# Research on the Impact of Outward Foreign Direct Investment on Domestic Regional Innovation —Empirical Analysis based on Spatial Durbin Model

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**Abstract**—Outward Foreign Direct Investment (OFDI) is one of the important channels for companies to coordinate R&D resources at home and abroad, and it will contribute to implementing the innovation driven strategy. Based on the provincial panel data from 2009 to 2016, this paper examines the impact of OFDI on domestic regional technological innovation with the Spatial Durbin Model. The result shows that, firstly, the regional innovation indicates positive spatial autocorrelation among provinces with the spatial distribution characteristics of "high-high agglomeration" and "low-low agglomeration". Secondly, OFDI has a significantly positive effect on domestic innovation, and could greatly promote the innovation of neighboring provinces through the spatial spillover effect. Thirdly, the above results are still valid with index substitute and endogenous test.

**Keywords**- outward foreign direct investment; innovation; spatial spillover; Spatial Durbin Model

## 1 INTRODUCTION

With the purpose of new systems for a higher-standard open economy, China's OFDI has developed rapidly and the investment structure has been improved. China’s outward foreign direct investment reached $153.71 billion in 2020 with a year-on-year increase of 12.3%, ranking top 1 in the world for the first time, and covering more than 80% countries or regions in the world. At the same time, there are also some new characteristics. On the one hand, the investment pattern has changed from resource acquisition type to technology sourcing type. Since 2009, OFDI in manufacturing and service industry has growth rapidly, in which the proportion of high-tech industries has increased significantly. On the other hand, the OFDI among eastern coastal areas is increasing more significantly, which is highly related to the level of regional innovation. The OFDI in the eastern region reached 71.39 billion dollars in 2020, accounting for 84.1% of the total investment, among which Guangdong, Shanghai, Zhejiang, Jiangsu, Shandong and Beijing ranked among the top 6. Besides, the total number of invention

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patents was 440691 in 2020, mainly distributed among economically developed regions, including Guangdong (70695), Beijing (63266), Zhejiang (49888), Jiangsu (45975), Shandong (26745), Shanghai (24208), etc.

With the expansion of technology sourcing OFDI, many literatures pointed out that OFDI had a significant impact on technological innovation in home countries, while it was different among regions. On the one hand, Dong Youde, Meng Xing (2014) [1] and Li et al. (2016) [2] confirmed that OFDI had a significant positive impact on domestic regional innovation by using the province data in China, among which the spillover effect in the eastern region was the most significant (Li Juan et al., 2017)[3]. On the other hand, Tobler (1970) [4] pointed out that there was spatial correlation between things, and near things were more related to each other. Li Dongkun and Deng Min (2016) [5] found that OFDI can not only promoted the rationalization of local industrial structure, but also significantly improved the industrial rationalization in neighboring provinces.

## 2 THEORETICAL ANALYSIS

OFDI provides an important opportunity for enterprises to participate in global R&D activities. Due to the positive externality of knowledge spillover, the knowledge capital accumulated by multinational corporations through OFDI will continue to spread in China, with the frequent interaction of products and personnel among surrounding areas. The former is called direct spillover and the latter indirect spillover. Specifically, from the perspective of direct spillover channels, enterprises could improve their innovation and efficiency through cooperation with foreign enterprises (Sun Lingxi and Chu Xiaoqian, 2018) [6], or they can also directly buy core technologies and hire local high-quality talents. From the perspective of indirect spillover channels, after acquiring new technologies through OFDI, enterprises will impose a strong transmission effect and enhance enterprises' innovation in surrounding areas through commodity, personnel and other economic interaction.

## 3 SPATIAL CORRELATION ANALYSIS

According to the First Law of Geography, near areas are more closely related. Based on the spatial distribution characteristics of inter-provincial OFDI and technological innovation, the study investigates the spatial autocorrelation of main variables. Referring to Li et al. (2016) [5], the regional innovation ($P$) is measured by the amount of patents granted. And referring to Potterie and Lichtenberg (2001) [7], the amount of knowledge spillovers obtained by provinces through OFDI is calculated as

$$S_{it}^{OFDI} = \frac{OFDI_{it}}{\sum_{i=1}^{n} OFDI_{it}} S_t^{OFDI} \tag{1}$$

Where, $S_t^{OFDI} = \sum \frac{OFDI_{jt}}{Y_{jt}} S_{jt}$ represents the international technology spillover obtained by China through OFDI in the period *t*, $OFDI_{jt}$ represents China's OFDI stock, $Y_{jt}$ represents the GDP of the country *j*, $S_{jt}$ represents the stock of R&D capital of the country *j*, and $OFDI_{it}$ represents the OFDI stock of province *i*. The OFDI data is attained from the statistical bulletin of China's outward foreign direct investment, and the GDP, R&D and other data are attained from the World Bank.

The study establishes a spatial weight matrix according to the geographical distance between provinces. It can be expressed as

$$W_{ij} = \begin{cases} 1/d_{ij} & i \neq j \\ 0 & i = j \end{cases} \tag{2}$$

Taking the OFDI technology spillover and patents granted of 30 provinces in China (Tibet is omitted due to lacking data) from 2009 to 2016 as the observation values, table 1 shows that the global Moran indexes are significantly positive, indicating that there is a strong spatial positive autocorrelation among provinces, showing the characteristics of high-high and low-low agglomeration.

**Table1.** Global Moran Index

| **year** | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|
| ***lnS$^{OFDI}$*** | 0.021* | 0.036** | 0.036** | 0.031** |
| ***lnP*** | 0.100*** | 0.104*** | 0.114*** | 0.112*** |
| **year** | 2013 | 2014 | 2015 | 2016 |
| ***lnS$^{OFDI}$*** | 0.053*** | 0.068*** | 0.078*** | 0.081*** |
| ***lnP*** | 0.106*** | 0.109*** | 0.105*** | 0.100*** |

Note: ∗∗∗ denotes p < 0.01, ∗∗ denotes p < 0.05, ∗ denotes p < 0.1. similarly hereinafter.

Figure 1 shows many eastern provinces such as Jiangsu, Zhejiang and Shanghai were in the first quadrant, indicating significant high-high agglomeration characteristics of $lnS^{OFDI}$. Figure 2 shows about 80% of the provinces were located in the first and third quadrants.

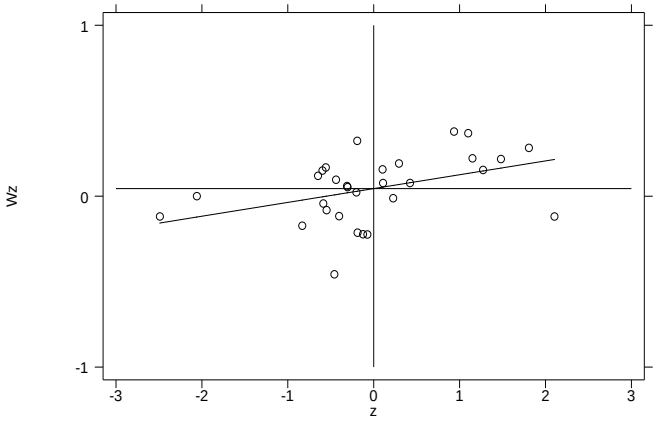


**Figure 1.** Scatter Plot of Local Moran Index in 2016 (lnSOFDI)

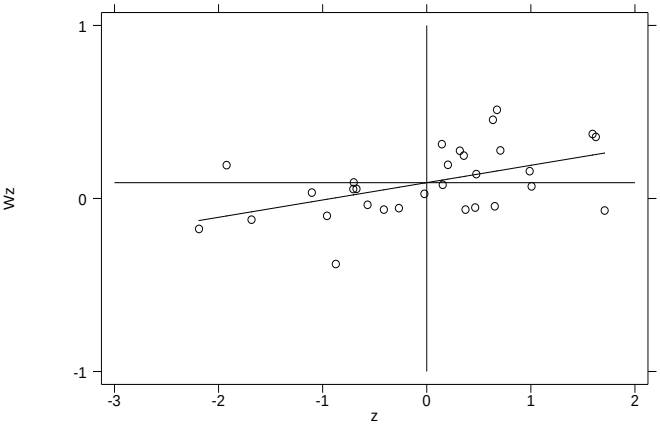


**Figure 2.** Scatter Plot of Local Moran Index in 2016 (*lnP*)

# 4 EMPIRICAL ANALYSIS

## 4.1 Model

Referring to Lesage (2000) [8], we use the Spatial Durbin Model (SDM) and it is set as

$$\begin{aligned} lnP_{it} &= \lambda \sum_{j=1}^{n} W_{ij} lnP_{it} + \beta_1 lnS_{it}^{OFDI} + \delta_1 \sum_{j=1}^{n} W_{ij} lnS_{jt}^{OFDI} \\ &+ \beta_2 X_{it} + \delta_2 \sum_{j=1}^{n} W_{ij} X_{jt} + \mu_i + \nu_t + \varepsilon_{it} \end{aligned} \tag{3}$$

In equation (3), $W_{ij}$ represents the spatial weight matrix, $\lambda$ represents the spatial autocorrelation coefficient, reflecting the spatial spillover of technological innovation among provinces, $\delta_1$ represents the coefficient of the spatial lag term of the core explanatory variable, $\mu_i$ and $\nu_t$ represents the regional fixed effect and time fixed effect respectively, and $\varepsilon_{it}$ represents the random error. $X_{it}$ indicates the control variables, including R&D (*SD*), inward foreign direct investment (*IFDI*), technology market activity (*T_trade*), human capital (*H*) and financial development (*FIN*). These data are derived from the statistical yearbooks of each province, and the China Labor Statistical Yearbooks.

### 4.2 Empirical Analysis

#### 4.2.1 Benchmark regression

In table 2, both the direct effect coefficient and indirect effect coefficient of OFDI reverse technology spillover are significantly positive, indicating that patent numbers will increase after provinces expand OFDI, and OFDI could also improve the technological innovation level of surrounding provinces. It would be more obvious as the provincial barriers are gradually weakened. As for control variables, SD, IFDI and FIN all show positive effects on innovation. Moreover, the indirect effect coefficient of *IFDI* is 0.611, indicating that *IFDI* could also impose spatial spillover effect.

**Table 2.** Benchmark Regression

| | *lnP* | | | *lnP* | | |
|---|---|---|---|---|---|---|
| | Direct | Indirect | Total | Direct | Indirect | Total |
| $lnS^{OFDI}$ | 0.099*** | 0.608* | 0.708* | 0.122*** | 0.565** | 0.687*** |
| | (2.583) | (1.787) | (1.954) | (3.554) | (2.174) | (2.602) |
| *lnSD* | | | | 0.147* | -1.784*** | -1.637*** |
| | | | | (1.788) | (-2.822) | (-2.589) |
| *lnIFDI* | | | | 0.140*** | 0.533* | 0.673** |
| | | | | (3.732) | (1.831) | (2.203) |
| *lnT_trade* | | | | 0.024 | -0.003 | 0.021 |
| | | | | (0.724) | (-0.289) | (0.693) |
| *H* | | | | 0.039 | -0.854 | -0.815 |
| | | | | (0.418) | (-1.444) | (-1.297) |
| *FIN* | | | | 0.526*** | -0.066 | 0.460** |

| | | | | |
|---|---|---|---|---|
| | | (3.782) | (-0.419) | (2.526) |
| *Wx lnS*$^{OFDI}$ | 0.630** | | 0.648*** | |
| | (2.526) | | (2.650) | |
| *Wx lnSD* | | | -1.913*** | |
| | | | (-3.494) | |
| *Wx lnIFDI* | | | 0.611** | |
| | | | (2.187) | |
| *Wx H* | | | -0.895 | |
| | | | (-1.604) | |
| *λ* | -0.087 | | -0.213 | |
| | (-0.365) | | (-0.854) | |
| *sigma2* | 0.030*** | | 0.026*** | |
| | (10.952) | | (10.935) | |
| Regional fixed effect | √ | | √ | |
| Time fixed effect | √ | | √ | |
| *logL* | 81.423 | | 96.321 | |
| *Obs* | 240 | | 240 | |
| *R2* | 0.349 | | 0.331 | |

### 4.2.2 Robustness

The study conducts a robustness test with index substitute and endogenous test: (1) Replacing the core explanatory by the per capita OFDI stock (*perOFDI*) (Nie Minghua and Qi Hao, 2019) [9]. (2) Replacing the original dependent variable with the new product sales (*Pro*) to measure the regional innovation (Xiao Renqiao et al., 2019) [10]. (3) The improvement in the technological innovation could also drive provinces to increase OFDI. In order to reduce the error caused by the endogenous, using lagged independent variables (*L.lnS*$^{OFDI}$) as the core explanatory variables.

**Table 3**. Robustness Test

| | (1)*lnP* | (2)*lnPro* | (3)*lnP* |
|---|---|---|---|
| *lnperOFDI* | 0.531** | | |
| | (2.436) | | |

| | | | |
|---|---|---|---|
| $lnS^{OFDI}$ | | 1.167*** | |
| | | (2.601) | |
| $L.lnS^{OFDI}$ | | | 0.633*** |
| | | | (3.307) |
| *L.lnP* | | | |
| *lnSD* | -1.265** | 0.076 | -1.845*** |
| | (-2.223) | (0.675) | (-2.759) |
| *lnIFDI* | 0.679** | 1.668*** | 0.687*** |
| | (2.231) | (2.971) | (2.629) |
| *lnT_trade* | 0.013 | 0.041 | 0.327* |
| | (0.459) | (0.789) | (1.663) |
| *H* | 0.054 | 0.065 | -0.051 |
| | (0.639) | (0.481) | (-0.795) |
| *FIN* | 1.123 | -0.312 | 1.576** |
| | (1.466) | (-0.257) | (2.530) |
| *Wx lnperOFDI* | 0.514** | | |
| | (2.125) | | |
| $Wx\ lnS^{OFDI}$ | | 1.071*** | 0.680*** |
| | | (2.771) | (2.682) |
| *Wx lnSD* | -1.528*** | | -2.483*** |
| | (-2.621) | | (-3.565) |
| *Wx lnIFDI* | 0.654** | 1.679*** | 0.780** |
| | (2.176) | (3.580) | -2.536 |
| *Wx lnT_trade* | | | 0.436* |
| | | | (1.777) |
| *Wx H* | | | |
| *Wx FIN* | 0.933 | -0.694 | 1.786** |
| | (1.019) | (-0.531) | (2.051) |
| $\lambda$ | -0.258 | -0.121 | -0.397 |
| | (-0.996) | (-0.524) | (-1.361) |
| *sigma2* | 0.026*** | 0.066*** | 0.020*** |

| | (10.930) | (10.950) | (10.194) |
|---|---|---|---|
| Regional fixed effect | √ | √ | √ |
| Time fixed effect | √ | √ | √ |
| *logL* | 94.768 | -13.657 | 110.554 |
| *Obs* | 240 | 240 | 210 |
| *R2* | 0.629 | 0.496 | 0.775 |

## 5 CONCLUSIONS

Based on the panel data of China from 2009 to 2016, the study empirically analyzed the impact of OFDI on regional technological innovation. The research finds that both the regional innovation and OFDI knowledge spillovers indicate positive spatial autocorrelation among provinces with the spatial distribution characteristics of "high-high agglomeration" and "low-low agglomeration". In addition, OFDI has a significant positive effect on domestic innovation, and could greatly promote the innovation of neighboring provinces. The robustness test including substituting the core indicators and dealing with the endogeneity, shows that regression results are in line with the above conclusion, namely, the spatial spillover effect of OFDI is significant. In the future, enterprises data can be used for further study, and more meaningful conclusions could be drawn at the micro level.

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