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A Study on the Impact of Multinational Innovation on Export Diversification of Chinese Enterprises

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Abstract

Against the backdrop of the accelerated evolution of the new industrial revolution, the global flow of innovation factors has accelerated, and innovation activities have increasingly broken through geographical restrictions, exhibiting deeply globalized characteristics. This paper employs a cross-country panel data-set for the period 2009-2015 based on the Chinese listed enterprises and multiple sources such as the CEPII database, and constructs a multiple fixed-effects model to conduct benchmark regression and heterogeneity analyses. To ensure the convinced regression results, this paper further applies three robustness methods for testing. It is found that, firstly, multinational innovation as a whole significantly increases the level of export diversification of enterprises, and this finding passes the robustness test. Among them, the promotion effect of foreign patent applications in China on export diversification is significantly stronger than that of Chinese overseas patent applications. Secondly, the heterogeneity analysis based on the level of national economic development shows that patent layout and technology introduction for high-income countries have a more significant effect on export product diversification, while the effect of low-income countries is relatively limited.

Keywords: Multinational Innovation, Overseas Patent Applications, Foreign Patents in China, Export Diversification of Enterprises.

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1. Introduction

The deep integration of the new round of scientific and technological revolution and industrial change has made scientific and technological innovation the core engine driving the economic and social development of the country, and has become an important variable affecting the evolution of the current international landscape. In recent years, China has vigorously strengthened the construction of the international scientific research environment, attached importance to international scientific and technological cooperation, and formed a globally competitive open innovation ecosystem, highlighting the strategic significance of transnational innovation in the context of open innovation for achieving high-level scientific and technological autonomy and building a strong scientific and technological country. Against the background of the continuous acceleration of the globalized production process, the importance of multinational innovation is becoming more and more prominent, and the dependence of the firms on external innovation resources has increased significantly (Arvanitis and Bolli, 2013; Chesbrough, 2003). Firms increasingly recognize the strategic value of integrating into international markets and acquiring advanced knowledge (Mostafiz et al., 2022). With the acceleration of the global flow of innovation factors, innovation activities break through geographical restrictions and present highly globalized characteristics, multinational innovation has become an important means of participating in global governance and a key path to integrate into the global innovation network. In this context, no matter the country or enterprise, purely relying on closed independent innovation can no longer maintain a sustained innovation momentum, and enhancing international innovation capacity has become a key way to enhance the international competitiveness of enterprises and cultivate new competitive advantages in foreign trade (Ortigueira-Sánchez et al., 2022).

In recent years, the participation of Chinese enterprises in global innovation activities has significantly increased, and the cooperation in innovation activities between China and other major innovation countries has been growing (Ma et al., 2009), leading to a dynamic development of multinational innovation characterized by a dual flow of patents. On the one hand, the number of overseas patent applications by Chinese enterprises has grown rapidly; on the other hand, the scale of patent applications by foreign enterprises in China has steadily expanded. According to statistics from the National Intellectual Property Administration, from 2013 to 2023, Chinese enterprises submitted a total of 70,000 overseas patent applications in 52 countries, with an average annual growth rate of over 20%; during the same period, the total number of patent applications by foreign enterprises in China reached 285,000, with an average annual growth rate of 5.6%. This trend indicates that Chinese enterprises are actively integrating into the global innovation network, seeking advanced technologies and knowledge, supporting the optimization of export structure and enhancing competitiveness, while also injecting new momentum into high-quality economic development. Theoretically, multinational innovation is essentially about building a competitive advantage in the global innovation network through the allocation of innovation resources worldwide. Enterprises acquire key technological resources through overseas patent applications to cope with international competition, while foreign patent applications in China provide local enterprises with opportunities for learning and upgrading, promoting their technological accumulation and product innovation. These two models have played a crucial role in enhancing industrial technological levels, optimizing export product structures, and cultivating new growth points for foreign trade.

A large body of research focuses on exploring the impact of multinational innovation on enterprise export performance (Leung and Sharma, 2021) and export intensity (Rodil et al., 2016), which are single-product dimensions. In contrast, export diversification, as an important indicator of enterprise international competitiveness, not only helps avoid deteriorating trade conditions (Athukorala, 2000), but also reduces the vulnerability to external shocks caused by specialization (Lectard and Rougier, 2018; Nguyen and Schinckus, 2023; Jansen, 2004). As such, it has become a key path for enterprises to deepen global division of labor and enhance the technological content of export products (Hausmann et al., 2007). A few studies suggest that the factors influencing export diversification include macroeconomic policies (Agarwal et al., 1995), foreign direct investment (Lectard and Rougier, 2018), trade liberalization (Osakwe et al., 2018; Li et al., 2021), enterprise characteristics (Majocchi and Bacchiocchi, 2005; Brunow et al., 2019), and institutional quality (Lei and Luo, 2022). Some scholars focus on the impact of single modes of multinational innovation, such as the promotion effect of overseas patent applications on export diversification (Sun, 2003).

Previous studies has predominantly focused on the role of multinational innovation in export scale (Rodil et al., 2016; Manova, 2013), while studies on its impact on export diversification are relatively limited. However, export diversification is not only an important manifestation of product structure complexity but also a key indicator for measuring a country or region's ability to cope with international market fluctuations. Furthermore, while many scholars have explored the various factors influencing export diversification (Agosin et al., 2012; Parteka and Tamberi, 2013), few have considered multinational innovation as a critical influencing factor, and there is also a lack of systematic analysis of the bidirectional interactive effects between foreign patents in China and China's overseas patent applications, the two modes of multinational innovation. In addition, there is a significant gap in comparative studies of how different multinational innovation modes influence export diversification, their mechanisms, and the strength of their effects. Although some scholars have attempted to reveal the mechanisms of multinational innovation, most of these studies are limited to the single perspective of Total Factor Productivity (TFP), neglecting other potential mediating and moderating factors (Ortigueira-Sánchez et al., 2022).

Therefore, this paper treats multinational innovation as the core driving factor influencing enterprise export diversification, which has important theoretical and practical value. To this end, the paper integrates the two modes of multinational innovation into a unified framework and comprehensively analyzes their effects on export diversification. To fill the research gap on mediating pathways, this paper innovatively introduces product innovation effects as a mediating variable and incorporates the levels of R&D investment and resource allocation efficiency in the destination country as moderating mechanisms. Through this comprehensive analytical framework, the paper aims to uncover the paths and strengths of the effects of different multinational innovation modes on export diversification, thereby providing theoretical and empirical support for Chinese manufacturing enterprises to optimize their export structure and enhance international competitiveness.

2. Literature Review and Theoretical Mechanism

2.1 Literature Review

Early research primarily focused on the impact of factors such as firms' global R&D strategies, international patent applications, and technological cooperation on export diversification. Through international patent applications and R&D investments, firms can not only enhance their own innovation capabilities but also promote the sharing and integration of global technological resources (Dunning and Lundan, 2008). Especially in emerging market countries, firms often establish overseas R&D centers or engage in technology acquisitions to rapidly catch up with technology and enhance their innovation capabilities (Sun and Du, 2010). Therefore, firms' global R&D strategies, international patent applications and technological cooperation, as well as the inflow and outflow of technology, are all important manifestations of multinational innovation.

As a precursor to multinational innovation, some scholars have explored its role in promoting firms' export diversification. Lewandowska et al. (2016) pointed out that by establishing connections with a diverse range of international innovation partners, firms can gain access to key technological resources and knowledge spillovers, thereby enhancing export intensity and expanding market share internationally. Especially in transition economies and emerging market economies, multinational innovation has provided firms with crucial opportunities to overcome technological barriers and enter high-end markets (Cantwell, 2009). International R&D cooperation, by pooling diverse technological resources, accelerates the realization of technological innovation and helps firms better respond to changing demands in different markets. This form of cooperation encourages firms to export a wider variety of products and enter more markets (Eaton and Kortum, 2002). Multinational innovation not only improves product quality but also, by optimizing market distribution, reduces the concentration of export markets, thereby driving export diversification. Furthermore, both technology export and technology import, as two modes of multinational innovation, have played a significant role in improving industrial technological levels and optimizing export product structures (Dunning and Lundan, 2008).

Some scholars have explored the impact of multinational innovation on export diversification from both micro and macro perspectives. From the micro perspective, multinational innovation breaks the boundary limitations of firms and countries. By building a global innovation network, firms can access technological resources and management experience worldwide, thereby improving production efficiency and market competitiveness. Multinational innovation helps firms develop new products and enhance the technological content and market adaptability of existing products (Filatotchev et al., 2009). These new products not only diversify the range of a firm's export products but also strengthen its competitiveness in international markets. From the macro perspective, multinational innovation plays a significant role in driving economic growth and the transformation of trade structures. Technological innovation, particularly through technology export methods such as overseas patent applications, can expand the coverage of technology markets and promote export product diversification (Castellani and Zanfei, 2006).

2.2 Theoretical mechanisms

Multinational innovation exerts a profound impact on export diversification through multiple mechanisms, including the "reverse forcing effect," "technology spillover effect," "absorptive capacity," and "cost reduction effect."

This effect primarily enhances firms' R&D capabilities and optimizes their export product structure through dual mechanisms: technological innovation pressure and market competition. First, the reverse forcing effect of Chinese overseas patent applications. As a critical manifestation of technology globalization, Chinese firms' overseas patent applications provide impetus for technological breakthroughs in international competition. On one hand, filing overseas patents helps firms secure international market share, protect intellectual property rights, and mitigate potential legal disputes. On the other hand, overseas patent portfolios strengthen firms' influence in global technology governance, particularly in shaping international technical standards. Moreover, the high-standard competitive environment in international markets compels firms to shift from quantity-driven, low-quality patenting strategies to high-tech, high-value-added multinational innovation. This transition fosters the optimization of export product structures and enhances diversification. Second, the reverse forcing effect of foreign patent inflows into China. As a concrete form of technology import, foreign patents entering the Chinese market profoundly impact domestic firms by intensifying competitive pressure and raising technological barriers. On one hand, foreign patent inflows force local firms to increase R&D investment and accumulate independent intellectual property to remain competitive. This reverse forcing mechanism effectively accelerates technological innovation and improves the quality and sophistication of export products. On the other hand, foreign patents help firms overcome path dependency—breaking free from technological lock-ins and developing higher-tier technological capabilities through technology absorption and independent innovation, ultimately achieving greater export diversification and complexity. In summary, both Chinese overseas patents and foreign patents in China significantly enhance firms' technological innovation capacity and export diversification through distinct reverse forcing mechanisms. This effect not only reflects the cross-border spillover of technological innovation but also reveals the intrinsic logic of how international-local interactions elevate corporate competitiveness.

The technology spillover effect is another important mechanism through which multinational innovation drives export diversification (Chang et al., 2013). Multinational innovation influences manufacturing export diversification through multinational technology transfer. In the process of international innovation collaboration, technology disseminators and technology receivers interact through coordinated production and R&D, enabling innovation participants to absorb external advanced technologies, shorten R&D cycles, quickly develop new products or processes (Blomström and Kokko, 1998), and provide high-quality new products to the international market. This, in turn, increases the technological complexity of export products (Hausmann et al., 2007). From the perspective of both technology inflows and outflows, the technology spillover effect significantly affects a firm's export diversification level. Foreign patents in China and Chinese overseas patent applications, through mechanisms like technology diffusion, knowledge exchange, and collaborative innovation, have a profound impact on firms' export diversification. It is worth noting that although both foreign patents in China and Chinese overseas patents indicate that technology spillover is one of the core mechanisms through which multinational innovation influences export diversification, the effectiveness of technology spillovers is constrained by the firm's technological absorption capacity. From the perspective of absorptive capacity theory, when a country's indigenous innovation capability reaches a high level, its firms' ability to absorb and utilize advanced external production technologies significantly improves, reflecting the firm's excellent learning ability. This enhanced capacity allows firms to efficiently internalize advanced technologies, optimize production processes, improve resource utilization efficiency, and further enhance product performance, thereby promoting the diversification of manufactured products and the expansion of product varieties. Firms with strong absorptive capacity can achieve rapid innovation through technology imports and exports, improving the quality and variety of export products. In contrast, firms with weak absorptive capacity may not be able to fully exploit the advantages of technology spillovers and may only gain access to low-end technologies, leading to a limited improvement in export diversification. Additionally, firms in technology-intensive industries generally possess higher absorptive capacity and R&D resource integration capabilities, enabling them to more effectively utilize the technology spillover effect to enhance their technological levels and export product structures.

Multinational innovation promotes export diversification through the cost-reduction effect (Flach and Irlacher, 2018). Jointly innovating enterprises can fully leverage newly developed technologies, which not only reduce technology development costs but also produce high-tech complex and diverse products. When firms participating in multinational innovation exhibit heterogeneous R&D capabilities, it facilitates technology sharing, whereas homogeneous R&D capabilities assist in cost-sharing. The motivation for firms to participate in multinational innovation is to rapidly and efficiently expand the range of product production (Niosi and Bellon, 1994). Finally, multinational innovation can significantly reduce trade costs, thus enhancing export diversification. In relatively stable multinational innovation relationships, partners gradually establish trust mechanisms, reducing credit costs. Through joint innovation actions, firms effectively address the issue of information asymmetry in external markets and lower information search costs. Research has confirmed that through multinational innovation, firms reduce costs, positively influencing export performance, export capacity, and export intensity, while also enhancing the international competitiveness of export products in international markets. Therefore, multinational innovation effectively increases production flexibility, reduces production costs, aids in the standardization and normalization of product production, and further enhances the diversity of export products. Although multinational innovation has a positive impact on export diversification through multiple effects, these effects exhibit significant differences in their mechanisms across different paths. Based on the above analysis, the following hypotheses are proposed:

H_{1a}: Chinese overseas patent applications promote the improvement of Chinese enterprises' export diversification.

H_{1b}: Foreign patent applications in China promote the improvement of Chinese enterprises' export diversification.

3. Model Construction

3.1 Benchmark regression model construction

To test the impact of multinational innovation on the export diversification of Chinese enterprises, including the effects of both Chinese overseas patent applications and foreign patent applications in China as two modes of multinational innovation, this paper constructs the following benchmark regression model:

$$Y_{\mathrm{ijh}t} = \alpha_0 + \alpha_1 \ln \mathrm{ex}pat_{ijt} + \alpha_2 control_{ijt} + \gamma_i + \delta_{\mathrm{h}} + \phi_t + \varepsilon_{ijt} \tag{1}$$

$$Y_{\mathrm{ijh}t} = a_0 + a_1 \ln impat_{ijt} + a_2 control_{ijt} + \gamma_i + \delta_{\mathrm{h}} + \phi_t + \varepsilon_{ijt} \tag{2}$$

where subscripts i, j, and t represent enterprise, destination country, and year, respectively. Y_{ijht} denotes export diversification from enterprise i to country j in year t, and measures include export diversification index (div) and export intensity (lnEX). $\mathrm{lnexpat}_{ijt}$ denotes patent applications filed by enterprise i's industry in country j in year t; $lnimpat_{ijt}$ denotes patent applications filed by j's industry in China in year t. lnexpat and lnimpat are patent differentiated multinational innovations, representing foreign patent applications in China and Chinese overseas patent applications, respectively. control denotes a series of control variables. the patent applications filed by firm i's industry in country j in year t. lnexpat and lnimpat are the different multinational innovations of patents, which represent foreign patent applications in China and Chinese patent applications abroad, respectively. control denotes a series of control variables to control for the effect of time-varying firm characteristics on exporting. γ is the firm fixed effect, δ is the firm fixed effects, Φ is year fixed effects, and ε is the error term.

3.2 Variable measurement and selection

3.2.1 The dependent variable

This paper measures the export diversification of enterprises from two dimensions, namely, enterprise export diversification index and enterprise export intensity. These two indicators are chosen to comprehensively and objectively analyze the actual situation of export diversification of enterprises. Drawing on Lopresti (2016), the export product diversification index in this paper adopts a Herfindahl-type indicator to measure the types of products exported by firms in different years and destination countries, reflecting the degree of product diversification; while the export intensity is measured by the total value of products exported by firms to a specific destination country, which reveals the role of multinational innovation of firms in driving the scale of exports. These two variables will comprehensively analyze the degree of firms' export diversification and their performance in the global market, helping to explore the impact of multinational innovation on firms' export growth and market competitiveness. The specific construction process is as follows:

1) Export diversification index measurement

This paper adopts the HHI index to measure the export diversification of enterprises, and specifically measures the degree of export diversification of each enterprise to each export destination country level each year.

$$div_{ijt} = 1 - \sum_{h \in \Omega_{ijt}} \left(\frac{sales_{ijth}}{\sum_{h \in \Omega_{ijt}} sales_{ijth}} \right)^2 \tag{3}$$

where div_{ijt} denotes the product diversification index at the firm-destination country-year level, i represents the firm, j represents the destination country, t represents the year, h represents the HS octave products exported by the firm, and Ω_{ijt} is the set of all octave products exported by firm i to country j in year t. $Sales_{ijth}$ is the h-products exported by firm i to destination country j in year t that firm i exported to country j in year t. It can be found that a larger value of div_{ijt} indicates a higher degree of diversification of the firm's exports to that country in that year, with a wider range of exported products and more average production. Conversely, a lower degree of diversification suggests that firms' production and export sales are more concentrated in a few products.

2) Export intensity measurement

In the process of enterprises' multinational innovation, the core products of patented technology further expand the export scale by virtue of the advantages of technological innovation, and other products related to the patented technology also turn to export due to the advantages of patent protection, and the export volume increases and the overall scale expands. In other words, multinational innovation of enterprises promotes product diversification along with the increase of export volume, thus reflecting the systematic effect of multinational innovation of enterprises on the promotion of product diversification of enterprises. This paper further adopts the export intensity of products exported by enterprises to the destination country in the same year as an dependent variable to verify this.

$$EX_{ijt} = P_{ijt}Q_{ijt} \tag{4}$$

Where EX_{ijt} is the scale of export of product h from enterprise i to country j in year t, P is the price, and Q is the number of products. In this paper, when calculating the total scale of China's exports of a certain type of product to a certain country in a certain year, firstly, since the total value of the scale of a certain type of product may originate from multiple export transactions, in which the unit price and transaction amount of each transaction may be different, when calculating the annual total value of China's exports of this type of product to that country, the exports of the same type of product under different modes of trade are combined to arrive at the overall total value of exports, rather than categorizing statistics based on the heterogeneity of trade modes.

3.2.2 The independent variable

The core independent variable selected in this paper is multinational innovation, which is measured from the dimensions of Chinese overseas patent applications and foreign patent applications in China, which can well capture the effects and differences of the two-way flow of technological knowledge in the process of multinational innovation, i.e. inflow and outflow. It can well capture the effect and difference of the two-way flow of technological knowledge in the process of multinational innovation, i.e. inflow and outflow. Specifically, the proxy variable for Chinese overseas patent applications is the number of patents filed by Chinese enterprises with foreign patent offices each year, denoted by *lnexpat*; while the proxy variable for foreign patent applications in China is the number of patents filed by foreign enterprises with the Chinese patent offices each year, denoted by *lnimpat*, and the source of the data is PATSNAP. In this paper, we define Chinese overseas patent applications as the number of patents filed annually with foreign patent offices by applicants whose address is in China. In this paper, foreign patent applications in China are defined as the number of patents filed with the State Intellectual Property Office of China (SIPO), where the applicant is a non-Chinese resident and the applicant's region or country is non-Chinese.

3.2.3 The control variable

The control variables in this paper are divided into two categories: firm level and country level, which include the following.
Enterprise-level control variables are selected as follows:

1) Financing constraints (*WW* index)

To measure the financing constraints of enterprises, this paper adopts the WW index proposed by Whited and Wu (2006). The index is calculated based on the enterprise's return on assets (ROA), which can effectively reflect the difficulty of obtaining external financing, which in turn affects the enterprise's innovation ability and the degree of export diversification.

2) Firm size (*size*)

Firm size is usually related to resource endowment, market influence and other factors, therefore, this study adopts the natural logarithm of firms' total assets as a proxy variable for firm size. This variable can better reflect the position and competitiveness of enterprises in the market.

3) Market size (*lnsale*)

Market size is one of the important influencing factors in an enterprise's internationalization strategy. This study measures the market size through the natural logarithm of the enterprise's total operating income, reflecting the enterprise's influence in the domestic and international markets and its degree of market penetration.

4) Firm's listing age (*lnage)*

The listing age of a firm can reflect its market experience and maturity. Therefore, this study obtains a firm's listing age by subtracting the firm's listing year from the current year and taking the natural logarithm as a measure of the firm's stage of development and market experience. Firms' data are obtained from the CSMAR database.

Country-level control variables are selected as follows:

1) The level of economic development of the destination country (*lngdpper*)

The level of economic development is an important factor affecting the demand for export products. This paper uses the per capital income of the destination country to measure the level of economic development of the destination country, reflecting the economic strength of the destination country and the potential of market demand, and the data come from the World Development Indicators (WDI).

2) Institutional quality (*ins*) of the destination country

In order to measure the legal and institutional environment of the destination country, this paper adopts the six dimensions of the World Bank Governance Indicators (WGI), including corruption control, efficiency of government control, political stability, quality of regulation, rule of law environment, and the degree of democratic deliberation, and calculates the average of the six types of indexes. Comprehensive measures of institutional quality are used to assess the legal and institutional environment of the destination country (Kaufmann et al., 2008).

3) Trade openness of the destination country(*trade*)

Trade openness has a significant impact on the degree of export diversification and internationalization of enterprises. Using the Freedom to Trade Internationally Index published by the Fraser Institute, the index covers trade barriers, tariff levels and international trade facilitation dimensions, reflecting the degree of openness of the destination country to international trade.

4) Level of Internet development in the destination country (*net*)

Internet infrastructure plays a crucial role in international trade and enterprise exports. This paper measures the Internet development level of the destination country through the geometric average of the number of mobile cellular users per 100 people, the number of fixed broadband users per 100 people and the number of fixed telephone users per 100 people. This indicator captures the level of digital infrastructure and penetration of communication technologies in the destination country.

This paper also considers the impact of geographic and cultural factors on export behaviour, including the following three variables: whether or not they share a common border (*contig*): a dummy variable taking the value of 1 (1 means they share a common border, 0 means they don't), which is used to reflect the impact of proximity on the export trade of firms; common distance (*lndist*): the natural logarithm of the geographic distance between the two countries, which reflects the cost of transport and the trade convenience; common language (*col*): takes the value of a dummy variable (1 indicates that the two countries share an official language, 0 indicates that they do not), which is used to assess the facilitating effect of language commonality on trade cooperation. Control variables are from WDI, WGI, Frey Report database, CEPII database.

4. Analysis of empirical results

4.1 Descriptive statistical analysis

Table 1 provides the descriptive statistical analysis. The mean value of the export product diversification index (*div*) is 0.3647 with a standard deviation of 0.312, which indicates that the sample firms exhibit significant heterogeneity in terms of export product diversification. The median value of 0.37 implies that the majority of firms' product diversification is at the lower middle level, while the maximum value reaches 0.96, indicating that a few firms excel in export product diversification. The mean value of export intensity (*lnEX*) is 11.5496 with a standard deviation of 2.669, which reflects that the sample firms generally have a high level of exports, but at the same time there is also a high degree of volatility. It is worth noting that the minimum value is 0, which may imply that some firms do not perform well in exports in some years. Among the proxy variables for multinational innovation, the mean values of Chinese overseas patent applications (*lnexpat*) and foreign patent applications in China (*lnimpat*) are 3.1173 and 4.0815, respectively, which suggests that the sample firms have active participation in multinational innovation, and that there are significant differences among the firms.

Table 1: Descriptive statistics for the main variables

Variables	N	mean	SE	mix	median	max
div	78054	0.3647	0.312	0.00	0.37	0.96
lnEX	78054	11.5496	2.669	0.00	11.73	20.30
lnexpat	78054	3.1173	2.186	0.00	2.94	8.90
lnimpat	78054	4.0815	2.511	0.00	3.81	9.56
roa	78054	0.0557	0.078	-3.99	0.05	1.21
size	72125	21.9505	1.297	17.39	21.74	26.18
lnsale	72125	21.5033	1.450	17.78	21.32	26.13
lnage	71407	1.7554	0.830	0.00	1.79	3.14
ww	72067	-1.0085	0.071	-1.51	-1.00	-0.57
lngdpper	78054	10.4060	0.718	8.46	10.66	11.59
ins	78054	0.7868	0.693	-0.40	1.08	1.85
trade	78054	7.6467	0.905	5.13	7.84	9.56
net	78054	41.6319	18.037	4.35	49.56	64.51
contig	78054	0.0852	0.279	0.00	0.00	1.00
col	78054	0.0371	0.189	0.00	0.00	1.00
lndist	78054	8.7905	0.718	6.86	9.00	9.86

4.2 Benchmark regression results

Table 2 presents the results of the benchmark regression of multinational innovation on Chinese firms' export product diversification. By strictly controlling for the three-dimensional fixed effects of time, firm and country, this paper comprehensively analyses the performance of Chinese firms in the two-way interactions of multinational innovation, including Chinese firms' overseas patent applications (Columns (1)-(2) of Table 2), and foreign patent applications in China (Columns (3)-(4) of Table 2) as well as their impacts on the export product diversification of firms. The specific analyses are as follows:

In terms of the role of overseas patent applications on export performance, the results in columns (1) and (2) of Table 2, show that the coefficients of *lnexpat* is 0.0107 and 0.2935 for *div* and *lnEX*, respectively, and they are all significant at the 1% significance level. This shows that by applying for patents overseas, on the one hand, Chinese enterprises can actively integrate into the global innovation network, obtain more information about the technological resources and needs of the international market, and further promote the diversification of export products; on the other hand, in the process of internationalization, the knowledge protection function of patents not only safeguards the technological advantages of Chinese enterprises in the international market, but also promotes the diffusion of technology in emerging markets, not only optimizing the On the other hand, in the process of internationalization, the knowledge protection function of patents not only protects the technological advantages of Chinese enterprises in the international market, but also promotes the diffusion of technologies in emerging markets, which not only optimizes the structure of export trade, but also enhances the bargaining power and brand influence of enterprises in the international market.

In terms of the role of foreign patent applications in China on export performance, the results in columns (3) and (4) of Table 2 show that the coefficients of *lnimpat* on *div* and *lnEX* are 0.0127 and 0.3253, and both of them are significant at the 1% significance level. This indicates that foreign enterprises provide valuable knowledge spillover effects and technical cooperation opportunities to local Chinese enterprises through the inflow of patented technologies. By absorbing foreign patented technologies, Chinese enterprises can quickly learn and apply the latest technological achievements, so as to develop more products suited to the needs of the international market, and then realize the diversification and expansion of export products.

From the comparison of the relative effects of technology inflow and outflow, the coefficient of the impact of foreign patent applications(*lnimpat*) in China on the diversification of export products (0.0127) is slightly higher than the coefficient of Chinese enterprises' overseas patent applications (*lnexpat*=0.0107), indicating that the spillover effect of technology inflow is more significant. The reason may lie in the path-dependence of technology spillover, i.e., foreign patent applications in China have higher technological content and are more in line with the demand of the local market, and thus have a more direct effect on the enhancement of enterprises' innovation capability. Second, the economic cost of technology flow, compared with the technology spillover from overseas patent applications, the direct introduction of foreign patents may be more efficient in practice due to higher localization adaptation and market fit.

In summary, the results of the benchmark regression confirm that multinational innovation has a significant role in promoting export product diversification and export intensity enhancement of Chinese firms, and the effect of technology inflow is stronger than that of technology outflow, thus confirming H_{1a} and H_{1b}.

4.3 Robustness test

In order to verify the robustness of the above benchmark regression conclusions, this paper adopts three types of methods to conduct the robustness test: replacing the fixed-effects model, replacing the core independent variables with the patent lag data, and employing the winsorization treatment.

1) Replacing the fixed effects model

Columns (1) to (4) of Table 3 report the regression results of adding joint firm-year fixed effects to mitigate the problem of omitted variables for firms over time. The regression results show that multinational innovation still has a positive impact on firms' export product diversification after the addition of each joint fixed effect, again suggesting that the benchmark regression is relatively robust and reasonable.

2) Replacing the core independent variables

Consider that there may be a certain lag effect in the promotion of multinational innovation in the diversification of firms' export products. After applying for patents overseas, enterprises usually need time to absorb and transform the acquired technological knowledge, a process that often requires continuous adjustments through R&D and production practices before it can finally be reflected in product diversification. Secondly, the technological spillover effect brought about by foreign enterprises' patent applications in China also needs some time to influence the innovation capability of local enterprises, which in turn promotes the diversification of export products. Therefore, in this paper, the patent applications of Chinese enterprises overseas and foreign enterprises in China are treated with one lag and two lags respectively, and are re-run as core independent variables in the regression analysis. The results, as shown in Table 4, show that the promotion effect of lag one on export product diversification is significantly positive for Multinational Innovation.

Table 2: Benchmark regression results

	(1)	(2)	(3)	(4)
	div	lnEX	div	lnEX
lnexpat	0.0107***	0.2935***		
	(0.0023)	(0.0268)		
roa	0.0013	0.2694**	-0.0002	0.2293**
	(0.0122)	(0.1095)	(0.0122)	(0.1096)
size	-0.0134	-0.0163	-0.0123	0.0136
	(0.0102)	(0.0682)	(0.0101)	(0.0701)
lnsale	0.0191	0.2728***	0.0190	0.2706***
	(0.0120)	(0.0676)	(0.0118)	(0.0681)
lnage	-0.0042	0.0530	-0.0041	0.0568
	(0.0070)	(0.0564)	(0.0070)	(0.0559)
ww	-0.0141	-0.2855	-0.0127	-0.2522
	(0.0681)	(0.3044)	(0.0685)	(0.3058)
lngdpper	0.0602***	1.9306***	0.0387	1.4311***
	(0.0218)	(0.2917)	(0.0247)	(0.2933)
ins	-0.0076	-0.7817***	0.0031	-0.4884***
	(0.0120)	(0.1523)	(0.0122)	(0.1559)
trade	0.0007	-0.1777**	-0.0066	-0.4056***
	(0.0106)	(0.0795)	(0.0102)	(0.0763)
net	-0.0013**	-0.0177***	-0.0017***	-0.0274***
	(0.0006)	(0.0066)	(0.0006)	(0.0073)
contig	0.0932***	2.2706***	0.0612*	1.5049***
	(0.0308)	(0.3585)	(0.0339)	(0.3577)
col	-0.0721***	-1.6401***	-0.0416*	-0.8802***
	(0.0234)	(0.3135)	(0.0248)	(0.3164)
lndist	0.0028	0.1361**	0.0056	0.1993***
	(0.0060)	(0.0666)	(0.0061)	(0.0667)
lnimpat			0.0127***	0.3253***
			(0.0025)	(0.0279)
_cons	-0.3956	-11.4270***	-0.1705	-5.8176*
	(0.3297)	(3.5323)	(0.3410)	(3.4306)
Firm FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	70822	70822	70822	70822
R^2	0.6850	0.5419	0.6855	0.5445

Note: *, ** and *** indicate p-values that are statistically significant at the 10 percent, 5 percent and 1 percent levels, respectively.

Table 3: Robustness test results of replacing the fixed effects model

	(1)	(2)	(3)	(4)
	div	lnEX	div	lnEX
lnexpat	0.0078***	0.1789***		
	(0.0005)	(0.0054)		
lngdpper	0.0518***	1.3643***	0.0382***	1.0416***
	(0.0042)	(0.0472)	(0.0044)	(0.0498)
ins	-0.0062***	-0.7230***	0.0015	-0.5456***
	(0.0022)	(0.0249)	(0.0021)	(0.0243)
trade	-0.0000	-0.2136***	-0.0058***	-0.3440***
	(0.0022)	(0.0248)	(0.0020)	(0.0232)
net	-0.0010***	-0.0023	-0.0013***	-0.0083***
	(0.0001)	(0.0015)	(0.0001)	(0.0016)
contig	0.0802***	1.6254***	0.0600***	1.1466***
	(0.0050)	(0.0572)	(0.0054)	(0.0612)
col	-0.0565***	-0.9183***	-0.0365***	-0.4484***
	(0.0053)	(0.0605)	(0.0055)	(0.0625)
lndist	0.0052***	0.2461***	0.0068***	0.2835***
	(0.0013)	(0.0144)	(0.0013)	(0.0145)
lnimpat			0.0087***	0.2031***
			(0.0005)	(0.0057)
_cons	-0.2001***	-3.1793***	-0.0341	0.7077
	(0.0383)	(0.4342)	(0.0398)	(0.4511)
Firm-Country FE	YES	YES	YES	YES
Firm-Year FE	YES	YES	YES	YES
N	70822	70822	70822	70822
R^2	0.7601	0.5795	0.7602	0.5805

Note: *, ** and *** indicate p-values that are statistically significant at the 10 percent, 5 percent and 1 percent levels, respectively.

3) Robustness test of winsorization treatment

In order to ensure the robustness of the findings, this study employs a 95% winsorization treatment in the regression analysis. The regression results from Table 5 after the winsorization treatment show that both the internationalized innovation activities of Chinese firms and the inflow of foreign technology have a significant and robust positive impact on the export performance of firms, which further verifies the reasonableness of the model setup.

Table 4: Robustness test results for replacing the independent variables

	(1)	(3)	(5)	(7)
	div	lnEX	div	lnEX
lnexpat_1	0.0094***	0.1603***		
	(0.0022)	(0.0168)		
roa	0.0023	0.2633***	0.0013	0.2487**
	(0.0128)	(0.1014)	(0.0128)	(0.1021)
size	-0.0055	-0.0099	-0.0044	0.0086
	(0.0110)	(0.0769)	(0.0111)	(0.0768)
lnsale	0.0159	0.2973***	0.0163	0.3038***
	(0.0119)	(0.0727)	(0.0118)	(0.0707)
lnage	-0.0022	0.0877	-0.0026	0.0810
	(0.0070)	(0.0573)	(0.0069)	(0.0531)
ww	-0.0022	0.3034	0.0030	0.4107
	(0.0750)	(0.3704)	(0.0762)	(0.3865)
lngdpper	0.0505**	1.3407***	0.0359	1.0485***
	(0.0197)	(0.1847)	(0.0224)	(0.1942)
ins	-0.0105	-0.7049***	-0.0015	-0.5526***
	(0.0102)	(0.0959)	(0.0106)	(0.0952)
trade	0.0043	-0.1990***	-0.0033	-0.3146***
	(0.0093)	(0.0545)	(0.0090)	(0.0520)
net	-0.0010*	-0.0019	-0.0012**	-0.0068
	(0.0005)	(0.0041)	(0.0005)	(0.0043)
contig	0.0829***	1.5160***	0.0605**	1.0819***
	(0.0272)	(0.2176)	(0.0296)	(0.2329)
col	-0.0598***	-0.9975***	-0.0372	-0.5770**
	(0.0211)	(0.2095)	(0.0230)	(0.2293)
lndist	0.0063	0.2232***	0.0078	0.2535***
	(0.0054)	(0.0480)	(0.0054)	(0.0489)
lnimpat_1			0.0100***	0.1810***
			(0.0022)	(0.0209)
_cons	-0.4524	-8.8494***	-0.2859	-5.7503**
	(0.2967)	(2.3127)	(0.3075)	(2.3387)
Firm FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	65106	65106	65106	651064
R^2	0.7347	0.5236	0.7348	0.5245

Note: *, ** and *** indicate p-values that are statistically significant at the 10 percent, 5 percent and 1 percent levels, respectively.

Table 5: Robustness test results of winsorization treatment

	(1)	(2)	(3)	(4)
	div_winsor	lnEX_winsor	div_winsor	lnEX_winsor
lnexpat	0.0089***	0.1388***		
	(0.0021)	(0.0159)		
roa	0.0028	0.1722*	0.0015	0.1520
	(0.0127)	(0.1018)	(0.0128)	(0.1018)
size	-0.0125	-0.0236	-0.0110	-0.0005
	(0.0107)	(0.0602)	(0.0107)	(0.0630)
lnsale	0.0160	0.2579***	0.0161	0.2596***
	(0.0120)	(0.0639)	(0.0118)	(0.0640)
lnage	0.0006	0.0498	0.0001	0.0422
	(0.0076)	(0.0483)	(0.0075)	(0.0479)
ww	-0.0177	0.2222	-0.0135	0.2868
	(0.0696)	(0.2919)	(0.0703)	(0.3028)
lngdpper	0.0460**	1.1279***	0.0289	0.8652***
	(0.0186)	(0.1673)	(0.0216)	(0.1745)
ins	-0.0062	-0.6481***	0.0028	-0.5081***
	(0.0098)	(0.0866)	(0.0101)	(0.0862)
trade	0.0008	-0.2014***	-0.0054	-0.3003***
	(0.0093)	(0.0512)	(0.0090)	(0.0490)
net	-0.0009*	0.0019	-0.0012**	-0.0030
	(0.0005)	(0.0038)	(0.0006)	(0.0039)
contig	0.0771***	1.3566***	0.0517*	0.9651***
	(0.0264)	(0.1982)	(0.0293)	(0.2088)
col	-0.0558***	-0.7907***	-0.0315	-0.4152**
	(0.0203)	(0.1925)	(0.0219)	(0.2074)
lndist	0.0051	0.2079***	0.0072	0.2395***
	(0.0054)	(0.0439)	(0.0055)	(0.0452)
lnimpat			0.0103***	0.1600***
			(0.0023)	(0.0190)
_cons	-0.2465	-5.4625**	-0.0752	-2.8169
	(0.3032)	(2.1620)	(0.3145)	(2.1595)
Firm FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	70822	70822	70822	70822
R^2	0.7206	0.5123	0.7208	0.5133

Note: *, ** and *** indicate p-values that are statistically significant at the 10 percent, 5 percent and 1 percent levels, respectively.

4.4 Heterogeneity tests based on national income level

This paper uses the World Bank's classification of countries, dividing the sample into high-income, middle-income, and low-income groups, and conducts separate regression analyses to examine the impact of multinational innovation on export product diversification. The regression results in Table 6 show that, in the high-income country group, both Chinese enterprises' overseas patent applications and foreign enterprises' patent applications in China significantly promote export product diversification. This indicates that innovation cooperation with high-income countries can effectively enhance enterprises' technological capabilities and product diversity. Moreover, the effect of foreign patent applications in China on export diversification is significant in both high-income and low-income countries, but not in middle-income countries, suggesting that there may be differences in knowledge spillover effects between high-income and low-income countries.

Table 6: Heterogeneity test results

	H	H	HM	HM	LM	LM
	(1)	(2)	(3)	(4)	(5)	(6)
	div	lnEX	div	lnEX	div	lnEX
lnexpat	0.0064**	0.1475***	0.0106**	0.0352	0.0180**	0.0701
	(0.0026)	(0.0281)	(0.0042)	(0.0285)	(0.0074)	(0.0436)
lnimpat	0.0061*	0.1884***	0.0011	0.0427	0.0111*	0.0780
	(0.0032)	(0.0323)	(0.0057)	(0.0370)	(0.0065)	(0.0571)
control	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
R^2	0.7625	0.5402	0.7513	0.6367	0.8654	0.7496

Note: *, ** and *** indicate p-values that are statistically significant at the 10 percent, 5 percent and 1 percent levels, respectively.

5. Conclusion

This paper discusses the impact of multinational innovation on enterprises' export diversification by manually collating multinational innovation data and measuring two indicators, namely export product diversification index and export intensity, and by constructing a multiple fixed-effects model. The main conclusions of this paper are as follows:

Firstly, the benchmark regression results show that cross-border innovation significantly promotes the diversification of enterprises' export products, especially foreign patent applications in China have a more significant effect on export diversification compared with Chinese enterprises' overseas patent applications, which suggests that technology introduction and localized innovation is an important way to enhance the export capability of enterprises, and the absorption of external advanced technological resources is crucial for enhancing the technological level and market competitiveness of enterprises. This indicates that technology introduction and localized innovation are important ways to enhance the export capability of enterprises, and the absorption of external advanced technology resources is crucial for enhancing the technological level and market competitiveness of enterprises.

Secondly, heterogeneity analysis based on the income level of countries shows that in the high-income country subgroup, both cross-border innovation modes, whether it is the overseas patent applications of Chinese enterprises or the patent applications of foreign enterprises in China, significantly and positively promote the diversification of export products. In addition, the contribution of foreign patent applications in China to the export diversification index is significant in both high-income and low-income countries, but the effect is not obvious in middle-income countries, suggesting that there may be differences in the knowledge spillover effects of innovation cooperation between high-income and low-income countries.

Based on main conclusions, policymakers should prioritize enhancing domestic absorptive capacity through targeted R&D subsidies and intellectual property protection reforms to maximize the technology spillover effects from foreign patent applications in China, particularly in high-income country collaborations. Governments should establish differentiated innovation cooperation frameworks: for high-income partners, deepen bilateral technology co-creation mechanisms through specialized innovation zones and joint patent pools; for low-income countries, develop phased technology transfer programs coupled with localized talent training to bridge implementation gaps. Enterprises, especially SOEs, need institutional reforms to emulate private firms' agility in assimilating foreign technologies, potentially through mixed-ownership incentives and cross-border innovation incubators. Multilateral financial institutions should create risk-sharing instruments to mitigate middle-income countries' innovation adoption barriers, addressing the observed implementation paradox through blended financing models that combine concessional loans with technical assistance packages.

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