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Latecomer firms' technological learning strategies for creative imitation: evidence from the Korean pharmaceutical industry

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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 the data of 61 listed Korean pharmaceutical firms over 19 years (1999 ~ 2017), we 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, we 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.

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Creative imitation; technology in-licensing; latecomer firms; pharmaceutical industry

1. Introduction

Latecomer firms (LCFs) from emerging or newly industrialised economies are often regarded as lacking technological and innovative capabilities compared to firms in developed countries (Kim 1997; Mathews 2002; Lee and Malerba 2017; Lee 2019). However, numerous studies have provided strong evidence that these LCFs can successfully catch up or compete with global industry leaders not only in medium– or low-tech industries, but also in high-tech industries such as electronics, bio-pharmaceuticals, telecommunication devices, and automobiles (Kale and Little 2007; Lee and Lim 2001; Li and Kozhikode 2008; Luo, Sun, and Wang 2011; Miao et al. 2018; Park and Ji 2020; Peng et al. 2022; Wang et al. 2019).

How is such catch-up possible for LCFs? In a recent review article, Malerba and Lee (2021) summarised that there have been two strands of literature: one focused on catch-up as a learning process by LCFs at the firm-level and the other focused on the firms' interactions with their surrounding innovation systems at the country-, sectoral-, and regional levels. The former strand has attracted some scholars, who view the catch-up process from a learning perspective (Figueiredo and Cohen 2019; Kale and Little 2007; Li and Kozhikode 2008; Luo, Sun, and Wang 2011; Miao, Salomon, and Song 2021). On the one hand, two primary types of learning strategies have been identified, namely, internal R&D investment and foreign technology in-licensing. These learning strategies help LCFs develop their own technological capabilities, which in turn enable them to catch up to industry leaders. On the other hand, some studies focus on the learning process, which often evolves as the company progresses through the catch-up stages. Notably, Kim (1997, 1999) proposed a three-stage catch-up model, 'duplicative imitation-creative imitation-innovation', a classical sequence that highlights creative imitation as a transitional phase in which a duplicative imitator

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may transform into an innovator. Although the existing literature has presented successful cases of those who were able to successfully complete this transformation (Guo et al. 2019; Mei and Yang 2021; Zhang et al. 2019), it is still extremely rare.

Then, why such a transition is so difficult? We find that the existing literature has not paid much attention to the middle stage of creative imitation despite its important role. In this paper, we focus on the early half stage of the catch-up process and investigate how two different LCF learning strategies affect creative imitation. We not only examine the independent effect of these two learning strategies on creative imitation but also investigate the interaction effect. We highlight the negative interaction between the two learning strategies as the main contribution of this paper since most of the existing literature has either not explored the possibility of the existence of an interaction effect or implicitly assumes that a positive interaction effect exists. Negative interaction is more likely to occur among LCFs since pursuing two learning strategies simultaneously requires a major increase in resource investment, which is particularly burdensome on the characteristically resource-constrained LCFs.

To verify the independent and interactive effects of internal R&D investment and foreign technology in-licensing on the outcomes of creative imitation among LCFs, we 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 strategies, which suggests that LCFs should avoid pursuing both at a high level. Rather, LCFs would be better served focusing on foreign technology in-licensing in the very early stages of the catch-up process, then slowly decreasing their dependence on licensing and investing more in internal R&D.

This paper contributes to the technological catch-up literature by focusing on creative imitation – the transitional phase through which LCFs become innovators. We identified two different learning strategies (i.e. internal R&D investment and foreign technology in-licensing) and examined their effects on creative imitation. Especially, we attempt to demonstrate the evolutionary process of capability development of LCFs by considering the potential interaction effect between these two learning strategies. This paper also complements the existing literature, which remains dominated by case studies, by introducing the Korean pharmaceutical industry as a promising empirical setting in this field.

2. Theory and Hypotheses

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

In the late 1990s, Kim (1997, 1999) proposed a classical conceptual model of technological learning by LCFs based on several successful cases in South Korea which suggests that the catch-up process follows a sequential path: duplicate imitation, then creative imitation, then innovation. In a recent review paper, Park and Ji (2020) stated that this three-stage model not only holds true for the mass-produced goods sectors but also for the Complex Products and Systems (CoPS) industries. The key argument in this stage model is that a transitional phase often exists in the catch-up process. Although it is true that most LCFs often enter an industry by imitating (i.e. reverse engineering) existing technologies or products from industry leaders (Chung and Lee 2015; Kale and Little 2007; Kim and Nelson 2000; Lee 2005; Luo, Sun, and Wang 2011) since their technological capabilities are far behind in the early stage of catch-up (Fan 2006; Kim 1997), such duplicate imitation does not necessarily enable LCFs to become innovators. To become innovators, LCFs should first become creative imitators.

Creative imitation often entails generating imitative products that offer new performance features (Schnaars 1994). It also requires a more complex and difficult development process that involves creatively reorganising or recombining – rather than blindly imitating – innovators' existing products or technologies to meet the needs of new customer segments or to enter new markets or sectors (Kim 1997; Lee and Zhou 2012; Wang et al. 2019). Thus, becoming creative imitators is not an easy task for LCFs as it requires making considerable efforts toward capability development (Giachetti, Lampel, and Li Pira 2017; Posen and Martignoni 2018, Shenkar 2010). Two different learning strategies for capability development in the early catch-up stage have been identified in extant literature: internal R&D investment and foreign technology in-licensing (Kale and Little 2007; Kim 1999; Li and Kozhikode 2008; Luo, Sun, and Wang 2011).

2.1.1. Internal R&D investment and creative innovation

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 et al. 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 emphasised 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 organisational 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 and 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 and Levinthal 1990). 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). Therefore, we hypothesise that:

H1: Accumulated internal R&D investment of latecomer firms has a positive relationship with their creative imitation.

2.1.2. Foreign technology in-licensing and 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 and Cassiman 1999). Foreign technology in-licensing is an alternative mechanism for internal R&D activities in terms of acquiring knowledge and technologies (Atuahene-Gima and Patterson 1993; Kim 1999; Laursen and Salter 2006; Veugelers and Cassiman 1999). Creative imitation begins with imitation of the latest innovative, cutting-edge original external technologies (Lee and 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 and Lejarraga 2016; Kim 1999; Laursen and Salter 2006; Sikimic et al. 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 and 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 and 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, and Chen 2013; Kim 1999). In the global market for technologies, LCFs can utilise 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 and Fosfuri 2003; Asheim and Isaksen 2002; Bianchi and Lejarraga 2016; Kim 1998; Sikimic et al. 2016). Therefore, we hypothesise that:

H2: Foreign technology in-licensing experience of latecomer firms has a positive relationship with their creative imitation.

2.2. The interaction between internal R&D investment and foreign technology in-licensing

Accumulated internal R&D investment and foreign technology in-licensing were both found to be key success factors in the catch-up literature. Foreign in-licensing is viewed as an effective learning strategy in the early stages of catching up, while internal R&D investment is highlighted more in the transitional phase (Park and Ji 2020). As LCFs upgrade their technological capabilities, they must decide whether to pursue both learning strategies or focus on one or the other in each catch-up stage. However, few studies have investigated the possibility of an interaction effect between the two learning strategies, and there is a lack of empirical evidence to support LCFs in choosing the optimal combination of learning strategies at a specific catch-up stage.

Thus, we propose two competing hypotheses on the interaction between accumulated internal R&D investment and foreign technology in-licensing experience to verify their interactive effects on creative imitation. Specifically, we first view the two learning strategies as complementary and hypothesise a positive interaction effect, then we hypothesise a negative interaction effect viewing the strategies as trade-offs.

2.2.1. The positive interaction between the two learning strategies

On the one hand, internal R&D activities and foreign technology in-licensing can be complementary learning strategies (e.g. Cassiman and Veugelers 2006; Ceccagnoli, Higgins, and Palermo 2014; Laursen, Leone, and Torrisi 2010; Laursen and Salter 2006; Veugelers and Cassiman 1999) and therefore exhibit a positive interaction effect. Firstly, when an LCF increases its internal R&D investment, the positive effect of foreign technology in-licensing on creative imitation will be enhanced. This increase in in-licensing indicates that the LCF will have a larger pool of technology assets that can be utilised in further creative imitation. If the LCF simultaneously increases its R&D investment, its absorptive capacity will be enhanced (Cohen and Levinthal 1990), which enables it to identify more promising in-licensing opportunities in foreign countries. Stronger absorptive capacity also can help the firm to evaluate the potential benefit of licenses under consideration more accurately, thus increasing the likelihood of these technologies resulting in successful creative imitation.

The positive effect of accumulated internal R&D investment can also be enhanced by foreign technology in-licensing. Previous literature shows that firms can create unique technological ideas by combining the knowledge and technologies resulting from internal R&D activities with those from external sources (e.g. Fleming and Sorenson 2004; Tsai and Wang 2008). In the same vein, the number of opportunities to recombine the knowledge accumulated by the LCF through its own internal R&D with that assimilated through licensing will be much greater when the LCF is more engaged in both types of learning. In other words, the internal R&D process of developing new knowledge and ideas for creative imitation will be enhanced by a broadened pool of licensed technology.

2.2.2. The negative interaction between the two learning strategies

On the other hand, there can be inherent trade-offs between internal R&D activities and foreign technology in-licensing, such that the two exhibit a negative interaction effect. The process of creative imitation requires both exploitative and explorative learning (March 1991) since the incumbent firms' technologies should be further developed in a creative way. LCFs can exploit existing knowledge by in-licensing foreign technology and exploring new ways of utilising this knowledge in combination with their own R&D. However, these two learning strategies often compete for scarce organisational resources (Fan 2006; Forbes and Wield 2008; Li and Kozhikode 2008), which leads to a trade-off situation (Lavie, Stettner, and Tushman 2010). That is, if an LCF buys more technologies on the external market via licensing, then less of its R&D budget can be allocated to investments in its internal R&D or in human capital. Therefore, increasing its foreign technology in-licensing will not necessarily result in creative imitation since doing so will reduce its capacity for internal R&D investment.

Furthermore, exploitation and exploration often exhibit conflicting organisational routines, which makes it more difficult to benefit from the simultaneous pursuit of both at a high level (Stettner and Lavie 2014). In the early stage of catch-up, LCFs usually focus on exploitation by imitating technologies licensed from foreign innovators (Kim 1997, 1999). As LCFs gradually accumulate foreign technology in-licensing experience, they tend to rely on the licensors to solve technical problems arising from the exploitation of technologies licensed (Lowe and Taylor 1998, 1999), which leads to the establishment of exploitation-focused learning routines. Unfortunately, such routines may hinder LCFs' depth of understanding of imitated knowledge and weaken their motivation to develop novel knowledge and therefore to engage in creative imitation. Therefore, even if an LCF is able to invest more resources in licensing while internally developing new technologies, the learning routine established via licensing will not help and may even impede the exploratory search process. Thus, efforts toward imitation may only lead to more duplicative imitation rather than creative imitation.

Based on the two different perspectives above, we propose competing hypotheses as follows:

H3a: Latecomer firms' accumulated internal R&D investment and foreign technology in-licensing experience positively interact to affect their creative imitation.

H3b: Latecomer firms' accumulated internal R&D investment and foreign technology in-licensing experience negatively interact to affect their creative imitation.

3. Empirical setting and methods

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). They 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 et al. 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).

We 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.

We 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 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. We categorised 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, we 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, we calculated the number of incrementally-modified drugs developed by a focal firm in a given year. As Kale and Little (2007) suggested, the pharmaceutical industry is a great context to distinguish creative imitation from either duplicate imitation or innovation since most of the information about drugs is public and highly regulated by the government. According to the Ministry of Food and Drug Safety of South Korea, an incrementally-modified drug is a drug that has slightly modified the structure, formulation, and use of an original drug and has been improved or technologically advanced compared to the original drug in terms of safety, efficacy, and usefulness. In contrast, a generic drug is a drug whose bioequivalence has been approved in terms of dose, safety, quality, and use, but is developed through a license-in or reverse engineering after the original drug's patent expires. Thus, incrementally-modified drugs can be used as a proxy to measure creative imitation because their development process requires creatively reorganising or recombining existing knowledge to develop more advanced and improved ones rather than blindly imitating the original drug.

Independent variables. We 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 and 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, we 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. We 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 experience from the distant past.

Control variables. We controlled for several firm-level factors that may impact creative imitation outcomes in LCFs. We 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 organisations such as foreign pharmaceutical companies, bio-ventures, specialised research institutes, or universities within the 5-year window before a given observation year. To take different patenting strategies into account, we 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, we 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, we 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. We 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), we 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, we 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, the OLS model may produce inconsistent and inefficient estimates (Long 1997). In such cases, either a Poisson or negative binomial regression model can be employed. If the dependent variable exhibits overdispersion, a negative binomial regression is more appropriate than a Poisson regression. We conducted a likelihood ratio test of *alpha* to verify whether there is an overdispersion issue in our data. The results indicate that the null hypothesis, that *alpha* is equal to 0, cannot be rejected. Thus, Poisson regression is more suitable for our data analysis since our data does not exhibit an overdispersion problem.

Since our dataset is a panel dataset, the choice between fixed effects and random effects models is an important consideration. To determine which model is more suitable for our analysis, we conducted the Hausman test, which compares the estimates obtained from the fixed effects and random effects models to identify which one provides more reliable estimates. Our Hausman test results indicate that we cannot reject the null hypothesis ($p = 0.7227$), indicating that the random effects model is more appropriate for our analysis. Therefore, we employed the panel Poisson regression model with random effects and present the results in the following section.

4. Results

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

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

* $p < 0.05$.

study were not affected by multicollinearity, we 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.

Table 2 presents the results of the panel Poisson regression model with random effects. Model 1 is the base model, which shows the effects of control variables only. In Model 2, we added two main explanatory variables – *Accumulated internal R&D investment* and *Foreign technology in-licensing experience*. In Model 3, the interaction term between the two explanatory variables is included.

In Hypothesis 1, we predicted a positive relationship between accumulated internal R&D investment and creative imitation of LCFs. Model 2 shows that the coefficient of *Accumulated internal R&D investment* is positive and significant ($\beta = 1.276$, $\rho < 0.01$), thus supporting Hypothesis 1. Hypothesis 2 proposed a positive relationship between foreign technology in-licensing experience and creative imitation of LCFs. Model 2 shows that the coefficient of *Foreign technology in-licensing experience* is positive and marginally significant ($\beta = 0.222$, $\rho < 0.1$), thus Hypothesis 2 is also supported.

Hypothesis 3a and Hypothesis 3b are competing hypotheses which predict the possible interaction effects between accumulated internal R&D investment and foreign technology in-licensing experience in opposite directions. Model 3 shows that the interaction term between the two main variables is negative and significant ($\beta = -0.281$, $\rho < 0.001$), which implies that the two variables have a negative interaction effect. Thus, Hypothesis 3b is supported. We will elaborate further on this result in the discussion and conclusion section.

5. Discussion and conclusions

This paper examines how two different technology learning strategies of LCFs, namely, internal R&D investment and foreign technology in-licensing, affect their creative imitation. More importantly, we focused on the interaction effect between these two learning strategies and hypothesised that both positive and negative interaction effects exist based on previous literature. Based on an analysis of Korean pharmaceutical industry data, we found that the two learning strategies negatively interact with each other. That is, a simultaneous increase in accumulated internal R&D investment and foreign technology in-licensing experience leads to less favourable creative imitation outcomes, thus implying the existence of an internal tension between these two learning strategies.

Table 2. Panel poisson regression model with random effects.

Variables	Model 1	Model 2	Model 3
Constant	−12.769*** (3.423)	−10.199** (3.472)	−11.351*** (3.014)
Domestic in-licensing experience	−0.086 (0.213)	−0.067 (0.209)	−0.067 (0.193)
International joint R&D experience	−0.400* (0.189)	−0.441* (0.182)	−0.425* (0.168)
Number of patents filed	0.005 (0.007)	−0.008 (0.008)	−0.005 (0.007)
Firm size (log scale)	0.990** (0.287)	−0.175 (0.407)	−0.113 (0.335)
Firm age	−0.039** (0.013)	−0.046** (0.014)	−0.041*** (0.011)
Slack resources (log scale)	−0.055 (0.252)	−0.177 (0.260)	−0.214 (0.233)
Firm performance	−0.275 (0.865)	−0.457 (0.952)	−0.365 (0.859)
Innovation experience	0.265 (0.162)	0.134 (0.170)	0.131 (0.152)
Duplicative imitation experience	0.005 (0.005)	0.008 (0.006)	0.006 (0.005)
Creative imitation experience	−0.054 (0.114)	−0.202† (0.122)	−0.051 (0.095)
Accumulated internal R&D investment(log scale)		1.276** (0.367)	1.284*** (0.321)
Foreign technology in-licensing experience		0.222† (0.131)	3.200*** (0.864)
Accumulated internal R&D investment × Foreign technology in-licensing experience			−0.281*** (0.080)
Year dummy	Included	Included	Included
Log likelihood	−213.61	−204.57	−201.63
Wald chi-squared	57.08***	64.75***	113.86***
N	771	771	771

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

This study contributes to the technological catch-up literature by focusing on creative imitation – the transitional phase through which LCFs become innovators. Although Kim's (1997, 1999) three-stage sequential catch-up model has been in the literature for 25 years, few studies have explicitly investigated the factors that lead to creative innovation. It seems that creative imitation is only considered as a conceptual component in the previous literature. One possible reason for this is that it is difficult to measure creative imitation empirically in a large sample context, which explains why most empirical studies in this field are still based on case studies (Mei and Yang 2021; Park and Ji 2020; Peng et al. 2022). This paper complements the existing literature, which remains dominated by qualitative studies, by introducing a promising empirical methodology and viable variables to be utilised in similar contexts.

Another contribution is that this paper attempt to elaborate on the interactive mechanisms between two learning strategies. In the previous literature, internal R&D investment has been highlighted as the most important learning strategy that drives LCFs to become creative imitators from duplicative imitators (Giachetti, Lampel, and Li Pira 2017; Kim 1999; Posen and Martignoni 2018; Shenkar 2010) and our findings are consistent with it. Foreign in-licensing, in contrast, has not gotten too much attention when it comes to creative imitation, although it was regarded as an effective learning strategy at the very early stage of catch-up. This calls for an evolutionary perspective in the catch-up literature since the technological capabilities developed by a certain learning strategy will definitely affect the choice of later learning strategy and its effectiveness. The matter is we still do not know which combination of learning strategies is most effective in different catch-up stages (Malerba and Lee 2021). Our findings show that to boost the effectiveness of the internal R&D investment on creative imitation, it is better to reduce the level of foreign in-licensing rather than the pursuit for both learning strategies at a high level. In other words, LCFs should decrease the resource allocation to foreign in-licensing and increase the portion to internal R&D investment to transform to be creative imitators. A new learning routine also needs to be established in this process, otherwise LCFs will lose learning momentum and becoming too dependent on the foreign licensors. These arguments are in line with the recent study by Peng et al. (2022), which suggested that LCFs should modify their ambidextrous learning strategies in different stages of catch-up.

The results also provide 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. Our findings imply that excessive reliance on foreign technology in-licensing to avoid uncertainty and minimise the risk of failure 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, generalisation of the empirical analysis results is limited because we 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 we can compare and analyse 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 and Little 2007; Ray and Ray 2021), the empirical results should be more generalisable.

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.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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