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Research article

Does two-way FDI promote technological innovation? — Evidence from China

Jingjing Li [a], Xianming Wu [b,*]

[a] School of Economics and Management, Hubei Polytechnic University, Huangshi, Hubei, China
[b] School of Economics and Management, Wuhan University, Wuhan, Hubei, China

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ABSTRACT

Two-way FDI indicates that China's technological catch-up process has entered a new stage. Mechanisms and conditions through which two-way FDI affects technological innovation require urgent attention. Based on China's provincial panel data, by using 2SLS tests, negative binomial model, and GMM estimation, this study finds that two-way FDI has a significant promoting effect on technological innovation, absorptive capacity has a positive moderating effect on the relationship between two-way FDI and technological innovation, and IPR protection has a negative moderating effect on the relationship between two-way FDI and technological innovation. The heterogeneity test shows that the interaction effect of IFDI, OFDI, and the moderating effect of absorptive capacity increase with the regional economic development and the passage of time. In contrast, the negative moderating effect of IPR protection decreases. This study contributes to the understanding of the two-way FDI at play in the technological innovation of emerging markets. It emphasises the promoting and restricting factors of two-way FDI in this process.

1. Introduction

In 2021, China's outwards foreign direct investment (OFDI) was 178.82 billion dollars, the inwards foreign direct investment (IFDI) was 173.48 billion dollars, while the two-way FDI was balanced. The formation of a two-way FDI pattern indicates that China's opening up to the outside world has entered a new stage, which further demonstrates that Chinese MNEs have begun to engage in more equal cooperation and competition with developed country multinational enterprises (MNEs). As this new chapter begins, there are many important questions for us to ponder and explore. For example, What are the mechanisms and conditions through which two-way FDI affects technological innovation? How can we view the impact of Chinese enterprises' capacity building, especially the improvement of absorptive capacity, on this process? How can we view the strengthening of the intellectual property protection (IPR) system, on this process? Analysing these problems is critical for revealing the innovation leap of emerging market enterprises, expanding FDI theories, and helping governments and enterprises make strategic decisions.

The two-way FDI process also helps Chinese enterprises to establish their innovation ability. The two-way FDI process accelerates the transformation of Chinese enterprises from imitation to innovation. Mainstream FDI theories attribute the determinants of FDI to ownership advantage, location advantage, and internalisation advantage, reflected by the eclectic paradigm or OLI paradigm of Dunning (1977) [1]. FDI is initiated by MNEs in developed countries, which must have an ownership advantage or firm-specific advantage (FSA) to overcome various difficulties in transnational operation, defeat local enterprises in the host country, and make

* Corresponding author.
E-mail addresses: lijingjing@hbpu.edu.cn (J. Li), wuxianming2012whu@163.com (X. Wu).

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OFDI profitable [2]. Buckley and Casson (1976) emphasised a specific type of forwards integration [3]; they illustrated the forwards integration from research and development (R&D) to production, which reflects the internalisation theory that knowledge is the key intermediate product flow within the enterprise. Rugman (1981) believed that FSA is a necessary but insufficient condition for enterprises to conduct OFDI [4]. An MNE aims to establish property rights over its FSA to protect it from diffusion. If national institution such as the IPR system is insufficient to prevent unnecessary proliferation, then the internal market would replace the external market.

The way in which emerging markets rely on two-way FDI to achieve innovation catch-up has changed the trajectory of traditional innovation development, which is a gap that the literature has not fully paid attention to or failed to answer clearly. The literature on overseas investment in emerging markets focuses separately on IFDI or OFDI. For example, Tang et al. (2020) used the OFDI data of 766 Chinese enterprises from 2008 to 2015. They concluded that China's OFDI is divided into exploratory OFDI and exploitative OFDI [5], which significantly positively impact enterprise performance. The impact of exploratory OFDI was found to last longer. Jiang et al. (2021) took Chinese manufacturing enterprises from 2002 to 2007 as samples. They found that the spillover effect of FDI and external R&D positively impacts enterprises' innovation performance [6]. However, firms with lower or higher levels of internal R&D have a stronger impact on external R&D than firms with medium levels of internal R&D. Sultana and Turkina (2020) modelled the global FDI network and concluded that the centrality of a country in the global FDI network is positively correlated with the technological progress of a nation. The absorptive capacity of a country positively moderates this relationship [7]. Contractor et al. (2021) found that emerging markets with more effective entrepreneurial laws, better cross-border international trade procedures and infrastructure attract more FDI [8]. However, the literature on OFDI in emerging markets mostly focus separately on IFDI and OFDI. To our knowledge, very little literature has studied two-way FDI's effect on innovation. Furthermore, many emerging markets, such as China, India, and Brazil, are in a period of economic and social transition, and their economic development is at an inconstant speed. The existing literature lacks the exploration of these countries' time and regional heterogeneity.

At the same time, the literature on two-way FDI mainly focuses on developed countries and lacks research on developing countries [9,10]. According to the investment development path theory of Dunning (1988), two-way FDI has an important relationship with the level of economic development of a country [11]. As developed countries are centers of global innovation, they are most concerned about how to prevent the diffusion of innovation in the process of innovation commercialisation [12], which is quite contrary to developing countries in the process of catching up. Developing countries, especially emerging markets, are most concerned with how to benefit from innovation diffusion to accelerate technological catch-up. Although developed countries are alert to the technological catch-up behavior of developing countries, emerging markets represented by China are still improving their innovation capacity quickly. With the enhancement of the competitiveness of local enterprises, MNEs have to adjust their market and technology strategies, which increases the possibility of technology spillover. Since OFDI has direct access to innovative technologies in developed countries (such as overseas M&A and overseas R&D), this not only accelerates the process of innovation catch-up but also forces IFDI to change the way it interacts with local companies. These ongoing changes are changing the pattern of global innovation and challenging the existing theories. Therefore, studying the phenomenon of two-way FDI in emerging markets is of great practical and theoretical importance.

The contributions of this study are mainly as follows. First, this study adds the link between internationalisation and technological innovation. Building upon previous literature discussing the impact of IFDI or OFDI separately [13–16], this study integrates IFDI and OFDI into a unified analytical framework to investigate the effect of two-way FDI on technological innovation from a complete and dynamic process. Furthermore, this study integrates time-regional heterogeneity with the progress of two-way FDI, which helps us understand how emerging markets leverage two-way FDI to promote technological innovation.

Second, this study enriches the international business (IB) literature on emerging markets. Prior literature mostly emphasises the factors that promote the progress of IFDI or OFDI in emerging markets [15–17]. In analysing the influence of two-way FDI, this study places the promoting and restricting elements within a unified analytical framework. Further, it discusses the moderating effect of absorptive capacity and IPR protection. In contrast to previous literature [18,19], this study finds that, after controlling for endogeneity, absorptive capacity plays a positive moderating role. Still, intellectual property protection hinders the relationship between two-way FDI and innovation. This phenomenon varies with changes in time and region. This finding helps to broaden the understanding of the promoting and restricting factors of two-way FDI on technological innovation.

2. Theoretical background and hypothesis

The determinants of FDI are also the determinants of the success of enterprises in the international market. In emerging markets, MNEs in developed countries face increasing competition from local competitors, making it no longer a matter of course for MNEs to outcompete local ones. For many MNEs in developed countries, emerging markets are the key to their global success and sustainable competitive advantage; however, the macroeconomic environment and relevant institutions in emerging markets are constantly changing. Marketisation reform and institutional transformation have attracted a large amount of FDI and spawned a new type of MNEs: emerging market multinational enterprises. These enterprises enter overseas markets, engage in active or risky ways of acquiring enterprises in developed countries. The MNEs in developed countries face a situation in which they compete simultaneously with emerging market enterprises in both their home and host countries. Faced with these challenges from emerging market companies, MNEs in developed countries also transform themselves, including engaging in reverse innovation, localisation, capacity renewal, learning from and cooperating with local companies. This transformation process is called moving "from foreign investors to strategic insiders" by Luo (2007) [20]. At the same time, emerging market companies are also competing with foreign competitors in two aspects; in the domestic market, they compete with IFDI and imports, while in overseas markets, they compete through OFDI and exports [21]. Although IFDI is usually in a relatively favourable competitive position, while OFDI is still at a relatively low technical level, an increasing number of emerging market multinational enterprises successfully challenging developed country multinational enterprises in both domestic and foreign markets [22].

2.1. IFDI and technological innovation of the host country

The impact of IFDI on technological innovation in host countries has always been controversial [23–25]. Many scholars have researched this issue, but the conclusions are very different, sometimes opposite [26]. An early representative study was conducted by Caves (1974) [27]. Caves (1974) tested the spillover effect of IFDI on local enterprises and found that foreign investment positively impacts the labour productivity (added value per worker) of local enterprises. Caves (1974) attributed this positive impact to allocative efficiency, technical efficiency and technology transfer. Similarly, Blomström and Kokko (1998) believed that local enterprises in host countries can benefit from foreign investment because of the demonstration effect, the flow of highly skilled workers, technology diffusion and the competition effect [28]. The positive impact of IFDI on the productivity improvement of local enterprises is attributed to the advanced technology and management knowledge brought about by IFDI.

Even so, many studies have found that this positive effect rarely occurs and even produces negative effects. The negative spillover or competition effect of IFDI mainly manifests in two aspects. One aspect is the market-stealing or crowding-out effect. In emerging markets, as foreign enterprises have obvious competitive advantages in technology and management, local enterprises are gradually losing domestic market share [29,30]. The second aspect is the labour/skill-stealing effect. Foreign enterprises can attract the most efficient and highly skilled employees by offering higher salaries, which might cause employees to flow from local enterprises to foreign enterprises and lead to a decline in the productivity of local enterprises [31].

These widely inconsistent conclusions show that the impact of IFDI on the technological innovation of the host country is a double-edged sword. IFDI can not only promote the technological innovation of the host country through demonstration effects, employee mobility, technological diffusion and competitive effects but also hinder the innovative ability of local enterprises through the market steal or extrusion effect, labour or skill steal effect. There is no doubt that positive and negative effects exist, but the intensity of the impact varies. Unlike the weak position of local enterprises in the early stage of introducing foreign investment, in the stage of two-way FDI, local enterprises grow into competitors that MNEs cannot ignore in developed countries. In some industries, local enterprises even surpass foreign competitors in domestic market share; this means that the market stealing or crowding-out effect of IFDI is reduced. At the same time, an increasing number of local companies can offer higher salaries and benefits to their employees, and foreign companies are losing their advantage in compensation and benefits; this means that the labour or skill stealing effects of IFDI are also reduced. With the increasingly fierce competition between local and foreign enterprises, foreign enterprises have to apply the most innovative technology within the host country, which accelerates the diffusion of technology and promotes the innovation of the host country. Therefore, we hypothesise as follows:

Hypothesis 1. In the two-way FDI stage, IFDI positively promotes the technological innovation of the host country.

2.2. OFDI and technological innovation in the home country

According to the existing studies, no consistent conclusion has been reached regarding the impact of OFDI on technological innovation in the home country; some studies have shown that OFDI improves the competitiveness of MNEs in emerging markets in both home and international markets [32,33], and has a positive impact on innovation in the home country [34]. Potterie and Lichtenberg (2001) studied the United States, Japan, and 11 European countries and found that imports and OFDI contribute to productivity growth in these countries [35]. Driffield et al. (2009) divided the host countries of OFDI of British enterprises into high-R&D countries and low-R&D countries. They found that both types of OFDI positively impact the UK's productivity growth [36]. However, Braconier et al. (2001) found neither an R&D spillover associated with OFDI nor a positive impact of OFDI on productivity in Sweden [37]. Bitzer and Görg (2009) found that the relationship between OFDI and the productivity of the home country varies among different countries; however, on average, the stock of OFDI in a country has a negative impact on the productivity of that country [38].

Such inconsistent findings remind us that the impact of OFDI on technological innovation in home countries needs to be addressed discreetly. As stated in the eclectic paradigm, these MNEs mainly take advantage of their existing advantages to maximise their profits in overseas markets [39]. These MNEs prevent the diffusion of innovation by internalisation; reverse innovation does not seem to be the main goal they pursue [3], which is distinctly different from MNEs in emerging markets. MNEs in emerging markets come from developing regions where innovation resources are relatively scarce. An important goal of OFDI in MNEs in emerging markets is to narrow this gap as soon as possible. As a result, these MNEs take a more adventurous and exploration-oriented approach to OFDI and make direct investments in developed countries at an early stage, including overseas M&As [40–42]. Since global technological resources are mainly concentrated in developed countries, proactive direct investment in developed countries contributes to geographical proximity to centers of technological innovation, thereby increasing the possibility of access to advanced technologies. Developed countries with rich knowledge assets also provide potential target enterprises for MNEs in emerging markets to acquire. As a tool to transfer, move, and reallocate innovative resources between the host country and the home country, OFDI can effectively coordinate the use of these innovative resources, give full play to the complementarity of resources, and accelerate the process of innovation catch-up. OFDI helps emerging market enterprises to better embed themselves in the national innovation system of the host country and improve their perception of technological change and ability to respond to the international market through direct contact with local suppliers and customers. Due to a technology gap, MNEs in emerging markets could conduct OFDI in technology-intensive countries in a targeted way and obtain innovative technology and human capital to improve their innovation ability through overseas

M&As and the establishment of overseas R&D institutions. In addition, this kind of OFDI can also promote innovation in the home country through the demonstration, competition, personnel flow, and industrial association effects. Thus, we hypothesise as follows:

Hypothesis 2. OFDI from emerging markets promotes technological innovation in the home country.

2.3. The interactive effects of two-way FDI

In addition to the influences of IFDI and OFDI on technological innovation mentioned above, IFDI and OFDI can also influence technological innovation through interaction effects. In the early stage of IFDI, the host country's domestic enterprises are relatively weak and must integrate into the global industrial chain division dominated by MNEs in developed countries. These enterprises are engaged in production activities with low added value at the low end of the global value chain, after a long period of "learning by doing", a large number of local enterprises can gradually gain a foothold in the middle- and low-end markets and begin to expand to value activities with high added value. To expand the market and acquire resources and technology, many local enterprises become MNEs in emerging markets and start to engage in OFDI [43]. In the new stage of two-way FDI, the competition between MNEs in developed countries and those in emerging markets becomes increasingly fierce. Some MNEs in emerging markets defeat their rivals in the domestic market and establish their own competitive position in the global market [44]. The formation of this new competition pattern forces participants to focus more on innovation, and technical ability becomes the key to the decisive victory.

With the rise of local competitors and changes in institutional and macroeconomic structures in emerging markets, MNEs in developed countries must also begin the transformation process. As early advantages based on technology, brands and management skills are eroded by competition, MNEs in developed countries have to accelerate their pace of innovation to stay ahead of the catch-up players. While some developed MNEs have to withdraw from the host country market due to the shrinking market share and loss of profitability, the remaining enterprises must rely more on the strength of their core technologies. At the same time, new FDI may enter emerging markets based on latest technological advantages. An important change is that MNEs in developed countries face increasing competitive pressure in emerging markets, and they pay more attention to cooperation with local competitors, localisation and reverse innovation [45,46]. Although there is still a gap between MNEs in emerging markets and MNEs in developed countries in terms of innovation capacity, such enterprises have made breakthroughs in some industries, strengthening their determination to catch up. With the accumulation of experience, these enterprises become more adept and confident in utilising both international and domestic resources; thus, the quantity and quality of their innovation grow rapidly. Due to the dynamic changes in competition, the advantages and disadvantages of MNEs in developed countries and emerging markets rise and fall, further stimulating the innovation efforts of both sides and expanding the opportunities for cooperation. The vast opportunities emerging markets present include bringing together the forces of IFDI and OFDI, promoting the flow of resources and knowledge through competition and collaboration and thus stimulating innovation. Therefore, we hypothesise as follows:

Hypothesis 3. The interaction between IFDI and OFDI significantly promotes technological innovation in emerging markets.

2.4. The moderating effect of absorptive capacity

Although two-way FDI positively affects technological innovation in emerging markets, absorptive capacity may affect this effect. Absorptive capacity refers to the ability to identify the value of new external knowledge, digest it and apply it to business activities [47]. Zahra and George (2002) distinguished absorptive capacity into potential (acquisition and digestion) absorptive capacity and realised (transformation and utilisation) absorptive capacity [48]. The existing knowledge stock of an enterprise affects its absorption and utilisation of new knowledge [49]. The R&D input of a firm is usually regarded as the proxy variable of absorptive capacity, which affects the technological progress of a firm in two ways. First, the R&D output generated from the R&D input can directly promote the technological progress of the firm; second, R&D investment strengthens the ability of enterprises to imitate, learn and absorb external technology and helps to obtain more external technology spillovers. Studies have found that the technology spillover effect of IFDI is significantly related to the absorptive capacity of local enterprises [50]. Some local companies rely too much on technology transfer from their partners and thus ignore R&D investment, resulting in a serious lack of independent innovation capacity. The joint venture dilemma of Chinese auto companies is a case in point. In contrast, some local enterprises, such as Huawei, Sany Heavy Industry and Geely, always insist on independent R&D in cooperation and competition with MNEs; thus, these enterprises forge new paths.

In terms of OFDI, although the outwards investment of latecomer enterprises has a positive effect on technological progress, the complexity of acquiring overseas technology should not be underestimated. At the same time, absorptive capacity is also affected by the level of infrastructure, trade openness, financial development, factor endowment, human resources, and other factors in a country [51]. The acquisition of external knowledge resources can only play its role if the external knowledge is integrated into the existing knowledge pool of the enterprise. However, due to the inherent differences between organisations, it is often very difficult to integrate this incomplete and fuzzy knowledge, and enterprises must rely on strong absorbent capacity to achieve the expected goals [52]. Thus, we hypothesise as follows:

Hypothesis 4a. Absorption capacity positively moderates the relationship between IFDI and technological innovation in the host country.

Hypothesis 4b. Absorption capacity positively moderates the relationship between OFDI and technological innovation in the home country.

2.5. The moderating effect of IPR protection

The quality of IPR protection strongly affects a country's innovation activities [53,54] and provides basic incentives for inventors to create and recover R&D costs [55]. Although all countries attach great importance to the protection of IPR, the actual quality of IPR protection varies widely among countries. Developed countries tend to have a higher quality IPR protection and have few doubts about their governments' commitment to protecting IPR. However, due to the lack of resources needed to implement strict IPR protection in developing countries, there are still differences in whether strict IPR protection benefits the economic development and social interests of developing countries; therefore, tacit infringement and piracy are common [56]. In the early stage of IFDI for emerging markets, local enterprises mainly learn from MNEs in developed countries through imitation and reverse engineering. If the host country protects IPR too tightly, it increases the cost of acquiring knowledge for local enterprises. In the two-way FDI stage, local enterprises accumulate certain abilities, transform from imitation to innovation, and make breakthroughs in some industries [26]. At this stage, emerging markets are present in the host countries of IFDI and the home countries of OFDI. On the one hand, it is necessary to strengthen IPR protection to attract high-quality IFDI; on the other hand, it is essential to attach importance to the construction of independent innovation capacity and vigorously support the development and growth of local enterprises, including the development of OFDI. Therefore, in this stage, the IPR protection system of emerging markets is gradually strengthened, the legal system is constantly improved, and the implementation process is increasingly transparent. For example, China has revised and improved its laws and regulations on IPR protection many times and set up special IPR courts. On March 15, 2019, the Second Session of the 13th National People's Congress passed the "Foreign Investment Law of the People's Republic of China" to further open up, actively promote foreign investment and protect the legitimate rights and interests of foreign investors. It is noteworthy that the construction of IPR protection systems in emerging markets is faced with certain complexity, which mainly comes from the competition between IFDI and OFDI in core technologies. On the one hand, MNEs in developed countries require host countries to strengthen the protection of IPR to prevent their key technologies from being infringed upon by competitors. On the other hand, local enterprises or MNEs in emerging markets are still in the early stage of innovation catch-up and need certain support and protection. This poses a challenge to the ability of emerging markets to protect IPR. Nevertheless, in the two-way FDI stage, the increasingly strengthened IPR protection measures in emerging markets still play a positive role in promoting the improvement of innovation ability. Therefore, we hypothesise as follows:

Hypothesis 5a. IPR protection positively moderates the relationship between IFDI and technological innovation in the host country.

Hypothesis 5b. IPR protection positively moderates the relationship between OFDI and technological innovation in the home country.

3. Methods

3.1. Model specification

The model used in this article is as follows:

$$INNOVA_{it} = \beta_0 + \beta_1 IFDI_{it} + \beta_2 OFDI_{it} + \beta_3 IFDI_{it} * OFDI_{it} + \beta_4 R\&D_{it} + \beta_5 IPR_{it} + \beta_6 \mathrm{Rand}D_{it} * IFDI_{it} + \beta_7 R\&D_{it} * OFDI_{it} + \beta_8 IPR_{it} * IFDI_{it} + \beta_9 IPR_{it} * OFDI_{it} + \sum_n \delta_n C_{it}^n + \lambda_i + \mu_t + \xi_{it} \tag{1}$$

Among these variables, $IFDI_{it}$, $OFDI_{it}$, $R\&D_{it}$, and IPR_{it} represent inwards foreign direct investment, outwards foreign direct investment, absorptive capacity and intellectual property protection of Chinese provinces. $\sum_n \delta_n C_{it}^n$ represents the control variables, including investment rate, degree of trade openness, degree of financial development, household savings, degree of marketisation, and human resources. i represents the province of China; t represents the year; β_0 represents the constant; λ_i and μ_t represent the individual effect and time effect, respectively; and ξ_{it} represents the error term.

3.2. Data description

We used China's provincial panel data from 2003 to 2017 to test our hypotheses. Since this period marked a critical phase in the rapid development of China's two-way FDI and a crucial period during which the Chinese government actively promoted technological innovation, we selected this timeframe for our study. The explained variable is technological innovation ($INNOVA_{\mathrm{it}}$). We used the number of patents granted in each province in that year. We used the IFDI (RMB constant in year 2000) in each province to measure the explanatory variable IFDI and took the natural logarithm. Similarly, we used the nonfinancial outwards direct investment (RMB constant in year 2000) in each province to measure the explanatory variable OFDI and took the natural logarithm.

The first moderating variable is absorptive capacity (*R&D*). We measured the absorptive capability by the percentage of the internal expenditure of the R&D funds in the province's GDP. The second moderating variable is intellectual property rights protection (IPR). We measured IPR by the legislative intensity of intellectual property rights in each province multiplied by its enforcement intensity. Considering that the Ginarte-Park index is only a measurement of the intensity of intellectual property legislation of a country, ignoring the influence of the intensity of law enforcement, this research used the intensity of IPR protection legislation multiplied by the intensity of law enforcement to measure the degree of IPR protection by referring to the research of Kondo (1995) [57]. We measured the intensity of intellectual property legislation in each province by the Ginarte-Park method. Law enforcement intensity included administrative protection level, judicial protection level, social public awareness level, economic development level and international supervision, with equal weights; that is, law enforcement intensity was found to be equal to the arithmetic mean of the scores of the five indicators. The specific measures were as follows: (1) We used legislative time to measure the completeness of the legal system, that is, the level of administrative protection. When the legislative time reached or exceeded 100 years, we scored legislative time as “1”; when the legislative time was less than 100 years, we scored the legislative as the actual legislative time divided by 100. (2) We took the proportion of lawyers as the index to measure the level of judicial protection, and we scored the proportion of lawyers as “1″ when the proportion of lawyers in the total population reached or exceeded 0.0005. When the percentage of lawyers in the population was less than 0.0005, we marked the percentage of lawyers score equal to the actual percentage divided by 0.0005. (3) We used the adult literacy rate to measure public awareness of intellectual property, and we scored the adult literacy rate as “1″ when the adult literacy rate was at or above 95 %. When the adult literacy rate was less than 95 %, we calculated the adult literacy rate by using the actual percentage divided by 95 %. (4) We used per capita GDP as an indicator to measure a country’s economic development level. When GDP per capita was $2000 or more, the GDP per capita was scored as “1”; when GDP per capita was less than $2000, the score for GDP per capita was equal to the actual GDP per capita (US dollars) divided by 2000. (5) We used WTO membership to measure the supervision and balance of the international community. From 1986 to 2005, the “WTO membership” index changed from 0 to 1 in the fifth year of WTO accession. We obtained the “proportion of lawyers”, “adult literacy rate” and “per capita GDP” from the data published on the website of the National Bureau of Statistics and the relevant data in the “China Statistical Yearbook”, “China Lawyers Yearbook” and “China Judicial Administration Yearbook".

We chose the investment rate as our control variable because a high investment rate signifies high production capacity and rapid economic development [58], promoting two-way FDI and innovation. We measured the controlled variable investment rate (*CAPI*) by the proportion of fixed asset investment in the whole society and the GDP of the province; since the trade openness (*IMEX*) serves as the foundation for attracting two-way FDI [59], we chose this variable as our second control variable and calculated this variable by the proportion of the total imports and exports of each province to its GDP. Financial support (*FINA*) plays a critical role in industry innovation [60], so we chose this variable as the third control variable and used the proportion of loans to the nonstate sector to measure financial development, assuming that if the loan allocation of state-owned enterprises (*SOE*) in each province is proportional to the fixed asset investment, then the degree of financial development = total loan/GDP × (1- fixed asset investment in state-owned economy/fixed asset investment in the whole society). We chose resident savings (*SAVE*) as our control variable because high resident savings signifies a region with a stable capital supply, playing a crucial role in two-way FDI. We measured this variable by the proportion of each province’s urban and rural residents’ savings deposits and the province’s GDP. We chose the degree of marketisation (*market*) as our control variable because marketisation facilitates the efficient allocation of resources and the transfer of technology [17], thus promoting innovation. we measured this variable using the proportion of nonstate-owned fixed asset investment in high-tech industries in the total fixed asset investment of the whole society. Human resources (*HR*) play a vital role in transferring knowledge and attracting FDI [61,62]; thus, we chose this variable as our control variable. We measured this variable according to each province’s average wage of urban and rural residents. The data sources are shown in Table 1.

Table 1
Variable descriptions and data sources.

Variables	N	Mean	Std	Min	MaX	Data source
INNOVA(take the logarithm)	450	8.9953	1.6556	4.2485	12.7149	National Bureau of Statistics
IFDI(take the logarithm)	450	14.2598	1.7259	9.2532	17.0331	iFinD
OFDI(take the logarithm)	450	11.7558	2.5194	3.9054	16.8033	Annual Statistics Bulletin of China’s OFDI
R&D	450	12.0652	9.1491	1.6770	59.8480	China Science and Technology Statistics
IPR	450	3.0796	0.3553	2.0605	4.1267	China Statistical Yearbook, China Lawyers Yearbook, China Judicial Administration Yearbook
CAPI	450	65.2097	23.8988	23.6562	147.9543	National Bureau of Statistics
IMEX	450	32.0155	39.1418	1.6953	172.2281	National Bureau of Statistics
FINA(take the logarithm)	450	77.5628	31.3885	7.4500	284.6600	China Financial Yearbook, China Statistical Yearbook, National Bureau of Statistics
SAVE	450	72.5544	16.7713	37.7656	192.6260	National Bureau of Statistics
market	450	44.8592	16.7792	15.5800	83.6200	Statistical Yearbook of High-tech Industries
HR	450	39.2776	21.8841	10.3970	134.9940	National Bureau of Statistics
ADFA(take the logarithm)	450	5.7569	1.7181	0.3365	9.4638	China Industrial Enterprise Database
TLFI(take the logarithm)	450	2.4532	1.7087	−3.9120	5.9804	China Foreign Economic Database
NFPL	450	70.9795	82.1097	0.0200	412.6800	China Industrial Enterprise Database

4. Main results

4.1. Correlation coefficient matrix

Table 2 shows the correlation coefficient matrix; it can be seen that the correlation coefficients between the explanatory variables, moderating variables, and control variables are below 0.85. Further examination of each regression model's variance inflation factor (VIF) shows that the VIF of all the variables in each model is far less than 5, indicating no serious multicollinearity problem among the variables. To eliminate the multicollinearity problem between the original variable and the interaction term formed by direct multiplication, this study adopted the method of mean centralisation, and the new variable is used for regression analysis.

4.2. 2SLS results

The relationship between IFDI and OFDI and technological innovation may be endogenous. There may be missing variable bias, this study selected three variables, namely, accumulated depreciation of fixed assets of foreign-invested industrial enterprises (ADFA), total loss of foreign investors (TLFI), and number of foreign project labour at year-end (NFPL), as instrumental variables of IFDI and OFDI; the study took the logarithm of the dependent variable and conducted 2SLS estimation, Variable descriptions and data sources are shown in Table 1.

As shown in Table 3, the minimum F value of each model is much greater than 10; thus, the null hypothesis of a weak instrumental variable can be rejected (as shown in the second line from the bottom of Table 4). When there are more instrumental variables than endogenous explanatory variables, we can adopt the overidentification test [63]. We used the Sargan test to determine whether the instrumental variables are exogenous, the P value of the Sargan test in every model is greater than 0.1, which means that the hypothesis of exogeneity of instrumental variables is supposed. Model 1, Model 2, and Model 3 are tests of IFDI and OFDI; in Model 3, when adding OFDI, the elasticity coefficients of IFDI and OFDI on innovation are 0.8945 and 0.355, respectively, remaining statistically significant at the 5 % level. This suggests that a 1 % increase in IFDI is associated with an approximate 0.89 % increase in technological innovation, while a 1 % increase in OFDI is associated with approximately a 0.36 % increase. Relative to OFDI, IFDI has a more substantial facilitating effect on innovation. This may be attributed to the fact that in China, the development of IFDI precedes that of OFDI, benefiting from more mature promotion policies and technology spillover channels. Hypothesis 1 and Hypothesis 2 are supported. Model 4 is a test of the interaction between IFDI and OFDI. From Model 4, we observed that, despite the lower elasticity coefficient of the interaction term compared to the individual effects of OFDI and IFDI, the impact on technological innovation is significant at the 1 % level. The coefficient indicates that when two-way FDI increases by 1 %, innovation grows by approximately 0.07 %. This could be attributed to the different developmental trajectories of IFDI and OFDI within the bilateral context, with the combined innovation impact temporarily weaker than that of IFDI and OFDI. However, over time, this situation may change. Importantly, Hypothesis 3 is supported. Model 5 and Model 6 test the moderating effect of absorptive capacity, and the results show that absorptive capacity has a significant positive moderating effect at the 1 % level. The elasticity coefficients are 0.0312 and 0.0186, indicating that when the interaction term between absorptive capacity and IFDI, as well as the interaction term between absorptive capacity and OFDI, increase by 1 %, it results in an approximate growth of 0.03 % and 0.02 % in technological innovation, respectively. Therefore, Hypotheses 4a and 4b are empirically supported. Model 7 and Model 8 test the moderating effect of IPR protection. The result shows that IPR protection has a significant negative moderating effect on the relationship between IFDI and technological innovation ($\beta = -0.0873$, $p < 0.05$) and a negative but not significant moderating effect on the relationship between OFDI and technological innovation ($\beta = -0.044$, $p > 0.1$); therefore, neither Hypothesis 5a nor Hypothesis 5b has been empirically supported. This negative significance highlights emerging markets' difficulties and challenges in IPR protection. On the one hand, how can IPR protection capacity be adapted to the needs of the transition from imitation to innovation? On the other hand, in the face of IFDI and OFDI, how can the relationship between protecting the IPR of MNEs in developed countries and supporting the establishment of the independent innovation capacity of local enterprises be balanced?

4.3. Heterogeneity test

4.3.1. Time heterogeneity test

This study divides the years into two phases: 2003–2010 and 2011–2017 because from 2011 to 2017, there were significant changes in the growth status and industry structure of both IFDI and OFDI in China. Regarding the growth status, China's OFDI increased from $317.212 billion in 2010 to $424.78 billion in 2011, marking the highest growth rate since 2003, and has consistently shown significant growth between 2011 and 2017. In terms of industry structure, the proportion of IFDI utilised in the service sector rose from less than 1/3 in 2003 to nearly 1/2 in 2011, representing a significant leap; therefore, considering the changes in two-way FDI between different periods, this study reexamines the relationship between two-way FDI and innovation in different yearly phases.

The results are shown in Table 4. Table 4 shows that the F value of each model in the first stage is greater than 10, which rejects the assumption that the instrumental variable is weak. At the same time, the Sargan value is more significant than 0.1, again proving the exogenity of the instrumental variable. The test of the two periods shows the following findings: first, the interaction effect of IFDI and OFDI on technological innovation shows a progressive trend over time. In the year 2003–2010, the result is slightly significant ($\beta = 0.0518$, $p < 0.1$), in the year 2011–2017, the impact is more significant ($\beta = 0.0718$, $P < 0.05$). This reflects that "bringing in" and "going out" are producing synergistic effect and promoting the improvement of technological innovation. Secondly, no matter "bringing in" or "going out", the moderating effect of absorptive capacity shows a significant difference over time, from not significant

Table 2
Correlation coefficient matrix.

	INNOVA	IFDI	OFDI	R&D	IPR	CAPI	IMEX	FINA	SAVE	market	HR	VIF
INNOVA	1.0000											
IFDI	0.7690***	1.0000										1
OFDI	0.7111***	0.6737***	1.0000									1.20
R&D	0.4894***	0.4557***	0.3435***	1.0000								1.33
IPR	0.5328***	0.5801***	0.8016***	0.4716***	1.0000							1.51
CAPI	−0.0399	−0.1364***	0.2433***	−0.2976***	0.2186***	1.0000						1.68
IMEX	0.4349***	0.4517***	0.3103***	0.6730***	0.4913***	0.5151***	1.0000					2.32
FINA	0.3014***	0.2604***	0.4750***	0.4709***	0.6626***	0.0576	0.4934***	1.0000				2.39
SAVE	−0.0100	−0.1122**	0.0884*	0.2516***	0.2418***	0.0219	0.2054***	0.4457***	1.0000			2.33
market	0.7063***	0.7116***	0.7426***	0.4953***	0.7242***	−0.0025	0.5379***	0.6205***	0.0541	1.0000		2.67
HR	0.4151***	0.3977***	0.7375***	0.2882***	0.8419***	0.3447***	0.2583***	0.7018***	0.2928***	0.6745***	1.0000	3.36

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 3
2SLS regression results in the second stage.

	INNOVA							
	Model1	Model2	Model3	Model4	Model5	Model6	Model7	Model8
IFDI	1.8979***		0.8945**	0.6541**	1.1335***	0.7093**	0.6501***	1.2197***
	(0.5731)		(0.3848)	(0.3180)	(0.3653)	(0.3054)	(0.1481)	(0.3663)
OFDI		0.6199***	0.3550**	0.4269***	0.2988**	0.4748***	0.1459	0.5346***
		(0.1048)	(0.1529)	(0.1393)	(0.1435)	(0.1474)	(0.1763)	(0.1925)
IFDI × OFDI				0.0674***				
				(0.0192)				
R&D					0.0234	0.0230		
					(0.0199)	(0.0188)		
IFDI × R&D					0.0312***			
					(0.0099)			
OFDI × R&D						0.0186***		
						(0.0055)		
IPR							−0.7934***	−1.3576***
							(0.1663)	(0.2201)
IFDI × IPR							−0.0873**	
							(0.0415)	
OFDI × IPR								−0.044
								(0.0505)
CAPI	−0.0008	0.0033	−0.0029	0.0061	−0.0012	0.0044	0.0089**	0.0035
	(0.0145)	(0.0056)	(0.0065)	(0.0055)	(0.0063)	(0.0058)	(0.0040)	(0.0050)
IMEX	−0.0123	−0.0062	−0.0091	−0.0007	−0.007	−0.0037	0.0095***	−0.0039
	(0.0085)	(0.0057)	(0.0055)	(0.0059)	(0.0052)	(0.0058)	(0.0022)	(0.0053)
FINA	0.0139*	−0.0005	0.0043	0.0029	0.0058	0.0039	−0.0004	0.0046
	(0.0078)	(0.0027)	(0.0038)	(0.0033)	(0.0037)	(0.0035)	(0.0026)	(0.0035)
SAVE	0.0052	0.0049	0.0060	0.0048	0.0054	0.0075	0.0067**	0.0125*
	(0.0140)	(0.0081)	(0.0094)	(0.0080)	(0.0095)	(0.0096)	(0.0032)	(0.0074)
market	0.0192*	0.0105	0.0143	0.0017	0.0078	0.0087	0.0168***	0.0054
	(0.0116)	(0.0100)	(0.0097)	(0.0110)	(0.0096)	(0.0095)	(0.0063)	(0.0126)
HR	−0.0459***	−0.0391***	−0.0423***	−0.0388***	−0.0427***	−0.0484***	0.0104	−0.0222*
	(0.0168)	(0.0103)	(0.0105)	(0.0099)	(0.0105)	(0.0114)	(0.0083)	(0.0130)
constant	8.9976***	11.4579***	10.6382***	10.1203***	10.3649***	10.5015***	6.6094***	10.0890***
	(1.8062)	(1.2095)	(1.2168)	(1.1727)	(1.2736)	(1.2898)	(0.5616)	(1.0526)
N	450	450	450	450	450	450	450	450
adj.R-sq	0.5409	0.7028	0.7224	0.7428	0.7279	0.7242	0.6722	0.6630
minimum eigenvalue	128.94	80.23	80.76	16.37	79.77	15.79	69.13	59.66
sargan	0.2362	0.1311	0.6091	0.1177	0.3664	0.7001	0.8003	0.7466

Standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

($p > 0.1$) in the year 2003–2010 to highly significant ($p < 0.01$) in the year 2011–2017, this indicates that the absorptive capacity of Chinese enterprises is constantly enhanced, which significantly enhances the promotion effect of two-way FDI on technological innovation. Thirdly, the moderating effect of IPR protection also changed dramatically in two periods, from highly negative significant ($p < 0.01$) in the year 2003–2010 to negative but not significant ($p > 0.1$) in the year 2011–2017. This shows that China's IPR protection system is constantly improving and no longer has a significant negative impact on the relationship between IFDI, OFDI, and technological innovation.

4.3.2. Regional heterogeneity test

Due to the significant differences between China's eastern and central-western regions regarding economic development, opening, and technological innovation ability, this study divides the area into the eastern and central-western regions in the regional heterogeneity test. As shown in Table 5, the F value of the first stage of 2SLS is greater than 10 in each model. In the first regression stage, instrumental variables are significantly correlated with explanatory variables ($p < 0.05$), so the hypothesis of weak instrumental variables is rejected. Sargan test does not deny the hypothesis of exogenity of instrumental variables at the level of $p > 0.1$.

The regional test has the following findings: First, although the promotion effect of IFDI and OFDI on technological innovation in the eastern region and the central-western region is significant, the interaction effect of IFDI and OFDI on technological innovation is significantly different between east and central-western region. The interaction effect of IFDI and OFDI in the eastern region is highly significant ($\beta = 0.1038$, $p < 0.01$), while in the central-western region is not significant, and the direction is negative ($\beta = -0.0264$, $p > 0.1$). This shows that two-way FDI has entered a benign interaction stage in the eastern region, and the interaction between the two sides can produce joint forces to promote technological innovation. However, in the central-western region, the resultant force has not yet formed, and the incoordination between the two sides still exists. Secondly, there is a significant difference between the eastern and central-western regions in the moderating effect of absorptive capacity. The absorptive capacity in the east region has a positive and significant impact ($\beta = 0.0188$, $p < 0.05$ and $\beta = 0.0087$, $p < 0.01$), while in the central-western region has an insignificant and negative effect. This indicates that due to long-term R&D investment, the eastern region has formed a strong absorption capacity,

Table 4
Time heterogeneity of 2SLS Test (to be continued).

	INNOVA (year 2003–2010)							
	Model1	Model2	Model3	Model4	Model5	Model6	Model7	Model8
IFDI	0.8082*** (0.1341)		0.7340*** (0.1429)	0.0540 (0.3051)	0.0413 (0.2995)	0.0539 (0.2928)	−0.1894 (0.2814)	−0.0483 (0.2837)
OFDI		0.9196*** (0.1555)	0.1194*** (0.0420)	0.7099** (0.2992)	0.5922** (0.2997)	0.6197** (0.2957)	1.0780*** (0.2864)	0.7581** (0.2940)
IFDI × OFDI				0.0518* (0.0292)				
R&D					0.0378*** (0.0116)	0.0373*** (0.0113)		
IFDI × R&D					0.0002 (0.0066)			
OFDI × R&D						0.0019 (0.0030)		
IPR							−1.1090*** (0.1541)	−0.9964*** (0.1624)
IFDI × IPR							−0.1964*** (0.0378)	
OFDI × IPR								−0.0883*** (0.0258)
constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
adj.R-sq	0.4392	0.4558	0.4556	0.4822	0.5050	0.5043	0.5402	0.5226
minimum eigenvalue	59.92	107.14	58.92	110.70	87.74	92.29	85.72	118.91
Instrumental variable correlation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
sargan	0.5161	0.1889	0.9499	0.4115	0.1713	0.4223	0.3110	0.7248
	INNOVA (year 2011–2017)							
	Model9	Model10	Model11	Model12	Model13	Model14	Model15	Model16
IFDI	0.7255*** (0.1410)		0.5889*** (0.1436)	0.4462 (0.2848)	0.7980*** (0.2912)	0.6969** (0.2836)	0.5684** (0.2691)	0.6129** (0.2755)
OFDI		0.6610*** (0.1722)	0.2235*** (0.0690)	0.0643 (0.3209)	−0.3289 (0.3204)	−0.2525 (0.3153)	0.2432 (0.3031)	−0.0576 (0.3072)
IFDI × OFDI				0.0718** (0.0350)				
R&D					0.0352*** (0.0087)	0.0375*** (0.0087)		
IFDI × R&D					0.0306*** (0.0071)			
OFDI × R&D						0.0183*** (0.0038)		
IPR							−0.0239 (0.0158)	−0.0060 (0.0168)
IFDIXIPR							−0.0632 (0.0688)	
OFDI × IPR								−0.0257 (0.0487)
constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
adj.R-sq	0.4392	0.4558	0.4556	0.4822	0.5050	0.5043	0.5402	0.5226
minimum eigenvalue	59.92	107.14	58.92	110.70	87.74	92.29	85.72	118.91
Instrumental variable correlation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
sargan	0.5161	0.1889	0.9499	0.4115	0.1713	0.4223	0.3110	0.7248

Standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

which can effectively absorb the technology spillover of IFDI and reverse the knowledge transfer of OFDI. However, the central-western region is still relatively weak in R&D investment. It has inadequate absorption capacity, and the absorption effect of IFDI technology spillover and OFDI reverse knowledge transfer is not ideal. Thirdly, regarding the moderating effect of IPR protection, the eastern and central-western regions have the same aspects and are in different places. The moderating effect of IPR protection on the relationship between IFDI and technological innovation is consistent with that of the central and western regions, both highly negatively significant ($\beta = -0.2295$, $p < 0.01$; $\beta = -0.1610$, $p < 0.01$). The moderating effect of IPR protection on the relationship

Table 5
2SLS regional heterogeneity test (to be continued).

	INNOVA							
	model1	model2	model3	model4	model5	model6	model7	model8
	Eastern region							
IFDI	0.9314*** (0.1793)		0.8170*** (0.2484)	0.582 (0.4281)	0.8014* (0.4151)	0.9838** (0.4144)	0.7660* (0.3984)	1.4801*** (0.4151)
OFDI		0.9946*** (0.1626)	0.1187* (0.0651)	0.5181 (0.3383)	0.4239 (0.3381)	0.3788 (0.3343)	0.7713** (0.3250)	0.1751 (0.3233)
IFDI × OFDI				0.1038*** (0.0400)				
R&D					0.0176** (0.0089)	0.0168* (0.0088)		
IFDI × R&D					0.0188** (0.0092)			
OFDI × R&D						0.0087*** (0.0033)		
IPR							−0.0477*** (0.0163)	−0.0236 (0.0169)
IFDI × IPR							−0.2295*** (0.0879)	
OFDI × IPR								−0.0032 (0.0362)
constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
adj.R-sq	0.6060	0.5686	0.4523	0.4428	0.4384	0.4406	0.4835	0.4935
minimum eigenvalue	122	93.44	81.82	109.38	82.83	86.68	79.76	91.76
Instrumental variable correlation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
sargan	0.2362	0.1311	0.3754	0.2196	0.1702	0.4080	0.7516	0.3147
	INNOVA							
	model9	model10	model11	model12	model13	model14	model15	model16
	Central-western region							
IFDI	0.7544*** (0.1362)		0.6217*** (0.1456)	0.1497 (0.3192)	0.2302 (0.3262)	0.3092 (0.3119)	0.2118 (0.2974)	0.3060 (0.2941)
OFDI		0.9916*** (0.1595)	0.1488*** (0.0465)	0.6658** (0.3168)	0.6169* (0.3226)	0.5852* (0.3170)	0.9328*** (0.3098)	0.5713* (0.3088)
IFDI × OFDI				−0.0264 (0.0314)				
R&D					0.0142 (0.0136)	0.0094 (0.0111)		
IFDI × R&D					−0.0119 (0.0093)			
OFDI × R&D						−0.0017 (0.0041)		
IPR							−0.7962*** (0.1551)	−0.9861*** (0.1605)
IFDI × IPR							−0.1610*** (0.0331)	
OFDI × IPR								−0.1544*** (0.0250)
constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
adj.R-sq	0.6060	0.5686	0.4523	0.4428	0.4384	0.4406	0.4835	0.4935
minimum eigenvalue	122	93.44	81.82	109.38	82.83	86.68	79.76	91.76
Instrumental variable correlation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
sargan	0.2362	0.1311	0.3754	0.2196	0.1702	0.4080	0.7516	0.3147

Standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

between OFDI and technological innovation is not substantial in eastern China, and the direction is negative ($\beta = -0.0032, p > 0.1$). At the same time, it is significantly negative in central-western China ($\beta = -0.1544, p < 0.01$). This shows that the IPR protection system significantly negatively impacts the relationship between IFDI and technological innovation in both the eastern and central regions. In contrast, for OFDI, only the central-western region has a significant negative impact on the relationship between OFDI and technological innovation, and the eastern region has no apparent negative impact.

4.4. Robustness tests

4.4.1. Negative binomial model

In this study, we introduced the dependent variable as a counting model and used the bidirectional fixed effect model of panel data. Poisson regression or negative binomial regression was proposed to verify the hypothesis. However, Poisson regression must meet a strong hypothesis of equal dispersion with equal expectation and variance. This article rejects the null hypothesis of "there is no excessive dispersion" through the LR test; therefore, we selected the negative binomial model for robust test. As shown in Table 6, the test results are consistent with Table 3. Hypothesis 1, 2, 3, 4a, 4b are further confirmed.

4.4.2. GMM estimation

Since GMM estimation can also address endogeneity, we employed GMM estimation as a robustness check for 2SLS. The results are shown in Table 7. The F value of every model reaches more than 10, rejecting the hypothesis of weak instrumental variables. At the same time, the Sargan-Hansen test passes the test at a level of 10 %, proving the exogeneity of instrumental variables. This article also carries out the first-stage correlation test on the instrumental variables, and the significance passes at 5 %. The significance of other major variables remains unchanged except that the interaction effect of IFDI and IPR protection is significantly different between GMM and 2SLS. The interaction between IFDI and intellectual property protection is not significant in the GMM model ($\beta = -0.0566$, $p > 0.1$), while in the 2SLS model, the negative effect is significant ($\beta = -0.0873$, $p < 0.05$). This difference reflects the complexity of the role of the IPR protection system in the relationship between IFDI and technological innovation. Although the interaction effects are different between GMM and 2SLS, the directions are negative, and the conclusions do not support Hypothesis 5a. In this sense, the empirical results of this article are robust.

Table 6
Negative binomial regression results.

	Model1	Model2	Model3	Model4	Model5	Model6	Model7	Model8
IFDI	0.2240***		0.1750***	0.1902***	0.2356***	0.1707***	0.1725***	0.1800***
	(0.0491)		(0.0465)	(0.0486)	(0.0548)	(0.0479)	(0.0549)	(0.0506)
OFDI		0.1422***	0.1235***	0.1446***	0.1317***	0.1336***	0.1239***	0.1032***
		(0.0248)	(0.0245)	(0.0262)	(0.0254)	(0.0257)	(0.0291)	(0.0257)
IFDI × OFDI				0.0152**				
				(0.0068)				
R&D					0.0016	0.0083		
					(0.0068)	(0.0060)		
IFDI × R&D					0.0120***			
					(0.0033)			
OFDI × R&D						0.0035***		
						(0.0012)		
IPR							−0.1148	−0.1643
							(0.1136)	(0.1459)
IFDI × IPR							−0.0392*	
							(0.0237)	
OFDI × IPR								−0.0348*
								(0.0200)
CAPI	0.0149***	0.0139***	0.0121***	0.0131***	0.0113***	0.0126***	0.0116***	0.0116***
	(0.0027)	(0.0027)	(0.0027)	(0.0029)	(0.0026)	(0.0028)	(0.0027)	(0.0033)
IMEX	0.0016	0.0014	0.0004	0.0017	0.0007	0.0006	0.0001	−0.0009
	(0.0024)	(0.0024)	(0.0024)	(0.0024)	(0.0024)	(0.0025)	(0.0031)	(0.0026)
FINA	−0.0008	−0.0023*	−0.0008	−0.0007	−0.0007	−0.0008	−0.0011	−0.0006
	(0.0017)	(0.0013)	(0.0016)	(0.0016)	(0.0015)	(0.0015)	(0.0018)	(0.0015)
SAVE	−0.0116**	−0.0094*	−0.0071	−0.0063	−0.0059	−0.0063	−0.0079**	−0.0068
	(0.0055)	(0.0054)	(0.0062)	(0.0063)	(0.0065)	(0.0064)	(0.0039)	(0.0066)
market	0.0193***	0.0163***	0.0153***	0.0115**	0.0099**	0.0121***	0.0185***	0.0164***
	(0.0046)	(0.0045)	(0.0045)	(0.0047)	(0.0044)	(0.0044)	(0.0061)	(0.0046)
HR	0.0137***	0.0090*	0.0060	0.0049	0.0066	0.0068	0.0084*	0.0121**
	(0.0046)	(0.0048)	(0.0050)	(0.0051)	(0.0050)	(0.0052)	(0.0047)	(0.0056)
constant	8.6493***	9.2281***	9.0486***	8.9490***	8.7447***	8.6990***	9.1429***	9.0921***
	(0.7225)	(0.6647)	(0.6986)	(0.6980)	(0.7260)	(0.7507)	(0.6132)	(0.6805)
lnalpha	−1.2379***	−1.2562***	−1.2771***	−1.2840***	−1.3048***	1.2982***	1.2827***	1.2849***
	(0.1513)	(0.1499)	(0.1511)	(0.1529)	(0.1555)	(0.1546)	(0.0639)	(0.1481)
N	450	450	450	450	450	450	450	450
Pseudo R^2	0.1046	0.1055	0.1065	0.1069	0.1079	0.1076	0.1068	0.1069

Standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 7
GMM estimation results.

	INNOVA							
	Model1	Model2	Model3	Model4	Model5	Model6	Model7	Model8
IFDI	1.9761**		0.9236**	0.5915*	1.0820***	0.6143**	0.6633***	1.2435***
	(0.7880)		(0.3853)	(0.3110)	(0.3537)	(0.2890)	(0.1645)	(0.4182)
OFDI		0.6288***	0.3475**	0.4462***	0.3090**	0.4830***	0.1517	0.5305**
		(0.1046)	(0.1535)	(0.1387)	(0.1406)	(0.1443)	(0.1911)	(0.2249)
IFDI × OFDI				0.0700***				
				(0.0191)				
R&D					0.0217	0.0169		
					(0.0199)	(0.0185)		
IFDI × R&D					0.0312***			
					(0.0099)			
OFDI × R&D						0.0174***		
						(0.0055)		
IPR							−0.7271***	−1.3516***
							(0.1863)	(0.3311)
IFDI × IPR							−0.0566	
							(0.0603)	
OFDI × IPR								−0.0423
								(0.0680)
CAPI	−0.0026	0.0033	−0.0032	0.0069	−0.0005	0.0051	0.0097**	0.0031
	(0.0128)	(0.0056)	(0.0065)	(0.0054)	(0.0061)	(0.0056)	(0.0048)	(0.0063)
IMEX	−0.0135*	−0.0067	−0.0094*	−0.0003	−0.0071	−0.0049	0.0089***	−0.0040
	(0.0080)	(0.0058)	(0.0055)	(0.0059)	(0.0052)	(0.0058)	(0.0023)	(0.0059)
FINA	0.0109	0.0002	0.0045	0.0020	0.0053	0.0033	0.0010	0.0047
	(0.0071)	(0.0027)	(0.0038)	(0.0031)	(0.0035)	(0.0034)	(0.0027)	(0.0039)
SAVE	0.0055	0.0058	0.0065	0.0031	0.0043	0.0064	0.0055	0.0128
	(0.0149)	(0.0082)	(0.0095)	(0.0075)	(0.0091)	(0.0094)	(0.0039)	(0.0112)
market	0.0197*	0.0113	0.0144	0.0007	0.0070	0.0062	0.0156***	0.0053
	(0.0116)	(0.0101)	(0.0097)	(0.0111)	(0.0095)	(0.0094)	(0.0060)	(0.0123)
HR	−0.0457**	−0.0412***	−0.0427***	−0.0372***	−0.0418***	−0.0447***	0.0074	−0.0226
	(0.0200)	(0.0102)	(0.0105)	(0.0099)	(0.0104)	(0.0113)	(0.0105)	(0.0167)
constant	9.5600***	11.4478***	10.6090***	10.3490***	10.5347***	10.7407***	6.7115***	10.0615***
	(1.4095)	(1.2317)	(1.2222)	(1.1531)	(1.2481)	(1.2717)	(0.6287)	(1.1742)
N	450	450	450	450	450	450	450	450
adj.R-sq	0.5146	0.6995	0.7204	0.7422	0.7323	0.7296	0.6726	0.6607
minimum eigenvalue	228.26	96.35	92.27	23.74	87.90	16.96	78.25	46.23
Instrumental variable correlation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sargan-Hansen	0.2362	0.1311	0.6091	0.1177	0.3664	0.1100	0.7924	0.7466

Standard errors are in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

5. Conclusion and discussion

5.1. Conclusion

This study aims to reveal the influence of two-way FDI on technological innovation. Based on the empirical analysis of China's provincial panel data from 2003 to 2017, this research finds that IFDI and OFDI significantly promote technological innovation. Further analysis confirms that the interaction between IFDI and OFDI has a significant positive impact on technological innovation. Absorptive capacity positively moderates the relationship between two-way FDI and technological innovation, and IPR protection negatively moderates the relationship between two-way FDI and technological innovation. The comparative analysis of the eastern and central regions shows that the interaction between IFDI and OFDI and the moderating effect of absorptive capacity are significant in the east area but not in the central-western region. Through the comparative analysis of two periods from 2003 to 2010 and 2011 to 2017, the interaction effect of IFDI and OFDI increases with the period, and the moderating effect of absorptive capacity changes from insignificant in the first stage to highly significant in the second stage, the moderating effect of IPR protection changes from highly significant negative in the first stage to negative but not significant in the second stage.

Through multiple methods, including the negative binomial model, 2SLS, and GMM estimation, this study finds that the promotion effect of IFDI and OFDI on technological innovation is highly stable, which is in contrast to the widespread disagreement currently existing in research [24,34], thereby reflecting the unique value of two-way FDI for technological innovation in emerging markets. For the interaction effect of IFDI and OFDI, the negative binomial model, 2SLS and GMM estimation results are all significant. The regional heterogeneity test shows that the eastern region is significant, but the central-western part is not. The temporal heterogeneity test finds that this interaction effect changes from slightly significant during 2003–2010 to very effective during 2011–2017. The moderating effect of absorptive capacity has been supported, this logic of inference is consistent with the conclusion found in Zhu and Motohashi (2023) [64], which may be related to the government's R&D investment. The moderating effect of the absorptive capacity of the eastern region is significant but not significant in the central-western area. The moderating effect of absorptive capacity is not significant from 2003 to 2010, while the result is significant from 2011 to 2017. This shows that the moderating effect of absorptive capacity has been continuously enhanced with time. The moderating effects of IPR protection differ in each model, but the direction remains negative. Although this result does not support the hypothesis of this article, the conclusion is similar with that of Belderbos (2021) [18]. The temporal heterogeneity test shows that the period from 2003 to 2010 is significantly negative, while the period from 2011 to 2017 is not. This indicates that the moderating effect of intellectual property protection has improved over time. Although this result does not support the hypothesis of this article, there are still similarities between the two in terms of changing trends.

5.2. Implications

The theoretical contributions of this study are mainly as follows. First, this research integrates IFDI and OFDI into a unified analytical framework to investigate the impact of two-way FDI on technological innovation from a complete process, which is an extension of the literature. The literature on IFDI or OFDI is usually separate, with studies of IFDI stemming from the perspective of technology spillover [24,51] and studies of OFDI stemming from the perspective of firm internationalisation [32,41]. There is a lack of connection between these two approaches. In this study, IFDI and OFDI are seen as two important sources of technological innovation in emerging markets, this research explores the influence mechanism of two-way FDI on technological innovation, this is a theoretical exploration of a major phenomenon that is currently taking place and helps us better to understand the process of technological catch-up in emerging markets. Second, in the process of analyzing the influence of two-way FDI on technological innovation, this study further discusses the interactive effect of IFDI and OFDI and the moderating effect of absorptive capacity and IPR protection, which helps us to understand the promoting and restricting factors of two-way FDI on technological innovation. The interactive effect of IFDI and OFDI represents the competition and interaction between multinational companies from developed countries and emerging market multinational companies that have grown up locally. Can this competition and interaction produce synergies and improve technological innovation? While this is an attractive question, the existing research does not pay enough attention [31,44]. Absorption capacity reflects the accumulation of technology and knowledge of local enterprises in emerging markets, and it forms the basis for the transformation of local enterprises from imitation to innovation. The findings of this research confirm that Chinese enterprises have begun to meet this condition. IPR protection is an institutional condition for emerging markets to realise the transformation to innovation. The findings of this study confirm that this institution is complicated, and China's current IPR protection system is still unable to promote the relationship between two-way FDI and technological innovation.

The findings of this study have important policy and management implications. From the government's perspective, this research's findings contain the following policy implications. First, combining the incentive policies of two-way FDI with national innovation policies is necessary. This study finds that two-way FDI has a significant promoting effect on technological innovation. Therefore, the government should consider the connection between the existing IFDI and OFDI policies and the national innovation strategy. While encouraging independent innovation, the government should also attach importance to the utilisation of external innovation resources. MNEs in developed countries often possess innovative technologies, and the government should actively attract technology-intensive foreign investment and support their R&D activities, as well as technological cooperation in China. In the meantime, the government should actively support Chinese enterprises in carrying out R&D activities overseas, especially in developed countries, encourage Chinese enterprises to acquire overseas enterprises with technological capabilities, provide policy facilitation and diplomatic support for these enterprises. Second, we need to promote the reform of the IPR protection system. This study finds that China's existing IPR protection system still has a negative moderating effect on the technological innovation effect of two-way FDI, IPR protection needs to be further adjusted, the focus of the law should shift to the protection and encouragement of innovation, the enforcement of the law should strengthen the fight against IPR infringement. From the perspective of enterprise management, the findings of this research have the following implications. First, Chinese enterprises and Western MNEs need to compete regarding frontier technology in domestic and international markets. Chinese companies have gradually accumulated technological capabilities and achieved success in some domestic and overseas markets. As the focus of the competition has begun to turn to innovative technology, the two sides have become increasingly confrontational. To cope with the new situation, Chinese enterprises not only to give play to the advantages of the local market but also to be good at penetration and expansion in overseas markets, to make full use of the complementarity of resources in the international and domestic markets, and to achieve breakthroughs in core technologies. Second, managers should invest in long-term R&D. This research finds that absorptive capacity has a positive moderating effect on the technological innovation effect of two-way FDI, which indicates that the accumulation of knowledge and technology is an important condition for obtaining external innovation resources. Long-term investment in R&D, especially in basic research, is the key to victory in fighting for technological commanding heights. Therefore, Chinese enterprises' R&D activities should be more inclined to the core technology and extend to the source of innovation.

5.3. Limitations

This study also has some limitations, which provide a direction for future research. First, this study explores the impact of two-way FDI on technological innovation with China as the research background. Although the Chinese background is representative, further testing is needed to determine whether the relevant conclusions can be extended to other emerging markets. Since two-way FDI is a symbolic phenomenon of technological catch-up in emerging markets, future studies can focus on similar problems in emerging markets such as India and Brazil to test whether the conclusions in this article are universal. Second, as the impact of two-way FDI on technological innovation involves both macro and enterprise levels, provincial panel data cannot fully reveal its inherent complex connections. Future research can adopt a nested analysis and consider macro, industry and enterprise levels. Third, while this study finds that IPR protection negatively moderates the technological innovation effect of two-way FDI, it fails to reveal its internal reasons fully. As China is in a stage of transformation from imitation to innovation, the reform of the IPR protection system should bear the brunt. How can the IPR protection system effectively protect the development of Chinese enterprises while encouraging innovation? Answering this question is very important for the success of Chinese enterprises who are playing catch up; at the same time, there is a disconnection between the legislation and enforcement of IPR protection, which affects the actual effect of IPR protection. Thus, future research should pay more attention to the enforcement process and improve the accuracy of the measurement of IPR protection.

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CRediT authorship contribution statement

Jingjing Li: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Xianming Wu:** Writing – review & editing, Writing – original draft, Supervision, Funding acquisition, Formal analysis, Conceptualization.

Data availability statement

The data used are available from the corresponding author on reasonable request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

The regression results of the first stage are introduced to confirm the significant correlation between endogenous variables and instrumental variables. As shown in Table 8; these new interaction terms were then used as instrumental variables of the original interaction terms. The results show that the three instrumental variables selected are highly correlated with IFDI ($p < 0.01$), that ADFA and NFPL are correlated with OFDI ($p < 0.01$ or $p < 0.05$), and that the instrumental variables generated by the interaction item are also associated with the interaction item ($p < 0.01$ or $p < 0.1$); thus, the instrumental variables are related to the endogenous variables.

Table 8
2SLS regression of the first stage (to be continued)

	Model1	Model2	Model3		Model4			Model5		
	IFDI	OFDI	IFDI	OFDI	IFDI	OFDI	FDI × OFDI	IFDI	OFDI	R&D × IFDI
ADFA		0.0062***	−0.0025***	0.0062***	−0.0016*	0.0088***	−0.0092	0.0023***	0.0074***	−0.0041
		(0.0019)	(0.0008)	(0.0019)	(0.0010)	(0.0022)	(0.0076)	(0.0007)	(0.0019)	(0.0062)
TLFI	0.02***		0.0197***	0.0085	0.0361***	0.0567***	0.5854***	0.0169***	0.0001	−0.1472***
	(0.0037)		(0.0051)	(0.0090)	(0.0113)	(0.0219)	(0.1340)	(0.0037)	(0.0090)	(0.0473)
NFPL	0.0025***	0.0031**	0.0031***	0.0031**	0.0035***	0.0042***	0.0091**	0.0036***	0.0046***	−0.0140***
	(0.0007)	(0.0013)	(0.0008)	(0.0013)	(0.0008)	(0.0013)	(0.0039)	(0.0007)	(0.0013)	(0.0048)
TLFI × ADFA					−0.0034*	0.0100***	0.1118***			
					(0.0018)	(0.0038)	(0.0200)			
ADFA × R&D								0.0130***	0.0428***	0.8625***
								(0.0034)	(0.0109)	(0.0327)
NFPL × R&D										
ADFA × IPR										
constant	0.7159	8.1369***	1.2343*	8.2087***	0.621	10.0116***	17.7281***	1.0354	8.9534***	−1.8909

(*continued on next page*)

Table 8 (*continued*)

	Model1	Model2	Model3		Model4			Model5		
	IFDI	OFDI	IFDI	OFDI	IFDI	OFDI	FDI × OFDI	IFDI	OFDI	R&D × IFDI
	(0.7419)	(1.8866)	(0.6501)	(1.8770)	(0.7602)	(2.0691)	(5.4039)	(0.6419)	(1.6096)	(5.0833)
controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	450	450	450	450	450	450	450	450	450	450
adj.R-sq	0.9134	0.8532	0.9368	0.8533	0.9376	0.8567	0.5364	0.9391	0.8651	0.9238

	Model6			Model7			Model8		
	IFDI	OFDI	R&D × OFDI	IFDI	OFDI	IPR × IFDI	IFDI	OFDI	IPR × OFDI
ADFA	−0.0022**	0.0072***	−0.1085***	−0.0015**	0.0093***	0.0003	−0.0015**	0.0093***	−0.0060***
	(0.0009)	(0.0021)	(0.0331)	(0.0007)	(0.0014)	(0.0011)	(0.0007)	(0.0014)	(0.0019)
TLFI	0.0176***	0.0038	−0.1576	0.0176***	0.0001	−0.0035	0.0176***	0.0001	−0.0042
	(0.0050)	(0.0090)	(0.0968)	(0.0035)	(0.0072)	(0.0058)	(0.0035)	(0.0072)	(0.0099)
NFPL	0.0038***	0.0047***	0.0052	0.0034***	0.0031**	0.0022**	0.0034***	0.0031**	−0.0037**
	(0.0008)	(0.0013)	(0.0194)	(0.0007)	(0.0014)	(0.0011)	(0.0007)	(0.0014)	(0.0019)
TLFI × ADFA									
ADFA × R&D									
NFPL × R&D	0.0002***	0.0004***	0.0205***						
	(0.0000)	(0.0001)	(0.0034)						
ADFA × IPR				0.0094***	0.0233***	0.0887***	0.0094***	0.0233***	0.1181***
				(0.0020)	(0.0041)	(0.0032)	(0.0020)	(0.0041)	(0.0056)
constant	0.5906	9.8299***	130.1420***	1.2285**	8.0859***	0.2287	1.2285**	8.0859***	4.6727***
	(0.7013)	(1.8731)	(30.0044)	(0.6203)	(1.2708)	(1.0142)	(0.6203)	(1.2708)	(1.7405)
controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	450	450	450	450	450	450	450	450	450
adj.R-sq	0.9386	0.8582	0.6048	0.9425	0.8821	0.8618	0.9425	0.8821	0.843

Standard errors are in parentheses; $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.
Standard errors are in parentheses; $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

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