

# Impact of Industrial Policies on the Regional Reverse Technology Spillover from OFDI

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**Abstract.** By sorting out the important industries mentioned in China's "11th Five-Year Plan" and "12th Five-Year Plan" and utilizing inter-provincial OFDI panel data from 2006-2015, this paper examines whether industrial policies effectively promote reverse technology spillovers from OFDI channel through a linear regression using the fixed effects model. In addition, this paper also examines the heterogeneity of industrial policy implementation by policy sources and regions, proving the robustness of the results. The empirical results show that industrial preferential policies have significantly promoted local OFDI reverse technology spillover, and the effect differed significantly between regions. The rationalisation of industrial structure, the regional economic growth and regional openness all have a positive impact on OFDI reverse technology spillover. Finally, in order to contribute to China's high-quality economic development, this paper puts forward some suggestions on how to implement industrial policies more effectively.

**Keywords:** Industrial Policy; OFDI; Reverse Technology Spillovers; Inter-industry Resource Allocation.

## 1. Introduction

With the development of the "Go Global" and "One Belt, One Road" strategies, the scale of China's OFDI continues to increase. According to the 2017 statistical bulletin of China's OFDI, by the end of 2017 a total of 25,500 domestic institutional investors had gone abroad and established 39,200 enterprises in host countries, spreading across 189 countries and regions. The OFDI stock surged from US\$33.22 billion in 2003 to US\$1,809.04 billion in 2017, which is a 54.5-fold increase compared to 2003, accounting for 5.9% of the global stock of OFDI. For three consecutive years from 2015 to 2017, China's OFDI investment stock exceeded that of FDI, making it a net exporter of capital.

The rapid development of OFDI is inseparable from the support of industrial policies and the needs of domestic industrial development. During the "11th Five-Year Plan" and "12th Five-Year Plan" period, governments at all levels in China proposed a series of industrial policies in relevant industrial fields, accurately guiding resources and factors, which largely encouraged the active participation of enterprises in international innovation cooperation and strengthened international specialized division of labor. Therefore, industrial preferential policies did have a crucial effect on the expansion and structural optimisation of OFDI in related industries.

In the process of vigorously upgrading traditional manufacturing industries and cultivating strategic emerging industries, China always abides by and implements the innovation-driven development strategy. It is internationally accepted that there are two channels of technological innovation for a country: one is the development of domestic technology; the other is the acquisition of international technology spillovers, i.e., international R&D spillovers are digested to facilitate the technological transformation of the home country. International R&D spillovers in turn arise from three channels: international trade, foreign direct investment (FDI) and reverse technology spillovers from OFDI. Therefore, the promotion of industrial policy for the OFDI will have a profound impact on the reverse technology spillover effect.

Based on the theoretical analysis, this paper examines the impact of industrial policy on OFDI reverse technology spillovers and explores how to make it more effective, so as to make some marginal contributions to the study of industrial policy effects and OFDI reverse technology spillovers theory.

## 2. Literature Review

There are two diametrically opposed viewpoints in the theoretical analysis of industrial policy. Aghion et al. (2015) [1] used China Industry Business Performance Database from 1998-2007 and examined the impact of industrial policy instruments such as government subsidies and taxes on firms' TFP, finding that industrial policies that promote firm competition significantly increase firm productivity. Song Lingyun and Wang Xianbin (2013) [2] found that the provincial five-year plan's industrial policies have significantly increased the productivity of the industries by directing resources to more productive enterprises. Quite the opposite, Beason and Weinstein (1996) [3] analyzed data of 13 industrial sectors in Japan from 1955-1990 and found that industrial preferential policies did not increase returns to scale or productivity of the target sectors. Jiang Feitao and Li Xiaoping (2015) [4] argued that China's industrial policy reflects a strong regulatory-type character of direct intervention in the market, restricting market competition and substituting government choices for market mechanisms, which had a negative impact on efficiency in some industries.

The literature on the OFDI reverse technology spillover effects began in the 1990s. Coe and Helpman (1995) [5] constructed a C-H Model to verify the existence of R&D spillover effects in the trade process. On the basis of the C-H Model, Lichtenberg et al (2001) [6] improved the model and established the L-P Model, which divided the international technology spillover pathways into international trade, FDI and OFDI reverse technology spillovers. As for how the OFDI reverse technology spillover contributes to the improvement of the overall productivity of the home country, Song Yuegang and Du jiang [7] used inter-provincial panel data to verify that OFDI by enterprises can obtain foreign R&D spillover through three mechanisms: agglomeration spillover, learning imitation and talent flow, which not only improves their own technological innovation capacity, but also radiates and drives the surrounding areas, thereby promoting regional technological innovation. Nevertheless, some scholars believe that there is uncertainty in the OFDI reverse technology spillover. Yin Dongdong et al. (2016) [8] held that it depends on the home country's ability to absorb technology spillovers from the host country, and when the absorptive capacity is less than a certain threshold, the reverse technology spillover effect won't appear. Wang Shuli et al. (2014) found that only when OFDI is a technology-seeking motive will there be a reverse technology spillover effect on the home country.

To sum up, as Nunn and Trefler (2010) [9] indicated, the implementation of industrial policy is limited by the regional economic development, institutional environment, industrial characteristics, policy tools, etc., so it cannot become a universal law. At the same time, there is a lot of controversy about the OFDI reverse technology spillover effect in the existing literature. Therefore, it becomes more necessary to evaluate the impact of industrial policy on the OFDI reverse technology spillover effect and to identify the working conditions. Based on the new era background of China's economic development speed adjustment and the pursuit of industrial transformation, this paper focuses on the impact of industrial policy on OFDI reverse technology spillovers to analyze the implementation effect of industrial policy and its influencing factors.

## 3. Data Sources

There are three types of main variables in this article, the core of which is the dependent variable, i.e., the indicator of industrial policy. The implementation process of China's industrial policies are as follows: firstly, governments at all levels list important industries in their respective five-year plans, which determine the development goals and directions of related industries. Subsequently, in order to achieve these goals, governments at all levels will formulate and implement specific industrial policies and supporting measures. So, in the Five-year plans, we can clearly find the industries that the governments will vigorously support within a certain period of time, with which we can examine the effects of the industrial policies.

Drawing on the studies of Yang Jidong et al. (2015) [10], this paper collates the priority industries covered in the "11th Five-Year Plan" and "12th Five-Year Plan" documents of the central and local

governments, matching them with the two-digit industries in the Industrial Classification for National Economic Activities to obtain the key industrial sectors.

OFDI statistics of China and all provinces are from the Statistical Bulletin of China's Outward Direct Investment and we have adjusted them to the constant US dollar price in 1978 with fixed asset price index to make the research more accurate. The GDP and R&D of each country are taken from the World Bank database. Besides, to avoid endogeneity problems caused by omitted variables, the rationalisation of industrial development (Th), the level of regional infrastructure development (id), economic growth rate (gr) and trade openness (open) of each province are included in the model, which come from provincial statistical yearbooks and the China Statistical Yearbook.

## 4. Model Construction and Variable Measurement

### 4.1 Model Building

In this section, we will discuss the impact of industrial preferential policies on OFDI reverse technology spillovers. First, we examine the overall situation of the important industries IMPIND, which are mentioned by the central government or by the provincial governments in their Five-year plans. They are then further divided into important industries  $IMP_{gs}$  mentioned by both the central government and the provincial governments; important industries  $IMP_g$  only mentioned by the central government; and industrial policies  $IMP_s$  only mentioned by the provincial governments, to examine whether there are differences in the reaction of provincial OFDI reverse technology spillovers to industrial policies from different sources. Therefore, we build the model as follows:

$$\ln Sfs_{jt} = \alpha + \beta IMP_{jmt} + \sum \gamma X_{jt} + u_j + u_m + u_t + \varepsilon_{jmt} \quad (1)$$

The interpreted variable  $\ln Sfs_{jt}$  is the logarithm of the foreign R&D capital stock obtained from OFDI channel by province  $j$  in year  $t$ , which measures the degree of OFDI reverse technology spillovers of each province. As the core explanatory variable,  $IMP_{jmt}$  is a dummy variable of important industries, which can represent four different important industries: IMPIND,  $IMP_{gs}$ ,  $IMP_g$  and  $IMP_s$ . If the industry  $m$  of province  $j$  in year  $t$  is designated as the priority industry by the Five-year plans,  $IMP_{jmt} = 1$ , meaning that the governments will implement industrial policies to focus on supporting it, otherwise  $IMP_{jmt} = 0$ . If the core coefficient  $\beta > 0$ , indicating that relative to non-key industries, the OFDI reverse technology spillover effect in key industries is stronger, which proves that industrial policies can effectively promote the regional OFDI reverse technology spillover. In addition, to avoid endogeneity problems caused by omitted variables, regional control variables, denoted by  $X_{jt}$  are added.  $u_j$ ,  $u_m$  and  $u_t$  represent province fixed effects, industry fixed effects and time fixed effects respectively.

### 4.2 Variable Measurement

#### 4.2.1 OFDI Reverse Technology Spillovers Effects

Referring to the practice of Bitzer et al (2008) [11], we will take the spillover of foreign R&D capital stock as the proxy variable of OFDI reverse technology spillover effects. Specifically, the spillover of foreign R&D capital stock across the whole country is calculated first, and then, with the proportion of the OFDI stocks in each province accounted for those nationwide, we obtain the provincial OFDI reverse technology spillover. The measurement formulas are as follows:

$$S_t^{ofdi} = \sum \frac{OFDI_{it}}{GDP_{it}} RD_{it}^d \quad (2)$$

$$Sfs_{jt} = \frac{OFDI_{jt}}{\sum_j OFDI_{jt}} S_t^{ofdi} \quad (3)$$

In formula (2),  $S_t^{ofdi}$  represents the foreign R&D capital stock spillover from China's OFDI channel in year t,  $OFDI_{it}$  and  $GDP_{it}$  refer to the China's OFDI stock to the country i and the GDP of country i during the period t respectively, and the  $RD_{it}^d$  is the R&D capital stock of host country i in year t. In formula (3),  $Sfs_{jt}$  denotes the foreign R&D capital stock spillover from OFDI of the province j in year t,  $\frac{OFDI_{jt}}{\sum_j OFDI_{jt}}$  is the proportion of the OFDI stocks in province j accounted for that in the whole country.

Concerning the measurement of  $RD_{it}^d$ , since it can't be obtained directly, we first calculate the R&D capital flow of relevant country based on the ratio of R&D capital flow to GDP in the World Bank database. Then we can convert the R&D capital flows to R&D capital stock through the perpetual inventory method, which is as shown below:

$$RD - S_t = RD - F_t + (1 - \delta)RD - S_{t-1} \tag{4}$$

Wherein,  $\delta$  is the depreciation rate, generally taking a value of 5%.  $RD - S_t$  and  $RD - S_{t-1}$  represent the R&D capital stock of the host country in period t and period t-1 respectively.  $RD - F_t$  refers to the R&D capital flow of the host country in period t. Besides, with 2006 as the base year, we can calculate the R&D capital stock of 2006 through the following method:

$$RD - S_{2006} = RD - F_{2007} / (g + \delta) \tag{5}$$

In the above formula, g denotes the annual geometric average growth rate of R&D capital stock from 2006-2015. By bringing the results of the base year of equation (5) into equation (4), we can obtain the R&D capital stock in the host country for each year, and then calculate the OFDI reverse technology spillover effect for each province by using equations (2) and (3).

#### 4.2.2 Control Variables

The level of regional industrial rationalization is measured by the Theil index (Th), and the specific calculation formula is as follows:

$$theil_t = \sum_{m=1}^{30} y_{j,m,t} \ln(y_{j,m,t} / l_{j,m,t}) \quad m=1,2,\dots,30 \tag{6}$$

During the period t and in the province j,  $y_{j,m,t}$  denotes the proportion of the output value of industry m in the regional GDP, and  $l_{j,m,t}$  represents the proportion of the employee number of industry m in the total number of staff in this region. If the factors of production can flow freely and sufficiently between industries, the indicator is 0, otherwise it is greater than 0, and the larger the value, the more irrational the industry is.

In addition, the degree of trade openness (open) is measured by the ratio of the total exports and imports of each province to the regional GDP, the infrastructure development level (id) of each province is calculated by (road mileage + railway mileage + inland waterway mileage)/land area.

#### 4.2.3 Summary Statistics

The descriptive statistics of main variable are shown in Table 1.

**Table 1. Descriptive Statistics**

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
IMPIND	8332	0.4786	0.4996	0	1
IMPgs	8332	0.2515	0.4339	0	1
IMPg	8332	0.1333	0.3399	0	1
IMPs	8332	0.0937	0.2915	0	1
lnSfs	8332	2.0336	8.1348	1.1529	12.7426
Th	8332	0.270	0.1489	0.0167	0.8212

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
gr	8332	0.1389	0.0699	-0.2240	0.3227
open	8332	0.3217	0.3882	0.0307	1.7653
id	8332	1.2321	0.5378	0.2327	2.9921

## 5. Empirical Results and Analysis

### 5.1 Regression Analysis

By using the benchmark regression of formular (1), we can obtain the regression results as Table 2 . From the Model (1) – Model (4), it can be seen that the coefficients of the important industries mentioned by different subjects are significantly positive after the inclusion of control variables, indicating that, all else being equal, the industrial preferential policies effectively promote OFDI reverse technology spillovers of the important industries compared to non-important industries. According to the Model (2), the coefficient of  $IMP_{gs}$  is 0.0027, while the mean of the dependent variable is 2.0336, indicating that if industry m is mentioned as the important industry by both central and local governments, the OFDI reverse technology spillover in relevant provinces will increase by 0.133% compared to the average level.

**Table 2.** Benchmark regression results

Variables	Model (1)	Model(2)	Model(3)	Model(4)	Model(5)
IMPIND	0.0165* (1.92)				
IMP <sub>gs</sub>		0.0027** (2.17)			0.0082** (2.18)
IMP <sub>g</sub>			0.0028** (2.27)		0.0051 (1.11)
IMP <sub>s</sub>				0.0171*** (2.93)	0.0176*** (2.95)
Th	-0.0224* (-1.72)	-0.0204** (-2.20)	-0.0204** (-2.30)	-0.0225** (-2.22)	-0.0232** (-2.23)
gr	0.1967*** (14.70)	0.1967*** (14.70)	0.1967*** (14.70)	0.1967*** (14.70)	0.1967*** (14.69)
open	0.5605*** (13.07)	0.5600*** (13.16)	0.5600*** (13.16)	0.5605*** (13.17)	0.5606*** (13.17)
id	-0.0473** (-2.19)	-0.0469** (-2.17)	-0.0468** (-2.17)	-0.0473** (-2.20)	-0.0473** (-2.19)
Adjusted R-squared	0.9623	0.9623	0.9623	0.9623	0.9623
Observation	8332	8332	8332	8332	8332

Note:\*\*\*, \*\* and \* represent the significance levels of 1%, 5%, and 10% respectively. Values in parentheses are t-statistics.

Subsequently, we examine whether there are differences in the effects of industrial policies from different sources by adding  $IMP_{gs}$ ,  $IMP_g$  and  $IMP_s$  to the Model (5). According to the result, we can conclude that industrial policies mentioned by both central and local governments as well as those only mentioned by local governments obviously promote OFDI reverse technology spillover, while those only mentioned by the central government do not have a significant effect on provincial OFDI reverse technology spillover. That is to say, compared with the industrial policies mentioned by the central government, those mentioned by provincial governments have a greater impact on the regional OFDI reverse technology spillover effect. This may be due to the fact that regional governments have more information about local resource endowments and development levels than the central government, so they have more confidence that certain industry will boost the local economy, and will therefore invest more in the industry to promote technological upgrading. The central

government, on the other hand, due to its insufficient knowledge of local economic information and its greater focus on economic transformation, may lead to its policies to be forward-looking and go beyond the actual development of regional industries, making industrial policy ineffective in resource allocation.

From the regression results of the control variables, the coefficient of Th is significantly negative, proving that the higher the degree of industrial structure rationalisation of a region, the greater the regional OFDI reverse technology spillover effect. The main reason is that the rationalisation of industrial structure can promote technology transformation, thus improving the domestic R&D level and easily capturing foreign R&D capital stock spillovers.

It can be also seen that the coefficients of both gr and open are positive and significant at 1% level, which indicate that the higher the level of regional economic growth, the more dynamic the economic development and the more sufficient the innovative resource. Besides, the higher the level of openness, the more the FDI and OFDI, the easier it is to enjoy R&D information from external markets, which in turn enhances the technological development of the home country.

## 5.2 Regional Heterogeneity Test

Due to the differences in the development level, the impact of industrial policies on OFDI reverse technology spillovers in different regions may be heterogeneous. Thus in this section, we generate three region dummy variables in accordance with the orientations and include their interaction terms with IMPIND in the model, whose empirical results are shown in the Table 3. We find that whether or not the model includes control variables, the industrial policies promote OFDI reverse technology spillovers at least at the 5% significant level. However, the coefficients reveals that industrial policies have a smaller impact on OFDI reverse technology spillovers in the eastern region, while the western region has the largest impact. That probably because the eastern region has taken the lead in development, with the relatively flexible allocation of market resources, while the western region has a lower level of marketisation and relies more on government domination for resource allocation, for which reason the industrial policies in the eastern region have the least impact on the OFDI reverse technology spillover effect.

**Table 3.** Industry policy effects in different regions: regression results

Variables	Model (1)	Model(3)
IMPIND × East	0.0046** (2.22)	0.0077** (2.37)
IMPIND × Central	0.0122** (2.54)	0.0155*** (2.69)
IMPIND × West	0.0227*** (3.08)	0.0255*** (3.23)
Control variables	NO	YES
R-squared	0.9610	0.9623
Observation	8332	8332

Note: \*\*\*, \*\* and \* represent the significance levels of 1%, 5%, and 10% respectively. Values in parentheses are t-statistics. YES means control variables are added, NO means no control variables are added.

## 6. Conclusions and Revelations

At a time when the effects of industrial policies are under constant debate, this paper analyzes the relationship between industrial policies and regional OFDI reverse technology spillovers by compiling important industries mentioned in China's "11th Five-Year Plan" and "12th Five-Year Plan" and calculating OFDI reverse technology spillovers using OFDI data of each province. The results show that industrial preferential policies can effectively promote the regional OFDI reverse technology spillover, and this conclusion is still robust after testing by regions. Besides, we further

examine the impact of industrial policies from different sources on the regional OFDI reverse technology spillover effect, the results show that industrial policies mentioned by local governments have a greater impact on the regional OFDI reverse technology spillover effect than those mentioned by the central government.

Based on the above conclusion, this paper proposes the following suggestions:

(1) At the stage of high-quality economic development, it is necessary to emphasise the rationality and necessity of government's macro-regulation. The marketisation process and the implementation of industrial policies should be complementary.

(2) Formulate industrial policies according to specific conditions of different regions and evaluate the effect of industrial policies in real time to avoid formalism in the implementation.

(3) Actively strengthen technological exchanges and cooperation with foreign countries and achieve international industrial integration to promote the domestic technological R&D and industrial upgrading.

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