

# FDI, The Impact of Import and Export Trade on Total Factor Productivity: Spatial Measurement Based on Provincial and Municipal Data

Xinyu Zhang

School of Economics and Management, Southwest Petroleum University, Chengdu, China.

## Abstract

**This article uses spatial econometric methods to analyze the spillover effects of total factor productivity in space, and examines the impact of 29 provinces and cities in China's use of foreign direct investment (FDI) and import-export trade, two core technology introduction methods, on total factor productivity from 2013 to 2022. The research results show that the total factor productivity of various provinces and cities in China exhibits a significant agglomeration phenomenon in space; Import activities have a positive driving effect on improving total factor productivity, while the impact of export activities on total factor productivity growth is not significant; FDI has played a positive role in promoting total factor productivity to a certain extent; There is a negative correlation between R&D investment and total factor productivity.**

## Keywords

**Total factor productivity; Spatial econometric model; FDI; import and export trade.**

## 1. Introduction

With the continuous deepening of global economic integration, how to achieve economic growth has become a focus of research for scholars at home and abroad. As an emerging economy, China has achieved remarkable results in economic development under the promotion of reform and opening up. In the past decade, China's GDP has grown at an average annual rate of over 6%. In 2023, China's annual GDP will reach 1.260582 trillion yuan, an increase of 5.2% over the previous year. While the economy is growing rapidly, it should be soberly recognized that China's economic development mainly stems from the expansion of the input of production factors. This "extensive" growth mode is not only constrained by resources and the environment, but also faces the severe challenge of the gradual disappearance of savings "dividends", making it difficult to achieve long-term sustainable development. To achieve sustainable economic growth in our country, it is necessary to increase the growth of Total Factor Productivity (TFP). Therefore, how to promote total factor productivity has become an urgent issue for China to transform its economic development mode.

Under open economic conditions, a country's total factor productivity growth depends not only on its own research and development activities, but also on its outward R&D investment and technology diffusion. From the perspective of the country's current technological catch-up strategy, relying excessively on time and high cost independent innovation models is not advisable. Therefore, China should use foreign direct investment and import and export trade as a link to introduce capital goods, intermediate products, and other high-tech products into developed countries. In view of this, this article explores the impact mechanism of FDI and import-export trade on TFP growth from two perspectives: FDI and import-export trade.

## 2. Literature review

At present, scholars at home and abroad mostly focus on the influencing factors of total factor productivity from the perspective of import and export or FDI alone, and there are relatively few literature examining the impact of both import and export trade and FDI on total factor productivity.

In terms of foreign research, HejaziW and Safarian, A.E. (1999)<sup>[1]</sup> added FDI variables to the Coe and Helpman models and found that the impact coefficient of FDI significantly decreased. Empirical results showed that foreign direct investment and import-export trade have a positive technology spillover effect on improving TFP, while FDI has a greater promoting effect on TFP than import-export trade. On the other hand, Wu (2006)<sup>[3]</sup> used the stochastic frontier method to examine the relationship between the openness of the Asia Pacific Economic Cooperation (APEC) and TFP growth from 1980 to 1999. The results indicate that both imports and exports have a positive impact on changes in technological efficiency. In terms of TFP growth, developed and developing countries have performed better than developed countries such as the United States.

In terms of domestic research, Huang Xianhai and Zhang Yunfan (2005)<sup>[10]</sup> studied the impact of import and export trade and FDI on TFP growth and found that both can promote the improvement of TFP, and they have symbiotic and complementary characteristics. However, the spillover effect of FDI on TFP is greater than that of import and export. He Yuanqing (2007)<sup>[7]</sup> theoretically studied the impact of FDI and import-export trade on TFP, and introduced human capital into the model based on this. It was found that both have positive technology spillover effects on TFP, and FDI has a strong promoting effect on TFP, but the promoting effect of exports on TFP is slightly weakened. Jiang Ren'ai and Feng Genfu (2012) conducted an empirical analysis on the effects of FDI, import and export trade, and knowledge spillover R&D of G7 member countries on China's TFP based on the CH model. They found that FDI has a significant promoting effect on China's TFP, and the contribution of import and export trade to TFP has also increased. However, FDI has little effect on improving China's TFP.

Overall, there is relatively little literature on the impact of FDI and import-export trade on total factor productivity. In such literature, most scholars believe that FDI promotes the growth of total factor productivity, while the impact of import-export trade on total factor productivity is more complex.

## 3. Measurement and Data Processing of Total Factor Productivity

### (1) Model setting

The Malmquist production index method originated from the scaling factor concept proposed by Malmquist in 1963, and was later combined with DEA (Data Envelopment Analysis) theory by Charnes et al. to define the Total Factor Productivity (TFP) index by using Malmquist's input-output distance function. From then on, MalmquistTFP index has been widely adopted in research on productivity measurement. Given the advantages of this method, this article adopts the DEA based Malmquist production index method to calculate total factor productivity and conducts a decomposition analysis of it.

### (2) Variable selection and data processing

Considering the availability of panel data, this paper selects 29 provinces and cities other than Xinjiang Uygur Autonomous Region, Xizang Autonomous Region, Taiwan, Hong Kong and Macao as research samples, with the time span from 2013 to 2022. The key variables involved in calculating total factor productivity (TFP) include total output, capital input, and labor input.

In terms of total output, this article uses the actual Gross Domestic Product (GDP) of these 29 provinces and cities from 2013 to 2022 as the measurement indicator, and calculates the GDP series based on 2013 to eliminate the impact of price changes.

In terms of labor input, this article selects the total number of employed people in 29 provinces and cities across the country as the representative of labor input, represented by L.

The calculation of capital stock adopts the "perpetual inventory method" and refers to the calculation method of Zhang Jun et al. In order to reduce calculation errors, this article takes 2013 as the base year and converts the capital stock of each province in 2013 from 1952 to 2013. At the same time, this paper adopts the price index of fixed assets investment to adjust, and determines that the depreciation rate of gross fixed capital formation in each province and city is 9.6%.

(3) Calculation results and analysis

According to the Malmquist production index method, we used data from 2013 to 2022, covering 29 decision-making units, involving one output variable and two input variables. Using DEAP2.1 software, we calculated the total factor productivity change index, technical efficiency change index, and technological progress change index of each province and city over the years.

Table 1 shows the annual average values of production indices for each province and city from 2013 to 2022, which have been processed and organized. From the table, it can be seen that among all 29 provinces and cities, only 7 provinces and cities including Shanxi, Hebei, Shaanxi, Gansu, Guizhou, Yunnan, and Hainan have a total factor productivity index (TFP index) greater than 1, indicating that these 7 provinces and cities achieved growth in total factor productivity from 2013 to 2022. Among them, Hainan has the highest TFP index, reaching 1.077. Among the 22 provinces and cities with TFP index less than 1, Jilin, Liaoning, Sichuan, and Zhejiang performed higher than the national average.

From the calculation results in Table 1, it can be seen that the Malmquist index, which measures China's technological progress index and technological efficiency index, are both less than 1. This indicates that during the period from 2013 to 2022, most provinces and cities in China did not achieve significant technological progress, and technological efficiency did not improve significantly. In terms of technological progress, although the national average level has not shown significant progress, Hainan's technological progress index is greater than 1, indicating that only Hainan has achieved technological progress from 2013 to 2022 nationwide. As for the changes in technical efficiency, except for the three provinces of Zhejiang, Shandong, and Qinghai which remain unchanged, the technical efficiency of Ningxia, Hebei, Shaanxi, and Gansu has improved, among them, Shaanxi has the largest increase, reaching 5.1 percentage points.

Table 1 Growth rate and decomposition of total factor productivity in various provinces and cities

Provinces	Technical Efficiency Change Index	Technological Progress Change Index	Total Factor Productivity Change Index
Beijing	0.982	0.901	0.885
Tianjin	0.964	0.879	0.848
Shanghai	0.964	0.906	0.879
Chongqing	0.968	0.897	0.878
Neimenggu	0.967	0.889	0.868
Guangxi	0.962	0.866	0.836

---

Ningxia	1.001	0.846	0.842
Heilongjiang	0.980	0.915	0.899
Jinlin	0.977	0.954	0.936
Liaoning	0.998	0.919	0.913
Shanxi	0.988	0.927	1.026
Hebei	1.035	0.922	1.009
Shanxi	1.051	0.936	1.022
Gansu	1.007	0.940	1.016
Sichuan	0.972	0.907	0.963
Guizhou	0.981	0.979	1.036
Yunnan	0.994	0.956	1.006
Hainan	0.996	1.012	1.077
Zhejiang	1.000	0.930	0.983
Shandong	1.000	0.898	0.826
Jiangsu	0.945	0.991	0.888
Anhui	0.926	0.926	0.836
Fujian	0.934	0.913	0.835
Jiangxi	0.942	0.943	0.868
Henan	0.988	0.919	0.853
Hubei	0.963	0.907	0.850
Hunan	0.985	0.892	0.839
Guangdong	0.988	0.943	0.907
Qinghai	1.000	0.928	0.899
Mean	0.981	0.921	0.912

---

#### 4. Empirical analysis

Based on sample data from 29 provinces and cities in China from 2014 to 2022, the spatial economic panel econometric method was used, and the spatial lag model and spatial error model were estimated using Matlab 7.0 software. In order to conduct a more intuitive comparative analysis, the weighted least squares method (WLS) of ordinary panel data was used for estimation. The specific results are shown in Table 2.

Table 2 Regression results at the national level

MODEL	WLS		SLM	
	Coefficient	t	Coefficient	t
C	0.954***	282.78	0.36***	6.90
ex	0.06***	2.26	0.13	0.68
im	0.04*	2.65	0.06**	2.15
fdi	0.04	1.15	0.15***	3.55
rd	-0.57*	-1.56	-0.59**	-2.70
P or $\lambda$			0.45***	6.57
ReviseR2	0.25		0.43	
LogL	25.80		241.29	
DW	1.69			
Likelihood			952.86	
p	0.000		0.000	
n	261		261	
Spatial dependency test	Statistical value		p	
LM (sar)	22.85***		0.000	

Note: \*\*\*, \*\* and \* indicate that the above variables are statistically significant at the 1%, 5% and 10% levels, respectively.

According to the analysis of WLS regression results, we found that the model has a high goodness of fit of 24.58%, indicating that Strong overall significance. The DW value reached 1.6854, which effectively alleviated our understanding of the explanatory variables Concerns about possible multicollinearity issues. Through careful observation, it can be found that:

① the export variable ex The coefficient is 0.0569 and passed the test at a significance level of 1%, which clearly indicates that exports have a significant positive driving effect on the growth of total factor productivity (TFP) in China;

② The coefficients of the import variable im and the R&D investment variable rd are 0.0402 and -0.5698, respectively, both passing the 10% significance level test. This indicates that imports have played a positive role in improving total factor productivity, but technology investment has shown a significant negative impact;

③ The coefficient of the foreign direct investment (FDI) variable FDI is 0.0428. Although it has a significant positive effect on the growth of China's TFP, this effect has not reached a significant level. This result may be due to two reasons: firstly, FDI itself does not have a significant effect on improving TFP; The second issue is that the WLS model we adopted may have problems in its settings, such as not fully considering the spatial correlation of TFP in geography.

By analyzing the regression results of the Spatial Lag Model (SLM) in the spatial econometric model, we can observe that compared to the regression results of Weighted Least Squares (WLS), the overall model's goodness of fit and log likelihood (LogL) are improved when spatial factors are introduced into the model. In addition, the spatial autoregressive coefficient  $\rho$  and spatial error regression coefficient  $\lambda$  are both significant at the 1% level, which further confirms the rationality and importance of introducing spatial factors. If we ignore the potential spatial correlations that may exist between economies, regression models based on ordinary least squares (OLS) may produce bias.

By comparing the WLS regression results with the SLM regression results, the following conclusions can be drawn:

① In the explanation of TFP spatial spillover, spatial variables have a significant impact on TFP. Among them, the spatial autoregressive coefficient  $\rho$  is 0.3895, and it has passed the 1% significance test, indicating that the TFP between regions has strong spatial dependence. This spatial dependence is mainly achieved through the transmission of overflow shocks in space. Statistically speaking, the value of  $\rho$  refers to the direction and degree of influence of changes in observed data on the measured data in a neighboring area. Therefore, a 1% change in TFP in neighboring provinces will result in a corresponding change of 0.3895% in TFP in each province and city within the province.

② In the SLM regression results, the coefficient of the export variable  $ex$  is 0.1256, indicating that exports have a positive impact on the growth of total factor productivity, but this impact is not significant. This is mainly due to the unreasonable structure of China's import and export commodities. According to statistics, labor-intensive products account for a large proportion of China's export products, and are mainly exported by foreign-funded enterprises. The impact of these exports on total factor productivity growth may be replaced by foreign direct investment (FDI). In contrast, the coefficient of the import variable  $im$  is 0.0589, and it passed the test at a significance level of 5%. The results show that imports have a significant promoting effect on the improvement of TFP. This is because Under the condition of import, many advanced foreign machinery and parts can be obtained, which will have an impact on the region after production. Contribute to overall productivity. At the same time, Chinese enterprises can also drive foreign countries by replicating them. The diffusion of advanced technology to domestic enterprises enhances China's TFP.

③ In the SLM regression results, the coefficient of the foreign direct investment variable  $FDI$  is 0.1526, and it passes the test at a significance level of 1%, indicating that FDI has a significant promoting effect on the growth of total factor productivity. This is mainly because foreign direct investment provides enterprises with a large amount of external resources, including management experience, business processes, marketing technology, cross-border distribution networks, technological innovation, and research and development. This additional resource promotes TFP growth through various means.

④ In the SLM model, the coefficient of the R&D investment variable  $rd$  is -0.586, and it passes the test at a significance level of 5%, indicating a negative correlation between R&D investment and total factor productivity growth. The reason for this is that there are still some problems in the utilization efficiency and investment structure of existing research and development investments. The main body of R&D investment by the Chinese government is large state-owned enterprises with strong budget soft constraints and poor principal-agent relationships. So, excessive R&D investment can lead to low investment efficiency, which in turn has a negative impact on the improvement of TFP.

## 5. Conclusions and policy recommendations

This article uses spatial econometric methods to conduct in-depth research on the impact of import and export trade and foreign direct investment (FDI) on total factor productivity (TFP) based on panel data from 29 provinces and cities in China from 2014 to 2022. By comparing the results of ordinary panel regression (using weighted least squares method WLS) and spatial panel regression (spatial lag model SLM), we have drawn the following core conclusions:

(1) FDI has a significant driving effect on the growth of total factor productivity, and this driving effect exceeds the technology spillover effects brought by import and export trade;

(2) Import trade has a significant positive impact on the growth of total factor productivity, while export trade, although also having a positive effect on the growth of total factor productivity, has not reached a significant level;

(3) In the controlled variable, the coefficient of research and development investment (R&D) is negative and significant, indicating a negative correlation between R&D investment and the growth of total factor productivity;

(4) China's total factor productivity exhibits significant spatial dependence between adjacent provinces and cities in terms of geographic space, which is achieved through endogenous spatial lag effects.

Based on the above conclusions, the following policy recommendations are proposed:

(1) To promote the growth of total factor productivity, China should further expand FDI and import scale, continue to optimize the foreign investment environment, especially in eastern coastal provinces and cities such as Guangdong, Jiangsu, Shanghai, etc. These regions have attracted a large amount of foreign investment, but there is still room for further expansion. By providing more favorable tax policies, simplifying approval processes, and strengthening intellectual property protection, we aim to attract more high-quality foreign-funded enterprises to settle in. At the same time, central and western provinces and cities such as Sichuan, Chongqing, Henan, etc. should also increase their efforts to utilize their resource and cost advantages to attract foreign investment, thereby driving local technological progress and industrial upgrading;

(2) In order to improve the technological content of China's export products and reduce dependence on exports from foreign-funded enterprises, central and western provinces and cities should encourage local enterprises to expand their international markets and reduce their dependence on exports from foreign-funded enterprises. The government can organize enterprises to participate in international exhibitions, build cross-border e-commerce platforms and other measures to help enterprises expand overseas markets. At the same time, through policy guidance and support, local enterprises are encouraged to strengthen independent research and development and brand building, in order to enhance the competitiveness of exported products;

(3) The government should increase domestic R&D investment, especially in strategic emerging industries and key core technology areas. For example, national level research and development centers and laboratories can be established in cities such as Beijing and Shanghai to attract top talents and teams from both domestic and international sources. At the same time, central and western provinces and cities should also establish provincial or municipal research and development centers based on their own industrial characteristics to promote technological innovation of local enterprises;

(4) When formulating policies on total factor productivity, full consideration should be given to the spatial interdependence between provinces and cities. Eastern coastal provinces and cities can strengthen cooperation and exchanges with central and western provinces and cities, and drive economic development and technological progress through industrial transfer and technology diffusion. At the same time, central and western provinces and cities should actively undertake industrial transfer and technology spillover effects from eastern coastal provinces and cities, and enhance their own development level.

## References

- [1] Coe D T, Helpman E. International r&d spillovers[J]. *European Economic Review*, 1995, 39(5):859-887.
- [2] Haskel J E, Pereira S C, Slaughter M J. Does inward foreign direct investment boost the productivity of domestic firms? [J]. *The Review of Economics and Statistics*, 2007, 89(3):482-496.

- [3] Wu Yanrui, Openness, productivity and growth in the APEC economies [J]. *Empirical Economics*, 2004(3):593-604.
- [4] Haddad M, Harrison A. Are there positive spillovers from direct foreign investment?: evidence from panel data for Morocco [J]. *Journal of Development Economics*, 1993, 42(1):51-74.
- [5] Grether J M. Determinants of technological diffusion in Mexican manufacturing: a plant level analysis [J]. *World Development*, 1999, 27(7):1287-1298.
- [6] Edwards S. Openness, productivity and growth: what do we really know? [J]. *The Economic Journal*, 1998, 108(447):383-398.
- [7] He Yuanqing. Opening up to the outside world and TFP growth: an empirical study based on inter-provincial panel data in China [J]. *Economics*, 2007, 6 (4): 1127-1142.
- [8] Xu Peiyuan: Spatial neighbor effect of TFP growth in Chinese provinces: an empirical study [J], *Journal of Shanxi University of Finance and Economics*, 2009 (9): 36-42.
- [9] Jiang Ren'ai, Feng Genfu. Trade FDI, Intangible technology spillover and China's technological progress [J]. *Management World*, 2012, (09): 49-60.
- [10] Huang Xianhai, Zhang Yunfan. Analysis of Technology Spillover Effects of Foreign Trade and Investment in China [J]. *International Trade Issues*, 2005, (01): 27-32.
- [11] Qiu Ting, Lv Hongfen, Tong Sujuan. The impact of trade openness on green total factor productivity: an empirical analysis based on panel data from 40 prefecture level cities in the Yangtze River Delta region [J]. *Science and Industry*, 2023, 23 (19): 101-107.
- [12] Cheng Yunjie, Zhang Zhifang. Research on the Impact of FDI on Green Total Factor Productivity in China's Manufacturing Industry: Based on Panel Data of Manufacturing Industries [J]. *Xinjiang Finance and Economics*, 2023, (01): 26-37.
- [13] Huang Qinghua, Liu Min, Hu Jiangfeng. Trade openness, environmental regulation, and green total factor productivity: an empirical test based on the Yangtze River Economic Belt [J]. *Journal of Southwest University (Natural Science Edition)*, 2021, 43 (07): 118-129.
- [14] Liu Yan. Research on the Impact of FDI on Green Total Factor Productivity in Anhui Province [J]. *Bohai Rim Economic Outlook*, 2020, (12): 75-77.
- [15] Lv Hongyan, Sun Xifeng, Qi Xiuhui. Institutional Innovation and Total Factor Productivity of Enterprises: Evidence from China's Pilot Free Trade Zones [J]. *Soft Science*, 2020, 34 (10): 76-83.
- [16] Hong Junjie, Mi Feifei, Yang Zhihao. Research on the Path to Promoting High Quality Development of Trade: Based on the Perspective of Total Factor Productivity [J]. *International Trade*, 2020, (04): 40-47.
- [17] Yan Huizhen. Research on the impact of foreign direct investment on green total factor productivity -- based on the provinces along the "the Belt and Road" [J]. *North Economic and Trade*, 2020, (04): 20-23.
- [18] Zhang Jianqing, Dong Jieming. The impact of foreign trade on the green total factor productivity level of provinces along the Belt and Road [J]. *Journal of Yunnan University of Finance and Economics*, 2019, 35 (12): 63-72.
- [19] Li Jia, Tang Yi. Trade Openness, FDI, and Total Factor Productivity [J]. *Macroeconomic Research*, 2019, (09): 67-79+129.
- [20] Cui Xinghua, Lin Mingyu. How does FDI affect the green total factor productivity of enterprises? -- Empirical analysis based on Malmquist Luenberger index and PSM-DID [J]. *Economic Management*, 2019, 41 (03): 38-55