Two-way FDI Spillover and China's Provincial Technology Progress
- Based on the High-Tech Industry Agglomeration Threshold Perspective

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ABSTRACT
Based on China's provincial panel data from 2011 to 2020, this paper empirically studies the dynamic relationship between two-way FDI spillover and China's provincial technology progress from the perspective of high-tech industry agglomeration. The results show that there exists significant single threshold effect of high-tech industry agglomeration between two-way FDI and provincial technology progress. Under the regulation of high-tech industry agglomeration, FDI spillover shows an increasing marginal effect relationship with technology progress, and OFDI spillover shows a U-shaped relationship. Human capital level, R&D capability, economic development level, trade openness and FDI all significantly promote provincial technology progress, but OFDI has no significant effect.

Keywords: *Two-way FDI, Technology progress, Threshold effect, High-tech industry agglomeration.*

1. INTRODUCTION

Under the conditions of globalized and open economy, the transregional flow of knowledge provides the possibility for the multi-channel technology spillover [1]. Foreign direct investment (FDI) and outward direct investment (OFDI) are the most important channels of international research and development (R&D) spillovers and powerful tools for developing countries to realize technological catch-up. For this reason, scholars have carried out extensive discussions on the relationship between two-way FDI spillover and technology progress. Lichtenberg (1998) defined the international R&D spillover channel as trade import, FDI and OFDI, and provided the spillover model and the weighting method [2]. Based on this model, Jiang (2005) analyzed the industry panel data from 1998 to 2002 in China, and found that FDI's competitive effect was not conducive to the growth of China's domestic enterprises' innovation ability, but promoted domestic enterprises' research and development activities through demonstration effect and the flow of scientific and technological personnel [3]. Wei (2018) analyzed that the impact of two-way direct investment on the technology progress and independent innovation, and the results showed that two-way FDI has significant negative effects on the China's technology progress [4]. Li and Wang (2021) studied that the two-way FDI of the logistics industry promotes China's TFP and the positive impact of logistics FDI on TFP is stronger [5].

In particular, since the accession to the WTO, China has realized deep integration with the global economy, and two-way FDI have shown a rapid growth trend. Especially with the 'Going global' strategy and the proposal of 'the Belt and Road Initiative', China has become one of the largest FDI and OFDI countries in the world. Unfortunately, the existing research between FDI, OFDI and China's technology progress is mostly based on linear assumptions, ignoring the heterogeneous nonlinear influence of spillover that may be affected by other factors [6]. Therefore, based on the provincial panel data from 2011 to 2020, this paper empirically studies the moderating effect of high-tech industrial agglomeration on the relationship between two-way FDI spillover and technology progress through the introduction of threshold model, and explores the nonlinear and heterogeneous characteristics of spillover effect.

2. MODEL CONSTRUCTION AND ANALYSIS

2.1. Model Construction

The explained variable of the model is the provincial technology progress level in China from 2011 to 2020. According to the Griliches-Jaffe knowledge production function and the Cobb Douglas production function, based on the analysis of the driving factors and the lag selection in the existing literature [7], the model also selects human capital level (HCL), R&D capability (RDC), economic development level (EDP) and trade openness (TO) as control variables except for the FDI and OFDI variables.

In order to reduce the possible heteroskedasticity and the time-lag effect, some variables take a logarithmic form which will be explained later and the variables take a period lag value. The article introduces Hansen threshold model with the high-tech industrial agglomeration as the threshold variable [8]. The main reason is that in recent years, high-tech industry is an important field to attract and utilize foreign investment. At the same time, the level of high-tech industry is closely related to research and development ability and learning ability, thus affecting two-way FDI spillover absorption [9]. Accordingly, the FDI spillover and OFDI spillover threshold model are established as formula (1) and formula (2).

$$\begin{aligned} TFP_{i,t} = \alpha_0 &+ \beta_1 FDI_{i,t-1} \cdot 1\,(r_{i,t} \le \gamma_1) \\ &+ \beta_2 FDI_{i,t-1} \cdot 1\,(\gamma_1 < r_{i,t} \le \gamma_2) + \cdots \\ &+ \beta_n FDI_{i,t-1} \cdot 1\,(\gamma_{n-1} < r_{i,t} \le \gamma_n) + \beta_{n+1} FDI_{i,t-1} \cdot 1\,(r_{i,t} > \gamma_n) \\ &+ \lambda OFDI_{i,t-1} + \sum \theta X_{i,t-1} + \xi_{i,t} + u_{i,t} \end{aligned} \tag{1}$$

$$\begin{aligned} TFP_{i,t} = \alpha_0 &+ \beta FDI_{i,t-1} + \lambda_1 OFDI_{i,t-1} \cdot 1\,(r_{i,t} \le \eta_1) \\ &+ \lambda_2 OFDI_{i,t-1} \cdot 1\,(\eta_1 < r_{i,t} \le \eta_2) + \cdots \\ &+ \lambda_n OFDI_{i,t-1} \cdot 1\,(\eta_{n-1} < r_{i,t} \le \eta_n) + \lambda_{n+1} OFDI_{i,t-1} \cdot 1\,(r_{i,t} > \eta_n) \\ &+ \sum \theta X_{i,t-1} + \xi_{i,t} + u_{i,t} \end{aligned} \tag{2}$$

In the formulas, i is the province, t is the year; *TFP* is the Total Factor Productivity, stands for provincial technology progress; *FDI* and *OFDI* represent provincial foreign direct investment and outward foreign direct investment respectively. X represents a series of control variables; r represents the threshold variable; n represents the number of thresholds; γ and η are threshold values; 1(•) is an indication function. If the expression in parentheses is true, the value is 1; otherwise is 0. α, β, λ are variable coefficients; ε measures the fixed effect of section, and μ is the random disturbance term acting on the technical change.

2.2. Index Selection and Stationarity Test

The paper selected 30 provinces except Tibet, Hong Kong, Macao and Taiwan, intercepted 2011~2020 as the observation years. The Malmquist index based on DEA method was used to measure TFP values as technology progress, and the base period was selected in 2011 measured by the regional output, labor force and capital stock. Two-way FDI has stock and flow class data, compared with the flow, stock data can reflect the accumulation effect to attract more foreign investment and outward foreign investment during stages, and the spillover effect of cumulative investment is more stable, and the data is less influenced by external force such as policy fluctuations. On the basis of the above analysis, this article selects provincial two-way FDI stock data in this study, and expressed by natural logarithm.

The model adopts the years of education proposed by Barro and Lee to measure human capital level (HCL). Considering the cumulative effect of technology, the perpetual inventory method is used to calculate R&D capability (RDC) which is expressed by natural logarithm with the depreciation rate of 9.6%, and the fixed asset investment price index is used to subtract. Economic development level (EDL) is usually measured by gross domestic product (GDP), per capita GDP and other indicators. Considering that there is a certain correlation between technological level and population density, this paper chooses per capita GDP indicator expressed by natural logarithm to measure. Trade openness (TO) reflects the degree of international exchange and cooperation, and the paper adopts the ratio of total trade import and export to GDP to measure. High-tech industry is a representative of technology-intensive industry, and the degree of agglomeration reflects the scale potential of the industry in the spatial dimension. Generally, methods to measure the degree of agglomeration include geographic concentration, Herfindahl index, EG index, spatial Gini coefficient, and entropy weight method, etc. In this paper, location entropy method is used to calculate the high-tech industries agglomeration (HIA) as the

threshold variable, expressed by dividing the national proportion of employed persons in regional high-tech industries by the national proportion of total employed persons.

3. EMPIRICAL RESULT

3.1. Model Positive Stationarity Test

Results of unit roots test including LLC test, Breitung test, IPS test, Fisher ADF, Fisher PP test showed that the variable passed the usual significance test at least at the 5% level, proving that the panel data sequence was stable. The Pedroni test was then performed as in Table 1.

Panel ADF and other tests reject the null hypothesis of 'no cointegration relationship' at the significance level of 5%, which means that there is a cointegration relationship between variables, and panel data regression analysis can be performed.

Table 1. Co-integration relationship test results

Pedroni Test	Panel V 7.763 (0.000)	Panel Rho 6.995 (0.000)	Panel PP -14.472 (0.000)	Panel ADF -2.256 (0.025)
	Group Rho 12.562 (0.000)	Group PP 10.720 (0.000)	Group ADF -7.733 (0.000)	
Kao Test	ADF -9.418 (0.000)			

P value is shown in parentheses.

3.2. Model Regression

Hansen threshold test results are shown in Table 2 and the 'self-sampling' times is 1000.

The panel model regression results are shown in Table 3, Column 1, and the threshold models regression results are shown in Table 3, Columns 2 and 3.

Table 2. Threshold effect test results

	n threshold	Estimated threshold	95% confidence interval	F value	BS
FDI	single threshold	0.751	[0.738, 0.782]	4.783***	1000
	double threshold	1.019	[1.019, 1.057]	0.345	1000
OFDI	single threshold	1.120	[1.115, 1.235]	4.558***	1000
	double threshold	1.314	[1.286, 1.373]	0.305	1000

Table 3. Threshold model regression results

Variable	Panel model （1）	Threshold model -FDI （2）	Threshold model -OFDI （3）
HCL	0.030** (1.859)	0.028**(1.854)	0.031* (1.311)
RDC	0.057***(5.307)	0.052***(3.953)	0.047***(3.830)
EDP	0.094** (2.247)	0.104**(2.176)	0.023**(2.232)
TO	0.176***(2.930)	0.202***(3.594)	0.197**(4.226)
FDI	0.062**(2.175)		0.059**(2.092)
OFDI	0.025 (0.682)	0.021(0.586)	
FDI·(*HIA*≤0.751)		0.043**(1.973)	
FDI·(*HIA*＞0.819)		0.071***(2.845)	
OFDI·(*HIA*≤1.120)			-0.014 (0.667)
OFDI·(*HIA*＞1.120)			0.031*(1.241)
R^2	0.692	0.687	0.6721

*, **, *** indicate significance at the 10%, 5% and 1% levels, respectively; t values are in parentheses.

3.3. Results Analysis

Firstly, the model construction has rationality and completeness. The R-Squared index of panel model and threshold model groups are close to 70%, which proves that the selected variables have strong explanatory power. According to the results in Table 3, human capital level, R&D capability, economic development level and trade openness significantly promote provincial technology progress. FDI plays a positive role in promoting provincial technology progress, and the regression coefficient is 0.062. The effect of OFDI

on technology progress fails to pass the significance test. Secondly, two-way FDI has a significant nonlinear threshold effect on technology progress. As shown in the Table 2, both FDI and OFDI pass the single threshold test significantly at 1% level when HIA is used as the threshold variable, but fail to pass the double threshold test. The HIA threshold value of FDI spillover is 0.751, and that of ODFI spillover is 1.120. Thirdly, high-tech industrial agglomeration has a moderating effect on technology progress spillover effect of two-way FDI. When the high-tech industrial agglomeration is lower than 0.075, the regression coefficient of FDI is 0.043, while when the high-tech industrial agglomeration exceeds 0.075, the regression coefficient increases to 0.071, which indicates that under the regulation of high-tech industry agglomeration, FDI spillover has a positive relationship with increasing marginal effect of provincial technology progress, and the higher degree of agglomeration means the more obvious positive effect of spillover. When high-tech industry agglomeration is lower than 1.120, the OFDI regression coefficient is -0.014, and OFDI spillover has a crowding effect on provincial technology progress. When the agglomeration exceeds 1.120, the positive effect appears, and the regression coefficient is 0.031, which indicates that under the regulation of high-tech industry agglomeration, OFDI spillover and provincial technology progress have a U-shaped relationship. If and only if provincial high-tech industry agglomeration is higher than 1.120, OFDI spillover has a positive effect on technology progress.

4. CONCLUSIONS AND RECOMMENDATIONS

This paper studies the influence of two-way FDI on provincial technology progress in China from the perspective of high-tech industry agglomeration, and introduces the Hansen threshold model and empirically analyzes the nonlinear influence mechanism of spillover and the moderating effect of high-tech industry agglomeration. China’s provinces should actively develop high-tech industries, rationally optimize industrial layout, enhance the scale effect and diffusion effect generated by agglomeration. At the same time, provinces actively guide foreign direct investment in technology-intensive industries and increase technology acquisition to promote the positive spillover impact of two-way FDI on China's scientific and technological development and innovation.

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