



Research on Technological Catch-up Mechanism of Latecomer Firms: a Strategic Alliance Perspective

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Abstract

Technological catch-up is becoming the most important and strategic decisions for latecomer firms to strengthen technological capability and enlarge market position. Set strategic alliance as research perspective, we study the mechanism how patent strategy selections of latecomer firms help realize catch-up effects via alliance cooperation. Results show that in the latecomer context, the goals or intentions for firms to participate in strategic alliances may vary greatly because of differences in technological capability or market positions, which then influence their patent strategy selection. Generally, the latecomer firms' patent strategies present typical regularity. Firms with lower technological capability or weaker market position tend to choose patent defensive strategy and patent leveraging strategy, and the strategic mix would help advance their strategic goals in technological catch-up.

Keywords: *Strategic alliance; Technological catch-up; Latecomer context*

I. INTRODUCTION

Technological catch-up is the process in which different parties like firms, S&T research institutions or centres in the latecomer countries or markets tend to narrow down technology gaps, and make their efforts to advance technology development [1]. Generally, there are two ways for firms to catch up with cutting-edge technologies, on one hand, some firms follow suit leading firms' advanced technology by technology introduction, assimilation and absorption; on the other hand, firms would try to foster technological leapfrog by adopting different technological paths according to technological creation or technological innovation [2]. Nonetheless, the latecomers firms are still have difficulties in technology internalization and catch-up, given those differences in technological development and industrial attributes.

As the gap between Chinese firms and leading foreign firms are narrowing gradually, the attitudes of leading firms towards technology transfer are more conservative, making traditional technological catch-up modes, technology introduction and imitation more likely to lead the latecomers to lag behind and be caught in continual catch-up traps. Due to their inherent disadvantages, latecomer firms are confronted with bottlenecks in technology capability and market development, calling for breakthroughs in two aspects, firstly, they need to break through the bottleneck of technological catch-up and capability leapfrog, and secondly, exploit new possible markets with their existing technological capabilities [2]. The technological development trajectory of major latecomer countries validated the influences and functions of technology introduction, assimilation, absorption and re-innovation on technological catch-up of latecomer firms [3-4]. In contrast to leading MNCs with cutting-edge technologies, most Chinese latecomer firms, lack of key technologies and core competence, are in the status of technology learning when cooperate with advanced MNCs [5]. Existing researches showed that latecomer firms can enact and formulate their market entry strategies by technology-oriented attempts like imitative innovation or independent innovation [7]. Imitation, or imitative learning, is a necessary stage for most latecomer firms, and it is critical for firms to accumulate experiences and capabilities during imitation process, from imitation to creative imitation, then comprehensive innovation, and finally independent innovation [8]. Globalization, however, to some extent, accelerates the diversification of market demand, deepens competition, and brings opportunities for latecomer firms to enter markets which are less competitive [9]. Technological alliances among firms have become a common and feasible alternative, making partner's portfolio an optimal and strategic way to acquire dispersed, complementary and heterogeneous resources, which then help improve technological capability [10]. In the latecomer context, factors

Influencing technological catch-up are diverse and complicated, including not only industrial technology characteristics, market structure at the micro level, but also resource elements and industrial policies at the macro level. Some researchers analysed how latecomer firms acquire and maintain competitive advantage and overcome technological disadvantages by linkage-leverage-learning, a framework built on Resource-based Theory [1].

Since synergy is the overall effects of systemic elements of multiple subsystems, some researchers focused on the roles of alliance cooperation and synergic innovation [1], which is a typical strategic alliance form. Focusing on strategic alliance firms as the research objects, in this paper we will discuss the mechanism how latecomer firms enhance technological catch-up via strategic alliance in the latecomer context.

II. LITERATURE REVIEWS

As systemic arrangement among firms, strategic alliance was first put forward by Hopland, president of DEC, and Nigel, a famous scholar in Management, in early 1980s, and they defined strategic alliance as collaboration consisting two or more firms with equivalent business domains, to enhance mutual advantages, to share risks, and to exploit production factors by virtue of different kinds of contracts, arrangements or relationships [11-12]. With the acceleration of economic globalization and intensification of intra-industrial competition, as well as the deepening of industrial integration, more and more firms, especially the latecomer firms regard strategic alliance as an important means to break the constraints of innovative resources as technology, knowledge and financial capital, improve technological capability and strengthen market position. In business practices, even in an unbalanced condition, firms have the incentives to establish or participate in alliances. Teece (1992) defined strategic alliance as contractual network formed by two or more firms to integrate resources, carry out operation activities under a common goal [13]. Confronted with disadvantages in both technologies and market competition, latecomer firms tend to make full use of various resources to leverage a quick learning, access to market, aiming at to catch up with the leading MNCs. Hagedoorn (1993) divided firms' alliance motivation into three aspects, motivations related to basic research, applied research and technology development, motivations referred to innovation processes, and also motivations relevant to market access and opportunity searches, which included access to or expansion of foreign markets or even internationalization [14]. Similar to Hagedoorn, Mowery, Oxley and Silverman (1998) found alliance motivations mainly unfolded in two aspects, namely technology access and market access [15]. Yan et al. (2003) stressed that alliance purposes were mainly to acquire knowledge, technology and other resources, seek for market power promotion, and reduce transaction cost and promote mutual learning [16]. Zhou et al. (2012) concluded that the main reasons why firms participate in patent alliance were to foster firms' development, to obtain technological advantage and to improve competitive advantages of products [17]. Compared with studies listed above, some researchers put more emphasis on technological or market factors. Kim (2007) indicated that firms tended to participate in strategic alliance to acquire new complementary technologies and reduce R&D risks and costs [18-19], and he also found that choice of alliance partners depended highly on firms' own technological capability and absorptive capability [20]. In their research, Yi et al. (2007) constructed an analytical framework based on resource, learning and firms' growth, and found that dominating motivations for both Chinese and foreign firms were to acquire complementary resources and enhance technological capability [21]. Some researchers investigated market factors, Grant et al. (2004) proved that the main motives for strategic alliance was access to market rather than technology [22], and McCutchen et al. (2004) found market acquisition and extension become the most important reasons for strategic alliance since 1990s [23].

According to studies involved with latecomer firms and strategic alliance, although some researchers had discussed the major reasons why latecomer firms establish or participate in strategic alliance, researches related to effects of strategic alliances, especially mechanism of technological catch-up were rather rare. In reality, mechanism of technological catch-up based on strategic alliance may vary because of firms' different goals or intentions in alliance, which makes it meaningful to conduct research on how latecomer firms catch up with leading firms via strategic alliance. Considering the strategic decisions and choices alliance firms may make, this study introduced patent strategy into analysis to examine how strategic alliance and patent strategy selection enhance firms' technological catch-up in latecomer context.

III. THEORETICAL FRAMEWORK AND HYPOTHESES

A. *Analytical framework of technological catch-up mechanism of alliance firms in latecomer context*

Based on prior researches related to latecomer, we defined latecomers firms as the ones with disadvantages in technological capability or market position. Take the alliance motivation of latecomer firms into consideration; we focus on technological catch-up mechanism of latecomer firms in two situations, technology acquisition and market access respectively [24].

As a means for firms to achieve their technological innovation or development goals, researches on patent strategy are mainly carried out in two aspects: first, Somaya (2012) proposed that patent strategies were formulated

in combination of firms' own characteristics and development strategies, and emphasized the role patent played in protecting innovative achievements [24]. Berkowitz (1993) demonstrated that patent was helpful to obtain the information of competitors' technologies, development degree of industrial technology and competitive situation [25]. Patent strategies were often used to realize firms' strategies; Berkowitz (1993) proposed patent strategy was a tool to ensure firms to acquire sustainable competitive advantages [25]. Second, some researchers introduced scientometrics into patent analysis, and used firms' patent information to analyze and identify patent strategies [25]. Some researchers began to use patent indicators to describe and measure firms' operational or innovative performance as early as the 1980s, Griliches et al. (1991) used patent indexes to measure firms' R&D activities [26], Trajtenberg (1990) suggested that patent can serve as an alternative indicator of R&D activities in the absence of financial data [27], Berkowitz (1993) used patent quality, technological capability and competitive degree to study firms' patent strategies [25]. In view of existing researches, we introduce and integrate patent strategy to represent technological catch-up goals of latecomer firms, and construct the analytical framework to study how latecomer firms achieve their technological catch-up goals by selecting and implementing patent strategies based on strategic alliance.

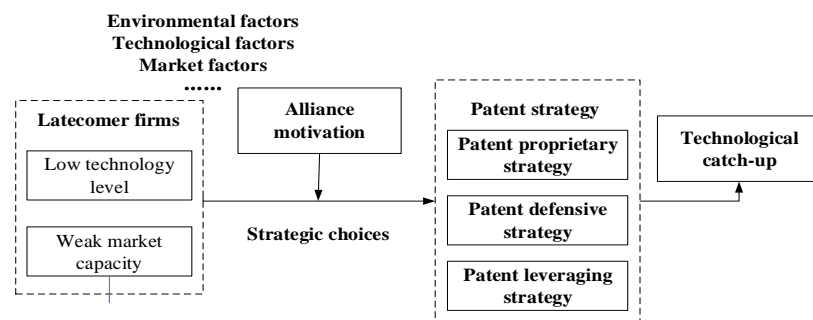


FIG.1. ANALYTICAL FRAMEWORK OF TECHNOLOGICAL CATCH-UP MECHANISM OF ALLIANCE FIRMS IN LATECOMER CONTEXT

Somaya (2012) divided patent strategy into patent proprietary strategy, patent defensive strategy and patent leveraging strategy [28]. Patent proprietary strategy is a course of action firms adopt to form and protect their technological advantages, avoid external technology imitation [28-30], and obtain excess profits [31]; patent defensive strategy is used to prevent and reduce the risks of falling into competitive disadvantages or being ripped off by other patentees [32-34], while patent leveraging strategy is to enhance firms' bargaining power and achieve direct or indirect profit opportunities by patent exclusive right, and realize leveraging effect of patent right.

B. *Mechanism of technological catch-up of alliance firms in latecomer context*

1) **Technological catch-up mechanism of alliance firms under technology acquisition intention**

It is generally accepted that technology acquisition is the major reason or intention for latecomer firms to establish or participate in strategic alliance, according to recent studies. The latecomer firms, with relatively lower technological capability, tend to acquire, adopt and utilize cutting-edge technologies of their alliance partners [24]. Some researchers discussed and illustrated the effects of alliance decision on firms' acquisition of innovative resources like technology and knowledge, improvement of learning ability and technological capability based on Resource-based Theory and Organizational Learning Theory [35-38]. Latecomer firms with no technology advantage or lower technological capability are inclined to obtain and make use of alliance partners' technologies. On the one hand, the leading technologies could help latecomer firms promote their own technological capability and knowledge stocks [24]; on the other hand, technological learning on the basis of strategic alliance would help allocate and utilize innovative resources optimally and rationally [39-41], and reduce latecomer firms' costs and risks in technology R&D, which then laid foundation for latecomers to acquire and adopt their alliance partners' advantageous technologies, and implement their catch-up intention. Take time factors and strategic goals into consideration, latecomer firms with lower technological capability tend to resort to patent defensive strategy to take advantage of their alliance partners' technologies, expand their patent portfolio [28], and reduce the costs and risks of patent technology infringement and technology R&D in the short term. While, at the same time, these latecomers would make use of patent leveraging strategy to learn, assimilate, absorb and internalize their partners' advantageous and competitive technologies [35], and to improve their technology capability [24]. Based on the analysis above, we could draw that latecomer firms would adopt patent defensive strategy and patent leveraging strategy to realize their technological catch-up goals. Accordingly, we present the following hypothesis:

Hypothesis 1: Latecomer firms with lower technological capability would acquire their alliance partners' advantageous technologies, and use patent defensive strategy and patent leveraging strategies to achieve technological catch-up goal under technology acquisition intention.

2) Technological catch-up mechanism of alliance firms under market access intention

Market access motivation is the alliance decision made by most latecomer firms to enter a new market and strengthen their market position. Firms with relatively weak market position tend to access to market information and resources, OEM, embed in marketing networks, or even participate in global value chains, to enter their target markets [42]. In practice, market structure, competitive advantage and market power all profoundly influenced latecomer firms' market positions, making the ones with weaker market position confronted with higher costs or risks in their production and operational activities. Researchers as Hagedoorn, Mowery and so on, pointed out that in conditions of higher risks or costs, latecomer firms with relatively weak market position tend to acquire market information, and embed in marketing networks by participating in alliances, to access to market and enhance their market power with the help of their partners' technological advantage or market position [24][43-44]. Most firms tend to set OEM, market information acquisition or marketing network embeddedness as their motivations. In order to reduce risks in patent infringement, these latecomer firms would choose patent defensive strategy to deepen the acquisition and understanding of both market and technological information to gain entry to new markets, making full use of their alliance partners' competitive technologies to do OEM [45-46], or to embed in partners' marketing networks, which in turn reduce the costs in market access [47], and enhance their market position and revenues. In the long run, with OEM and marketing network embeddedness, these latecomers would implement patent leveraging strategy to learn, absorb and assimilate their partners' technological advantages on the basis of market access, to further enhance their technological catch-up [24]. From the analysis above, we proposed that latecomer firms tend to choose patent defensive strategy and patent leveraging strategy in market access orientation; hence we put forward the hypothesis:

Hypothesis 2: Latecomer firms with weak market position tend to access to new target market and reduce market risks via strategic alliance, and adopt patent defensive strategy and patent leveraging strategies to implement technological catch-up under market access intention.

IV. DATA, VARIABLES AND EMPIRICAL STUDY

A. *Data source and sample selection*

In this paper, latecomer firms were taken as the research objects, strategic alliance and patent indicator were chosen as data sources. According to existing studies, strategic alliance data were selected from Cooperative Agreements and Technology Indicators Database (CATI). Since Information Technology (IT) industry started early and is relatively mature, technologies in IT industry are updating at a relatively fast speed, making the development of IT industry itself a typical technological trajectory, so sample alliances and firms are limited to IT industry. For firms' patent strategy, we drew on the definition of Somaya, and combined the patent indexes of sample firms and patent strategy quantification to distinguish and represent the patent strategies a certain firm adopts in sample period. Patent data of sample firms were retrieved from USPTO.

After retrieved alliance numbers in IT industry from CATI, we depicted its changing trends in sample years, from which we can find that from 1980 on, alliance numbers in IT industry showed a steady upgrading trend, with more 140 alliances in each sample year. In view of the comparability of the alliance numbers and changing trends, 1981 was set as the starting year, and yearly alliance data was adapted to each sample year. Due to the dynamic changes in technological capability and market position of alliance firms, no firms would exist in the same alliance continuously in the whole sample period, or they may change their alliance intentions according to their changing strategic decisions, the times a sample firms participated in alliances were used as key factors in primary selection. In order to ensure the typicality of sample firms, we chose the firms attended at least 15 times as the primary samples. Combined with the R&D Scoreboard released by Department for Business, Innovation & Skills of UK, we compared and matched R&D investment and intensity of the primary samples, and found 72 of them had higher and more obvious R&D activities, indicating that these firms may tend to promote their technological capability, so these firms were chosen as samples for following empirical studies.

B. *Variable definition and operationalization*

Dependent variables: patent strategy was set as the dependent variable, according to Somaya's definition and distinction principles, concentration rate of patent fields, numbers of patent fields, changes in numbers of core patent fields, patent license, and technological standard establishment were used to measure and quantify patent strategies [24-25], and the quantitative schemes of patent strategy were listed in Tab. 1.

Patent strategy	Quantification methods
patent proprietary strategy	HHI increases, with fewer patent fields, and patent counts in core field increases → $S_1 = 1$
patent defensive strategy	Patent licensing (cross licensing) → $S_2 = 1$
	HHI decreases caused by the increase of core patent fields → $S_2 = 1$
patent leveraging strategy	Technological standard establishment → $S_3 = 1$
	HHI decreases caused by the increase of core patent fields → $S_3 = 1$
	HHI decreases caused by the increase of numbers in non-core patent fields → $S_3 = 1$

TAB. 1 QUANTITATIVE INDICATORS OF FIRMS’ PATENT STRATEGY

Note: HHI is Herfindahl-Hirschman Index, used here to denote concentration rate of patent fields.

Independent variables: in consideration of different goals or intentions alliance firms had, the alliance of sample firms were retrieved from the short description of alliance purpose (AIMs) from CATI. Since alliance motivations in CATI were mainly presented in words or texts, we introduced and used text mining technique to quantify sample firms’ alliance motivation. Considering keywords related to certain AIMs, we retrieved all the ones contained technology acquisition intention and market access intention by keywords matching [48-49]. With the analysis and processing function, we divided the raw data of sample firms into each sample period, and count numbers of alliances of each firm in sample period and then calculated the ratio of different motivations to represent alliance motivation of sample firms.

Control variables: according to existing researches, variables as nation, age, sub-industrial attributes and alliance partners may influence their alliance motivation and selection of patent strategies; we introduced these variables as control variables. Firms’ national attribute were brought in as dummy, $Nation_k = \begin{cases} 1, US \text{ firms} \\ 0, non-US \text{ firms} \end{cases}, k = 1, 2, \dots, n$, if a certain firm is a US firm, $Nation_k = 1$, or else $Nation_k = 0$; the age of sample firm is the sample period minus its founded year; sample firms’ industrial attribute was distinguished by introducing three groups of dummies, $Ind_{1k} = \begin{cases} 1, software \\ 0, non-software \end{cases}, k = 1, 2, \dots, n$, $Ind_{2k} = \begin{cases} 1, telecom \\ 0, non-telecom \end{cases}, k = 1, 2, \dots, n$, $Ind_{3k} = \begin{cases} 1, non-IT \\ 0, IT \end{cases}, k = 1, 2, \dots, n$; At last, number of alliance partners in each period was introduced to control and avoid its effect.

C. Empirical results and discussion

For each patent strategy, since latecomer firms had only two choices, namely “choose” or “not choose”, the dependent variable had only two possible values, 0 and 1; when variable with only two values was set as dependent variable, binary choice model was adopted to test the effect of independent variables on dependent variables [50]. Binary choice model is used to test the possibility of any given individual make a certain choice between the two. Based on the selection of regression model, dependent variables, independent variables and control variables, we construct the regression model of patent strategies selection of alliance firms in the latecomer context to examine the mechanism of alliance intention on latecomer’ patent strategy selection. The regression model is: $S_{it} = \alpha + \beta_1 M_{it} + \beta_2 Nation + \beta_3 Age_{it} + \beta_4 Ind1 + \beta_5 Ind2 + \beta_6 Ind3 + \beta_7 N_{p_{it}} + \mu_{it}$, in which, S_{it} represented patent strategy firm i used in period t , M_{it} denoted alliance intention of firm i in period t , $Nation$ was the nation attribute, Age_{it} was firm i ’s age in period t , Ind_1 , Ind_2 and Ind_3 was the firms’ industrial attribute, $N_{p_{it}}$ was the numbers of alliance partners of firm i in period t , α was constant and μ_{it} was the random disturbance [50]. Therefore, based on the measurement indexes in the regression model, Eviews6.0 is used for the regression analysis.

Particulars	S ₁		S ₂		S ₃	
	1	2	3	4	5	6
C	0.05	0.15	0.70	0.24	0.87	0.21
M ₁	0.13 (0.98)		0.65*** (4.65)		0.93*** (6.77)	
M ₂		0.26 (0.86)		0.51* (1.79)		0.50* (1.82)
Nation	-0.07 (-0.91)	-0.07 (-0.90)	0.15* (1.73)	0.14* (1.64)	-0.17** (-1.98)	-0.17** (-2.12)
Age	0.01 (0.47)	0.01 (0.56)	0.02 (0.85)	0.01 (0.35)	0.01 (0.65)	-0.01 (-0.08)
Ind ₁	-0.07 (-0.68)	-0.06 (-0.61)	-0.23** (-2.19)	-0.26** (-2.54)	-0.06 (-0.60)	-0.11 (-1.07)
Ind ₂	0.10 (0.80)	0.10 (0.82)	-0.22* (-1.74)	-0.20* (1.67)	-0.17 (-1.31)	-0.14 (-1.09)
Ind ₃	-0.20 (-1.48)	-0.20 (-1.49)	0.01 (0.08)	0.01 (0.08)	-0.20 (-1.40)	-0.19 (-1.41)
N _p	0.01 (1.11)	0.01 (1.17)	0.02*** (3.51)	0.03*** (3.22)	0.04*** (4.75)	0.03*** (4.34)
M _c Faden R ²	0.06	0.06	0.19	0.15	0.35	0.20
LR	8.35	8.12	40.85***	21.33***	74.45***	29.76***

Tab.2 Regression results of the choice of patent strategies of alliance firms in latecomer context

Note: M₁ denoted technology acquisition, M₂ denoted market access; S₁ denoted patent proprietary strategy, S₂ denoted patent defensive strategy, S₃ denoted patent leveraging strategy; Nation denoted nation, Age denoted the age, Ind₁ denoted the firm belong to software industry, Ind₂ denoted the firm belong to telecom industry, Ind₃ denoted the firm belong to non-IT industry, N_p denoted the number of alliance partners; ***, **, * denoted passed the significance test in 1%, 5%, 10% respectively.

Due to differences in latecomer firms’ alliance intentions, we tested the choices of latecomers’ patent strategies respectively, and the regression results were listed in Tab.2. Model 1, 3 and 5 demonstrated patent strategy selection of latecomer firms with lower technological capability. The regression results showed latecomer firms’ who intended to participate in strategic alliance to acquire technology and realize technological catch-up would resort to both patent defensive strategy and patent leveraging strategy to implement their intentions, and would not choose patent proprietary strategy. When studied the independent variable of patent proprietary strategy, the goodness of fit in regression model was too low to pass the significance test, meant technology acquisition intention cannot incur the use of patent proprietary strategy. The regression models of patent defensive strategy and patent leveraging strategy both demonstrated higher goodness of fit, and the variables can pass the significance tests, indicated that latecomer firms’ alliance intention affected the choice of patent strategies, and thus promote their technological catch-up, H1 is verified.

Model 2, 4 and 6 revealed patent strategy selection of latecomer firms with weak market position. The regression results in market access intention showed that firms with weak market position tended to choose patent defensive strategy and patent leveraging strategy. To be specific, the regression model of patent proprietary strategy had a low goodness of fit, and the effect of variables cannot pass the significance test, in other words, latecomer firms’ with weak market position will not strengthen their market position by the application of patent proprietary strategy. In contrast, when tested patent defensive strategy and patent leveraging strategy, both of the two models achieved a higher goodness of fit and the variables could pass the significance test, indicated that latecomer firms’ intention in technological catch-up via strategic alliance led to the implementation of patent defensive strategy, which was also true to patent leveraging strategy. That meant latecomer firms were inclined to use patent defensive strategy and patent leveraging strategy to enhance their market position and realize their catch-up goals. From these results, H2 is approved.

V. CONCLUSION

Set technological catch-up of latecomer firms as the research object, we first defined the concept of latecomer firms, and introduced patent strategy to construct the analytical framework of technological catch-up mechanism of latecomers. Since more and more firms regarded strategic alliance as an important means and way to reduce risks, obtain market position and improve technological capability, therefore, the research is carried out from strategic alliance perspective, and CATI alliance database was used as the data source. As firms’ strategic decision that guided the action direction, goal and path, the process of patent strategy selection always called for a complicated and continual operation, including comparing, refining and optimizing action plans.

The choices of patent strategy of latecomer firms', based on strategic alliance, were always seen as an important way to catch up with cutting-edge technology, or even leapfrog technology boundary. With the definition and distinction of Somaya, we empirically tested how strategic alliance intentions promote latecomers' patent strategy selection and then promote their technological catch-up. Results indicated that due to different goals or intentions to participate in strategic alliance, the alliance latecomer firms tended to choose their patent strategies according to their technology or market attributes. However, the selection of patent strategy of latecomer firms' showed typical regularity. For latecomer firms, no matter the ones with lower technological capability or weak market position, their alliance intentions were always accompanied by a relatively clear and concrete purpose. The latecomer firms, who focused on technology acquisition or market access, tended to give high priority to patent defensive strategy to strengthen their technology capability or market position, and use patent leveraging strategy complementarily to help promote their goals of technological catch-up. Therefore, for the latecomer firms, the strategic alliance set on the basis of their strategic intentions has no doubt to become an important means to improve their technological capability, strengthen their market position and realize technological catch-up.

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