign licensors (Fleming & Sorenson, 2004; Higgins & Rodriguez, 2006; Kim, 1997; Tsai & Wang, 2008). In other words, in the process of innovation, LCFs can gain synergy effects by concurrently conducting internal R&D activities and foreign technology licensing-in. Therefore, I hypothesize that:

H4a. The positive effect of a latecomer firm's accumulated internal R&D investment on its international technology licensing-out is strengthened as the latecomer firm has more foreign technology licensing-in experience.

On the other hand, repeated licensing-in of foreign technologies may weaken incentives for latecomer's internal R&D staffs to strive to learn. Kim (1997, 1999) argues that in terms of absorptive capacities, LCFs' intensity of efforts to learn is more important than a current level of their knowledge base to become an innovator. LCFs' internal R&D staffs have difficulty in controlling the licensed technologies from foreign licensors due to the lack of LCFs' internal technological capabilities and restricted rights to the licensed technology as defined in the contract (Walter, 2012). When a problem arises in the process of using the licensed technologies, LCFs' internal R&D staffs may rely on the licensor to solve the problem (Lowe & Taylor, 1998, 1999). This can lead to them losing their momentum to learn intensely and becoming too dependent on the external licensors' technologies and know-how (Atuahene-Gima, 1993; Atuahene-Gima & Patterson, 1993; Enkel, Gassmann, & Chesbrough, 2009; Lowe & Taylor, 1998; Walter, 2012).

Because organizations learn through repetitive experiences of specific behaviors (e.g. Levitt & March, 1988), routines that technically rely on foreign technology licensors can be set up in LCFs' R&D departments that repeatedly experience foreign technology licensing-in. These routines will act as an organizational mechanism to weaken the motivation for voluntary learning of the LCFs' R&D members, which hinders their in-depth understanding of imitated knowledge and the creation of novel knowledge for innovation. Even if the tangible and intangible resources essential for internal R&D activities are acquired through the accumulation of internal R&D investments, the lowered learning motivation of internal R&D staffs will reduce the productivity of internal R&D investments in terms of innovation outcome at the firm level. As international technology licensing-out is a direct consequence of a firm's innovative technologies or products.

LCFs' organizational identities can also affect the impact of their internal R&D activities on foreign technology licensing-out. The more active LCFs are in foreign technology licensing-in, the stronger their identity or image as a "follower" or "technology imitator". This reinforced image as a "technology imitator" can act as a mechanism by which potential foreign technology customers devalue the innovativeness or superiority of technologies and products developed by LCFs through their own R&D activities. Therefore, I hypothesize that:

H4b. The positive effect of a latecomer firm's accumulated internal R&D investment on its international technology licensing-out is weakened as the latecomer firm has more foreign technology licensing-in experience.

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Insert Figure 1 about here

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4. EMPIRICAL SETTING AND METHOD

4.1. Data

I conducted empirical analyses within the context of the Korean pharmaceutical industry. The Korean pharmaceutical industry is an appropriate context to test the hypotheses of this study. In the 1960s and 1970s, under government-driven initiatives for domestic production of drugs, Korean pharmaceutical companies entered the pharmaceutical industry by imitation. To fulfill the goals set by the Korean government, Korean pharmaceutical companies reverse engineered, in-licensed or manufactured original products invented by industry leaders of advanced countries/regions such as US, Japan and EU and subsequently sold the "imitation" products in the Korean domestic market. Since the 1990s, while maintaining their imitation strategy, some Korean pharmaceutical companies have developed new original drugs and incrementally modified drugs based on their own capabilities and have launched them into the domestic market. In the late 1990s, these companies even started to enter foreign markets through licensing out their technologies and products.

I tested the hypotheses by constructing a panel data set of 66 Korean pharmaceutical companies for 21 years (1999 ~ 2019), listed on the Korea Stock Exchange as of Dec 31, 2020. Licensing information of Korean pharmaceutical companies was collected using TS-2000 (Web-based reputable database of Korean companies' business information managed by Korea Listed Companies Association), Korea Pharmaceutical Industry R & D White Papers published by Korea Drug Research Association, Korea Pharmaceutical Company Directory Books published by Korea Health Industry Development Institute, Korea Pharmaceutical Data books published by Korea Pharmaceutical and Bio-Pharma Manufacturers Association, company websites and press releases. Financial and business information and R&D activities of sample companies were collected through DART (Web-based reputable database of Korean companies' business and financial information managed by Financial Supervisory Service of Korean government), KIND (Web-based reliable database of Korean companies' disclosure information managed by KRX (Korea Exchange)), TS-2000 and Pharmaceutical Industry Reports published by Korea Health Industry Development Institute.

On the Korea Stock Exchange, there were a total of 148 listed companies coded as pharmaceutical manufacturing industry. Based on annual reports disclosed in DART, I categorized 148 listed companies as general pharmaceutical companies, animal pharmaceuticals specialists, raw material specialists, medical device specialists, biopharmaceutical specialists, and therapy specialists. To secure sample firms suitable for the purpose of our research, I decided to choose only general pharmaceutical companies as sample firms. Due to data availability issues, I was only able to use 66 sample firms for hypotheses testing.

4.2. Variables & Method

Dependent variable. To observe the level of LCFs' international technology licensing-out at the firm-level, I calculate the number of publicly-disclosed international technology licensing-out contracts signed by the focal firm in the focal year.

Independent variable. I measured the level of LCF's accumulated internal R&D investment by calculating the natural logarithm of the total R&D expenditure in the 5-year windows before the observation year. In the pharmaceutical industry, long-term R&D investments must be preceded for LCFs to succeed in developing innovative technologies or products (Kale & Little, 2007). According to the '2019 Korea Pharmaceutical Industry R&D White Paper', on average, 5~10 years of R&D investment is required for Korean pharmaceutical companies to develop innovative new drugs or pipelines which can be licensed out internationally. To measure LCFs' foreign technology licensing-in experience, I calculate the total number of publicly-disclosed international technology licensing-in contracts signed by the focal firm within 5-year windows before the observation year. I use 5-year windows following Sikimic et al. (2016)'s approach which assumes that recent licensing-in experience is more relevant to firms' innovative activities than the experience from the distant past. International joint R&D experience is measured by the number of cases in which LCFs have conducted joint research or development projects for R&D purposes with foreign external organizations such as foreign pharmaceutical companies, bio-ventures, specialized research institutes, universities within 5-year windows before the observation year.

Control variable. I controlled for several firm level factors that probably have impacts on the LCF's international technology licensing-out. I controlled for domestic technology licensing-in experience which may significantly confound the effect of accumulated internal R&D investment, foreign technology licensing-in experience and international joint R&D experience on the dependent variable. Domestic technology licensing-in experience was calculated by the total number of publicly-disclosed domestic technology licensing-in contracts signed by a focal firm within 5-year windows before the observation year. To take account of LCF's different patenting strategies, I also controlled for the number of patents filed by a firm within 5-year windows before the observation year. Additionally, firm size is controlled by the total revenue of a focal firm in the observation year of the dependent variable (using a natural logarithm form). To measure firm age, I subtracted the year of establishment of a focal firm from the observation year of the dependent variable. Since LCFs with more financial slack resources can try more projects with a higher risk of failure and internalize upstream and downstream activities for innovation, I controlled slack resources measured by the logarithm of the percentage of total current liabilities to total current assets in the observation year of the dependent variable. Firms with better performance can allocate more financial resources to innovation activities. I controlled for firm performance, measured by return on assets—the ratio of total income divided by total assets in the observation year. To control for firm-level degree of internationalization, I calculated the percentage of overseas sales compared to total sales at the firm level in the observation year (Contractor, Kumar, & Kundu, 2007; Sanders & Carpenter, 1998). To consider LCF's orientation of technological learning (Kim, 1997), I controlled for firms' duplicative imitation experience, creative imitation experience, and innovation experience.

Duplicative imitation experience is calculated by the total number of generic drugs developed by the firm. Creative imitation experience is calculated by the total number of incrementally modified drugs developed by the firm. Innovation experience is measured by the number of new original drugs developed by the firm. These three experience-related variables were calculated using a 5-year window before the observation year of the dependent variable. Lastly, I accounted for year-specific unobserved heterogeneity by including year dummies in the regression models.

4.3 Method

As our dependent variable is a count variable, which has a positive integer value, I can employ panel Poisson or negative binomial regression model to test our hypotheses (Wooldridge, 2013). As LR test shows that the dependent variable of this study can be over-dispersed in all models, the results is reported based on panel negative binomial regression model. When analyzing panel data at the firm level, either fixed effects or random effects models can be used, depending on whether there is significant firm heterogeneity between panels. However, Hausman test is not valid in case of panel count regression models (Wooldridge, 2013), I chose random effect model as a base model. While the fixed-effects model drops 38 firms, which have no experience of international technology licensing-out over time, out of 66 LCFs, LCFs that have no experience of international technology licensing-out during the time frame of our panel dataset can contribute to the likelihood function of a random-effect model. This is because a random-effect model admits all panels regardless of the existence of within-variation over time (Wooldridge, 2013)[2]. To take account of time-lag effects, all explanatory variables were lagged 1 year.

5. RESULTS

5.1. Results of Hypothesis Testing

Table 1 presents the descriptive statistics and the correlation matrix between variables. Accumulated R&D investment showed a positive correlation of 0.299 with international technology licensing-out as predicted in Hypothesis 1, and was statistically significant at the 5% level. Foreign technology licensing-in experience and international technology licensing-out showed a positive correlation of 0.066 as predicted in Hypothesis 2a, but were not statistically significant. International joint R&D experience and international technology licensing-out showed a positive correlation of 0.214 as predicted in Hypothesis 3 and statistically significant at the 5% level. The correlation matrix does not show any troubling collinearity among the variables, except for firm size and accumulated internal R&D investment. To ensure that the results of this study are not affected by multicollinearity, I calculated the variance inflation factors (VIFs) associated with the model covariates. VIFs of firm size and accumulated internal R&D investment were 4.21 and 4.25, respectively and all other VIFs were below 2, suggesting that there is no significant bias in the estimated

[2] However, if the assumption of the independent random-firm effects uncorrelated with explanatory variables is violated, the results from random-effects models may suffer from the inconsistency due to omitted variables (Song, 2002; Greene, 1997).

models resulting from a multicollinearity problem.

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Insert Table 1 about here

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Table 2 presents the results of random effect panel Poisson regression analyses through Model 1 to Model 6. Model 1 is the base model which shows the effects of control variables only. I added accumulated internal R&D investment, foreign technology licensing-in experience and international joint R&D experience as independent variables to Model 2, Model 3, and Model 4, respectively. In Model 5, these independent variables were inserted all at once into the base model. The explanatory power of Model 1 increased significantly by adding the main independent variables. In Model 6, I tested the models adding the interaction term of accumulated internal R&D investment and foreign technology licensing-in experience. All estimated models have high explanatory power ($p < .001$).

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Insert Table 2 about here

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In Hypothesis 1, I predicted a positive relationship between a LCF's accumulated internal R&D investment and international technology licensing-out. In Model 2, 5, and 6, the coefficient of accumulated internal R&D investment was consistently positive and significant ($p < 0.05$), supporting Hypothesis 1. Hypothesis 2a and 2b proposes positive and negative relationships between a LCF's foreign technology licensing-in experience and international technology licensing-out, respectively. An empirical analysis of these hypotheses show intriguing results. While the coefficient of foreign technology licensing-in experience in Model 3 ($p < 0.1$) and 5 ($p < 0.1$) were negative and significant, the coefficient in Model 6 ($p < 0.01$) was positive and significant. Therefore the results support Hypothesis 2b in Model 3, 5 while support Hypothesis 2a in Model 6. I will further elaborate on this result in the following section. Hypothesis 3 suggests a positive relationship between a LCF's international joint R&D experience and international technology licensing-out. The results of Hypothesis 3 in all models were not statistically significant.

The coefficients of the interaction term of accumulated R&D investment and foreign technology licensing experience in Model 6 was negative and significant, which means Hypothesis 4b is supported. Figure 2 shows the moderation effect of LCFs' foreign technology licensing-in experience. That is, LCFs' foreign technology licensing experience weakens the positive effect of LCFs' accumulated internal R&D investment on their international technology licensing-out. I will further elaborate on this result in the following section.

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Insert Figure 2 about here

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5.2. Robustness check

To verify that the results are not an artifact of the statistical specification, the findings from different regression models for count data, including conditional fixed effects negative binomial model, negative binomial GEE population averaged model, random effects Poisson model, conditional fixed effects Poisson model, and Poisson GEE population averaged model are presented in Table 3. Except conditional fixed effects negative binomial and Poisson model cases, the results consistently support our hypotheses. While the fixed effects models have the advantage of utilizing within variation for a given firm to control unobserved firm heterogeneity, conditional fixed-effects Poisson and negative binomial models drops 38 firms, which have no experience of international technology licensing-out over time, out of 66 panels in this study. Hypothesis 1 was not statistically supported in the conditional fixed effects models due to the loss of degrees of freedom caused by the dropouts of the 38 panels.

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Insert Table 3 about here

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6. DISCUSSION AND CONCLUSION

This study empirically proved the determinants for international technology licensing-out for LCFs based on the literature on LCFs' technological learning and catch-up, resource and capability-based perspectives, and organizational identity theory. LCFs mainly use foreign technology licensing-in and international joint R&D as a means of securing external useful technologies or knowledge in the catch-up process (Zhang et al. 2021). I found that LCFs' foreign technology licensing-in experience can have a "double-edged sword" impact on their international technology licensing-out. In the global market for technologies, LCFs have an organizational identity of 'follower' or 'technology imitator’. The more LCFs license in foreign technologies, the stronger their existing organizational identity. This makes it difficult for LCFs to secure the legitimacy of their innovation activities from potential foreign licensing partners, negatively affecting their formation of international technology licensing-out.

On the other hand, LCFs may enhance their international technology licensing-out through active internal R&D activities with the complementary capabilities to manage international licensing contracts and inter-organizational networks accumulated through foreign technology licensing-in experience. However, LCFs’ excessive reliance on foreign technology licensing-in may undermine the motivation for self-learning and innovation creation of their internal R&D staffs and allows potential foreign technology customers devalue the innovativeness or superiority of technologies and products developed through their own R&D activities. In short, in order for LCFs to increase the possibility of international technology licensing-out, it is necessary to actively conduct internal R&D parallel with foreign technology licensing-in, but beware of excessive foreign technology licensing-in.

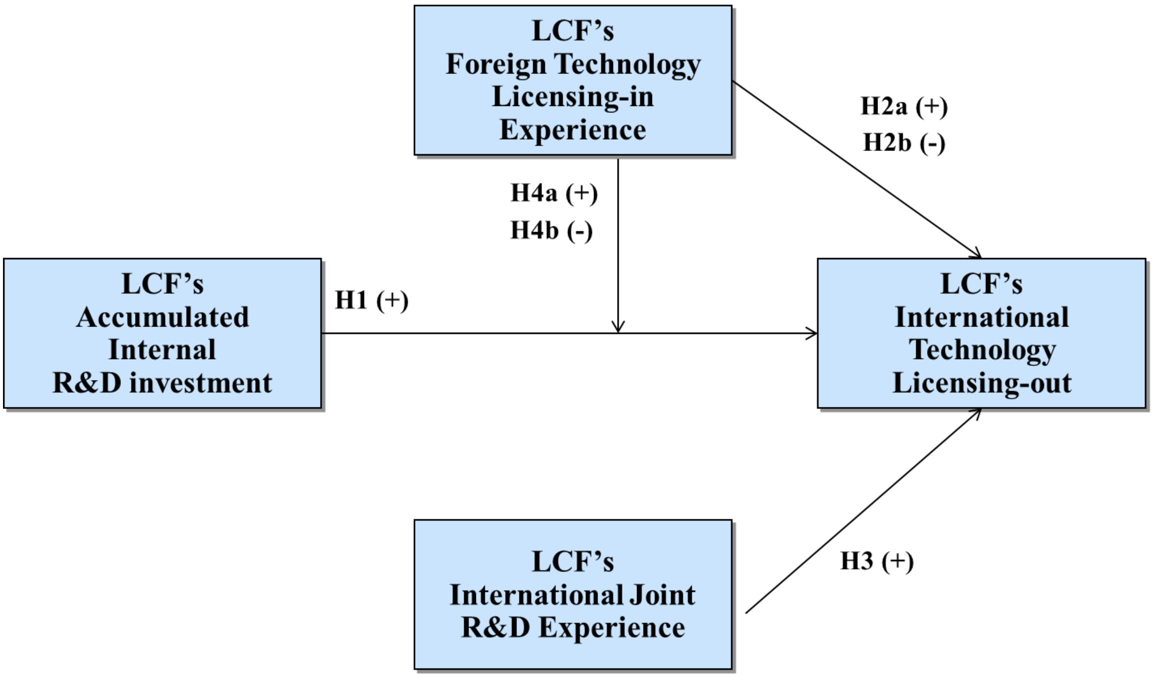
This study theoretically contributes in three aspects. First, the determinants of foreign technology licensing-out of LCFs have been relatively overlooked in the literature on technological learning and catch-up mechanisms of LCFs. In this study, I contribute to the elaboration and development of catch-up literature by presenting the explanatory factors for LCFs’ international technology licensing-out. Second, the effect of the organizational identity on the formation of inter-organizational dyadic relationship was empirically verified in the context of the formation of international technology licensing contract. What's intriguing here is that LCFs' images of "tech. imitators" to external stakeholders may affect negatively the formation of their international technology licensing-out. If LCFs strategically carry out internal R&D, they can overcome the image of a "technology imitator" that is reinforced by foreign technology licensing-in transactions. Third, the accumulation of foreign technology licensing-in experience can negatively affect LCFs' innovation creation process based on internal R&D. Existing literature that empirically studied the effect of internal R&D and technology licensing on the innovation at the firm level considered internal R&D and technology licensing-in as an alternative or complementary mechanism. However, the results of these studies have been inconsistent or not statistically significant. I provide a fresh perspective to the relevant literature by presenting the hypothesis that technology licensing-in experience can negatively affect the innovation productivity of internal R&D investments, as well as the empirical evidence that supports it.

This study provides important practical implications for LCFs' top managers. In LCFs with an organizational identity of "technology imitator", it is highly likely to face resistance from internal members such as middle managers and external stakeholders when managers actively decide to invest in internal R&D (Hoon & Jacobs, 2014; Huy, 2011). Nevertheless, the ambitious CEO or top management team of LCFs who want to catch up or surpass foreign industry leaders must pursue a firm strategy that combines selective foreign technology licensing-in and internal R&D. This strategy gives LCFs an opportunity to overcome its image as a "technology imitator" in the international market for technologies and to enter overseas markets or implement an open innovation strategy through technology licensing-out.

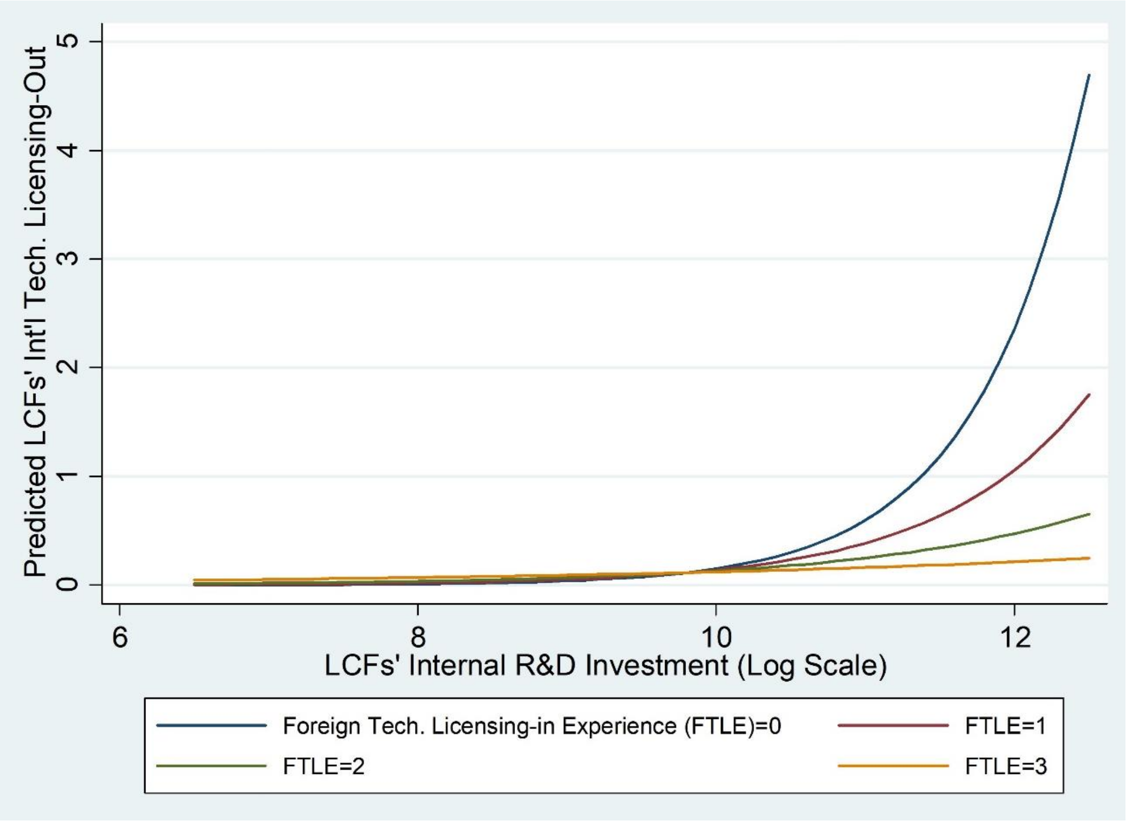
This study has several limitations, and these limitations should be resolved in future studies. Firstly, the generalization of empirical analysis results is limited because I used one industry of one country as an empirical context for research. It would be empirically and theoretically meaningful to expand the context of this research to other countries such as India, which have successfully performed the catch-up process in the pharmaceutical industry so far (Chittoor, Sarkar, Ray, & Aulakh, 2009; Kale & Little, 2007; Ray & Ray, 2021). Second, this study assumes that an innovative technologies or products developed by LCFs can be licensed out abroad generally. I haven't made a distinction between the nature of innovation. However, the likelihood of a LCF's international technology licensing-out may vary depending on whether the LCF's innovation is closer to incremental or radical innovation (e.g. Wu, Harrigan, Ang, & Wu, 2019), or exploitative or exploratory innovation (e.g. Jansen, Van Den Bosch, & Volberda, 2006). Incremental innovation or exploitative innovation developed by LCFs will be difficult to become an attractive target for licensing-in to potential foreign technology buyers. For these types of innovative technologies and products, it is likely that there are already many competing technologies in the market, or that industry leaders are developing similar technologies internally. On the other hand, if a LCF develops radical innovation or exploratory innovation based on a path-creating catch-up strategy, it is more likely to license it out internationally. What is interesting here is that the opposite logic can also be presented. This is because it may be difficult to secure legitimacy from external stakeholders when a LCF with the image or organizational identity of a 'technology imitator' develops radical innovation or exploratory innovation. It will be a very interesting research topic to empirically study the impact of innovation characteristics or innovation strategies of LCFs on the international technology licensing-out potential through in-depth data analysis of their R&D pipelines and patents portfolio.

Another limitation of this study is that the various mechanisms such as organizational status, organizational prestige, reputation, which external stakeholders consider when predicting or judging organizational behavior under bounded rationality, have not been considered during the development of theories and hypotheses. If these variables are also considered with organizational identity as determinants for LCF's international technology licensing-out, it is expected to make a significant contribution to open innovation theory and LCFs' technological catch-up literature.

[Figure 1] Research model



[Figure 2] Moderation effect of LCFs' foreign technology licensing-in experience



[Table 1] Descriptive statistics and correlations (N=678)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. International technology licensing-out	1													
2. Accumulated internal R&D investment (log scale)	0.299*	1												
3. Foreign technology licensing-in experience	0.066	0.325*	1											
4. International joint R&D experience	0.214*	0.416*	0.154*	1										
5. Domestic technology licensing-in experience	0.027	0.118*	0.131*	0.036	1									
6. Number of patents filed	0.344*	0.651*	0.200*	0.651*	0.042	1								
7. Firm size (log scale)	0.262*	0.851*	0.396*	0.336*	0.142*	0.560*	1							
8. Firm age	0.122*	0.362*	0.203*	0.065	0.128*	0.126*	0.443*	1						
9. Slack resources (log scale)	-0.086*	-0.092*	-0.033	-0.089*	-0.062	-0.119*	-0.174*	-0.151*	1					
10. Firm performance	0.025	0.182*	0.061	0.032	-0.007	0.086*	0.220*	0.053	0.170*	1				
11. Degree of internationalization	0.132*	0.194*	0.017	0.081*	0.039	0.219*	0.207*	-0.021	-0.174*	0.016	1			
12. Duplicative imitation experience	0.083*	0.112*	0.127*	0.002	0.165*	0.163*	0.199*	0.112*	-0.231*	-0.038	0.089*	1		
13. Creative imitation experience	0.220*	0.419*	0.129*	0.184*	-0.099*	0.409*	0.334*	-0.004	0.014	0.032	-0.026	0.244*	1	
14. Innovation experience	0.372*	0.418*	0.241*	0.241*	0.079*	0.346*	0.373*	0.252*	-0.106*	0.023	0.307*	0.020	0.249*	1
Mean	0.124	9.618	0.496	0.230	0.344	16.954	11.474	46.586	5.512	0.034	8.067	62.251	0.368	0.149
SD	0.479	1.560	0.930	0.813	0.707	23.998	1.024	19.276	0.639	0.151	13.543	32.054	0.966	0.429
Min	0	4.954	0	0	0	0	7.493	1	3.638	-0.796	0	1	0	0
Max	6	13.282	6	8	6	180	14.188	119	8.127	0.274	91.4	213	9	5

* $p < 0.05$

[Table 2] Result of Random effect panel negative binomial regression model

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	-6.609*	-4.551	-7.493*	-6.286*	-5.579	-7.337*
	(3.700)	(3.521)	(3.751)	(3.767)	(3.628)	(3.769)
Domestic licensing-in experience	0.172	0.143	0.234	0.161	0.209	0.336
	(0.206)	(0.207)	(0.208)	(0.208)	(0.209)	(0.212)
Number of patents filed	0.008	-0.002	0.009	0.005	-0.003	-0.000
	(0.007)	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)
Firm size	0.568†	-0.342	0.676*	0.521†	-0.245	-0.211
	(0.310)	(0.478)	(0.314)	(0.316)	(0.459)	(0.456)
Firm age	0.003	0.000	0.001	0.003	-0.002	-0.003
	(0.012)	(0.011)	(0.012)	(0.012)	(0.011)	(0.012)
Slack resource	-0.402	-0.443	-0.430	-0.364	-0.451	-0.474
	(0.281)	(0.278)	(0.284)	(0.291)	(0.291)	(0.295)
Firm performance	0.719	0.532	0.710	0.711	0.537	0.534
	(0.675)	(0.669)	(0.671)	(0.687)	(0.668)	(0.676)
Degree of internationalization	-0.001	-0.002	-0.003	0.001	-0.003	-0.002
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Duplicative imitation experience	0.008	0.007	0.009	0.008	0.008	0.007
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
Creative imitation experience	0.267†	0.156	0.276*	0.292*	0.178	0.229
	(0.141)	(0.141)	(0.143)	(0.145)	(0.148)	(0.151)
Innovation experience	0.727***	0.642***	0.776***	0.755***	0.738**	0.752**
	(0.199)	(0.201)	(0.203)	(0.203)	(0.212)	(0.223)
Accumulated internal R&D investment		0.941*			0.974*	1.142**
		(0.428)			(0.421)	(0.444)
Foreign technology licensing-in experience			-0.276†		-0.337†	3.420**
			(0.180)		(0.181)	(1.268)
International joint R&D experience				0.230	0.213	0.244
				(0.258)	(0.264)	(0.265)
Accumulated internal R&D investment x Foreign technology licensing-in experience						-0.353**
						(0.122)
Year dummy	Included	Included	Included	Included	Included	Included
Log-likelihood	-194.211	-190.996	-192.973	-193.815	-188.957	-185.499
Wald Chi-square	56.99***	65.69***	54.86***	53.48***	55.25***	50.63**
N	678	665	678	678	665	665

Standard errors are in parentheses. † $p < 0.1$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

[Table 3] Result of other regression models for count data (full models)

Variables	Negative binomial			Poisson		
	Random Effects	Conditional Fixed Effects	GEE PA	Random Effects	Conditional Fixed Effects	GEE PA
Constant	-7.337*	-11.018†	-6.901*	-9.181*	-	-6.849*
	(3.769)	(5.837)	(3.329)	(3.700)		(3.051)
Domestic licensing-in experience	0.336	0.237	0.258	0.376†	0.315	0.327*
	(0.212)	(0.256)	(0.197)	(0.198)	(0.228)	(0.163)
Number of patents filed	-0.000	0.010	0.001	0.002	0.010	0.002
	(0.008)	(0.011)	(0.008)	(0.008)	(0.010)	(0.006)
Firm size	-0.211	1.316†	-0.549	-0.260	1.225†	-0.239
	(0.456)	(0.721)	(0.420)	(0.447)	(0.682)	(0.360)
Firm age	-0.003	-0.010	-0.002	-0.004	0.017	-0.005
	(0.012)	(0.037)	(0.010)	(0.011)	(0.094)	(0.010)
Slack resource	-0.474	-0.245	-0.593*	-0.504†	-0.253	-0.616*
	(0.295)	(0.357)	(0.281)	(0.290)	(0.335)	(0.257)
Firm performance	0.534	0.514	0.256	0.626	0.587	0.342
	(0.676)	(0.800)	(0.636)	(0.658)	(0.773)	(0.519)
Degree of internationalization	-0.002	0.012	-0.004	-0.005	0.013	-0.007
	(0.012)	(0.018)	(0.012)	(0.012)	(0.017)	(0.010)
Duplicative imitation experience	0.007	0.013	0.004	0.008	0.010	0.001
	(0.008)	(0.010)	(0.006)	(0.008)	(0.009)	(0.006)
Creative imitation experience	0.229	0.235	0.251*	0.240	0.217	0.218*
	(0.151)	(0.195)	(0.129)	(0.151)	(0.185)	(0.108)
Innovation experience	0.752**	0.835***	0.770***	0.788***	0.809	0.561***
	(0.223)	(0.219)	(0.232)	(0.212)	(0.213)	(0.169)
Accumulated internal R&D investment	1.142**	-4.419	1.376***	1.181**	-0.461	1.029**
	(0.444)	(4.527)	(0.424)	(0.441)	(0.609)	(0.350)
Foreign technology licensing-in experience	3.420**	3.698*	3.566**	3.643**	3.473**	3.176**
	(1.268)	(1.473)	(1.345)	(1.257)	(1.497)	(1.152)
International joint R&D experience	0.244	0.489†	-0.057	0.253	0.431	-0.048
	(0.265)	(0.281)	(0.243)	(0.252)	(0.273)	(0.199)
Accumulated internal R&D investment x Foreign technology licensing-in experience	-0.353**	-0.377**	-0.364**	-0.378**	-0.358*	-0.321**
	(0.122)	(0.143)	(0.127)	(0.121)	(0.146)	(0.109)
Year dummy	Included	*Excluded*	Included	Included	*Excluded*	Included
Log-likelihood	-185.499	-123.569	n/a	-186.705	-125.483	n/a
Wald Chi-square	50.63**	25.52*	106.40***	54.94**	29.38**	144.62***
N	665	275	665	665	275	665

Standard errors are in parentheses. † $p < 0.1$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

OVERALL CONCLUSION

In this doctoral thesis, I investigated how the heterogeneity of LCFs' technological learning strategies affects their creative imitation, innovation and international out-licensing at the firm-level in the context of the Korean pharmaceutical industry. Three studies in this thesis consistently contribute to the extant literature on technological catch-up by LCFs, which was previously mostly based on case studies or computational modeling, by empirically verifying the explanatory factors involved in developing creative imitation, innovation, and international out-licensing in LCFs.

This thesis has several theoretical contributions as follows. In Study 1, the results of the study show that accumulated internal R&D investment and foreign technology in-licensing experience have a positive impact on the development of creative imitation in LCFs, as suggested in the existing case research. However, experience with foreign technology in-licensing in LCFs can mitigate the positive impact of accumulated internal R&D investment on creative imitation, acting as a 'double-edged sword' and ultimately having a negative effect on creative imitation in LCFs. This causal relationship has been overlooked in research and case studies based on existing theories; my analyses revealed that a more complex and subtle mechanism is at work between the technology learning of LCFs and the development of creative imitation. In Study 2, I found the paradoxical effects of creative imitation experience on LCFs' innovation. This discovery allows us to gain a deeper understanding of why LCFs are hard to innovate even if they conduct intensive R&D investment in parallel with the efforts of creative imitation. Excessive creative imitation strategy can be an obstacle for firms within the imitator group to move to the innovator group (Caves and Porter, 1977; Lee, 2003) even though creative imitation may contribute to increasing diversity within an industry (e.g. Posen et al., 2013; Posen and Martigoni, 2018) and LCFs' performance in the short-run. In Study 3, the effect of the organizational identity on the formation of inter-organizational dyadic relationship was empirically verified in the context of the formation of international technology out-licensing contract. What's intriguing here is that LCFs' images of "technology imitators" to external stakeholders may affect negatively the formation of their international technology out-licensing. If LCFs strategically carry out internal R&D, they can overcome the image of a "technology imitator" that is reinforced by foreign technology in-licensing transactions.

Although industry leaders continue to innovate based on abundant resources and capabilities, successful LCFs evolve from imitation to innovation and succeed in threatening or surpassing the competitive advantages of the leaders. Most of the literature dealing with the catch-up mechanism of LCFs has been qualitatively studied on exceptional success stories of some LCFs. In this thesis, based on the technological learning model of LCFs, I verified the effects of LCFs' accumulated internal R&D investment, technology imitation experience, and international joint R&D experience on firm-level innovative outcome such as creative imitation, innovation, and international technology out-licensing based on quantitative research methodology. It is expected that the core implications derived from this paper can provide useful implications for the establishment of innovation strategies for LCFs.

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국 문 초 록

후발기업의 기술적 학습 및 추격 모델, 개방형 혁신 문헌, 자원 및 역량 기반 관점, 조직 정체성 문헌을 바탕으로 본 논문은 후발기업 간 기술 학습 전략의 이질성이 기업 수준의 창조적 모방, 혁신 및 국제 라이선싱 아웃에 미치는 영향을 탐구한다. 연구 1에서는 축적된 내부 R&D 투자와 해외 기술 라이선싱 인 경험이 후발기업의 창조적 모방에 독립적, 상호작용적으로 어떤 영향을 미치는지 살펴본다. 나는 축적된 내부 R&D 투자나 해외 기술 라이선싱 인 경험이 후발기업의 창조적 모방 창출에 독립적으로 긍정적 영향을 미친다는 것을 보였다. 그러나 축적된 내부 R&D 투자와 해외 기술 라이선싱 인 경험이 동시에 증가하면 창조적 모방 결과가 줄어들어 이 두 학습 모드 사이에 긴장이 존재한다는 것을 발견했다. 연구 2는 축적된 내부 R&D 투자, 해외 기술 라이선싱 인 경험, 창조적 모방 경험이 후발기업의 혁신에 어떻게 독립적이고 상호작용적으로 영향을 미치는지 검증한다. 후발기업의 축적된 내부 R&D 투자와 창조적 모방 경험은 각각 혁신에 긍정적인 영향을 미치는 것으로 나타났다. 그러나 나는 후발기업의 창조적 모방 경험이 축적된 내부 R&D 투자와 혁신 사이의 긍정적인 관계를 약화시키는 것을 발견했으며, 이는 후발기업의 창조적 모방 전략이 혁신에 미치는 역설적 효과를 시사한다. 후발기업 혁신에 대한 해외 기술 라이선싱 인 경험의 효과는 독립효과의 경우와 축적된 내부 R&D 투자와의 상호작용 효과의 경우 모두 통계적으로 유의하지 않았다. 연구 3에서는 축적된 내부 R&D 투자, 해외 기술 라이선싱 인 경험, 국제 공동 R&D 경험이 후발기업의 국제 기술 라이선싱 아웃에

어떠한 영향을 미치는지 살펴보았다. 축적된 내부 R&D 투자는 후발기업의 국제 기술 라이선싱 아웃에 긍정적인 영향을 미치는 반면, 국제 공동 R&D 경험은 유의한 영향을 미치지 않았다. 그러나 해외 기술 라이선싱 인 경험의 효과는 다소 복잡했다. 해외 기술 라이선싱 인 경험과 축적된 내부 R&D 투자 간의 상호작용을 고려할 때 해외 기술 라이선싱 인 경험은 후발기업의 국제 기술 라이선싱 아웃에 독립적으로 긍정적인 영향을 미치는 반면, 축적된 내부 R&D 투자와의 상호작용을 통해서는 부정적인 영향을 미쳤다. 실증분석은 21년(1999~2019) 간에 대한 한국 제약산업의 66개 상장 후발기업의 패널 데이터 세트를 기반으로 수행되었다. 본 논문의 실증적 분석 결과는 후발기업의 혁신 창출 메커니즘에 내재된 복잡하고 미묘한 인과관계를 보여줌으로써 후발기업의 보다 정교한 혁신 및 추격 전략 수립에 중요한 시사점을 제공한다.

주요어: 후발기업의 혁신, 캐치업, 기술적 학습, 기술 라이선싱, 창조적 모방, 한국 제약산업

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