Original Research Article

Research on the influence of Foreign Direct Investment on technological innovation in Jiangsu Province

Abstract: Under the background of the in-depth development of economic globalization, Jiangsu province, as a big province of China's opening to the outside world, actively introduces foreign investment. The inflow of FDI not only promotes the economic development of Jiangsu province, but also can produce technology spillover effect, which has an important impact on the technological innovation of Jiangsu Province. Jiangsu has developed economy and should accelerate the improvement of its own innovation level in the rapid development of knowledge economy today. Therefore, it is of great practical significance to study the influence of FDI inflow on technological innovation in Jiangsu Province. In this paper, the relevant data of Jiangsu province from 2005 to 2018 are selected as variables. Through empirical analysis, it is found that the inflow of FDI plays a positive role in promoting technological innovation in Jiangsu Province. Finally, countermeasures and suggestions are put forward for how to rationally utilize FDI in Jiangsu province and improve the level of technological innovation.

Keywords: FDI；technological innovation；Jiangsu；technology spillover effect

1. Introduction

According to the report to the 19th CPC National Congress, "Innovation is the primary driving force for development and the strategic underpinning for building a modernized economy." It is an indisputable fact that the era of knowledge economy is coming. As the core of the era of knowledge economy in the future, innovation is an important driving force to promote the development of economy in the direction of high quality. China has been implementing the opening-up policy from 1978 to 2020,and the scale of foreign direct investment is getting bigger and bigger. According to statistics, the scale of foreign investment utilization in China reached 144.4 billion US dollars in 2020, ranking first in the world. As a large economic province in China, Jiangsu is located at the intersection of "One Belt and One Road" construction and has a superior geographical position. Jiangsu actively implements the policy of opening up to the outside world and takes the lead in China in opening up. In 2020, Jiangsu attracted 28.38 billion dollars of foreign direct investment, ranking first in China. In terms of economic development,Jiangsu's per capita GDP was 24,842 yuan in 2015, and reached 115,168 yuan in 2018. It can be seen from the above data that the rapid development of

foreign capital introduction in Jiangsu province has driven the improvement of economic development level in Jiangsu province to a certain extent. Therefore, this paper takes Jiangsu province as the research object to study the relationship and influence between foreign direct investment and technological innovation in Jiangsu Province, which is not only conducive to improving the technological innovation level of Jiangsu Province, increasing the competitiveness of enterprises, but also conducive to the improvement of the overall economic level of Jiangsu Province.

2. Literature Review

With the deepening of economic globalization, foreign direct investment (FDI), as one of the main driving forces of a country's economic growth, has been studied and concerned by scholars at home and abroad. Lu Gao (2021) studied FDI from the national and regional levels, and selected the provincial panel data of China from 2004 to 2018 to establish a model. He found that FDI inflow has a positive effect on the technological innovation capacity of eastern and central China, but the positive effect on western China is not obvious and there are regional differences. Ou Xiaoyuan (2019) made an empirical analysis of FDI and technological innovation based on the data of the Yangtze River Economic Belt and found that the inflow of FDI has a significant technology spillover effect on technological innovation in the Yangtze River Economic Belt. Lin Yunjie (2017) in FDI of producer services as the research object, using the panel data, from two aspects of regional difference and difference in industry to study the effect of producer services FDI to technological innovation, the empirical results show that this influence exists regional differences, the western region to promote role, the largest in eastern and central regions of smaller.Ye Jiao et al. (2014) took Jiangsu Province as the research object and found that FDI had a positive spillover effect on technological innovation in Jiangsu Province, which was better than the national average level.

Although the above scholars found in their research that the inflow of foreign direct investment is beneficial to technological innovation, not all scholars agree with it. They believe that the impact of foreign direct investment on technological innovation is not significant or even negative. Zheng Zhanpeng (2014) believes that the impact of foreign direct investment on China's technological innovation is not only related to regional differences, but also related to technological creation, and that the impact of FDI on China's technological innovation is not significant. Guo Liping (2014) found that foreign direct investment not only did not produce significant technology spillover effect on Chinese enterprises, but also inhibited the technological innovation of enterprises in eastern China.

3.Overview of FDI and technological innovation in Jiangsu Province

3.1 Current situation of FDI

3.1.1 Scale characteristics of attracting FDI in Jiangsu

With the deepening of economic globalization, transnational investment activities have become one of the important means for countries to seek economic development. Since the reform and opening up, foreign direct investment has effectively promoted the improvement of China's economic development level. Jiangsu opened to the outside world earlier, has been practicing the policy of opening to the outside world, actively introduce foreign investment, encourage foreign investment, promoting the formation of all-round high-level opening up pattern, and striving to become a strong open province. In 2005, actual foreign investment in Jiangsu province doubled to us $2,559.248 in 2018, up from US $1,318,339. The amount of foreign capital actually used increased year by year from 2015 to 2012, and reached the maximum value in 2012. The amount of foreign capital actually used decreased year by year from 2012 to 2015, and began to increase year by year after 2015. In the past ten years, foreign investment has increased and decreased, but on the whole, it has increased in fluctuation.

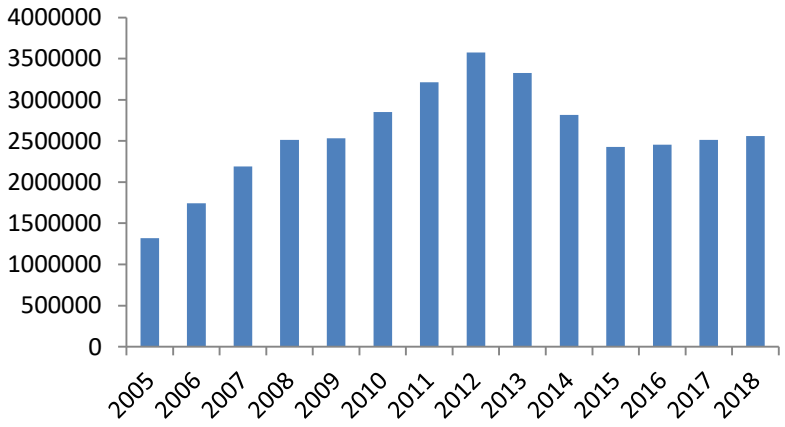

Fig. 1. Actual amount of foreign capital used in Jiangsu Province from 2005 to 2018

3.1.2 Regional characteristics of attracting FDI in Jiangsu

As a large province attracting foreign direct investment in China, Jiangsu attracts a large scale of foreign direct investment. In order to obtain the maximum benefit, foreign-funded enterprises generally invest in areas with a higher level of economic development and better investment environment. Due to the influence of economic foundation, geographical location, natural environment and policy, there are significant differences in FDI in Jiangsu Province. The following figure shows the overall scale of foreign investment attracted by the three regions of Southern Jiangsu, Central Jiangsu and northern Jiangsu from 2005 to 2018. It is not difficult to see: Foreign investment is mainly concentrated in southern Jiangsu, which has developed economy and attracted the largest scale of foreign investment. In 2012, the scale of

foreign investment attracted by southern Jiangsu reached the maximum and then showed a downward trend, which is consistent with the trend of the actual amount of foreign capital used in the whole Jiangsu Province. From 2005 to 2011, central Jiangsu attracted more foreign capital than northern Jiangsu, and after 2011, northern Jiangsu gradually overtook, and the two attracted foreign capital amounts tend to be close, the difference is small.Overall, the gap is gradually narrowing.

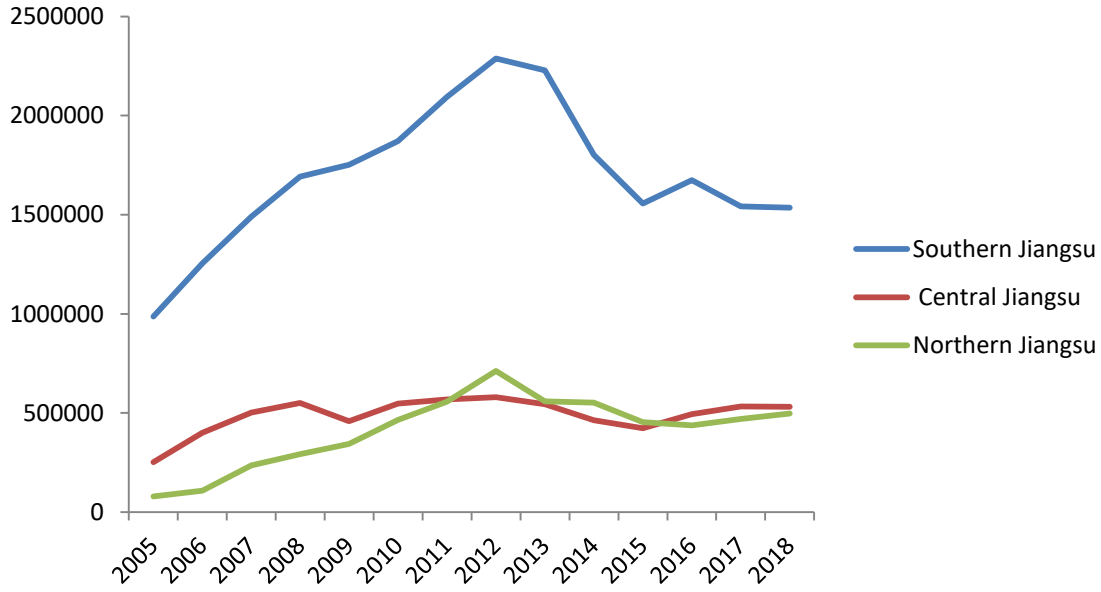

Fig.2. Amount of foreign capital attracted by Southern Jiangsu, Central Jiangsu and northern Jiangsu during 2005-2018

3.1.3 Industrial characteristics of attracting FDI in Jiangsu Province

With the improvement of economic development level, the industrial structure of Jiangsu province is constantly optimized, and the direction of foreign investment is gradually shifting to knowledge-intensive and technology-intensive industries. Take 2018 as an example, the tertiary industry attracted foreign capital and the secondary industry attracted foreign capital close, accounting for 50% and 49% respectively, the primary industry attracted foreign capital accounted for only 1%, foreign capital is shifting to the tertiary industry, the service industry in Jiangsu Province has achieved great development.

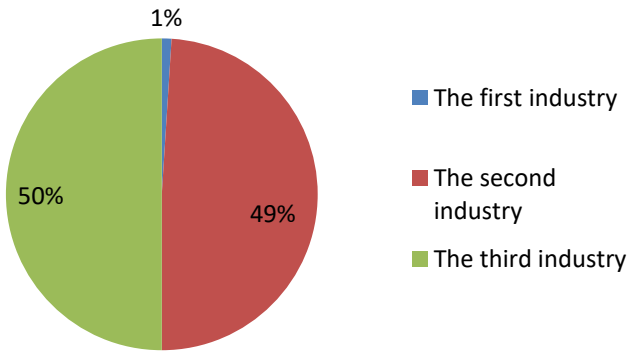

Fig.3. Proportion of FDI attracted by three industries in Jiangsu province in 2018

3.2 Current situation of technological innovation

3.2.1 Investment in innovation

The investment of R&D personnel and funds is a main index of technological innovation ability. As can be seen from the table below, both R&D personnel and R&D funds are increasing year by year. Moreover, the R&D expenditure of Jiangsu province in 2018 has reached 2.5044293 million yuan. As a whole, the proportion of R&D expenditure in China fluctuates. To sum up,Jiangsu province's R&D labor input and capital input are increasing.

Table 1 Full-time equivalent of R&D personnel and internal expenditure of R&D funds in Jiangsu Province from 2005 to 2018

Year	Full-time Equivalent of R&D Personnel in Institutions of Higher Learning (Person/year)	Proportion in China (%)	Internal EXPENDITURE of R&D Expenditure (ten thousand yuan)	Proportion in China (%)
2005	16535	7.28	2698292	11.01
2006	17631	7.27	3460695	11.52
2007	17578	6.92	4301988	11.59
2008	17374	6.51	5809124	12.58
2009	17016	6.18	7019529	12.10
2010	17513	6.05	8579491	12.15
2011	19686	6.58	10655109	12.27
2012	20880	6.66	12878616	12.51
2013	22189	6.83	14874466	12.56

2014	23082	6.89	16528208	12.70
2015	23875	6.73	18012271	12.71
2016	26350	7.32	20268734	12.93
2017	27063	7.08	22600621	12.84
2018	25990	6.33	25044293	12.73

3.2.2 Innovative output

The output of scientific and technological activities is reflected in national or regional awards, patents, production and sales of new products of enterprises. This paper analyzes the output of technological innovation in Jiangsu province mainly through the number of patent authorization.It can be seen from the number of patents granted, only 13,580 patents were granted in 2005, while 306,996 patents were granted in 2018. Among them, the number of patent granted reached its maximum value in 2013, and then began to decline. Generally speaking, it still rose in a fluctuation.

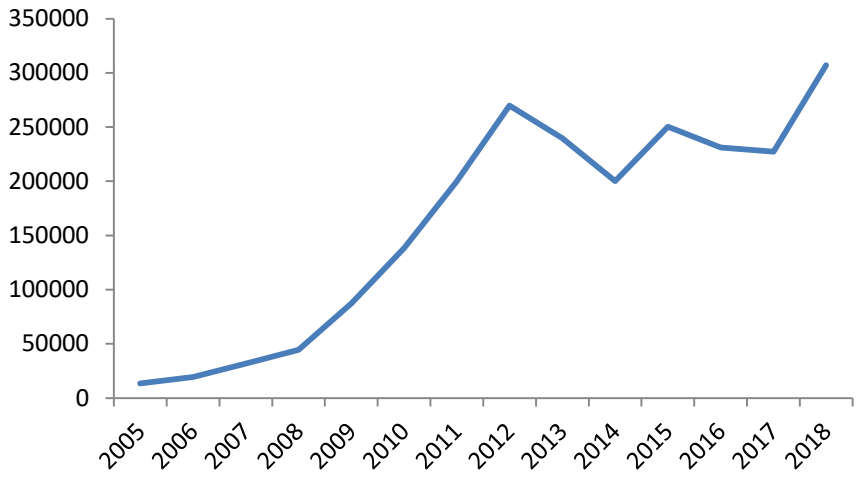

Fig.4. Number of patents granted in Jiangsu Province from 2005 to 2018

4. Empirical Analysis

4.1 Variable selection and model setting

In this paper, the number of patent grants is taken as the proxy variable of technological innovation, which is also the explained variable of this paper. Taking actual utilization of FOREIGN capital as the core explanatory variable, per capita GDP, total import and export volume, technology market turnover, internal R&D expenditure and the number of college students per 10,000 population were selected as explanatory variables.

Table 2 Selection of main variables

Variable		Define	Meaning
Explained variable	Y	Number of patents granted	Technological innovation
Core explanatory variable	X1	Actual use of foreign capital	Foreign direct investment
Explanatory variables	X2	Per capita GDP	Economic development level
	X3	Total import and export volume	Level of opening up
	X4	Technology market turnover	R&D labor input
	X5	R&D expenditure internal expenditure	R&D capital investment
	X6	The number of university students per 10,000	Population and the level of human capital

In order to avoid the impact of heteroscedasticity on regression results, this paper took natural logarithms of all variables and established the following equation : LnY=C+$\beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + \beta_6 LnX_6 + \varepsilon$,$\varepsilon$ is the random error term.

4.2 Empirical analysis

4.2.1 Stationarity test

ADF test method is adopted in this paper, and the test results are shown in the following table:

Table 3 Results of stationarity test

Variable	ADF test value	Critical values at each significance level			P-value	Whether smooth
		1%	5%	10%		
Lny	-3.00	-4.06	-3.12	-2.70	0.0609	NO
ΔLny	-1.34	-2.77	-1.97	-1.60	0.1586	NO
$\Delta^2 Lny$	-4.15	-2.79	-1.98	-1.60	0.0007	YES
Lnx1	-2.22	-4.12	-3.14	-2.71	0.2089	NO
ΔLnx1	-2.31	-2.77	-1.94	-1.60	0.0258	YES
Lnx2	-4.34	-4.06	-3.12	-2.70	0.0062	YES
Lnx3	-2.25	-4.89	-3.83	-3.36	0.4275	NO
ΔLnx3	-5.16	-4.12	-3.14	-2.71	0.0020	YES
Lnx4	-2.26	-4.89	-3.83	-3.36	0.4231	NO

ΔLnx4	-3.68	-4.12	-3.14	-2.71	0.0209	YES
Lnx5	-5.38	-4.20	-3.18	-2.73	0.0018	YES
Lnx6	-5.07	-4.06	-3.12	-2.70	0.0019	YES

Δ represents a first order difference, Δ^2 represents the second order difference。

As can be seen from the above table, LnX_1 (per capita GDP), LnX_5 (internal expenditure of R&D funds) and LnX_6 (number of college students per ten thousand population) are stable at the original level, while LnY (number of patents granted), LnX_1 (actually used foreign capital), LnX_3 (total import and export) and LnX_4 (technology market turnover) are not stable at the original level. There is a unit root. After first-order difference, LnX_1, LnX_3 and LnX_4 are stable, and there is no unit root phenomenon. After second-order difference, LnY is stable, and there is no unit root phenomenon.

4.2.2 Co-integration test

Before the co-integration test, step-to-step regression should be conducted to eliminate the non-significant variables in the possible co-integration regression.

Table 4 Correlation coefficients between variables

Variable	LnY	LnX1	LnX2	LnX3	LnX4	LnX5	LnX6
LnY	1.0000						
LnX1	0.8139	1.0000					
LnX2	0.9448	0.6246	1.0000				
LnX3	0.9626	0.7807	0.9478	1.0000			
LnX4	0.9091	0.5467	0.9654	0.9184	1.0000		
LnX5	0.9538	0.6501	0.9986	0.9519	0.9577	1.0000	
LnX6	0.9603	0.8002	0.9453	0.9430	0.8513	0.9560	1.0000

As can be seen from the correlation coefficient matrix, the correlation coefficient of each explanatory variable is high, and there is serious multicollinearity among explanatory variables. Stepwise regression method is used to modify the multicollinearity and select or eliminate the control variables to determine the best regression model. After repeated corrections, X1, X4 and X6 are finally determined as explanatory variables, and X2, X3 and X5 are difficult to overcome multicollinearity. Next, E-G two-step method was used to conduct co-integration test for variables LnY, LnX_1, LnX_4 and LnX_6.

OLS method was used to carry out co-integration regression. The regression results were shown in the figure below, and the residual sequence was named e.

Table 5 OLS regression results

Variable	Coefficient	Std.Error	t-Statistic	Prob.
C	-7.644696	4.360872	-1.753020	0.1101
LNX1	1.270355	0.338748	3.750144	0.0038
LNX4	0.545921	0.105793	5.160256	0.0004
LNX6	2.381011	1.024037	2.325122	0.0424
R-squared	0.980311	Mean dependent var		1.047940
Adjusted R-squared	0.974405	S.D. dependent var		0.463204
S.E. of regression	0.074106	Akaike info criterion		-2.131682
Sum squared resid	0.054917	Schwarz criterion		-1.949094
Log likelihood	18.92177	Hannan-Quinn criter.		-2.148584
F-statistic	165.9675	Durbin-Watson stat		1.864358
Prob(F-statistic)	0.000000			

After OLS regression, it can be obtained:

$LnY=-7.644696+1.270355LnX_1+0.545921LnX_4+2.381011LnX_6$,

R^2=0.980311, The revised R^2=0.974405,F=165.9675。

The unit root test is performed on residual sequence E, and the output results are shown in the figure below:

Table 6 Co-integration test results

Variable	ADF statistics	1% threshold	5% threshold	10% threshold	P-value	Conclusion
e	-3.633413	-4.121990	-3.144920	-2.713751	0.0224	Smooth

The value of ADF is -3.633413, which is less than the critical value of -3.144920 at the significance level of 5%. Therefore, residual series E rejects the null hypothesis at the significance level of 5%, that is, residual series is stationary series without unit root.Through the co-integration test above, it can be seen that LnY, LnX1, LnX4 and LnX6 have a co-integration relationship and a long-term stable relationship between them. Such a long-term and stable relationship is shown as: the actual use of pinch, technical market turnover in Jiangsu province, the number of college students per ten thousand people mouth is proportional to the patent grant, the actual use of pinch, technical market turnover and the number of college

students per ten thousand people mouth increase will raise the level of technology innovation in Jiangsu province, the technical innovation plays a positive role in promoting. From 2005 to 2018, every 1% increase in the actual utilization of foreign capital in Jiangsu province, the number of patent granted will increase by 1.270355 units, that is, the technological innovation level of Jiangsu province will improve; Each 1% increase in technology market turnover, the number of patent authorization increased by 0.545921 units; If the number of college students per 10,000 population increases by 1%, the number of patents granted in Jiangsu will increase by 2.381011 units. R^2=0.98, indicating that 98% of the sum of squares of total deviations is explained by sample regression lines, representing a good goodness of fit of the model. The p-value of the f-statistic used to test the significance of the whole equation is 0.0000, which also indicates that the regression equation is highly significant. To sum up, the overall impact of all explanatory variables in the model on the explained variables is significant.

5.Conclusion

According to the above empirical analysis, the inflow of FDI will promote the improvement of technological innovation level in Jiangsu Province, and technological market turnover and human capital level have a positive role in promoting the improvement of innovation level. In order to make more reasonable use of foreign capital, give full play to the maximum effect of foreign capital and promote the technological level of Jiangsu Province, this paper puts forward the following countermeasures and suggestions.

5.1 Improve the quality and optimize the environment for investment attraction

Jiangsu province, as a major province in attracting foreign investment in China, should continue to adhere to the principle of "attracting foreign direct investment", unswervingly take the road of attracting foreign direct investment, improve the quality of foreign direct investment while ensuring the scale of foreign investment, and promote the improvement of foreign direct investment quality. In order to ensure the quality of foreign investment, it is necessary to raise the entry threshold of foreign investment, reduce the introduction of foreign investment with low technical level and encourage the introduction of foreign investment with high technical level. In addition, a good investment environment can improve investors' confidence in local investment, so Jiangsu province should optimize the investment environment within the province. On the one hand, infrastructure should be upgraded to better serve the public strengthen market supervision, improve work efficiency, and ensure the fairness, fairness and openness of market competition. On the other hand, we should strengthen the protection of intellectual property rights, attach importance to the legislative work of intellectual property rights, improve China's attraction to foreign investment, improve laws and policies related to

investment introduction, formulate and perfect preferential policies for investment introduction, and create a transparent and open external environment for investment attraction.

5.2 Increase investment in scientific research and improve human capital

The development of technological innovation activities cannot be carried out without long-term, sustained and stable capital investment. According to statistics, in 2020, Jiangsu province invested 300,593 billion yuan in R&D funds, an increase of 8.1% over the previous year, and the investment in scientific and technological funds ranks among the top in China. Jiangsu province should increase technological innovation input in the whole society, ensure sufficient and stable resource support, and ensure high efficiency and high quality output of scientific and technological innovation activities. It should also be noted that capital should be invested in industries with high technological innovation output as far as possible. For those industries with low added value and low technological innovation output, input should be reduced or even no input. In addition to sufficient funds, human capital is also an important factor affecting technological innovation, which requires more talents. The empirical study above shows that the level of human capital has the greatest impact on technological innovation. On the one hand, we should increase education expenditure, improve the education system, enhance the stock of human capital, and accumulate excellent scientific and technical personnel. On the other hand, perfect the talent introduction policy, implement preferential welfare policy to attract high-tech talents, meet the demand of high-tech talents for technological innovation, strengthen the talent exchange and cooperation with foreign-funded enterprises, and improve the level of human capital.

5.3 Improve our capacity for independent innovation and achieve innovation-driven development

Independent innovation is the fundamental way to maintain the competitiveness of enterprises. Technology spillovers from foreign direct investment, will promote the ascension of the level of technology innovation from outside, in addition to the external effect, also we should departure from the inside.Enterprises are encouraged to carry out scientific research cooperation with local universities and research institutions, and make good use of the human resources of universities and institutions, which can not only reduce the production cost of enterprises, but also improve the innovation level of enterprises. At the same time of independent innovation, we should not forget to learn the advanced technology of foreign companies, carry out technical cooperation with foreign companies, internalize and absorb the introduced technology, and finally transform it into our own technology. Enterprises should actively carry out innovation communication activities, improve innovation input, create

innovation culture, create innovation atmosphere, and actively improve the level of independent innovation, so that the whole Jiangsu province can achieve innovation-driven development through the progress of science and technology.

Reference

[1] Ye Jiao, WANG Jialin. Research on the impact of FDI on local technological innovation: An empirical study based on Jiangsu Province panel Data [J]. International Trade Issues,2014(01):131-138.]

[2] Zheng Z P. A comparative study on the impact of international technology spillover channels on China's technological innovation -- based on the provincial panel data model [J]. Science research management,2014,35(04):18-25.

[3] guo l p. an empirical study on technology spillover effects of foreign direct investment [J]. Financial theory & practice, 2014,12 (3) : 112-115.

[4] Zhang Yongmei, DING Yan. Research on the impact of FDI on manufacturing technology innovation in Henan Province [J]. Commercial Economics,2021(11).

[5] Lin YUNjie. Research on the impact of FDI on technological innovation in producer services [D]. Jimei University,2017.

[6] Gao L. Research on the impact of foreign direct investment on China's technological innovation capability [D]. Jilin University of Finance and Economics,2021.

[7] Ou Xiaoyuan. The Impact of FDI on technological innovation [D]. Zhongnan University of Economics and Law,2019.

[8] Xie Jian. Research on the impact of FDI introduction on technological innovation in Shanxi Province [D]. Anhui University,2019.

[9] Sun Min. The impact of Foreign Direct Investment on technological innovation in Shandong Province [D]. Liaoning University,2017.

[10] Li Xiaochen. Research on the independent innovation effect of FDI: Theory and Demonstration [D]. Central University of Finance and Economics,2015.