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Foreignization and Innovation: Insights from Heterogenous Supply Chains

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Abstract

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Keywords: Innovation; Foreignization; Supply Chain; Ownership

JEL classification: O31, G32, R15

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1. Introduction

China has been facing great challenges in attracting Foreign Direct Investment (FDI) recently. As shown in Figure 1, after joining the World Trade Organization (WTO) in 2001, the inward flow of FDI to China surged, significantly boosting the country's innovation and economic growth (Chen et al., 2023). China emerged as the world's largest recipient of FDI inflows (BoP, current US$) in 2011[1]. However, this upward trend halted after the fourth quarter of 2013. Notably, the value of FDI inflows plummeted from $101.27 billion in the first quarter of 2022 to a negative $11.8 billion in the third quarter of 2023, which marked the first instance of negative FDI values in China since 1998.

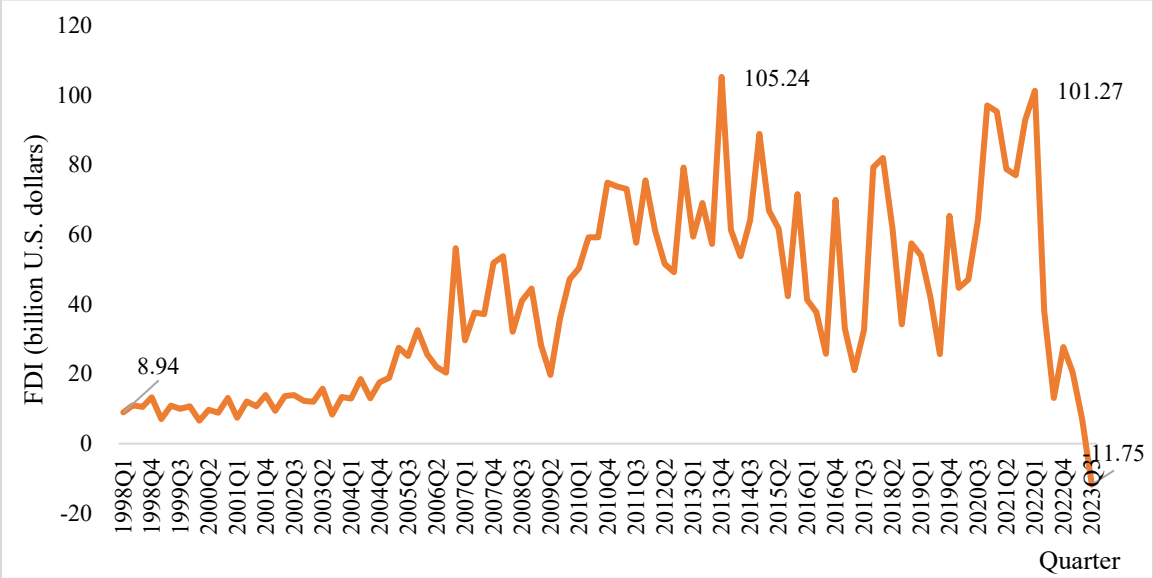

Figure 1: Value of FDI inflows to China (1998-2023, quarterly)

Source: Time-series balance of international payments (BPM6), released by China's State Administration of Foreign Exchange on December 29th, 2023, https://www.safe.gov.cn/safe/2019/0627/13519.html

What impact will this challenge have on China's future economic growth? To address this query, we conduct a comprehensive analysis of the effects of foreign shareholding on technological innovation within China, a key determinant of its long-term economic expansion. FDI often brings not only capital but also advanced technologies and management expertise, especially for developing economies (Guadalupe et al., 2012; Cheng et al., 2021).

[1] Source: https://data.worldbank.org/indicator/BX.KLT.DINV.CD.WD?locations=CN-US

Regarding dependent variable, we consider not only the quantity but also the quality of patents. Foreign shareholding, the independent variable, is a concept that, while closely related to FDI, differs from it. Changes in foreign shareholding can be regarded as a form of FDI, assuming the total amount of capital stock remains constant. In reality, the growth of FDI is frequently accompanied by an increase in the foreign shareholding, mainly because acquisitions are a prevalent method for multinationals to enter new markets (Guadalupe et al., 2012). However, FDI can also occur with an increase in a firm's total investments, even in the absence of any changes in foreign shareholding ratio. From a corporate governance standpoint, shareholding ratio influences the decision-making authority in a company, such as decisions related to engaging in innovation activities. Therefore, it could have a substantial impact on innovation. While FDI is usually analyzed at the region level, this paper offers an exploration of firm-level narratives across diverse dimensions, including ownership, province, and sector-specific aspects.

Shareholding is also closely linked with ownership. In China, a shareholding of 25% is classified as Foreign-Owned Enterprises (FOEs)[2], whereas this threshold is typically set at 50% in most countries. However, decision-making still requires ownership exceeding 50%. Yet, influencing decisions regarding innovation activities does not necessarily hinge on ownership surpassing 50%. Foreign capitals in firm with foreign shareholding less than 50% or even 25% may have still have some impact on innovation activities. We will investigate the impact of foreign shareholding in not only FOEs, but domestically-owned enterprises (DOEs). DOEs and FOEs differs greatly in management, technologies, regulations, etc. FOEs typically tend to adopt international management practices and more advanced technologies from their parent companies or multinational groups. Additionally, considering national security issues, the regulation of FOEs may be more stringent. Therefore, the role of foreign shareholdings in the two types of firms may vary significantly.

FOEs can be further subdivided into enterprises owned by Hong Kong, Macau, and Taiwan (HMTOEs)[3] and other foreign-owned enterprises (OFOEs). Foreign shareholding

[2] The Chinese government offers preferential policies to FOEs. To attract more foreign investments, China lowers the threshold for FOEs.

[3] The unique constitutional principle of "one country, two systems" in China delineates distinct economic institutions for HMT, which resemble those of developed countries, particularly with a higher degree of marketization compared

in HMTOEs may have a different impact on innovation compared to that in OFOEs for at least four reasons: (1) The cultural background and social environment of HMT bear similarities to mainland China. This similarity often facilitates a smoother adaptation and integration for investors from these regions when operating within mainland China. Conversely, OF investors typically encounter greater cultural disparities and language communication challenges. (2) While HMTOEs are basically export-oriented and motivated by cheap labors, OFOEs are more market-oriented (Zhang, 2005) because they have to adhere to international investment legal frameworks such as the rules of the World Trade Organization. (3) Compared with HMTOEs, OFOEs are more required to adhere to China's foreign investment access policies. Depending on the industry, there may be certain restrictions or special approval procedures in place for OFOEs. (4) HMTOE and OFOE have different distribution in regions and sectors (Chen et al., 2023), as well as supply chains. Hence, it is crucial to distinguish between them. However, this differentiation is not adequately explored in the current academic research related to FDI or ownership.

This paper contributes to the related literature in at least three ways: Firstly, we contribute to the literature on the innovation effect of FDI or foreign ownership by focusing on the pivotal role of supply chains. Although the influence of foreign shareholding on innovation within the host sector is well-documented, its effect on downstream innovation often goes unnoticed. Moreover, while the impact on immediate downstream firms might be easily recognized, the effects on indirectly linked downstream firms (such as the downstream of downstream firms) remain largely unexplored.

Secondly, we contribute to the literature on supply chains by considering the heterogeneity of ownerships. Most research papers using Chinese input-output tables are constrained to analyzing data along the dimensions of province and sector. However, innovation performance exhibits substantial variation across different ownership structures (Pan et al., 2022). Therefore, it is essential to include the ownership dimension in the innovation analysis.

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to mainland China. Within China's statistical framework, enterprises invested in or controlled by firms from these three regions are classified as FOEs.

Thirdly, we investigate the foreign shareholding in DOEs, an aspect that has been consistently overlooked. Given the definition's threshold for FOEs[4], an increase in foreign shareholding within DOEs is also a form of FDI. However, existing related studies either focus on multinationals (Crescenzi et al., 2015), equate the investment made by FOEs with FDI (Dai & Tanaka, 2023), or or study regional level FDI without considering ownership (Cheng et al., 2021).

The remainder of this paper is structured as follows: Section 2 outlines the data sources and matching process, along with the empirical models employed. Section 3 presents the empirical findings, including baseline regression results, robustness checks, analyses of heterogeneity, and examinations of endogeneity, among others. In Section 4, further discussions are provided, taking into account the influence of policies and institutions. This encompasses considerations of factors such as patent subsidy policies, intellectual property rights institutions, marketization, and corruption. Section 5 offers discussions on the key findings and their policy implications.

[4] Firms with foreign shareholding ratio more than 25% are defined as FOEs in China. However, the threshold is 50% for most countries.

2. Data and Model

2.1 Data

The calibration of the supply chains is conducted using the input-output tables obtained from Chen et al. (2023). This dataset is noteworthy as it provides ownership-related data for China's interprovincial IO tables, encompassing 42 sectors and 31 provinces across five benchmark years (1997, 2002, 2007, 2012, 2017). The ownership categories include DOE, HMTOE, and OFOE. With this vital information at our disposal, we are capable of examining the influence of FDI in the upstream sectors, taking into consideration the various ownership structures, on the innovation of the focal sector with distinct ownership characteristics. Given that the input-output structure tends to be relatively stable over time, we can extrapolate the data from discrete years to create a continuous series by applying the principle of proximity. For instance, we assume that the structure for the years 2005, 2006, 2008, and 2009 is identical to that of 2007, while the structure for the years 2010, 2011, 2013, and 2014 is considered to be the same as that in 2012.

The dependent variable—innovation in our study is measured using Chinese patent data. We utilize micro-level patent information spanning from 1995 to 2018, encompassing over 20 million records. This dataset includes three patent categories: invention patents, industrial design patents, and utility models. The extensive details provided on citations, claims, and international patent classifications (IPCs) enable us to develop a range of patent quality indicators, including exploring and exploiting innovation. Although the quantity of patents may not provide a compelling indicator of innovation, metrics that assess quality could offer a more convincing gauge. Such indicators have already been widely employed in existing literature (Pan et al., 2022).

The independent variable, foreign shareholding, is derived from firm-level data, including the Annual Survey of Industrial Firm Data (ASIF) and Chinese listed company data. The ASIF database covers nearly 5 million industrial firms above a specified size, with data ranging from 1995 to 2013. In contrast, the listed company data comprises only about 50 thousand records, but spans from 2007 to 2022. Despite its smaller sample size,

the listed company data is comprehensive, covering all sectors, including agriculture and services, and offers more recent information compared to ASIF.

The control variables in our analysis are primarily derived from the ASIF and China's listed company data. However, these sources lack information on imports and exports, which are significant factors influencing innovation. To address this gap, we match the firm data with HS (Harmonized Commodity) six-digit level China's customs data to acquire these variables. We categorize trade (imports and exports) into three types based on the classification by broad economic categories (BEC): intermediate goods, capital goods, and consumer goods. Given that innovation is intrinsically linked to production, intermediate goods and capital goods are more likely to influence innovation as compared to consumer goods.

For matching the patent data with the firm data, we employ the year and firm names as the linking variables. We aggregate our matched data and find that the outcomes are in accordance with the macro-level data released by the China National Intellectual Property Administration.

To match the customs data with the firm data, we initially use year and firm names as the key linking variable. For the unmatched portion of the sample, we then employ year, postal codes and telephone numbers as additional linking variables. In the final step of the matching process, we use year, postal codes and the names of the firms' representatives as the link variables. This method results in 846,644 successful firm-year matches for the period of 2000-2013. To incorporate the significant control variables—imports and exports, we had to reduce our final sample period to 2000-2013.

We consolidate the aforementioned firm-level data by aggregating it annually, and then categorize it by province-sector-ownership. Following this, we match this aggregated data with the supply chain data.

Table 1 presents descriptive statistics for the main variables used in our regression models.

Table 1: Descriptive Statistics

Variable	Obs	Mean	SD	Min	Max
$Innovation$	35,250,256	13.4524	27.6011	0.0000	72.0228
$Export$	35,250,256	11.8438	8.0961	0.0000	22.3307
$Import$	35,250,256	11.0717	7.9300	0.0000	22.1013
$Sale$	35,250,256	13.6397	4.2585	0.0000	19.7238
$R\&D$	35,250,256	5.3025	4.2585	0.0000	14.1385
$Kintensity$	35,250,256	8.1280	2.3360	2.0739	13.1798
FS	35,250,256	0.3586	0.3548	0.0000	1.0000
UP^{direct}	35,250,256	0.0000	0.0008	0.0000	0.8609
$UP^{indirect}$	35,250,256	0.0002	0.0121	0.0000	1.1793
FS_OF	35,250,256	0.1921	0.3015	0.0000	1.0000
UP^{direct}_OF	35,250,256	0.0000	0.0006	0.0000	0.8609
$UP^{indirect}\_OF$	35,250,256	0.0001	0.0086	0.0000	1.1632
FS_HMT	35,250,256	0.1664	0.2820	0.0000	1.0000
UP^{direct}_HMT	35,250,256	0.0000	0.0004	0.0000	0.3986
$UP^{indirect}\_HMT$	35,250,256	0.0001	0.0079	0.0000	1.1457

2.2 Model

Measure of FDI

The decision-making process of firms regarding innovation activities is significantly influenced by their stakeholders. Consequently, variations in the share of foreign paid-in capital, which significantly mirror the effects of firm-level FDI, is likely to affect innovation. The firm data includes various classifications of paid-in capital based on ownership. We consolidate these into three categories: DOE, HMTOE, and OFOE.

The data from listed companies includes details about their five largest suppliers and customers, enabling firm-level analysis of supply chains. However, this dataset does not include information on suppliers and customers outside the top five, nor does it cover indirect suppliers and customers. To overcome this limitation, we utilize input-output tables, which are capable of capturing both direct and indirect supply chain relationships.

Consequently, we have to aggregate the firm-level data on the share of foreign paid-in capital to a more macroscopic province-sector-ownership level. This is achieved by using the ratio of each firm's paid-in capital to the total paid-in capital of its respective province-sector-ownership as a weighting factor.

Regression model

We index the sector by i and j, ownership by o and p, and province by r and s. Additionally, we employ the symbols j, o and r to denote sector-ownership-province of the target sector, while i, p and s are utilized to represent the upstream sector. t indicates the year in question. We use V and X to signify the nominal value added and output, respectively. M refers to the inflow of intermediate goods from other provinces. Furthermore, FS represents the foreign shareholding ratio.

Sector i has the capacity to directly supply intermediate goods to sector j, thereby acting as its direct upstream sector. In addition, sector i can provide intermediate goods to the suppliers of sector j, thus serve as an indirect upstream sector for sector j. Leontief inverse matrix of the input-output table encapsulates both direct and indirect upstream effects.

UP^{direct} is measured as the weighted foreign shareholding in direct upstream sectors, with direct input coefficient $\frac{M_{ips,jor,t}^{direct}}{X_{jor,t}}$ as the weight. $UP^{indirect}$ is measured as the weighted foreign shareholding in indirect upstream sectors, with the gap between Leontief inverse and direct input coefficient $\left(\frac{M_{ips,jor,t}}{X_{jor,t}} - \frac{M_{ips,jor,t}^{direct}}{X_{jor,t}}\right)$ as the weight.

$$Up_{jor,t}^{direct} = \sum_{ips} \frac{M_{jor,t}^{direct}}{X_{jor,t}} \frac{M_{ips,jor,t}^{direct}}{\sum_{ips} M_{ips,jor,t}^{direct}} \cdot FS_{ips,t} = \sum_{ips} \frac{M_{ips,jor,t}^{direct}}{X_{jor,t}} \cdot FS_{ips,t} \quad (1)$$

$$Up_{jor,t}^{indirect} = Up_{jor,t} - Up_{jor,t}^{direct} = \sum_{ips} \left(\frac{M_{ips,jor,t}}{X_{jor,t}} - \frac{M_{ips,jor,t}^{direct}}{X_{jor,t}}\right) \cdot FS_{ips,t} \quad (2)$$

The regression analysis can be carried out based on equation (3). The dependent variable $y_{jor,t}$ signifies the innovation metrics (quantity, quality) of sector j ownership o in province r for the year t. β_1 quantifies the impact of FDI within the focal sector, β_2 captures the direct effects of FDI in the upstream sectors, β_3 measures the indirect effects of FDI in the upstream sectors.

Control variables, which could potentially influence innovation outcomes, are included in $\sum \gamma X_{jor,t}$, such as profit rate, export, import, and global value chain (GVC) position, among others. α is the intercept term and $\varepsilon_{jor,t}$ is the random error term.

$$y_{jor,t} = \alpha + \beta_1 FS_{jor,t} + \beta_2 Up_{jor,t}^{direct} + \beta_3 Up_{jor,t}^{indirect} + \sum \gamma X_{jor,t} + \varepsilon_{jor,t} \quad (3)$$

Concerning heterogeneity, our analysis can be extended to explore how foreign shareholding across different types of firm ownership affects companies with varied ownership structures. For further discussions, we investigate the role of governmental and market institutions in shaping innovation outcomes. We consider three key factors: patent subsidy policy, intellectual property institution, and marketization level.

3. Empirical Evidence

3.1 Baseline regression

In term of the dependent variable, we will use patent quantity and quality-weighted patent quantity to measure innovation in our baseline regression. Initially, innovation is represented by the quantity of patents. The primary explanatory variables consist of the FS in the target sector, as well as UP^{direct} and $UP^{indirect}$ in upstream sectors. We incrementally incorporate these three explanatory variables into the regression model. Logarithms are applied to both the dependent variable and all six variables. Additionally, the six control variables are consistently included in all models.

Table 1 illustrates that the coefficient of FS remains consistently significant and positive across all models, indicating the positive impact of foreignization in the target sector on innovation. Furthermore, the coefficient of UP^{direct} is significantly positive, suggesting that foreignization in upstream sectors also positively influences innovation. Consequently, disregarding the impact of upstream sectors would lead to an underestimation of the effect of foreignization on innovation. However, the coefficient of $UP^{indirect}$ is insignificant. This implies that the influence of foreign shareholding on downstream innovations is confined to the direct downstream sectors.

The coefficients of all the control variables are significant and positive. The positive coefficient of $Export$ aligns with the demand-pull hypothesis initially proposed by Schmookler (1966), indicating that an increase in market demand promotes innovation. The positive impact of $Import$ is consistent with the findings of Bloom et al. (2016). Generally, higher sales indicate that the firm has more profits available to invest in innovation activities, which explains the positive coefficient of $Sale$. R&D is a necessary input for innovation output and is typically regarded as a factor in the innovation production function (De Rassenfosse & de la Potterie, 2009; Antonelli & Fusillo, 2023), which explains the positive coefficient of $R\&D$. In general, capital-intensive sectors are more likely to engage in innovation activities, compared with labor-intensive sectors, which explains the positive coefficient of $Kintensity$.

Given the variation in quality among patents, it's imperative to consider patent quality when measuring innovation using patent data. We utilize quality-weighted patent quantity

in our analysis as most literature do (Cheng et al., 2020). Remarkably, our findings remain consistent even when accounting for patent quality.

Table 1: Foreignization Effect on Innovation (Quantity & Quality)

Variables	Innovation (quality-weighted patent quantity)		
FS	0.4421***	0.4418***	0.4420***
	(0.0166)	(0.0166)	(0.0166)
UP^{direct}		34.6929***	35.2919***
		(8.0832)	(8.1634)
$UP^{indirect}$			-0.2886
			(0.4252)
$Export$	0.1216***	0.1216***	0.1216***
	(0.0009)	(0.0009)	(0.0009)
$Import$	0.1377***	0.1377***	0.1377***
	(0.0009)	(0.0009)	(0.0009)
$Sale$	0.7393***	0.7392***	0.7392***
	(0.0037)	(0.0037)	(0.0037)
$R\&D$	1.2191***	1.2191***	1.2191***
	(0.0017)	(0.0017)	(0.0017)
$Kintensity$	1.7305***	1.7305***	1.7305***
	(0.0038)	(0.0038)	(0.0038)
Year	Yes	Yes	Yes
Sector	Yes	Yes	Yes
Own	Yes	Yes	Yes
N	35250256	35250256	35250256

3.2 Foreign shareholding: OF v.s. HMT

Table 2 illustrates that HMT shareholding in a target sector fosters innovation, while OF shareholding in the target sector tends to inhibit innovation. This indicates that investments from HMT regions are more inclined to participate in innovation activities in China compared to investments from OF economies. Typically, the technology of foreign-owned companies is readily available, originating from their parent companies abroad, and they have little motivation to innovate in the host country. Regarding the direct upstream sectors, HMT shareholding tends to impede innovation in the target sectors, whereas OF shareholding has no significant impact on innovation. This means that firms with higher OF shareholding tend to provide higher quality intermediate goods to downstream sectors, compared with firms with higher HMT shareholding. Additionally, neither HMT nor OF shareholdings in the indirect upstream sectors have a significant impact on innovation in the target sector. This further suggests that the influence of foreign shareholding on downstream sectors faces challenges in transmission through complex supply chains.

Table 2: Foreignization Effect on Innovation (Quantity & Quality): OF v.s. HMT

Variables	Innovation (quality-weighted patent quantity)		
FS_OF	-0.7464***	-0.7466***	-0.7463***
	(0.0206)	(0.0206)	(0.0206)
UP^{direct}_OF		47.5918***	48.8117***
		(10.6963)	(10.8835)
$UP^{indirect}\_OF$			-0.5788
			(0.5661)
FS_HMT	1.6089***	1.6087***	1.6087***
	(0.0200)	(0.0200)	(0.0200)
UP^{direct}_HMT		13.0930	12.9931
		(12.7410)	(12.7660)
$UP^{indirect}\_HMT$			0.0368
			(0.6119)
$Export$	0.1213***	0.1213***	0.1213***
	(0.0009)	(0.0009)	(0.0009)
$Import$	0.1380***	0.1379***	0.1379***
	(0.0009)	(0.0009)	(0.0009)
$Sale$	0.7477***	0.7476***	0.7476***
	(0.0037)	(0.0037)	(0.0037)
$R\&D$	1.2192***	1.2192***	1.2192***
	(0.0017)	(0.0017)	(0.0017)
$Kintensity$	1.7279***	1.7279***	1.7279***
	(0.0038)	(0.0038)	(0.0038)
N	35250256	35250256	35250256

3.3 Heterogeneity in firm ownership

Foreign investments are present not only in FOEs but also in DOEs. Typically, foreign shareholding in DOEs tends to be lower compared to that in FOEs, and foreign capital may exert varying influences on firms with different ownership structure. In this study, we undertake a heterogeneity analysis focusing on firm ownership, making a clear distinction between DOEs, and two types of FOEs (i.e. OFOEs and HMTOEs).

3.3.1 Ownership

Table 3 displays the results of the innovation effects of foreignization in DOEs, OFOE and HMTOEs, respectively. Foreignization in DOEs within the target sector exhibits a significantly negative impact on innovation. However, the foreignization in the upstream DOEs shows a positive effect on the innovation of the target sector. In addition, the foreign shareholding in the indirect upstream sectors does not show a significant effect on the innovation of the target sector.

Foreignization in OFOEs and HMTOEs within the target sector demonstrates a significantly positive impact on innovation. Additionally, the foreignization in the direct upstream OFOEs and HMTOEs also positively influences the innovation of the target sector. While foreign shareholding in the indirect upstream OFOEs exhibits a significantly negative effect on innovation of the target sector, that in the indirect upstream HMTOEs does not show a significant effect on innovation within the target sector.

Table 3: Foreignization Effect on Innovation (Quantity & Quality)

Variables	Innovation (quality-weighted patent quantity)		
	DOE	OFOE	HMT
FS	-10.8658***	2.9069***	2.6537***
	(0.1446)	(0.0224)	(0.0209)
UP^{direct}	25.92*	63.6721***	30.1676**
	(15.2085)	(14.9114)	(11.8584)
$UP^{indirect}$	4.0646	-0.9134*	-0.2763
	(6.8310)	(0.5497)	(0.5989)
$Export$	0.2173***	0.0671***	0.1112***
	(0.0017)	(0.0012)	(0.0010)
$Import$	0.2654***	-0.1758***	-0.0225***
	(0.0016)	(0.0011)	(0.0011)
$Sale$	1.4420***	0.9717***	0.8851***
	(0.0075)	(0.0060)	(0.0051)
$R\&D$	1.1304***	1.2092***	1.3821***
	(0.0028)	(0.0028)	(0.0031)
$Kintensity$	1.6388***	2.1601***	1.5007***
	(0.0074)	(0.0062)	(0.0051)
N	14509564	10541728	10198964

3.3.2 Ownership and foreign shareholding

Both OF and HMT shareholding in DOEs are responsible for the negative effect of foreignization. The positive direct upstream effect of DOEs is driven by an increase of OF shareholding in upstream DOEs.

Both OF and HMT shareholding in OFOEs contribute to the positive effect of foreignization. OF shareholding playing a more prominent role in this positive upstream effect compared to HMT shareholding in direct upstream OFOEs. In addition, OF shareholding is responsible for the negative indirect effect in OFOEs.

HMT shareholding in HMTOEs contributes positively to innovation, whereas OF shareholding in HMTOEs has a negative effect. The positive direct upstream effect is driven by an increase in OF shareholding, rather than HMT shareholding in the direct upstream HMTOEs.

Whereas HMT shareholding in OFOEs contributes positively to the innovation of OFOEs, OF shareholding in HMTOEs have a negative impact on the innovation of HMTOEs. This suggests that capitals from other countries are very cautious when it comes to engaging in innovation activities in China, compared to capitals from HMT regions.

Table 4: Foreignization Effect on Innovation (Quantity & Quality): OF v.s. HMT

Variables	Innovation (quality-weighted patent quantity)		
	DOE	OFOE	HMTOE
FS_OF	-4.5939***	2.9260***	-0.3874***
	(0.2165)	(0.0230)	(0.0347)
UP^{direct}_OF	47.6056***	78.9450***	31.5256**
	(18.1018)	(20.1616)	(15.6086)
$UP^{indirect}\_OF$	2.0473	-1.1612**	0.0442
	(11.0056)	(0.5744)	(1.2755)
FS_HMT	-16.9717***	2.7947***	2.9997***
	(0.1739)	(0.0385)	(0.0214)
UP^{direct}_HMT	-8.1518	41.2435*	26.0453
	(24.0068)	(22.1531)	(18.3604)
$UP^{indirect}\_HMT$	6.2818	0.1148	-0.2855
	(7.2457)	(1.3965)	(0.6080)
$Export$	0.2171***	0.0673***	0.1115***
	(0.0017)	(0.0012)	(0.0010)
$Import$	0.2664***	-0.1767***	-0.0210***
	(0.0016)	(0.0011)	(0.0011)
$Sale$	1.4423***	0.9733***	0.8878***
	(0.0075)	(0.0060)	(0.0051)
$R\&D$	1.1299***	1.2091***	1.3761***
	(0.0028)	(0.0028)	(0.0031)
$Kintensity$	1.6391***	2.1627***	1.4974***
	(0.0074)	(0.0062)	(0.0051)
N	14509564	10541728	10198964

4. Further Discussions

Governmental and market institutions are crucial determinants in shaping innovation outcomes. This paper delves into two key factors: patent subsidy policy, intellectual property institution. On one hand, to accelerate the promotion of patent growth, Shanghai initiated its first pilot patent funding policy in 1999. By 2007, this policy had been expanded almost nationwide, with the subsidy amount for patents continuously increasing. On the other hand, since joining the World Trade Organization, China has actively fulfilled its international obligations to protect intellectual property rights by extensively revising laws and regulations related to intellectual property, including the Patent Law.

We manually collected patent subsidy policy data from 1999 to 2020 across 351 prefecture-level cities nationwide. The primary sources of data were various prefecture-level city government websites, including that of general administrations, science and technology bureaus, intellectual property bureaus, finance bureaus, and market supervision administrations, supplemented by other publicly available sources. Throughout the process of constructing this database, over 1500 policy documents were amassed, resulting in a corpus exceeding 2 million words.

Following the approach of Fang et al. (2017), this study utilizes the Intellectual Property Protection Index of 61 prefecture-level cities from the "China Urban Competitiveness Report" (2002-2010) published by the Chinese Academy of Social Sciences to measure the intellectual property institution. For data before 2002 and after 2010, a temporal extension method is applied, and for cities not included in the report, estimates are made using methods such as distance estimation and jurisdictional inference. Subsequently, the data is aggregated to the provincial level to align with our primary dataset.

Table 6 presents the outcomes obtained after incorporating the interaction term between foreign shareholding and patent subsidy. The coefficients of foreign shareholding are basically in line with those in the baseline regression model. The interaction term demonstrates a significantly positive coefficient for the target sector, indicating the promotional effect of patent subsidy policies, which aligns with the findings in the existing literature. However, the coefficient of the interaction term for the direct upstream sectors is significantly negative. This suggests that while patent subsidy policies may have

encouraged innovation in the upstream sectors, such innovation might not necessarily translate into improved product quality. In essence, subsidies aimed at the upstream sectors may not effectively enhance the quality of intermediate goods for downstream sectors.

Table 7 displays the results after adding the interaction term between foreign shareholding and intellectual property institution. The coefficients of foreign shareholding provide additional confirmation of the robustness of the baseline regression. The interaction term demonstrates a significantly negative coefficient for both the target sector and direct upstream sectors. The indicator of intellectual property institution is represented as a ranking, where a smaller indicator denotes a stronger intellectual property institution. Thus, a negative coefficient indicates a positive impact of intellectual property institution on innovation. In contrast to patent subsidy policies, the enhancement of intellectual property institutions in upstream sectors (or provinces) yields a positive impact on downstream sectors.

Table 6: The Role of Patent Subsidy Policy

Variables	Innovation (quality-weighted patent quantity)		
FS	0.2328***	0.2312***	0.2317***
	(0.0177)	(0.0177)	(0.0177)
$FS\_Subsidy$	0.0002***	0.0002***	0.0002***
	(0.0000)	(0.0000)	(0.0000)
UP^{direct}		107.9861***	110.7030***
		(13.6650)	(14.0930)
$UP^{direct}\_Subsidy$		-0.0446***	-0.0459***
		(0.0051)	(0.0052)
$UP^{indirect}$			-0.8940*
			(0.5160)
$UP^{indirect}\_Subsidy$			0.0004
			(0.0003)
$Export$	0.1216***	0.1216***	0.1216***
	(0.0009)	(0.0009)	(0.0009)
$Import$	0.1373***	0.1373***	0.1373***
	(0.0009)	(0.0009)	(0.0009)
$Sale$	0.7372***	0.7371***	0.7371***
	(0.0037)	(0.0037)	(0.0037)
$R\&D$	1.2183***	1.2183***	1.2183***
	(0.0017)	(0.0017)	(0.0017)
$Kintensity$	1.7279***	1.7279***	1.7279***
	(0.0038)	(0.0038)	(0.0038)
N	35250256	35250256	35250256

Table 7: The Role of Intellectual Property Institution

Variables	Innovation (quality-weighted patent quantity)		
FS	9.9994***	9.9970***	9.9981***
	(0.0288)	(0.0288)	(0.0288)
FS_IP	-0.2769***	-0.2769***	-0.2769***
	(0.0007)	(0.0007)	(0.0007)
UP^{direct}		116.4164***	121.8800***
		(21.9530)	(22.8009)
UP^{direct}_IP		-3.1873***	-3.3543***
		(0.6654)	(0.6875)
$UP^{indirect}$			-2.0404**
			(0.9804)
$UP^{indirect}\_IP$			0.0557**
			(0.0259)
$Export$	0.1181***	0.1181***	0.1181***
	(0.0008)	(0.0008)	(0.0008)
$Import$	0.1209***	0.1209***	0.1209***
	(0.0009)	(0.0009)	(0.0009)
$Sale$	0.6868***	0.6868***	0.6868***
	(0.0037)	(0.0037)	(0.0037)
$R\&D$	1.1846***	1.1846***	1.1846***
	(0.0017)	(0.0017)	(0.0017)
$Kintensity$	1.6295***	1.6296***	1.6296***
	(0.0038)	(0.0038)	(0.0038)
N	35250256	35250256	35250256

5. Concluding remarks

Our research yields five significant insights: (1) A rise in foreign shareholding correlates with an enhancement in innovation, as measured by quality-adjusted patent counts, within the target firms. Foreignization in upstream sectors also exerts a positive influence on innovation in downstream sectors. This highlights the crucial insight that overlooking the cascading effects through supply chains would lead to a significant underestimation of the pivotal role played by foreign shareholding in promoting innovation. However, this effect is primarily manifested through direct supply chains rather than indirect ones.

(2) Investments from HMT regions are more inclined to participate in innovation activities in China compared to investments from OF economies. However, firms with higher OF shareholding tend to provide higher quality intermediate goods to downstream sectors, compared with firms with higher HMT shareholding. Typically, the technology of foreign-owned companies is readily available, originating from their parent companies abroad, and they have little motivation to innovate in the host country.

(3) While foreignization in DOEs have negative impact on innovation, that in FOEs (including OFOEs and HMTOEs) have positive impact on innovation. The increase in foreign shareholding contributes to innovation only when firms are owned by foreign capitals. In addition, the augmentation of foreign shareholding in OFOEs confers more pronounced benefits on both recipient and downstream firms than does a similar increase in HMTOEs.

(4) Whereas HMT shareholding in OFOEs contributes positively to the innovation of OFOEs, OF shareholding in HMTOEs have a negative impact on the innovation of HMTOEs. This suggests that capitals from other countries are very cautious when it comes to engaging in innovation activities in China, compared to capitals from HMT regions.

(5) Patent subsidy policies foster innovation in the target province. However, subsidies directed at upstream provinces may not effectively improve the quality of intermediate goods for downstream provinces, consequently having no impact on downstream innovations. In comparison, the enhancement of intellectual property institutions yields a positive impact on innovation both directly and through supply chains. This suggests that

a well-developed institution enhances the ability of foreign shareholding to effectively contribute to innovation.

China has been shifting from foreignization to domestication, especially since recent years. This transition, whether proactive or reactive, has resulted in a decrease in FDI dividend. Consequently, the Central Government of China introduced the principle of "dual circulation," emphasizing the primary focus on domestic circulation, with both domestic and international circulations mutually reinforcing each other. The empirical findings presented in this paper yield several policy implications for China to address the emerging trend:

(1) Tailoring policies to support and integrate foreign investment within supply chains can enhance innovation. Foreignization remains a crucial strategy for promoting innovation, thereby supporting long-term economic growth. Attracting foreign investment with a focus on the needs of domestic supply chains can optimize the benefits derived from FDI. Supply chains should be given significant consideration when assessing the potential impacts of foreign investment withdrawal prior to policy formulation. This approach ensures that foreign investment aligns with the strategic sectors and stages of supply chains that are critical for domestic economic development and resilience.

(2) The distinct roles and impacts of OFOEs and HMTOEs should be carefully considered in policy-making processes in order to maximize their positive effects on fostering innovation. OF shareholdings is still prudent in engaging in innovation activities in China, compared to HMT shareholdings, but OF shareholdings do possess advantages over HMT shareholdings in terms of providing high-quality intermediate goods. Recognizing the unique contributions and potential challenges posed by these two categories of foreign investment can enable more targeted and effective policy strategies.

(3) Enhancing market mechanisms and legal infrastructures for intellectual property rights ought to be the focus of China's reform efforts to maximize the benefits derived from FDI. The implementation of patent subsidy policies should be approached with caution, considering their limited impact through supply chains and high costs.

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Appendix

Table A1: Foreignization Effect on Innovation (Quantity)

Variables	Innovation (patent quantity)		
FS	0.4364***	0.4361***	0.4363***
	(0.0200)	(0.0200)	(0.0200)
UP^{direct}		35.8610***	36.6341***
		(7.5544)	(7.6644)
$UP^{indirect}$			-0.3572
			(0.4688)
$Export$	0.1823***	0.1823***	0.1823***
	(0.0010)	(0.0010)	(0.0010)
$Import$	0.2589***	0.2589***	0.2589***
	(0.0011)	(0.0011)	(0.0011)
$Sale$	1.2046***	1.2046***	1.2046***
	(0.0042)	(0.0042)	(0.0042)
$R\&D$	1.6673***	1.6673***	1.6673***
	(0.0020)	(0.0020)	(0.0020)
$Kintensity$	1.9938***	1.9938***	1.9938***
	(0.0042)	(0.0042)	(0.0042)
Year	Yes	Yes	Yes
Sector	Yes	Yes	Yes
Own	Yes	Yes	Yes
N	35250256	35250256	35250256

Table A2: Foreignization Effect on Innovation (Quantity): OF v.s. HMT

Variables	Innovation (patent quantity)		
FS_OF	-0.7805***	-0.7808***	-0.7804***
	(0.0247)	(0.0247)	(0.0247)
UP^{direct}_OF		48.4721***	49.9420***
		(10.1440)	(10.3902)
$UP^{indirect}\_OF$			-0.6714
			(0.6464)
FS_HMT	1.6332***	1.6329***	1.6329***
	(0.0239)	(0.0239)	(0.0239)
UP^{direct}_HMT		14.6182	14.6027
		(12.6169)	(12.7071)
$UP^{indirect}\_HMT$			(0.0026)
			(0.6735)
$Export$	0.1820***	0.1820***	0.1820***
	(0.0010)	(0.0010)	(0.0010)
$Import$	0.2591***	0.2591***	0.2591***
	(0.0011)	(0.0011)	(0.0011)
$Sale$	1.2133***	1.2132***	1.2132***
	(0.0042)	(0.0042)	(0.0042)
$R\&D$	1.6675***	1.6675***	1.6675***
	(0.0020)	(0.0020)	(0.0020)
$Kintensity$	1.9917***	1.9917***	1.9917***
	(0.0042)	(0.0042)	(0.0042)
N	35250256	35250256	35250256

Table A3a: DOE Foreignization Effect on Innovation (Quantity)

Variables	Innovation (patent quantity)		
FS	-3.6912***	-3.6932***	-3.6957***
	(0.1914)	(0.1914)	(0.1914)
UP^{direct}		23.2874*	20.2660
		(12.8056)	(14.1886)
$UP^{indirect}$			4.7992
			(8.6285)
$Export$	0.1528***	0.1528***	0.1528***
	(0.0020)	(0.0020)	(0.0020)
$Import$	0.5561***	0.5561***	0.5561***
	(0.0019)	(0.0019)	(0.0019)
$Sale$	2.0371***	2.0371***	2.0371***
	(0.0081)	(0.0081)	(0.0081)
$R\&D$	1.4391***	1.4391***	1.4391***
	(0.0035)	(0.0035)	(0.0035)
$Kintensity$	1.8813***	1.8813***	1.8813***
	(0.0077)	(0.0077)	(0.0077)
N	14509564	14509564	14509564

Table A3b: DOE Foreignization Effect on Innovation (Quantity): OF v.s. HMT

Variables	Innovation (patent quantity)		
FS_OF	3.8459***	3.8427***	3.8410***
	(0.2361)	(0.2361)	(0.2362)
UP^{direct}_OF		42.7437***	40.3490**
		(15.4669)	(17.9713)
$UP^{indirect}\_OF$			3.6370
			(12.1606)
FS_HMT	-11.1344***	-11.1346***	-11.1382***
	(0.2416)	(0.2417)	(0.2417)
UP^{direct}_HMT		-7.3986	-11.2180
		(23.6031)	(24.9185)
$UP^{indirect}\_HMT$			6.4386
			(10.0345)
$Export$	0.1528***	0.1528***	0.1528***
	(0.0020)	(0.0020)	(0.0020)
$Import$	0.5569***	0.5569***	0.5569***
	(0.0020)	(0.0020)	(0.0020)
$Sale$	2.0355***	2.0355***	2.0355***
	(0.0082)	(0.0082)	(0.0082)
$R\&D$	1.4398***	1.4398***	1.4398***
	(0.0034)	(0.0034)	(0.0034)
$Kintensity$	1.8804***	1.8804***	1.8804***
	(0.0077)	(0.0077)	(0.0077)
N	14509564	14509564	14509564

Table A4a: OFOE Foreignization Effect on Innovation (Quantity)

Variables	Innovation (patent quantity)		
FS	2.8804***	2.8801***	2.8806***
	(0.0286)	(0.0286)	(0.0286)
UP^{direct}		59.4856***	63.9346***
		(13.2156)	(13.6449)
$UP^{indirect}$			-0.9339
			(0.6149)
$Export$	0.2266***	0.2266***	0.2266***
	(0.0015)	(0.0015)	(0.0015)
$Import$	-0.2253***	-0.2253***	-0.2253***
	(0.0014)	(0.0014)	(0.0014)
$Sale$	1.2863***	1.2861***	1.2861***
	(0.0068)	(0.0068)	(0.0068)
$R\&D$	1.6027***	1.6027***	1.6027***
	(0.0034)	(0.0034)	(0.0034)
$Kintensity$	2.8951***	2.8950***	2.8950***
	(0.0068)	(0.0068)	(0.0068)
N	10541728	10541728	10541728

Table A4b: OFOE Foreignization Effect on Innovation (Quantity): OF v.s. HMT

Variables	Innovation (patent quantity)		
FS_OF	2.8988***	2.8984***	2.8990***
	(0.0292)	(0.0292)	(0.0292)
UP^{direct}_OF		68.2924***	76.9276***
		(16.8538)	(17.3046)
$UP^{indirect}\_OF$			-1.1510*
			(0.6550)
FS_HMT	2.8111***	2.8984***	2.8110***
	(0.0493)	(0.0292)	(0.0493)
UP^{direct}_HMT		68.2924***	45.0030**
		(16.8538)	(21.8608)
$UP^{indirect}\_HMT$			0.0244
			(1.7386)
$Export$	0.2270***	0.2270***	0.2270***
	(0.0015)	(0.0015)	(0.0015)
$Import$	-0.2264***	-0.2264***	-0.2264***
	(0.0014)	(0.0014)	(0.0014)
$Sale$	1.2882***	1.2881***	1.2881***
	(0.0069)	(0.0069)	(0.0069)
$R\&D$	1.6026***	1.6026***	1.6026***
	(0.0034)	(0.0034)	(0.0034)
$Kintensity$	2.8989***	2.8989***	2.8989***
	(0.0068)	(0.0068)	(0.0068)
N	10541728	10541728	10541728

Table A5a: HMTOE Foreignization Effect on Innovation (Quantity)

Variables	Innovation quantity		
FS	3.3538***	3.3534***	3.3535***
	(0.0261)	(0.0261)	(0.0261)
UP^{direct}		37.0429***	37.7464***
		(12.2539)	(12.3493)
$UP^{indirect}$			-0.2676
			(0.6451)
$Export$	0.2347***	0.2347***	0.2347***
	(0.0014)	(0.0014)	(0.0014)
$Import$	0.0273***	0.0273***	0.0273***
	(0.0015)	(0.0015)	(0.0015)
$Sale$	1.3392***	1.3392***	1.3392***
	(0.0060)	(0.0060)	(0.0060)
$R\&D$	2.0069***	2.0069***	2.0069***
	(0.0037)	(0.0037)	(0.0037)
$Kintensity$	1.6766***	1.6766***	1.6766***
	(0.0065)	(0.0065)	(0.0065)
N	10198964	10198964	10198964

Table A5b: HMTOE Foreignization Effect on Innovation (Quantity): OF v.s. HMT

Variables	innovation quantity		
FS_OF	0.4343***	0.4340***	0.4340***
	(0.0451)	(0.0451)	(0.0451)
UP^{direct}_OF		40.6184**	40.5248**
		(16.5429)	(16.5850)
$UP^{indirect}\_OF$			0.0801
			(1.6490)
FS_HMT	3.6834***	3.6831***	3.6832***
	(0.0265)	(0.0265)	(0.0265)
UP^{direct}_HMT		29.3226	30.9709
		(20.2345)	(20.3340)
$UP^{indirect}\_HMT$			-0.2595
			(0.6856)
$Export$	0.2350***	0.2350***	0.2350***
	(0.0014)	(0.0014)	(0.0014)
$Import$	0.0287***	0.0287***	0.0287***
	(0.0015)	(0.0015)	(0.0015)
$Sale$	1.3424***	1.3424***	1.3423***
	(0.0060)	(0.0060)	(0.0060)
$R\&D$	2.0009***	2.0009***	2.0009***
	(0.0037)	(0.0037)	(0.0037)
$Kintensity$	1.6737***	1.6737***	1.6737***
	(0.0065)	(0.0065)	(0.0065)
N	10198964	10198964	10198964