

Research on the Relationship between Bidirectional FDI and Regional Innovation Capability ---Based on the Threshold Effect of Regional Financial Development

Yan Han¹

¹School of Finance and Economics, Jiangsu University, Zhenjiang, Jiangsu, CHN

Abstract—Based on China's inter-provincial panel data from 2008 to 2018, this paper introduces regional financial development as a threshold variable, constructs a nonlinear threshold regression model, and discusses the nonlinear relationship between bidirectional FDI and regional innovation capacity. The study finds that FDI and OFDI have obvious threshold effect on the innovation ability of various regions in China, and the threshold variable is regional financial development: only when the level of financial development exceeds the threshold, the effect of FDI and OFDI on the improvement of regional innovation ability is more significant. In the future, China should make every effort to improve the level of financial development, and more vigorously promote the development of regional innovation capacity based on the policy of "bringing in" and "going out".

Keywords— Bidirectional FDI: Regional Innovation Capability: Regional Financial Development: Nonlinear Panel Threshold Model.

I. INTRODUCTION

Innovative development is the first driving force for development. Technological progress promotes innovation and development, and technological progress mainly comes from domestic independent research and development and international technology spillover. With the gradual disappearance of national boundaries and the integration of global politics and economy, FDI and OFDI have become more and more obvious in stimulating technological progress. Therefore, making full use of the reverse technology spillovers of FDI and OFDI is self-evident in its value in enhancing national innovation capabilities. The process of bidirectional FDI acting on innovation capability is affected by many factors, and the level of regional financial development is one of the key factors. In the past, when scholars studied the relationship between bidirectional FDI and innovation ability, they often ignored the influence of geographical heterogeneity factors, such as the level of regional financial development. Linear relationships, if ignored, can lead to biased research conclusions. Therefore, this paper takes regional financial development as a threshold variable, constructs a threshold regression model, and explores the effect of regional financial development in the process of bidirectional FDI affecting innovation capabilities.

This paper uses the 2008-2018 inter-provincial panel data in China to analyze the relationship between bidirectional FDI and regional innovation capabilities in a nonlinear threshold regression model from the perspective of regional financial development. The research results show that: first, the relationship between bidirectional FDI and regional innovation capability is nonlinear, which is manifested as the threshold effect of regional financial development; second, only when the level of regional financial development exceeds

the threshold value, is bidirectional FDI significant. Actively promote the improvement of regional innovation capabilities.

The breakthrough points of this paper are as follows: first, in the past, most scholars studied the utility of innovation capability from a single perspective of FDI or OFDI. All may become the main way for technology spillover. Based on this, this paper introduces both FDI and OFDI as research objects, which enriches the existing research. Second, based on the perspective of regional financial development, this paper discusses the nonlinear relationship between bidirectional FDI and innovation ability, and empirically tests the threshold effect of bidirectional FDI on innovation ability.

II. LITERATURE REVIEW

The existing literature at home and abroad mainly focuses on three aspects: first, analyze the impact of FDI on innovation ability. Fu Miao^① conducted research based on panel data, and the results showed that FDI has both technology spillover effect and technology crowding out effect, but the former is more significant, that is, it has a significant effect in positively promoting the improvement of innovation ability. Li Zheng^② proved that FDI has a positive effect on innovation efficiency by building a spatial panel econometric model, and the utility value has regional heterogeneity. Tang Yihong^③ discussed the innovation effect of FDI with the service industry as the object, and the results showed that the competitive effect and learning effect of FDI greatly promoted the innovative development of service enterprises in the host country. However, some research conclusions point out that FDI is not beneficial to the improvement of innovation ability and innovation efficiency. Foreign scholars Ruane^④ and Lee^⑤ have obtained similar research results. Second, analyze the impact of OFDI on innovation ability. Xia Jingwen^⑥ confirmed OFDI's international technology spillover by taking

the level of marketization as the threshold variable, and with the continuous improvement of the level of marketization, OFDI will more significantly stimulate the improvement of total factor productivity. Li Juan^⑦ pointed out that OFDI's technology spillover has a positive effect on the improvement of independent innovation capabilities of all provinces in China, and the way that OFDI promotes technological progress and thus the improvement of innovation capabilities is mainly through the investment of independent R&D capital and human capital. The research of Yang Shidi^⑧ found that OFDI significantly improved the efficiency of regional green technology R & D and green achievement transformation, and the promotion effect on the latter was more obvious. Kogut^⑨ pointed out in the article that the R & D expenditure-intensive industries in the United States are the main targets of Japan's foreign investment, and the purpose of investment is to learn and absorb the advanced technology of the United States. Similarly, some scholars believe that OFDI inhibits innovation. Yin Dongdong^⑩ used the GMM method to estimate based on the absorption capacity, and found that China's OFDI did not reflect positive reverse technology spillover effects. The research of Hong^⑪ shows that OFDI hinders the innovation performance of emerging market countries, mainly because the purpose of OFDI is to seek resources and markets, which leads to the reduction of investment in home countries, which in turn affects the improvement of home country innovation performance. Third, analyze the relevant factors affecting the innovation effect of bidirectional FDI. The study of Li Mei^⑫, Xie Jianguo^⑬, He Xingqiang^⑭ found that economic development, financial development, R&D intensity, technological gap, level of opening up, infrastructure construction, human capital and absorptive capacity are all important influencing factors.

Based on the above analysis, it can be seen that most domestic and foreign scholars in the past studied the impact of FDI or OFDI on innovation, did not include them in the same analysis framework, and the consideration of influencing factors is relatively lacking. The technological spillover effect of bidirectional FDI should be analysed under the same framework, and the influence of regional heterogeneity factors such as regional financial development differences should be introduced. Only in this way can we more systematically and comprehensively understand the value of China's major national strategies driven by the two wheels of "bringing in" and "going out".

III. RESEARCH DESIGN

A. Model setting

The threshold effect refers to the phenomenon that in the economic system, when the value of one variable reaches a certain value, another variable suddenly turns to other development directions (structural mutation), and this value is called the threshold value. This paper takes regional financial development as the threshold variable, and studies the relationship between bidirectional FDI and regional innovation capability by constructing a nonlinear panel threshold regression model. The model is designed as follows:

$$\begin{aligned} \ln inv_{it} &= \beta_1 \ln FDI_{it} I(\ln fin_{it} \leq \gamma) + \beta_2 \ln FDI_{it} I(\ln fin_{it} > \gamma) + \alpha_1 \ln open_{it} + \alpha_2 \ln RTI_{it} + \alpha_3 \ln hum_{it} + \alpha_4 \ln urb_{it} + \mu_i + \varepsilon_{it} \quad (1) \\ \ln inv_{it} &= \beta_1 \ln OFDI_{it} I(\ln fin_{it} \leq \gamma) + \beta_2 \ln OFDI_{it} I(\ln fin_{it} > \gamma) + \alpha_1 \ln open_{it} + \alpha_2 \ln RTI_{it} + \alpha_3 \ln hum_{it} + \alpha_4 \ln urb_{it} + \mu_i + \varepsilon_{it} \quad (2) \end{aligned}$$

The above equations (1) and (2) are threshold regression equations based on regional financial development to analyze the impact of FDI and OFDI on innovation with FDI and OFDI as independent variables. In equations (1) and (2), inv stands for regional innovation capability, FDI stands for foreign direct investment, $OFDI$ stands for foreign direct investment, $open$ stands for openness level, RTI stands for technology investment level, hum stands for human capital, urb stands for urbanization level, i represents the region, t represents the year, γ represents the threshold value to be estimated, ε_{it} represents the random error term, μ_i represents the individual effect of the cross-sectional data of each province that does not change with time, and $I(\cdot)$ is an indicative function.

First, assume that $\beta_1 = \beta_2$, that is, verify whether the threshold effect exists. If the assumption is confirmed, the threshold effect does not exist. When there is a significant threshold effect, Hansen calculates the confidence interval of the threshold value γ through the construction of the likelihood ratio statistic $LR(\gamma)$, and the LR test can further test the authenticity of γ , that is, to verify the threshold estimation whether the value is equal to the true value.

In the presence of a single threshold effect, Hansen can also perform multiple threshold tests. For example, double threshold means that the sample data is divided into three groups. The equation of the double threshold regression model with FDI as the independent variable is expressed as follows. By analogy, the equation with OFDI as the independent variable can be obtained, which will not be repeated here.

$$\ln inv_{it} = \beta_1 \ln FDI_{it} I(\ln fin_{it} \leq \gamma_1) + \beta_2 \ln FDI_{it} I(\gamma_1 < \ln fin_{it} \leq \gamma_2) + \beta_3 \ln FDI_{it} I(\ln fin_{it} > \gamma_2) + \alpha_1 \ln open_{it} + \alpha_2 \ln RTI_{it} + \alpha_3 \ln hum_{it} + \alpha_4 \ln urb_{it} + \mu_i + \varepsilon_{it} \quad (3)$$

B. Variable selection

This paper uses the provincial panel data of China from 2008 to 2018. Due to the serious incompleteness of the data in Tibet, Hong Kong, Macao and Taiwan, this paper finally uses the data of 30 provinces in China. The relevant indicators are set as follows:

1. Regional Innovation Capability (inv)

The China Regional Innovation Capability Report published by the China Science and Technology Development Strategy Research Group measures innovation capability from multiple dimensions, including innovation performance, innovation environment, and R&D investment. This report is more systematic and scientific. Therefore, this paper uses the comprehensive indicators of each region in the report.

2. Outward Foreign Direct Investment ($OFDI$)

This paper uses foreign direct investment stock.

3. Foreign Direct Investment (FDI)

This paper uses the actual amount of foreign capital used.

4. Regional Financial Development (fin)

This paper uses the ratio of the sum of the loan balance and deposit balance of all financial institutions in each province to the GDP of the same period.

5. *Open Level (open)*

This paper uses the ratio of the total import and export volume of each province over the years to the GDP of the same period.

6. *Degree of investment in technology (RTI)*

This paper uses the proportion of the investment in science and technology in the fiscal expenditure of each province over the years.

7. *Human Capital (hum)*

This paper uses the more common measurement methods in the literature, expressed as the average years of education in each region.

8. *Urbanization Level (urb)*

The level of urbanization is one of the main indicators reflecting the degree of regional economic development. This paper uses the ratio of the urban population to the total population in each province.

C. *Data source*

The data used in this article come from the "China Regional Innovation Capability Report", "China's Foreign Direct Investment Statistical Bulletin", "China Statistical Yearbook" and the provincial statistical yearbooks over the years.

IV. EMPIRICAL ANALYSIS

A. *Threshold estimation*

First check whether the threshold effect exists. It can be seen from Table 1 that whether the independent variable of the model is lnFDI or lnOFDI, there is a threshold effect on regional financial development. When the independent variable is lnFDI, the single-threshold effect is significant at the 1% level, but the double-threshold effect does not pass the significance test; when the independent variable is lnOFDI, the single-threshold effect is significant at the 10% level, but the double-threshold effect also failed the significance test. Therefore, a single threshold model is used for analysis in the following. The threshold effect is significant, indicating that the influence of bidirectional FDI on China's regional innovation capacity has a single threshold effect with regional financial development as the threshold variable.

TABLE I. Threshold Effect Significance Test

	Independent Variable is lnFDI		Independent Variable is lnOFDI	
	Single Threshold	Double Threshold	Single Threshold	Double Threshold
F value	31.670	14.051	24.442	10.011
P value	0.003	0.233	0.053	0.410
10%	20.604	17.375	19.026	17.418
5%	23.947	21.003	25.424	19.359
1%	27.011	28.308	36.561	26.243

B. *Parameter estimation and result analysis*

After verifying the existence of the threshold effect and estimating the threshold value, the parameters of the model can be estimated. Taking lnFDI as an example, Table 2 shows

the parameter estimation results after regression of the model with lnFDI as the independent variable and regional financial development as the threshold variable. It can be seen from Table 2 that there is a non-linear relationship between FDI and innovation capability, which is manifested as a single threshold effect based on regional financial development. When the regional financial development level is lower than 0.7221, the coefficient of FDI is 0.012, but it does not pass the significance test, indicating that although FDI positively stimulates regional innovation ability at this time, the effect is not significant. When the regional financial development level exceeds 0.7221, the coefficient of FDI is 0.058, and it is significant at the 5% level, indicating that FDI has an obvious positive role in promoting the improvement of regional innovation capabilities. This means that the higher the level of regional financial development, the more conducive to FDI's innovation effect. The reason may be that the higher the level of financial development in the region, the easier it is for enterprises to invest in financing, technology and product research and development, and human capital cultivation, which is more conducive to attracting more foreign-funded enterprises to invest in building factories.

TABLE II. Model parameter estimation results with FDI as threshold variable

Variab les	Coeffici ent	Standard Deviation	P value	T value	95% Confidence Interval	
lnopen	0.023	0.014	0.101	1.640	0.015	0.076
lnRTI	0.056	0.016	0.000	3.551	0.025	0.087
lnhum	-0.002	0.125	0.990	-0.013	-0.247	0.244
lnurb	0.148	0.068	0.030	2.182	0.132	0.413
lnFDI(ln fin ≤ 0.722)	0.012	0.008	0.131	1.521	-0.004	0.027
lnFDI(ln fin > 0.722)	0.058	0.007	0.044	0.763	-0.009	0.069

V. CONCLUSION AND SUGGESTION

The results of the model constructed in this paper show that there is a nonlinear relationship between bidirectional FDI and regional innovation capabilities, which is embodied in the threshold effect based on regional financial development. That is, bidirectional FDI has a positive promoting effect on the improvement of innovation ability, but this incentive effect is more significant in regions with a high level of regional financial development.

Based on the above research conclusions, this paper puts forward the following constructive opinions: first, from the perspective of FDI, the financial development of most provinces in my country is at a relatively low level, which is not conducive to the role of FDI in promoting the development of innovation capabilities through technology diffusion. Therefore, when introducing foreign capital, local governments should introduce a series of policies to support financial development, and combine high-quality foreign investment on the basis of the sound development of the financial market, so as to more effectively promote the improvement of innovation capabilities. Second, from the perspective of OFDI, the financial market environment of

most provinces in my country restricts the reverse technology diffusion of OFDI. Therefore, as the pace of going abroad is accelerating, local governments should take corresponding measures, such as comprehensively deepening financial system reforms, especially supply-side reforms, improving the operation of capital markets, etc., to promote the diffusion and absorption of OFDI reverse technology, and further promote innovation ability development.

REFERENCES

- [1] Fu Miao. "Spatial Quantitative Analysis of Technology Spillover Effects of Foreign Direct Investment," *International Economic and Trade Exploration*, vol. 4, issue 7, pp. 57–69, 2009.
- [2] Li Zheng, Yang Siying, He Bin. "Does FDI Inhibit or Improve China's Regional Innovation Efficiency?—An Analysis Based on the Inter-provincial Spatial Panel Model," *Economic Management*, vol. 39, issue 4, pp. 6–19, 2017.
- [3] Tang Yihong, Yu Feng, Wang Xiaoyan. "Do Chinese Service Enterprises Gain Innovation from FDI in Services?—Empirical Evidence from the Second Economic Census and Patent Microdata," *Journal of Beijing Normal University (Social Science Edition)*, vol. 21, issue 3, pp. 130–143, 2018.
- [4] Ruane F, Ugur A. "Foreign Direct Investment and Productivity Spillovers in Irish Manufacturing Industry: Evidence From Plant Level Panel Data," *International Journal of The Economics of Business*, vol. 12, issue 7, pp. 53–66, 2005.
- [5] Lee G. "The Effectiveness of International Knowledge Spillover Channels," *European Economic Review*, vol. 50, issue 6, pp. 275–288, 2006.
- [6] Xia Jingwen, Li Jingqing. "The impact of economic marketization on the reverse technology spillovers of China's foreign direct investment: a threshold regression analysis based on China's provincial panel data," *Technical Economy*, vol. 33, issue 9, pp. 17–24, 2014.
- [7] Li Juan, Tang Peihan, Wan Lu, Pang Yougong. "Foreign Direct Investment, Reverse Technology Spillover and Innovation Capability: An Empirical Analysis Based on Provincial Panel Data," *World Economic Research*, vol. 16, issue 4, pp. 59–71, 2017.
- [8] Yang Shidi, Liu Yajun. "Can China's Foreign Direct Investment Improve Regional Green Innovation Efficiency: From the Perspective of Intellectual Property Protection," *International Economic and Trade Exploration*, vol. 37, issue 2, pp. 83–98, 2021.
- [9] Kogut B, Chang S J.. "Technological capabilities and Japanese foreign direct investment in the United States," *Review of Economics and Statistics*, vol. 43, issue 7, pp. 401–413, 1991.
- [10] Yin Dongdong, Zhang Jianqing. "Research on the Reverse Technology Spillover Effect of my country's Foreign Direct Investment—An Empirical Analysis Based on the Perspective of Absorptive Capacity," *International Trade Issues*, vol. 27, issue 1, pp. 109–120, 2016.
- [11] Hong J, Zhou C. "Technology gap reverse technology spillover and domestic innovation performance in outward foreign direct investment: evidence from China," *China and World Economy*, vol. 27, issue 2, pp. 1–23, 2019.
- [12] Li Mei, Liu Shichang. "Regional Differences and Threshold Effect of Reverse Technological Spillover of Outward Direct Investment—Through Regression Analysis Based on China's Provincial Panel Data," *Manage the World*, vol. 11, issue 1, pp. 21–32, 2012.
- [13] Xie Jianguo, Wu Guofeng. "The Threshold Effect of FDI Technology Spillover—Based on China's Interprovincial Panel Data from 1992 to 2012," *World Economic Research*, vol. 11, issue 5, pp. 74–79, 2014.
- [14] He Xingqiang, Ou Yan, Shi Wei. "Research on FDI Technology Spillover and China's Absorptive Capacity Threshold," *World Economy*, vol. 10, issue 3, pp. 52–76, 2014.