How does policy create an opportunity window for China's digital economy?*

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Abstract

From the initial stage of "bringing in" foreign firms to the stage of "going out" (going global), the four-decade development process of China is not just about its participation in globalization, but also about Chinese firms' innovation based on global knowledge sourcing. This study provides a new interpretation of the technology catching-up of Chinese firms, incorporating the theory of windows of opportunity, considering policies as windows for international knowledge sourcing and technology catch-up. It assesses the impact on innovation performance of inward and outward foreign direct investment policies as institutional windows for knowledge sourcing, aims to identify the effective width of windows of opportunity and establishes how these policies lead to outstanding innovation performance by latecomers over time by leveraging external knowledge. Threshold models were adopted using data from multiple sources on 187 Chinese listed firms in the digital industry, including 2,807 firm-year observations. The results show that nonlinear relationships exist between institutional windows and innovation performance. The roles and mechanisms of institutional windows of opportunities in Chinese firms' knowledge-sourcing process demonstrate the decisive effects of the Government's internationalization policies and their role in promoting the development of Chinese digital technologies. Implications are elaborated for both policymakers and Chinese multinational firms in the digital industry.

Keywords: institutional windows of opportunity, knowledge sourcing; internationalization policy, technology catch-up, innovation performance

JEL classification codes: F21, F23, L96, O3, O33

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1. Introduction

In 1978, with China's reform and open-door policy, the country began its catching-up process in the manufacturing sector under the Government's guidance and supportive policies. Soon, a wave of multinational enterprises (MNEs) flooded into China and brought a large amount of foreign direct investment (FDI) (UNCTAD, 2015), which created new developmental momentum for the country. Starting with China's 10th Five-Year Plan in 2001, policies began to target the acceleration of technology transfer through FDI under the "trading market for technology" plan and the indigenous innovation initiative (Luo et al., 2010). After engaging in a gradually accumulative process of technological catch-up, Chinese enterprises improved their innovation capability (Dutrénit, 2000; Cantwell, 2017). Policies that incentivized further sourcing of external knowledge emerged, promoting outward FDI (OFDI) by Chinese firms as a means to access and acquire more advanced technology by rapidly expanding to diverse host countries (Clegg et al., 2016). According to UNCTAD (2017), China's OFDI soared in 2016, up 44 per cent to $183 billion, making the country the world's second largest FDI home for the first time and a net outward investor; its FDI inflows were $134 billion, making it the third largest recipient of foreign capital in the world.

From the initial stage of "bringing in" to the final stage of "going out", this development trajectory demonstrates the roles of these policies in not only the internationalization performance but also the technology sourcing and innovation strategies of Chinese firms. Institutional demands drive the process of sourcing knowledge for advanced technology using public tools. Hence, a set of policy incentives can be considered important institutional windows of opportunity for development of science and technology, which is based on the introduction, digestion and absorption of external knowledge and the progress of indigenous innovation. The appearance of an opportunity window does not necessarily lead to a successful innovation, a result that greatly depends on knowledge sourcing and learning during the opportunity window, during which timely strategic responses must be made and actions taken (Lee and Malerba, 2017). The complex process is triggered by and conducted through a series of institutional measures and policy arrangements. The outcome of the process is that the innovation capacity of Chinese enterprises has improved significantly, providing a classic case of technological catch-up, allowing us to understand the process of knowledge sourcing by Chinese digital enterprises during their pursuit of innovativeness.

Drawing on the international literature on knowledge sourcing and windows of opportunity in technological innovation and based on multiple, large-scale databases containing 2,807 firm-year observations, this study first identifies the institutional windows of opportunity. It then delineates the roles of the institutional opportunity window in the knowledge-sourcing process and innovation, and finally it explains how emerging MNEs (EMNEs), from a technology-deficient background, develop and maintain their competitive advantages in the global market in response to homeland institutional influences. In addition, heterogeneity analysis furthers understanding of the knowledge-sourcing behaviour of enterprises in the country's unique institutional context. The research is embedded in the context of the rapid development of the digital industry in China. In sum, we endeavour to explore two research questions: (1) How do the bringing-in and going-out policies create opportunity windows for digital firms to source knowledge externally? (2) What are the roles of opportunity windows in digital innovation?

The paper delivers insights on how governments create windows of opportunity to enhance innovation performance through international knowledge sourcing – insights that could have implications for industry, EMNEs and governments in their strategic decision-making with regard to internationalization and innovation. This study provides an analysis of the evolutionary process of institutional windows during an extended period of time, allowing more accurate capture of their roles and the evolution of their roles in the knowledge-sourcing process. The results show that knowledge sourcing in China was increasingly proactive during 2006–2020, a period that witnessed several major policies and initiatives that the Government formalized to support the development of technology capabilities in the country and in firms. Among these, the National Middle- and Long-term Plan for Science and Technology Development (2006–2020) (MLP) was one of the most influential.

2. Research context

At a critical time for knowledge sourcing through international business, China pursued technology development policies that combined the purposes of global market entry and technology catch-up. From 2003 to 2020, the Government formulated a number of major policies and measures to cultivate the technological capabilities of the country's main innovators, among which the Outline of the MLP is one of the most influential and provides the appropriate context for this study. During this period, the values of both inward and outward FDI (IFDI and OFDI) increased significantly as developed countries increasingly assigned core research and development (R&D) to China (Grosse, 2019). Consequently, knowledge seeking became a prominent motivation in international business activities (Dachs and Zahradnik, 2022).

A key challenge for policymakers in today's global economy is digital development. The digital economy is having a major impact on global patterns of investment (UNCTAD, 2017), and with the growing influence of the digital industry on the Chinese economy, it is instructive to study the institutional window of opportunity for the industry in the context of the country's digital upgrading. According to the White Paper on the Development of China's Digital Economy (CAICT, 2020), the digital industry accounted for 38.6 per cent of gross domestic product by 2020, as the digital economy was becoming increasingly important to the country's economic development. Innovation in the digital industry is key to developing a high-quality digital economy. With the support and guidance of several national policies and the combined effect of the boom in cloud computing, artificial intelligence, big data, 5G and other next-generation information technologies, the digital industry has made outstanding achievements in innovation (Zhang et al., 2021). Some digital enterprises have become pillars of the country's new economy and high-tech industries, and are among the most active players in the global innovation ecosystem (Dachs and Zahradnik, 2022). These enterprises rely not only on internal R&D but also on external knowledge sources through international partnerships. Digital firms enjoy the convenience of knowledge flows through an open virtual network and the advantages of being borderless.

Thus, digital firms are the most active players in global innovation activities, with strong innovation capability, operating in a technologically dynamic environment where advanced knowledge is created constantly and quickly (Dachs and Zahradnik, 2022). According to the definition of digitalization in the G20 digital economy report, the digital industry includes software and information and communication technology (ICT), Internet and electronic information manufacturing (UNCTAD, 2021). We therefore define the Chinese firms that operate within this broad theme as digital enterprises.

3. Literature review

3.1 Knowledge sourcing for technological innovation through internationalization

Numerous studies identify the sources of innovation, with a focus on internationalization activities, such as FDI, trade and overseas R&D (Li et al., 2012; Sabir et al., 2019). Knowledge-based technological capabilities have long been recognized as an important source of competitiveness for firms. Seeking technological knowledge is particularly important for firms in emerging markets because of the increasingly fierce battle for innovation capabilities (Mudambi, 2008; Child and Rodrigues, 2005; Luo and Tung, 2007; Rui and Yip, 2008).

A widely held belief is that many EMNEs obtain technological knowledge by using IFDI and OFDI as key learning and catch-up mechanisms (Dunning, 1998; Luo and Tung, 2007; Mudambi, 2008) – China in particular (Buckley et al., 2007). As the globalization of production reshapes the international economic landscape, developing countries are emerging as outward investors (UNCTAD, 2005). Technology transfer and knowledge spillovers through the IFDI of MNEs from developed countries have been recognized as a crucial reason for the latecomers' technology development and catching-up, at early stages (Fu et al., 2011). These latecomers develop and accumulate basic technological capability (Cui et al., 2017; Fu et al., 2018), based on which, together with their institutional advantages, they can gradually compete with advanced MNEs in their home markets and expand in other developing host markets (e.g. Guo et al., 2019; Sabir et al., 2019). In recent decades, latecomer firms have actively acquired technological assets through OFDI (Deng, 2009), especially from developed countries that have industry-specific comparative technological advantages (Li et al., 2012). Mathews' LLL (linkage-leverage-learning) model argues that EMNEs engage in OFDI to develop competitive advantages from external relationships (Mathews, 2006). EMNEs turn to OFDI to acquire more advanced technological capability. International expansion thus becomes a springboard to acquire strategic resources globally (Luo and Tung, 2007).

3.2 Institutional-based view of knowledge sourcing by EMNEs

A growing interest of the institution-based view on EMNEs is how institutional factors are unique to emerging markets, affecting innovation development (Chen et al., 2012; Lee et al., 2015; Pearce and Zhang, 2010). Governments are among the most salient institutions in emerging economies, with a critical influence through regulatory policies and control over scarce resources, which shape firms' country-specific advantages (Rugman and Li, 2007; Tang and Pearce, 2017). Most studies focus on how government regulations and internationalization policies stimulate innovation (Lazzarini, 2015; Zhou et al., 2017) and how various forms of State ownership foster firm performance (Peng et al., 2008). The technological capability of emerging firms is influenced top down, i.e. from government interventions (e.g. Guennif and Ramani, 2012) to innovation systems (e.g. Malerba and Nelson, 2011), and down to the firm level.

Scholars maintain different views on the impact of government policies on firm innovation. Some researchers stress that EMNEs have country-specific advantages to exploit initially; these are often only temporary and as such are just an avenue by which to access the knowledge-based capabilities that will help create and sustain competitive advantage in the long term (Kedia et al., 2018; Lei et al., 2019; Miao et al., 2018). Some hold that government policies, particularly regulations on market entry or technology transfer (Branstetter, 2018), facilitate the inward knowledge-observing process. For example, the Chinese Government applied the "technology for market" strategy, under which it allows foreign companies to enter the Chinese market in exchange for technology transfer to domestic companies or establishment of R&D centres in the country (Zhou and Liu, 2016). Other scholars focus on the process of outward knowledge sourcing. Because of insufficient firm-level competitive resources, most emerging firms internationalize with the support of institutional conditions and policies (Mathews, 2006; Rugman et al., 2016). The institutional theorists point out that the supportive policies and industrial structure of the home country play crucial roles in Chinese firms' global expansion (Grosse, 2019) and that some good results have been achieved in some key industries, such as high-speed rail and telecommunication (Liu et al., 2017; Yap and Truffer, 2019).

Emerging firms, therefore, have strong incentives to accumulate global technology and build cross-border knowledge to acquire knowledge resources and advanced technological capabilities that enable them to catch up with industry leaders in the global market (Awate et al., 2015; Cantwell, 2017; Li et al., 2012; Mudambi, 2008). Alon (2010) emphasized the differences in mechanisms of knowledge-sourcing activities among enterprises with different ownership in emerging economies under incentive policies. This institutional difference creates a comparative advantage in terms of ownership structures, leading to heterogeneity in international business strategy. In practice, Chinese State-owned enterprises (SOEs) are believed to be better able to obtain more direct policy support, whereas private enterprises have the responsiveness to apply policies more flexibly.

3.3 Institutional windows of opportunity for knowledge sourcing

The concept of windows of opportunity has been applied to explain the catching-up phenomenon in global settings (Lee and Malerba, 2017; Shin, 2017). Government institutions exert a major influence in emerging markets. Changes in government intervention in industry that enable emerging enterprises to catch opportunities to leapfrog development are considered as institutional windows of opportunity for latecomers (Perez and Soete, 1988; Guennif and Ramani, 2012; Lee and Malerba, 2017). Thus, the institutional window is created through government intervention in an industry or through systemic changes in institutional conditions (Lee and Malerba, 2017; Vértesy, 2017), usually used as a specific country advantage for emerging firms (Rugman et al., 2016).

Liu (2017) states that the inverted U shape of institutional factors affects innovation performance, which indicate that institutional opportunities for knowledge sourcing may close if not accompanied by changes in institutions and innovation systems. Moreover, the costs of acquisition and imitation have increased as the overall technology gap between China and the West has narrowed (Liu, 2017). Some knowledge-seeking strategy is applied by the enterprises being "locked out" from critical technologies in industry and ineffective policy (Sauter and Watson, 2008).

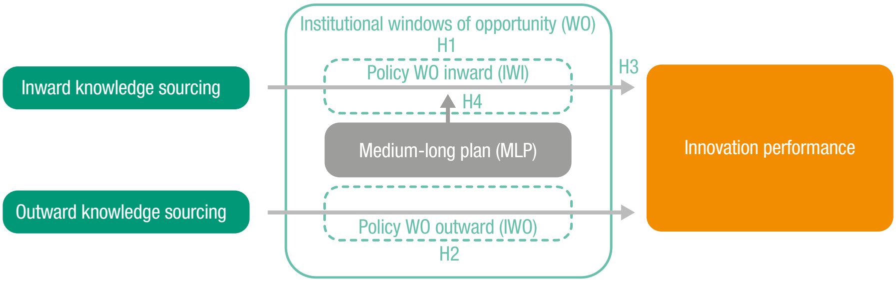
This paper contributes to the theory and policy by using the threshold effect mode and extending the measurement of institutional windows of opportunity.

By measuring the open period of a window, we can derive a rough estimation of the time lag between policy introduction and eventual effect, and try to explain what level of policy incentives might trigger the opening of opportunity windows. From the perspective of existing research, there is still no framework to study the mechanism of impact of IFDI and OFDI as indicators for institutional variables on the innovation performance of enterprises and to measure the institutional window of opportunity. This study focuses on the role of IFDI and OFDI policies in the knowledge-sourcing process of digital enterprises in China and how they affect, respectively, the threshold and the mechanism to enter the window of opportunity for technological innovation of enterprises. This paper also explores the degree to which Chinese enterprises of different ownership types differ in their abilities to sense and seek opportunity windows, in their responses to windows and in their innovation performance. We try to explain the differences in performance and mechanism. Is the threshold effect brought about by policy incentives consistent for enterprises of different ownership?

4. Hypotheses development

Because of the unique institutional settings of government, it plays a significant role in enabling latecomer firms to develop competence at home and abroad (Cuervo-Cazurra and Ramamurti, 2014). To keep up with the competition and develop the capability to confront a fast-changing technical world, external knowledge sourcing is an important path for firms – a way to tap into new ideas and technologies from beyond their boundaries (Monteiro and Birkinshaw, 2017) and fundamentally transform their core competence to enhance their long-term competitiveness (Li et al., 2012). Hence, knowledge sourcing has become a strategic purpose motivating IFDI and OFDI (Dunning and Lundan, 2008) (figure 1).

Figure 1. Structure of the knowledge-sourcing process of China's digital MNEs



Source: Authors' elaboration.

Bringing-in opportunity window

Institutional reforms appear to be an important determinant of FDI attraction in developing countries, as they can provide space, resources and opportunities for catching up (Mu and Lee, 2005; Pack and Saggi, 2006). Governments can effectively align market-driven incentives with knowledge-sourcing purposes to influence the behaviour of firms in their pursuit of technological catch-up and innovation performance. At the beginning of the economic reform period in the late 1970s, the Chinese Government opened the domestic market to foreign investors and provided favourable tax, regulatory and infrastructure conditions. The policy was inspired by the Government's goal to catch up economically and in basic technology rather than to achieve original innovation. As latecomers, Chinese firms started from a resource-meagre position as they did not possess strong technological resources, advanced management skills and marketing techniques (Wang et al., 2012) and could not offer firms sustainable competitive advantages in operating in an increasingly globalized and ever-changing context. A wave of multinational enterprises (MNEs) entered China and provided a large amount of FDI (World Bank, 2015). At this early stage, Chinese firms required strategic knowledge from successful firms. Given the policy orientation and supported by investment regulations, many were encouraged to pursue collaboration with foreign investors, primarily to gain access to technologies and know-how, rather than to exploit existing resources and capabilities (Liu and Woywode, 2013; Luo and Tung, 2007; Rui and Yip, 2008). In other words, they used FDI as a channel to overcome their disadvantages (Child and Rodrigues, 2005; Mathews, 2002). Rapid responses to policy incentives enabled the process of learning from inward spillovers of foreign knowledge. In 2008, the Government began to withdraw favourable policies for foreign companies, although the overall growth trend continued (Liu et al., 2017). We surmise that the bringing-in policy opened a window of opportunity for operationalizing Chinese firms' knowledge-seeking strategies and firms recognized the time slot. The "trading market for technology" policy produced the expected effect of expanded knowledge sources.

Hypothesis 1:

Bringing-in opportunity windows and exits have positive effects on knowledge acquisition within a certain window period.

Going-out opportunity window

In the gradual and cumulative process of technological catch-up, enterprises enhance their knowledge base (Dutrénit, 2000; Cantwell, 2017). When an enterprise has acquired the basic technical knowledge suitable for a low-end market or mastered certain core technologies through indigenous innovation, it gradually cultivates the ability to carry out OFDI. Especially in the technology field, with its short cycle times and large initial-knowledge stock, the latecomers from China tend to reach a higher level within a shorter cycle time, have easier access to knowledge and show greater adaptability.

China has established clear direction about the types of OFDI it would like to encourage, in particular technology-related OFDI, and has created a supportive environment that helps strong firms to invest abroad for the purpose of becoming globally competitive MNEs. Among internationalization paths, cross-border mergers and acquisitions (M&As) are a major mechanism of overseas expansion that facilitates the integration of advanced technology. Greenfield investment is adopted to directly obtain more advanced technical knowledge and intellectual resources, in order to enhance innovation ability. By providing a stable and supportive institutional environment, government policy and incentives in relation to the promotion of OFDI also enabled strong Chinese firms to choose longer-term M&As as a means to acquire technology from global giants (Hitt et al., 2004). The initial firms capable of seeking patented technology may be large SOEs, as they can use government sponsorship and financial underwriting to secure strategic assets through purchases and associated learning opportunities (Child and Rodrigues, 2005; Sabir et al., 2019). Their international expansion aims to increase market share and to acquire and adapt technology from diverse sources to match firms' existing knowledge base. Consequently, the Government formulated a series of policies as institutional support for the acquisition of foreign knowledge in the form of tax measures and favourable financing (UNCTAD, 2005). However, as domestic industries upgrade, financial markets develop and policies are further updated, more private companies (such as Huawei, Tencent and Byte Dance) were able to invest overseas. The empirical analysis shows that after 2003, Chinese enterprises' technology-oriented OFDI gradually increased (Luo et al., 2010). The Government's policy support for technology-oriented outbound investment may have played an important role in Chinese companies' overseas investment decisions. The effort to drive Chinese firms to invest abroad gained momentum after the implementation of the "go global" strategy (announced in 2001), which played a crucial role in Chinese firms' internationalization. Therefore, we surmise that in the technological catch-up process, the existence of a "going-out" institutional window will increase knowledge sourcing at a faster speed within a certain time slot (Li et al., 2016). We propose:

Hypothesis 2:

Going-out opportunity windows and exits have positive effects on knowledge acquisition within a certain window period.

Variations of two windows in knowledge-sourcing process

In the research framework of this paper, we also focus on the impact of knowledge sourcing on latecomer firms' innovation performance. According to the literature, institutional demand and pressures are the key elements affecting internationalization strategy and activities, and provide growth points for innovation (Lazzarini, 2015; Zhou et al., 2017; Awate et al., 2015; Mudambi, 2008; Rugman and Li, 2007).

Research on the nature of the digital industry shows that the effectiveness of policy stimulus for knowledge sourcing is not linear. Both incumbents and latecomers are equal in the face of institutional arrangements. Latecomers can use this opportunity to offset the disadvantage of being latecomers. However, by reacting to institutional arrangements, the first movers' capability enhancement in terms of technology and market demand led the narrowing of the window for the latecomers (Kim and Park, 2019). The costs of learning and imitation have increased as the overall technology gap between latecomers and advanced countries has narrowed (Liu, 2017). The sharp increase in technological standards by incumbents weakens the latecomers' advantages derived from institutional arrangements. The knowledge-sourcing process moves towards increasing internal investment in innovation and internal R&D, adopting a cost-out strategy and thereby increasing efficiency (Choquette et al., 2021). Based on these assumptions, it is reasonable to believe that in the empirical test, there may be a threshold that divides the different impacts of knowledge sourcing on enterprise innovation performance. When knowledge sourcing exceeds the threshold value, the impact of the institution window on enterprises' innovation performance will begin to decline. Owing to the weak absorptive capacities of latecomers in the early stage of the knowledge process and the imitation lag for innovation, the technological gap between latecomers and advanced foreign investors lags knowledge transfer for innovation performance.

Hypothesis 3:

Knowledge sourcing has a curvilinear relationship (inverted-U) with latecomers' innovation performance.

Internal Commitment: MLP for R&D investment

Research has pointed out that as more FDI flows into emerging economies, the catching-up EMNEs progress (Alon et al., 2018; Li et al., 2017; Luo and Tung, 2007). Some insights into the IFDI-OFDI linkage have been explored (Xia et al., 2014). Latecomers in emerging markets are learning from the foreign MNEs' inward knowledge-sourcing process, which could foster their subsequent OFDI.

Yet, the ultimate purpose of knowledge sourcing is to build a firm's core technology and innovation capacity. Whether latecomer firms can transform the technological advantages of FDI into technological progress depends on their absorptive capacity (Zhang et al., 2010). Spillovers of advanced technology from foreign investors improve domestic production and technical capacity for innovation. However, the competition and crowding-out effects of the industry intensify the pressure of blocked-in technology transfer in EMNEs’ home markets (Acemoglu, 2006), which may push them to seek internal development of technology. This compels supplementary policies to encourage internal technology investment.

The MLP, a government commitment to technology development, was created to stimulate domestic enterprises’ R&D investment so as to promote technological capacity, in order to strengthen knowledge bases for acquiring frontier technology through outward knowledge sourcing. First, the Government subsidized focal sectors for R&D activities, which may encourage more R&D expenditure by enterprises. Subsequently, the Government promulgated policies, laws and legislation to sustain capability-building in domestic firms so that they can better utilize foreign technology so to develop their own core technology. This formed overlying effects for innovation, leading to more technology spillovers. This, in turn, provides opportunities for technological learning of firms (Fan, 2006; Dunning and Lundan, 2008) and increases the probability of catch-up on frontier technology. For example, in government-initiated programmes such as science parks, the Government provides financial resources and tax incentives to attract firms to locate in the park. These policies create new industrial clusters and market segments and attract more competitive foreign investment, leading to firm-specific advantages in building up knowledge sourcing through OFDI.

Hypothesis 4:

R&D investment positively moderates the relationship between institutional windows and knowledge sourcing.

5. Methodology

5.1 Data

The data was collected from multiple, large-scale databases by first obtaining data on 187 Chinese listed telecommunication companies from 2006 to 2020 from the China Stock Market Accounting Research database. We matched using R and Python from IncoPat, zephyr and UNCTADstat, and then combined them as panel data. The sample consists of data on 1,801 patents matched by stock codes for each of the 187 listed digital companies with their annual report data and contains 2,807 firm-year observations for the period from 2006 to 2020.

Here, we start with static linear models, to verify the results. To explore the effectiveness of the policy window on knowledge sourcing through internationalization, we then establish difference GMM (generalized method of moments) and system GMM models (Wooldridge, 2010). Then we apply threshold models to investigate potential nonlinear relationships between the effective range of policy windows and different directions of knowledge sourcing.

5.2 Model specification

Static model

$$lnpatent_{it} = \beta_0 + \beta_1\, lnIKS_{it} + \beta_2\, lnOKS_{it} + \beta_3\, lnIWI_{it} + \beta_4\, lnIWO_{it} + \sigma X_{it} + \vartheta_{it} + \varepsilon_{it} \quad (1)$$

The benchmark linear regression aims to investigate the impacts of knowledge sourcing through IFDI and OFDI and their associated opportunity windows on firm innovation performance. This study looks for the length of institution windows by examining for how many consecutive years the policies have impacts on knowledge sourcing and innovation. We use IFDI and OFDI as the threshold variables to estimate the length of windows for innovation, and we adopt R&D input as a moderating variable, to test the moderating effect of the MLP on the relationship of institutional window and innovation.

The model in this paper is based on the panel data threshold model of Hansen (1999). The basic equation given is

$$\gamma_{it} = \mu_i + \beta_1 x_{it} I(q_{it} \le \gamma) + \beta_2 x_{it} I(q_{it} > \gamma) + \varepsilon_{it} \quad (2)$$

Equation (2) is equivalent to

$$y_{it} = \begin{cases} \mu_i + \beta_1 x_{it} + \varepsilon_{it}, q_{it} \le \gamma \\ \mu_i + \beta_2 x_{it} + \varepsilon_{it}, q_{it} > \gamma \end{cases} \quad (3)$$

Where i represents the region, t represents the year, I is the indicator function, q_{it} is the threshold variable, γ is the threshold value to be estimated and ε_{it} is the random disturbance term. Referring to Hansen's threshold model, the threshold regression model of this study is set as follows:

Threshold model

$$lnpatent_{it} = \alpha_0 + \alpha^* lnpatent_{i,t-1} + \alpha_1 lnIKS_{it} \cdot I(lnIWI_{it} \le \gamma) + \alpha_2\, lnIKS_{it} \cdot I(lnIWI_{it} > \gamma) + \sigma X_{it} + \vartheta_i + \varepsilon_{it} \quad (4)$$

$$lnpatent_{it} = \alpha_0 + \alpha^* lnpatent_{i,t-1} + \alpha_1 lnOKS_{it} \cdot I(lnIWO_{it} \le \gamma) + \alpha_2\, lnOKS_{it} \cdot I(lnIWO_{it} > \gamma) + \sigma X_{it} + \vartheta_i + \varepsilon_{it} \quad (5)$$

Where γ is the threshold value.

In order to prove the existence of U-shaped relationship, researchers usually use the following mathematical model for regression:

$$Y = \beta_0 + \beta_1 X + \beta_2 X^2 \quad (6)$$

Accordingly, we construct the following model:

$$lnpatent_{it} = \beta_0 + \beta_1 lnIWI_{it} + \beta_2 lnIWI_{it}^2 \quad (7)$$

$$lnpatent_{it} = \beta_0 + \beta_1 lnIWO_{it} + \beta_2 lnIWO_{it}^2 \quad (8)$$

5.3 Variable specification

Dependent variable

Growth of innovation is the outcome of technology spillover. The literature mainly uses the number of patents (*patent*) to measure firms' innovation outputs and reflect outcomes of technology spillovers. Considering the validity of innovation, we use patents granted as the dependent variable.

Independent variables

Inward knowledge sourcing (*IKS*) – knowledge sourcing through IFDI – and outward knowledge sourcing (*OKS*) – knowledge sourcing through OFDI – are the classifications of learning styles in the field of innovation in international business. Learning activities can be divided into inward and outward according to whether they occur inside or outside a country's boundary (Dahlander and Gann, 2010; Mazzola et al., 2012). Inward knowledge sourcing is the means to integrate innovation and technology resources that spill over from the activities of MNEs in domestic markets. We use the percentage of foreign enterprises in total enterprises for *IKS*. Outward knowledge sourcing enables latecomers to catch up with frontier technology and knowledge through embeddedness of advanced countries. We use M&As of the digital industry to describe *OKS*.

Indigenous innovation (*Iinno*) reflects the ability to innovate. R&D capital expenditure reflects the investment intensity of firms in equipment for improving innovation and plays an irreplaceable role. In general, a high level of firm expenditure on R&D indicates a willingness to engage in technological innovation for catch-up. In this paper, the investment intensity of R&D is adopted to describe indigenous innovation, i.e. R&D expenditure as a share of total expenditure.

Threshold variable

Firms hitchhiking on the ride of opportunity reflects the effective range of policy support for internationalization action. Scholars in international business contend that latecomers build up initial technological capabilities by imitating technologies gained from IFDI and related technology transfer or spillovers (Lee et al., 2005; Wu and Zhang, 2010). FDI, often dictated by MNEs' knowledge-seeking motives, is one of the most efficient channels to access and acquire strategic assets (Mathews, 2006). IFDI is the product and direct outcome of the open door policy. Thus, the value of IFDI is used to indicate the policy window of opportunity for inward technology spillovers. As firms' technological capabilities develop, they locate their OFDI in host countries with more advanced technologies and other strategic assets, where they catch up to technology frontiers, which is the result of the going-out policy. Therefore, both IFDI and OFDI reflect policy support for the technology catch-up of EMNEs. Thus, in this paper, IFDI flows and OFDI flows are adopted in the model as policy windows.

Control variables

We accounted for several attributes that may be expected to contribute to explaining the dependent variables. First, we controlled for absorptive capacity by R&D personnel investment (*rdp*), using the number of employees involved in R&D divided by the total number of employees. Investment in R&D personnel can increase the knowledge reserve of society and provide the human capital basis for technological innovation.

We also controlled for the age of the firm (*age*), on the basis that older firms have more experience and potentially more extensive resources, which may allow them to learn from international technology spillovers. We also distinguished firm ownership as a dual variable (0 = private, 1 = SOE), as additional knowledge-sourcing performance due to governmental support. Size of firms (*size*), reflects scale differences in tolerances of R&D risks, which directly affects firms' innovation enthusiasm. Tables 1 shows the definition of variables, and the descriptive statistics of variables are provided in table 2.

Table 1. Definition of variables

Variable	Abbreviation	Data description	Data source
Dependent variable			
Innovation performance	*patent*	Patent granted (patent1 = all patents granted, patent2 = patent for invention)	Incopat
Independent variable			
Policy WO inward	*IWI*	FDI flows	China, Ministry of Commerce; UNCTADstat
Inward knowledge sourcing	*IKS*	Number of enterprises with foreign capital in an industry as a share of the total number of enterprises	China, National Bureau of Statistics

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Table 1. Definition of variables (Concluded)

Variable	Abbreviation	Data description	Data source
Policy WO outward	*IWO*	OFDI flows	*Statistical Bulletin of China's Outward Foreign Direct Investment*
Outward knowledge sourcing	*OKS*	M&As	CSMAR database
Moderator variable			
Indigenous innovation	*Iinno*	Firms' R&D expenditure as a share of total expenditure	CSMAR database
Control variable			
Size	*size*	Total assets	CSMAR database
Age	*age*	Year of establishment	CSMAR database
Ownership	*dual*	Private = 0, SOE = 1	CSMAR database
Absorptive capacity	*rdp*	Number of R&D personnel	CSMAR database
Efficiency of R&D	*CapRD*	R&D expenseas a share of total revenue	CSMAR database

Source: Authors' compilation.
Note: CSMAR = China Stock Market & Accounting Research, M&As = mergers and acquisitions, OFDI = outward foreign direct investment, R&D = research and development, SOE = State-owned enterprise, WO = window of opportunity..

Table 2. Descriptive statistics of variables

Variable	N	p25	p50	p75	Minimum	Maximum	Mean	Standard deviation
patent1	1 801	28.0	73.0	234.0	0.4	25 000.0	346.3	1060.0
patent2	1 571	7.0	18.0	60.0	0.0	2780.0	89.9	249.8
IWI	2 793	183.4	281.4	367.5	14.9	512.3	270.4	108.6
IKS	2 200	41.3	64.9	90.6	0.0	464.3	74.8	59.3
IWO	2 681	158.1	276.8	394.6	1.6	634.3	275.5	140.6
OKS	1 943	69.1	258.8	923.1	0.0	71 000.0	1619.0	5 010.0
Iinno	1 795	91.6	302.5	960.4	0.1	17 000.0	979.3	1 778.0
size	2 428	163.1	349.5	934.9	1.1	150 000.0	1423.0	6 613.0
CapRD	2 485	18.8	36.0	55.0	0.0	985.1	51.6	66.8

Source: Authors' estimations.

6. Results and analyses

6.1 Correlation analysis

In order to deal with the problem of multicollinearity, we conducted correlation analysis, using the Pearson correlation coefficient to represent the strength of correlation and artificially eliminate collinear variables without losing important information. Table 3 shows the correlation coefficients.

Table 3. Correlation coefficients of the main variables

	patent1	IWI	IKS	IWO	OKS	linno	size	age	rdp
IWI	0.109***								
IKS	-0.018	0.006							
IWO	0.114***	0.989***	0.016						
OKS	-0.013	0.110***	0.057	0.081**					
linno	0.100***	0.030	-0.047	0.021	0.103***				
size	0.478***	0.023	-0.032	0.034	0.071**	0.068*			
age	-0.033	0.441***	0.150***	0.438***	0.052	-0.001	0.072**		
rdp	0.102***	0.933***	0.023	0.928***	0.024	0.040	-0.006	0.396***	
CapRD	0.021	0.117***	-0.028	0.125***	-0.019	0.027	-0.148***	-0.259***	0.119***

Source: Authors' estimations.
Note: *** p < 0.01, ** p < 0.05, * p < 0.10.

Benchmark linear regression

We conducted basic linear regression, which indicated that inward and outward knowledge sourcing have significant roles in promoting innovation performance (table 4). In terms of policy incentives, the effect of inward policy incentives is not significant, but the regression coefficient of outward policy incentives passes the significance test at the level of 1 per cent. This indicates that they have a strong promotion effect in improving the innovation performance of enterprises (rather than inward policy incentives).

Table 4. Benchmark linear regression

Variable	Lnpatent1
LnIKS	0.211*** (0.055)
LnOKS	0.030** (0.014)

/...

Table 4. Benchmark linear regression (Concluded)

Variable	Lnpatent1
LnIWI	0.327 (0.272)
LnIWO	0.519*** (0.182)
Constant	-1.171* (0.652)
Number of observations	931
R^2	0.075
R-squared within	0.196

Source: Authors' estimations.
Note: *** p < 0.01, ** p < 0.05, * p < 0.10.

6.2 Threshold model test

6.2.1 Bootstrap

It can be seen from table 5 that in the case of 300 Bootstrap self-sampling there are two threshold values, for the policy window of opportunity – inward (*IWI*) and outward (*IWO*). The impact of the two variables on enterprise innovation performance has stage characteristics, indicating nonlinear relationships between innovation performance and inward and outward knowledge sourcing within the range of the policy window of opportunity.

Table 5. Threshold effect test

Threshold variable	Threshold	F-statistic	Probability	Crit10	Crit5	Crit1
LnIWI	Single	46.910	0.000	7.977	9.527	13.792
	Double	17.680	0.000	7.492	9.014	12.263
	Triple	3.150	0.800	10.759	12.801	18.787
LnIWO	Single	26.160	0.000	8.117	9.182	11.759
	Double	12.810	0.003	6.556	8.424	11.074
	Triple	4.770	0.763	13.857	15.500	20.445

Source: Authors' estimations.

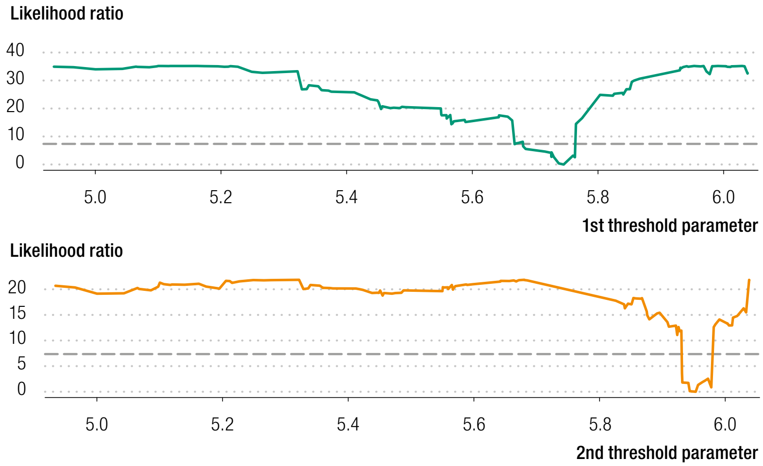
6.2.2 Determination of threshold value of two institutional windows of opportunity

Phased test of IWI

According to the estimated results of the threshold effect of *IWI* in figure 2, the corresponding likelihood ratio value of *IWI*'s threshold estimate is significantly smaller than the critical value of 7.35. Therefore, we believe that the obtained threshold estimate is true and valid. The results show that the impact of *IWI* on innovation performance has two stages, which can be regarded as the window opening in the first stage and further opening in the second stage.

The bringing-in policies have encouraged firms to pursue FDI to acquire advanced technology, which underpins innovation performance. Such policy direction enhanced inward knowledge spillovers, expanding the expected effect of knowledge sources for innovation. The institutional preference opens the window for domestic digital firms to catch up technologically. The second stage indicates that with the increase in inward knowledge sourcing, the institutional window shows a trend of strengthening for further opening, rather than closing. In formulating various institutional measures and incentives (e.g. gradually reducing the negative list of investment), China constantly encourages FDI, to keep the positive effect of technological knowledge spillover for innovation. Therefore, H1 is accepted for the existence of an inward institutional window of opportunity because of the positive effect on knowledge sourcing for innovation.

Figure 2. Likelihood ratio for institutional window for inward FDI (IWI)

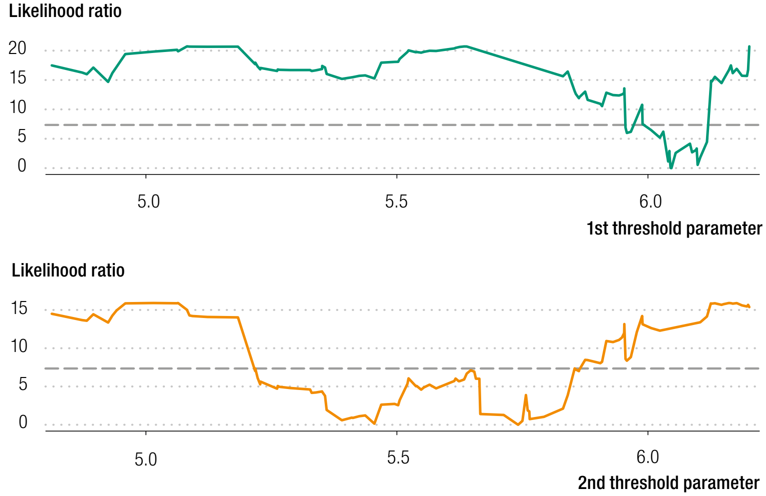


Source: Authors' estimations.

Phased test of IWO

According to the estimated results of the threshold effect of *IWO* in figure 3, the corresponding likelihood ratio value of *IWO*'s threshold estimate is significantly smaller than the critical value of 7.35. Therefore, we believe that the obtained threshold estimate is true and valid. The results in table 6 show that the impact of *IWO* on innovation performance shows two obvious stages, which can be regarded as the window opening and then further expanding. Outward knowledge sourcing is promoted by the Chinese Government's "go global" strategy, which opened the window for learning advanced technology through outbound investment. This policy orientation enhanced outward knowledge seeking, stimulating further innovation. Innovation activities gaining momentum with continued implementation of OFDI incentives explains the second stage of further opening-up of the institutional window for outward knowledge sourcing, which is the same as *IWI*. This indicates that with the increase in outward knowledge sourcing, the trend is for the institutional window to open further rather than closing. China promotes OFDI in formulating various institutional incentives (e.g. reformations of the foreign exchange management system and the administrative approval system, the launch of the Belt and Road Initiative), to maintain the positive effect on advanced technological knowledge-seeking for innovation. Therefore, H2 is accepted for the existence of the outward institutional window because of the positive effect on outward knowledge sourcing for innovation.

Figure 3. Likelihood ratio for institutional window for outward FDI (IWO)



Source: Authors' estimation.

Table 6. Threshold model estimates of two phrases of IWO

Policy WO inward		Policy WO outward	
LnIWI ($\gamma \leq 5.745$)	0.050 (0.042)	LnIWO ($\gamma \leq 5.741$)	-0.008 (0.018)
LnIWI ($5.745 < \gamma \leq 5.853$)	0.142*** (0.043)	LnIWO ($5.741 < \gamma \leq 6.047$)	0.039** (0.018)
LnIWI ($5.853 < \gamma$)	0.226*** (0.044)	LnIWO ($6.047 < \gamma$)	0.094*** (0.019)
lnsize	0.051 (0.050)	lnsize	0.333*** (0.060)
lnCapRD	0.051 (0.058)	lnCapRD	-0.071 (0.067)
lninno	0.043 (0.033)	lninno	-0.039 (0.035)
Constant	3.140*** (0.415)	Constant	2.498*** (0.463)
Number of observations	927	Number of observations	912
R-squared	0.128	R-squared	0.161

Source: Authors' estimations.
Note: *** $p < 0.01$, ** $p < 0.05$.

6.2.3 Measure of window of opportunity

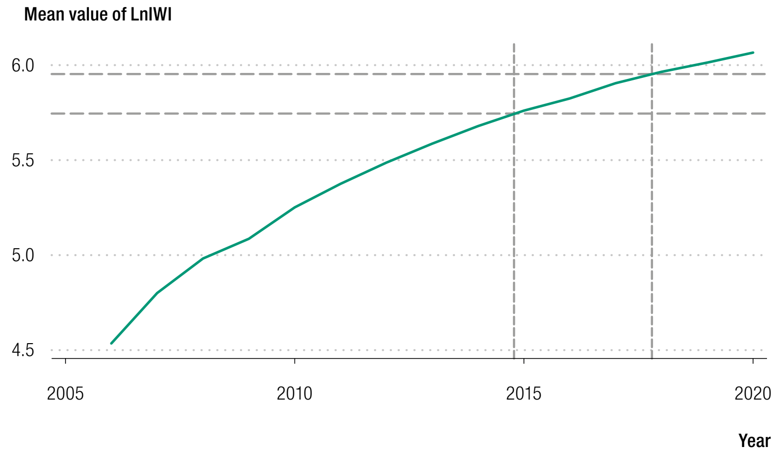
In order to identify the window periods, we obtain the mean value of *lnIWI* and *lnIWO* in each year (table 7). By comparing them with the threshold value of the threshold regression model, we can determine the years of the corresponding windows. For *IWI*, the window opened for the first time in 2014 and was further opened in 2016 (figure 4). For *IWO*, the window period also opened for the first time in 2014 and was opened further after 2018 (figure 5). This explains that not all policies can form institutional windows of opportunity for purposes of innovation. The window creates a promotional effect on knowledge sourcing for innovation in a specific time period. The possible reason for the further opening-up stage of *IWO* being later than that of *IWI* is that in the early stage of international expansion, Chinese MNEs mainly sought niche markets rather than more advanced technology. Therefore, H1 and H2 are also accepted for the existence of effective timing of windows of opportunity.

Table 7. Mean values of LnIWI and LnIWO

Year	LnIWI	LnIWO
2006	4.535	4.196
2007	4.801	4.342
2008	4.982	4.616
2009	5.086	4.727
2010	5.251	5.026
2011	5.375	5.227
2012	5.487	5.364
2013	5.587	5.52
2014	**5.679**	**5.66**
2015	5.761	5.77
2016	**5.825**	5.872
2017	5.905	5.989
2018	5.965	**6.073**
2019	6.013	6.144
2020	6.066	6.217

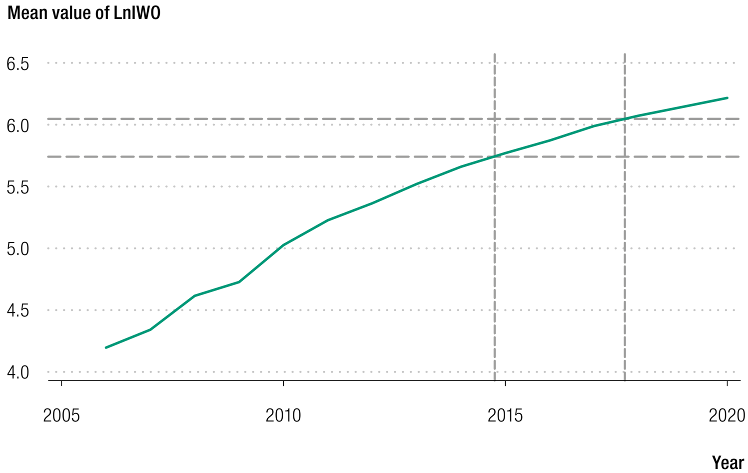
Source: Authors' estimations.

Figure 4. Policy window of opportunity for inward FDI



Source: Authors' estimations.

Figure 5. Policy window of opportunity for outward FDI



Source: Authors' estimations.

6.2.4 Heterogeneity analysis of firm's ownership structure

We further analyse the heterogeneity of enterprise ownership, trying to explore the different performances and characteristics of the threshold effect of the innovation performance of SOEs and private enterprises under institutional incentives.

Heterogeneity of firm ownership on IWI

The threshold effect test shows opposite results (table 8): SOEs failed to pass the double threshold test, and private enterprises passed it.

Table 8. Threshold effect test

Threshold variable	Threshold	F-statistic	Probability	Crit10	Crit5	Crit1
LnIWI (SOE)	Single	11.470	0.000	5.273	6.006	7.218
	Double	2.960	0.317	4.699	5.673	6.558
LnIWI (Private)	Single	23.570	0.000	7.702	9.942	13.351
	Double	10.530	0.027	7.086	8.513	12.559

Source: Authors' estimations.

According to the regression results in table 9, we can infer that for enterprises with different ownership, the threshold effect brought by policy incentives is similar and obvious. For SOEs, there is mainly one threshold in the inward policy window, and the threshold coefficient shows a significant impact on the promotion of inward knowledge sourcing on innovation performance. Private enterprises have experienced two policy thresholds, and the increase in the coefficient of the influence variable is relatively stable and phased. In general, after crossing the threshold, the threshold coefficient of SOEs is slightly higher than that of private enterprises.

Table 9. Heterogeneity of ownership in IWI

Variable	State-owned enterprise	Private enterprise
lnsize	0.199* (0.118)	-0.015 (0.056)
lnCapRD	0.082 (0.083)	-0.127 (0.089)
lnInno	-0.070 (0.055)	0.121*** (0.041)
lnIKS ($\gamma \leq 5.76$)	0.170 (0.115)	0.006 (0.044)
lnIKS ($5.76 < \gamma \leq 6.047$)	0.295*** (0.112)	0.136*** (0.047)
lnIKS ($6.047 < \gamma$)	-	0.257*** (0.049)
Constant	1.867** (0.821)	3.938*** (0.514)
Number of observations	406	508
R-squared	0.123	0.200

Source: Authors' estimations.
Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Heterogeneity of firm ownership on IWO

SOEs and private enterprises failed to pass the significance test of 5 per cent in the double threshold test, so we chose to return to a single threshold for these two models (table 10).

Table 10. Threshold effect test

Threshold variable	Threshold	F-statistic	Probability	Crit10	Crit5	Crit1
lnIWO (SOE)	Single	7.540	0.027	5.030	5.904	8.512
	Double	5.410	0.063	5.029	5.712	7.262
lnIWO (Private)	Single	22.130	0.000	5.654	7.089	8.736
	Double	4.970	0.073	4.592	5.260	7.154

Source: Authors' estimations.

As shown in the results in table 11, outward knowledge sourcing has no significant effect on innovation performance before OFDI, reaching the threshold value as it fails. After passing the threshold value, outward knowledge sourcing improves significantly in the promotion of innovation performance, in SOEs and private enterprises.

Table 11. Heterogeneity of ownership on IWO

Variable	State-owned enterprise	Private enterprise
lnsize	0.274** (0.112)	0.370*** (0.072)
lnCapRD	0.142 (0.096)	-0.029 (0.082)
lninno	-0.148** (0.066)	0.041 (0.054)
lnOKS ($\gamma \le 5.634$)	0.0278 (0.023)	-0.019 (0.024)
lnOKS ($5.634 < \gamma$)	0.095*** (0.027)	0.107*** (0.025)
Constant	2.663*** (0.821)	2.034*** (0.564)
Number of observations	368	351
R-squared	0.135	0.299

Source: Authors' estimations.
Note: *** $p < 0.01$, ** $p < 0.05$.

6.3 Estimation of variations of two windows in knowledge sourcing process

6.3.1 Inward knowledge sourcing

As can be seen in table 12, *IKS* is significant in one-term regression and passes the significance test at the 1 per cent level. The coefficient of the quadratic term of *IKS* is significantly negative and different from the first-order term, which meets part of the conditions of the inverted U-shaped relationship.

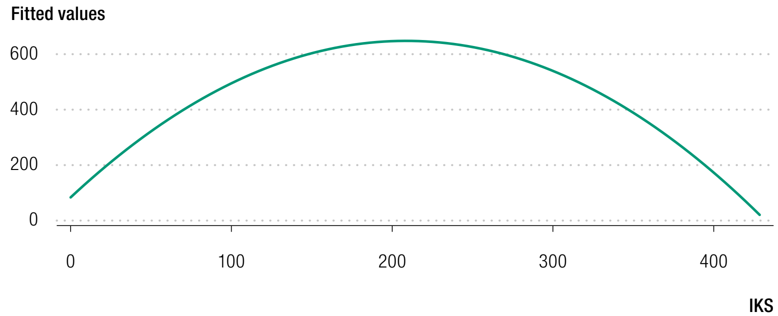
The three-step method proposed by Lind and Mehlum (2010) is used to test the data range, whether the slope at both ends of the data is steep enough and the relationship between its upper and lower bounds through a U-test (table 12). Figure 6 shows the regression curve, from which it can be preliminarily judged that the inverted U-shaped relationship is established. The result well explains the spillover effects and crowding-out effect of inward knowledge sourcing for innovation.

Table 12. Estimation of change of IKS

Variable	(1)	(2)
IKS	4.167*** (0.698)	9.370*** (1.375)
IKS2		-0.017*** (0.004)
Constant	45.460 (81.690)	-198.800** (98.670)
Number of observations	1 469	1 469

Source: Authors' estimations.
Note: *** $p < 0.01$, ** $p < 0.05$.

Figure 6. Regression of change of inward knowledge sourcing (IKS)



Source: Authors' estimations.

6.3.2 Outward knowledge sourcing

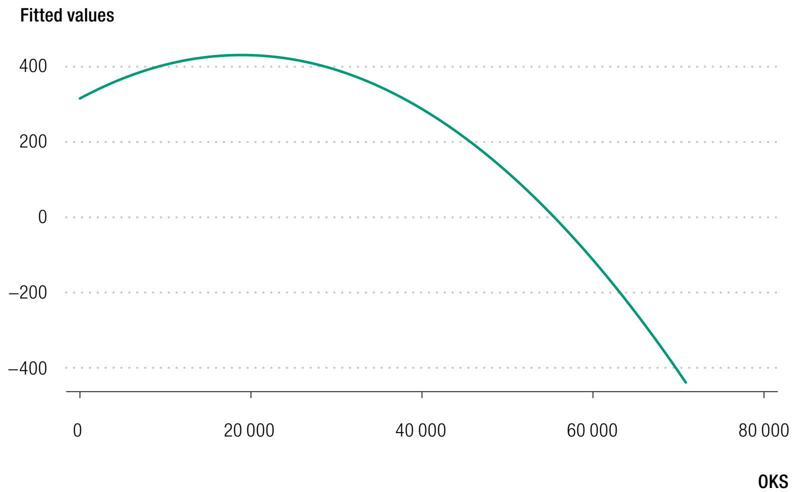
It can be seen in table 13 that *OKS* fails to pass the significance test in a regression but still shows an inverted U-shape (figure 7). The possible reason is that technology innovation by EMNEs improves only when reverse technology spillovers occur through outward knowledge sourcing. M&As, as one approach for outward knowledge sourcing, can be driven not only by the desire to acquire advanced technology, but also by the opportunity to produce for niche markets, reducing the emphasis on technological innovation. Therefore, H3 is partly accepted.

Table 13. Estimation of change of OKS

Variable	(1)	(2)
OKS	0.001 (0.006)	0.011 (0.013)
OKS2		0.000 0.000
Constant	308.300*** (54.500)	299.800*** (55.300)
Number of observations	1 355	1 355

Source: Authors' estimations.
Note: *** $p < 0.01$.

Figure 7. Regression of change of outward knowledge sourcing (OKS)



Source: Authors' estimations.

6.4 Moderating effect test

We use indigenous innovation as a moderator variable to test the influence mechanism of indigenous innovation when policy incentives affect innovation performance. The interaction terms *Inlinnoiwi* and *Inlinnoiwo* of *IINNO*, *IWI* and *IWO* are generated and used as threshold variables to establish the moderating effect for inward and outward knowledge sourcing. As shown in table 14, *IWI* with indigenous innovation is suitable for double-threshold regression, whereas *IWO* with indigenous innovation fails to pass the threshold regression. The possible reason is that the main purpose of *IWI* for knowledge sourcing is to take advantage of knowledge spillovers. To reduce the crowding-out effect of FDI, promotion of indigenous innovation is a key solution.

Table 14. Threshold effect test

Threshold variable	Threshold	F-statistic	Probability	Crit10	Crit5	Crit1
InlinnoIWI	Single	10.370	0.070	9.430	11.256	14.384
	Double	9.590	0.090	9.086	10.915	12.842
InlinnoIWO	Single	6.530	0.270	8.991	10.893	16.161
	Double	7.010	0.237	9.152	10.700	13.450

Source: Authors' estimations.

The results in table 15 show that when the moderating variable (enterprise R&D investment) is at different levels, the impact of inward policy incentives on enterprise innovation performance differs significantly. The R&D investment of enterprises first promotes the main regression, and the promotion effect weakens after the R&D investment increases to a certain level. When R&D investment continues to increase, the promotion effect appears again but its degree is reduced. Subsidies help loosen financial constraints, thereby boosting firms' ability to appropriate new external technologies. The Government incentives contributed to rises in R&D investment for promoting indigenous innovation in general. However, the weakened effect trend implies that the subsidies support raises the issue of "picking the winners", i.e. the Government has chosen to subsidize enterprises that have strong innovation capabilities rather than to promote innovation.

H4 is accepted because of the enhancement of the policy effect of *IKS* on innovation.

Table 15. Moderating effect of R&D investment for innovation performance

Policy WO Inward	
lnlnnoIWI ($\gamma \leq 28.7114$)	0.1220*** (0.0461)
lnlnnoIWI ($28.7114 < \gamma \leq 34.7231$)	0.0256 (0.0427)
lnlnnoIWI ($34.7231 < \gamma$)	0.1070** (0.0485)
lnsize	0.1830*** (0.0591)
lnCapRD	0.1470** (0.0640)
LnIWI	0.7340*** (0.1260)
Constant	-1.4920*** (0.5760)
Number of observations	733
R-squared	0.195

Source: Authors' estimations.
Note: *** $p < 0.01$, ** $p < 0.05$.

6.5 Robustness

6.5.1 Robustness test of lagged treatment

In order to avoid the influence of the endogeneity of the model on the empirical results, all explanatory variables are lagged one, two and three periods. The results show that the two models with *IWI* and *IWO* as threshold variables maintain the same number of thresholds, which is a double threshold.

For *IWI*, the significance of the threshold variable remains highly consistent, indicating that the previous results are robust. Moreover, in the three intervals separated by the threshold variable, the threshold coefficient is the same as that without lag, showing an upward trend. For *IWO*, the significance of the threshold variable is not consistent, but it is relatively stable in general. To sum up, we can judge that the overall threshold regression has a certain robustness.

6.5.2 Robustness test of the U-shaped relationship

In order to prevent the possibility of some extreme observations leading to results more directly, we adopted the practices of some scholars (Barnett and Salomon, 2006; McCann and Vroom, 2010; Souder et al., 2012), excluding some outliers from the sample and re-estimating the model, and found that the main results were still the same. For the U-shaped relationship between *IKS* and enterprise innovation performance that has been preliminarily verified, we add a cubic term to the equation to test whether this relationship may be S-shaped rather than U-shaped. The result shows that a cubic term does not improve the fitting of the model, and the reliability of the quadratic relationship is further verified.

7. Conclusion and policy implications

This study, based on quantitative analysis, deepens the comprehension of the role of IFDI and OFDI in the innovation of emerging-market enterprises through knowledge sourcing. Taking a different approach to measure the function of policy incentives as institutional windows of opportunities, we examine to what extent and in which cases Chinese digital companies' innovation performance is improved by sourcing knowledge through IFDI and OFDI.

The research results show that the impacts of inward and outward knowledge sourcing on innovation performance are significant. The two policy windows remained open and expanded further without any sign of closure, indicating that Chinese digital enterprises are encouraged to conduct international knowledge sourcing under consistent policy stimulations. For both FDI and OFDI, the advanced technology brought by knowledge sourcing continuously and effectively improves the innovation level of enterprises. On the one hand, in the digital industry, the acceleration in iteration of technology forces firms to continuously acquire knowledge, engage in learning and innovate to remain competitive. Attracting FDI as a means to acquire technologies is still one of the core policies for stimulating knowledge-sourcing channels. On the other hand, OFDI creates reverse knowledge spillovers to emerging markets, which diversifies knowledge-sourcing channels for bringing innovation to the next level.

For inward sourcing, the window opened for the first time in 2014 and again in 2016. For outward sourcing, the window also opened for the first time in 2014 and then again after 2018. It is evident that the institutional windows of opportunity for knowledge sourcing and innovation are much prolonged. Notably, the effective time of the windows of opportunity, which both started in 2014, lags the release of the policies, possibly indicating that not all releases can become windows of opportunity, which can be formed only in triggering conditions. From 2014, Chinese firms seized on institutional windows of opportunity for technology catch-up through intentional knowledge sourcing in the wave of digitalization. In addition, the results show that – unlike as argued in prior research – Chinese firms first relied on attracting FDI to bring in technology and then used OFDI to springboard, and that IFDI and OFDI jointly promoted the acquisition of external technologies.

From the threshold regression coefficient, we can see that enterprise innovation performance is more sensitive to inward policy incentives than outward ones. This may be because, compared with improving innovation performance, the innovation orientation of outward policy incentives is weak where enterprises use investment to carry out non-innovation activities such as marketing. At the same time, outward knowledge sourcing of Chinese MNEs often has higher operating costs than that of domestic enterprises. A fairer and more convenient overseas business environment and unimpeded international trade channels will help improve innovation performance. It is important for government policymaking to deepen economic and trade cooperation with overseas countries, especially developed countries and countries with key technologies, promoting multi-country investments for scale (UNCTAD, 2017).

In the heterogeneity analysis, we find that for enterprises of different ownership, the threshold effect brought by policy incentives is evident. At the knowledge-sourcing level, SOEs and private firms perform similarly at home and abroad. It is worth noting that for bringing-in policy incentives, the innovation performance of SOEs has a relatively significant positive relationship with enterprise size, while the relationship with R&D investment is weak. In contrast, the expansion of enterprise scale does not improve innovation performance but had an observable positive relationship with R&D investment. As for “go global” policy incentives, for private enterprises, scale becomes a decisive factor, and the relationship between R&D investment and innovation performance is not significant. For SOEs, in contrast, R&D investment has a certain negative impact on innovation performance. To sum up, we believe that policy incentives should be adjusted according to enterprise ownership and the institutional environment.

In the U-test, there is a robust U-shaped relationship between *IKS* and innovation performance, but the U-shaped relationship between *OKS* and innovation performance is not significant. The diminishing effect of *IKS* for innovation indicates a crowding-out effect of foreign capital. Simply relying on a single direction of knowledge sourcing is insufficient for sustainable innovation. *OKS* occurs at the beginning of EMNEs’ search for advanced technology search outside, which they expand through OFDI later on to develop indigenous innovation capability.

By adding the moderator, the process mechanism of knowledge sourcing is made much clearer. Under the stimulus of FDI incentives, R&D investment enhanced the positive effect of inward knowledge sourcing on firms’ technology innovation.

The result explains the importance of in-house R&D in technology innovation. R&D investment reflects the willingness of firms to engage in indigenous innovation, which may further improve their absorptive capacity for knowledge sourcing.

To promote knowledge sourcing for innovation by EMNEs, we present the following insights:

(1) Active implementation of policy windows of opportunity for MNEs.

The internationalization of technology spillovers by MNEs has important implications for policymaking. UNCTAD (2005) stresses the need for coherent national policies to ensure greater benefits from this evolution. With the acceleration of economic development and globalization, China has been actively integrating into the global economy. It has put forward the strategy of the bringing-in window to encourage foreign enterprises to invest in Chinese enterprises and trade for advanced technology for innovation. The "trading market for technology" strategy attracted foreign capital, but the real effect of inward knowledge sourcing on technological innovation appeared much later, after the policy launched. This indicates that a bringing-in window opened in preparation for building up the absorptive capacity of domestic enterprises and expanding technology spillovers in the early stage, thereby generating an agglomeration effect that attracts more inflows of technology and knowledge. The MLP promulgates policies, laws and legislation to sustain the capability-building of domestic firms, so that they can better utilize foreign technology develop their core technologies. These policies create new industrial clusters and market segments and attract more competitive foreign investment, leading to an agglomeration effect of foreign investment.

The "going global" window brought opportunities for Chinese firms to not only integrate into the international market and achieve economies of scale, but also narrow the gap with technologically developed enterprises. Moreover, their OFDI has indeed brought about better innovation.

(2) Seizing the policy windows for knowledge sourcing and innovation

Responding to the institutional window by utilizing the favourable policies allows EMNEs to acquire knowledge for innovation. Through a series of policy arrangements, strategic knowledge seeking can be activated. The construction of innovative institutional mechanisms can adapt to or promote technological progress, e.g. launching targeted policies. The launching of policies is not the start of an opportunity window; only when firms engage in knowledge-sourcing activities can the window take effect. The incentives of policies play a complementary role in promoting innovation. In other words, the opening of the opportunity window does not necessarily lead to the realization of innovation, but depends on firms actively taking advantage of the window.

In the process of sourcing knowledge, identifying and seizing a potential opportunity window is the key to promoting technology innovation. The identification of the window itself is highly competitive; that is, only if latecomers anticipate the existence of an opportunity window earlier than their competition can they capture the value of opportunity. In other words, identifying policy windows depends not only on attributes of the window, but also on subjective judgement of innovation capability (or knowledge absorptive capacity) and selection of knowledge-sourcing modes. In building a deeply integrated national open innovation system, the Government should adapt measures to expand the width of such windows.

(3) Strengthening internal R&D investment to make policy incentives more effective for knowledge sourcing

Both the Government and enterprises should increase their financial investment in R&D to encourage indigenous innovation. R&D investment has a positive effect on promoting technological innovation under strong policy guidelines. In the process of sourcing knowledge from developed countries, R&D investment intensity enables policies to trigger knowledge seeking more effectively. This may bring more opportunities for EMNEs seeking more advanced technology. However, government support for R&D expenses of enterprises can have drawbacks. The possibility of "picking the winners" lowers the technology catch-up effect of incentives and makes enterprises take advantage of loopholes such as rent-seeking behaviour, or cheating subsidies through a large number of low-quality innovations. Therefore, governments should implement dynamic adjustments to the selection criteria for R&D-subsidized firms according to their knowledge-seeking motives, enabling accurately targeted incentives under the policy window, and take relevant measures to fundamentally improve indigenous innovation ability by supporting domestic enterprise development in the digital economy, by improving facilitation of innovative financing approaches (UNCTAD, 2017). In addition, because of current international competition tensions in technology, the effectiveness of government support for international knowledge sourcing is affected by the external market, in the digital innovation ecosystem in particular. Thus, the policy incentives for international knowledge sourcing are weakened, which requires enhancing support for investment in indigenous innovation.

(4) The design of future incentive policies for developing countries

Future policies could follow these three rules: first, for a sustainable window effect, policy tools should co-evolve with the country's science and technology strategies, balanced between international business and innovation. Second, to make sure firms see and seize opportunity windows, governments should combine the use of top-down initiatives and reward incentives. Third, policymakers should consider the heterogeneity between the target audiences of new policies, which can be pertinent for the internationalization of SOEs and private enterprises, respectively.

As a final observation, and recognizing that one of the limitations of this study is that it has not fully incorporated the implications of ongoing tensions in international technology competition, future research on policies supporting technological development in the current innovation ecosystem will have to consider the external influence on knowledge sourcing brought about by changes in laws on foreign investment in technology sectors and in digital competition, particularly in developed countries.

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