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Analysis on the Impact of FDI in Eastern China on Local Innovation

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Innovation is an important strategic support for China to accelerate the building of a strong science and technology nation. As the largest developing country attracting FDI, China's FDI has become an exogenous driving force for development, and the technology spillover generated by FDI plays a key role in improving China's innovation capacity. In order to further study the impact of FDI on local innovation in eastern China, based on the panel data from 2008 to 2018, this paper takes 12 provinces, municipalities and autonomous regions in eastern China as research samples to make an empirical analysis on the data of FDI and the relevant indicators of local innovation capability. Based on the empirical results, it is concluded that FDI, R&D personnel input, the degree of trade openness and the level of economic development all have a significant promotion effect on the improvement of local innovation capability in the east, but R&D capital investment, on the contrary, has a suppressing effect on local innovation capability in the east to a certain extent. According to the conclusion, this paper puts forward some suggestions that we should attract high-quality foreign investment, invest R&D funds reasonably, increase the investment of R&D personnel and expand the level of opening to the outside world.

Keywords: FDI; panel data; local innovation capability; empirical analysis.

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1. INTRODUCTION

Since the reform and opening up, China has implemented the development strategy of "bringing in and going out" and vigorously attracted foreign direct investment (FDI), which has solved the problem of capital and technology gap in China's economic development to a great extent. According to the current situation of international direct investment, China has become one of the largest recipients of FDI. From 2008 to 2018, the actual investment flow of China's FDI has increased from US $108.3 billion to US $138.3 billion. According to the 2019 World Investment report, China's outbound investment flows accounted for 14.1% of global flows in 2018, ranking second in the world. The report of the 19th CPC National Congress proposed to "promote the formation of a new pattern of all-round opening up" and focus on the construction of "Belt and Road Initiative" to protect the legitimate rights and interests of foreign investment. Obviously, foreign direct investment has played a huge role in increasing domestic capital, providing good employment, establishing new advantages in international cooperation and competition, and significantly promoted China's economic growth and regional development.

With the continuous strengthening of the trend of economic globalization, technological innovation plays a more important role in enhancing the comprehensive national strength. Since the 18th CPC National Congress, China has vigorously implemented the innovation-driven development strategy with technological innovation as the core.Eastern China has always maintained the fastest economic growth and the strongest economic vitality in the country.With the large inflow of foreign direct investment,a large part of foreign direct investment has been imported into the high-tech industry. The reason is that the high-tech industry has the characteristics of high growth rate, high stability and great development prospects. However, while foreign direct investment has a favorable impact on the development of innovation capability through demonstration and imitation effect, knowledge spillover effect, direct effect and so on, it may also have some negative effects. On the one hand, foreign direct investment enhances innovation ability through technology spillover effects formed by direct and indirect effects, but on the other hand, it may also be because foreign direct investment has a relatively leading technological level, resulting in occupying the space of domestic innovation investment after entering the Chinese market, so foreign-invested enterprises are likely to prefer to protect core technologies and fail to produce effective technology spillovers. As a result, foreign advanced science and technology can not spread to China in time.

Therefore, how to ensure the introduction of foreign capital on the basis of the steady development of local innovation in the eastern region, and how to make rational use of foreign capital has become the key issues that we pay close attention to and discuss. This paper makes an empirical analysis based on the panel data of 12 provinces, municipalities and autonomous regions(include Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, Hainan) in eastern China from 2008 to 2018, studies the impact of FDI on the innovation capability of eastern China, and gives specific countermeasures and suggestions.

2. LITERATURE REVIEW

With the in-depth research of domestic and foreign scholars on the impact of FDI on technological innovation capability, through the summary and analysis of the previous literature, we can find that scholars have not reached a unified conclusion, there are mainly three different viewpoints:

The first point of view is that FDI has a positive effect on the innovation ability of the host country. Cheung and Lin [1] empirically analyze the impact of FDI on China's innovation and development through panel data, and propose that FDI can promote the overall level of research and development in China, and the spillover effect of FDI is especially prominent in design patents. Liu Xing and Zhao Hong [2] based on the analysis of provincial panel data, it is concluded that foreign direct investment can improve China's overall innovation capability, and plays the most significant role in promoting patent applications in eastern China. Antonietti R et al. [3] proposed that foreign direct investment significantly promoted patent application activities, and large-scale FDI significantly promoted patent innovation activities in knowledge-intensive industries. Liu Wenhua [4] analyzes the panel data of the Yangtze River Economic Belt and finds that foreign direct investment plays a significant role in promoting the scale of regional output with strong innovation, as well as R&D output in areas with weak innovation.

The second point of view is that FDI has no obvious promoting effect on the innovation ability of the host country, and even has a certain inhibitory effect. Salvador Barrios [5] concluded that the impact of FDI on the independent R&D level of Spanish industry is not significant, and even has a negative effect on some economically backward countries. Girma S [6] uses industry data to analyze that foreign direct investment has a certain negative impact on the scientific and technological innovation capability of the enterprise industry. Zhang Qian et al. [7] made an empirical analysis on the panel data of 30 provinces in China and concluded that FDI did not have a significant positive effect on the improvement of China's overall innovation capability. Sub-regional studies found that FDI not only did not promote the innovation development of the eastern and western regions, on the contrary, played a certain inhibitory effect. Cheng Li et al. [8] the dynamic panel data model is used to study the impact of FDI on the independent innovation efficiency of China's high-tech industry. It is concluded that FDI with the characteristics of low-tech growth and FDI with high- tech knowledge- intensive characteristics have no obvious positive impact on the efficiency of industrial independent innovation.

The third point of view is that certain prerequisites are needed for FDI to promote the innovation capability of the host country. Li Mei and Tan Liwen [9] according to the empirical results, they conclude that the inflow of FDI has little direct impact on China's scientific and technological innovation capability. Only when the economic development level and human capital level of a region exceed a certain threshold, will FDI have a positive spillover effect on the local innovation level. Niu Zedong and Zhang Qianxiao [10] use the nonlinear panel smooth transformation regression model to test the technology spillover and threshold effect of FDI in different industries, and draw the conclusion that the premise that FDI has a positive effect on innovation spillover is when the technology level and human capital of the enterprise industry reach a certain threshold. Luo Jun and Chen Jianguo [11] through the establishment of a double threshold effect model, it is concluded that the impact of FDI on regional innovation capability is closely related to the investment of R&D funds and researchers in the region. The more R&D funds and researchers invest, the more significant the ability of FDI to promote innovation. Gong Xinshu and Li Yongcui [12] concluded that there is a significant FDI scale stock double threshold effect on the impact of FDI entry speed on technological innovation efficiency. When the FDI scale stock is lower or higher than the threshold, the impact of FDI entry speed on regional innovation efficiency will be different.

To sum up, domestic and foreign scholars use different research methods and select different variables to study the impact of FDI on technological innovation capability from different perspectives, so the conclusions are quite different. This paper establishes a regression model based on the panel data of 12 provinces, municipalities and autonomous regions in eastern China from 2008 to 2018 to explore the effect of FDI on the ability of local innovation in the eastern region, so as to provide a new perspective and idea for eastern China to use FDI to promote innovation efficiency.

3. EMPIRICAL ANALYSIS

3.1 Selection of Variables

Explained variable: local innovation capability (NPA). It represents the ability to use new technologies to carry out all kinds of practical activities and constantly create value in the corresponding fields. Referring to the previous research of many scholars, it is considered that the patent data can be used as an important index to measure the innovation ability of a country or a region, so this paper selects the number of patent applications to express the ability of independent innovation.

Explanatory variable: foreign direct investment (FDI). It is expressed by the stock of foreign direct investment in the eastern provinces, municipalities and autonomous regions, and the logarithm is taken to represent the level of foreign direct investment in each region.

Control variables: (1) R&D investment (RDI). The internal expenditure of R&D is used as an indicator to measure. The internal expenditure of R&D reflects the amount of capital that a regional government and enterprises are willing to invest in scientific research and innovation. Generally speaking, more R&D funds will improve the efficiency of technological innovation in the region, and it is expected that R&D funds will have a positive impact on the ability of independent innovation. [2] R&D personnel input (HN). This paper uses the full-time equivalent of

R&D personnel in industrial enterprises above scale to measure. The full-time equivalent of R&D personnel in industrial enterprises above scale refers to the sum of the working time of full-time personnel and part-time personnel, which can reflect the real manpower investment in scientific research of government enterprises. It is expected that the input of R&D personnel has a positive impact on the ability of local innovation. [3] Trade openness (TO). This paper is measured by the ratio of the total amount of imports and exports to the gross domestic product. The higher the degree of trade openness, the more advanced technology can be obtained, so as to improve efficiency and reduce production costs. It is expected that the impact of trade openness on the ability of local innovation is positive. [4] Level of economic development (GDP). The variables are reflected by the gross domestic product of each region. Usually, the higher the level of economic development of a region, the stronger its ability to attract foreign investment, thus promoting the technological innovation capability of the region. It is expected that the level of economic development has a positive effect on the ability of local innovation.

3.2 Setting of the Model

Based on the Explained variables, explanatory variables and control variables selected above, this paper uses the panel data of twelve eastern provinces, municipalities and autonomous regions from 2008 to 2018 for regression analysis. In order to eliminate the heteroscedasticity when building the model, logarithmic processing is performed on the previously selected variables to construct the panel regression model shown in formula (1):

$$\ln NPA_{it} = \alpha_0 + \alpha_1 \ln FDI_{it} + \alpha_2 \ln RDI_{it} + \alpha_3 \ln HN_{it} + \alpha_4 \ln TO_{it} + \alpha_5 \ln GDP_{it} + \mu_{it} + \varepsilon_{it} \quad (1)$$

In formula (1) i denotes provinces, cities and autonomous regions, and t denotes the year, where α_0 indicates the constant term, the α_k denotes the coefficient of each μ_{it} denotes the individual effect of provinces, cities and autonomous regions, and ε_{it} denotes the random error term.

3.3 Descriptive Statistics of the Data

When discussing the influence of FDI on the ability of local innovation in eastern China, this paper selects the panel data of 12 provinces, municipalities and autonomous regions in eastern China from 2008 to 2018 for empirical analysis. The data sources are China Statistical Yearbook, China Science and Technology Statistical Yearbook and China fixed assets Statistical Yearbook from 2008 to 2018. The descriptive statistics of each variable data are shown in Table 2.

Table 1. Variables and measures

Variable type	Meaning of variables	Variable symbols	Measurement indicators
Explained variables	local innovation capability	NPA	Number of patent applications
Explanatory variables	Foreign Direct Investment	FDI	Foreign direct investment stock
Control variables	R&D investment	RDI	Internal expenditure of R&D
	R&D personnel input	HN	Full-time equivalent of R&D personnel in industrial enterprises above scale
	Trade openness	TO	Total amount of imports and exports / GDP
	Level of economic development	GDP	Regional GDP

Table 2. Descriptive statistics of variables

Variable	N	Mean	Median	Std. Dev.	Min	Max
lnNPA	132	10.88	11.28	1.657	6.772	13.59
lnFDI	132	15.69	15.93	1.137	12.69	17.48
lnRDI	132	14.68	14.90	1.543	9.079	16.86
lnHN	132	11.12	11.23	1.402	6.317	13.34
lnTO	132	0.574	0.475	0.376	0.109	1.597
lnGDP	132	9.949	10.04	0.881	7.296	11.51

3.4 Correlation Analysis

In correlation tests, a positive or negative correlation coefficient indicates a positive or negative correlation between variables; the closer the absolute value of the correlation coefficient is, the stronger the correlation is. As can be seen from Table 3, the correlation coefficients between foreign direct investment, internal expenditure, full-time equivalent of R&D personnel in industrial enterprises above scale, GDP and the number of patent applications accepted are positive and the absolute value is close to 1, that is, there is a strong positive correlation. However, the correlation between the number of patent applications accepted in the degree of trade openness is not obvious [13].

3.5 Stationarity Test

The data selected in this paper belong to long panel data, so it is necessary to test the unit root to avoid the pseudo-regression of variables. As shown in Table 4, we use LLC test and ADF test to test the stationarity of each variable sequence. if both methods reject the original hypothesis, it can show that the stationary data are used in this paper. According to the results of unit root test, the original sequences of lnRDI, lnHN, lnTO and lnGDP all reject the original hypothesis, so they can be considered to be stationary series.We also found that lnNPA and lnFDI were not stable in the original sequence, but in first-order difference sequence shows a stationary state, as shown in Table 5.

3.6 Hausman Test

From the test results, we can see that $P < 0.05$, reject the original hypothesis, indicating that the relevant data of each variable accords with the fixed effect model. However, due to the reasons set by the model in this paper, in order to fully consider all the variables, we decided to use the mixed effect model.

Table 3. Correlation analysis of variables

Correlation	lnNPA	lnFDI	lnRDI	lnHN	lnTO	lnGDP
lnNPA	1					
lnFDI	0.936	1				
lnRDI	0.911	0.862	1			
lnHN	0.915	0.825	0.953	1		
lnTO	0.428	0.354	0.262	0.321	1	
lnGDP	0.877	0.785	0.924	0.932	0.184	1

Table 4. Analysis of stationarity of variables

Variable	LLC	Prob.	ADF	Prob.	Stationarity
lnNPA	-2.48587	0.0065	23.6015	0.4846	Instability
lnFDI	-4.87640	0.0000	32.5534	0.1139	Instability
lnRDI	-6.19362	0.0000	47.4971	0.0029	Stationary
lnHN	-3.50033	0.0002	43.8029	0.0080	Stationary
lnTO	-10.1016	0.0000	59.7412	0.0001	Stationary
lnGDP	-11.0687	0.0000	55.8498	0.0000	Stationary

Table 5. First order difference test

1st difference	LLC	Prob.	ADF	Prob.	Stationarity
∆lnNPA	-5.62367	0.0000	42.4254	0.0116	Stationary
∆lnFDI	-4.69148	0.0000	53.9822	0.0004	Stationary

Table 6. Hausman test results

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	13.87065	5	0.0165

Table 7. Regression results

Variable	Coefficient	t-Statistic	Prob.
lnFDI	0.7703	11.99	0.000***
lnRDI	-0.0493	-0.66	0.511
lnHN	0.2983	3.26	0.001***
lnTO	0.5573	5.16	0.000***
lnGDP	0.4634	4.83	0.000***
C	-8.7319	-14.37	0.000***

Note:* indicates passing the significance test at the 1% level*

3.7 Analysis of Regression Results

According to the regression results, the goodness of fit R^2 of the model is 0.9542 and the adjusted goodness of fit R^2 is 0.9524, indicating that the goodness of fit of the regression model is good, and the F statistic far exceeds the critical value of the significant test, and the corresponding *P*-value is 0.000. It shows that the explanatory variables and control variables in the model have a significant impact on the explained variables as a whole.The empirical results show that the *P*-value of foreign direct investment (lnFDI) is significant at the 1% level and the regression coefficient of lnFDI is 0.7703, indicating that our theoretical belief that the technological spillover effect generated by FDI in a region will drive the level of technological development in that region is correct. As the eastern region has obvious geographical advantages and is richer in various resources, the government has formulated many incentive policies to attract foreign investment, which tends to generate the FDI agglomeration effect, thus promoting the technological innovation capability. The *P*-value of R&D investment (RDI) shows insignificant and the regression coefficient is negative, which indicates that more R&D capital investment will instead inhibit the technological innovation capability of the eastern region, which is not consistent with the expected result [14-15]. This may be due to the low effective utilisation of R&D funds and the lack of a sound fund management system, which has resulted in a large amount of funds being used for technological imitation and is prone to corruption, leading to low research output. The *P*-value for R&D personnel input (HN) is significant at the 1% level and the regression coefficient is positive. This indicates that a large investment in research manpower will promote a region's level of technological innovation, so in order to efficiently enhance a region's innovation capability, it should focus on attracting talents and establishing a sound scientific talent management system. The *P*-value of the degree of trade openness (TO) is significant at the 1% level and the regression coefficient is positive, indicating that it is in line with the expected result that the higher the degree of trade openness, the more it can promote the improvement of a region's innovation capability. The *P*-value for the level of economic development (GDP) is significant at the 1% level and the regression coefficient is positive and large in absolute value, which indicates that the level of economic development of a region contributes significantly to the growth of the level of science and technology innovation. The eastern region of China has a better economic environment and is therefore better able to promote the autonomous innovation behaviour of the region.

4. SUMMARY AND RECOMMENDATIONS

4.1 Summary

Based on the panel data of 12 provinces, municipalities and autonomous regions in eastern China from 2008 to 2018, this paper studies the impact of FDI on local innovation capability. Through empirical analysis, it is concluded that among the selected explained variables and control variables, foreign direct investment, R&D personnel input, trade openness and economic development level have significant positive effects on the improvement of eastern innovation capability. However, R&D investment has a certain inhibitory effect on the ability of local innovation in the east.

4.2 Recommendations

4.2.1 Insist on attracting high-quality foreign investment

From the above findings, it is clear that the technological spillover effect of FDI can continuously inject new vitality into the local innovation activities of the eastern region. The eastern region of China should therefore insist on attracting foreign investment, but not just in terms of the quantity of foreign investment introduced,

but also to encourage the attraction of high quality FDI, as the introduction of capital can be accompanied by the introduction of some advanced foreign technology and highly qualified personnel. The governments of different provinces should purposefully attract foreign investment and develop advantages according to the actual situation of the region, while promoting synergistic development between different provinces to narrow the gap and enhance the overall innovation capacity of the region.

4.2.2 Reasonable investment of R&D funds to improve research output rate

From the empirical results, we can see that the investment of R & D funds has a certain inhibitory effect on the ability of local innovation in the east. It shows that the R & D investment of the government in the eastern region does not match its scientific research output, and the output rate is low. Therefore, while ensuring the investment of scientific research funds in the eastern region, we should constantly optimize the management of talents and funds for scientific research projects, optimize the structure of human and financial investment, and deepen reform and innovation. Then, the government needs to set up relevant supervision and inspection mechanisms to ensure that R & D funds can be implemented and standardized, so as to maximize the utilization rate of funds and achieve maximum achievements in scientific research and innovation.

4.2.3 Increase the investment of R&D personnel

The government of the eastern region should pay more attention to the input of R&D personnel and to the process of knowledge production to knowledge output in the provinces to achieve continuous strengthening of technological innovation capacity. The government should formulate some welfare policies to attract high-level scientific and technological innovation talents, establish a flexible mechanism for the introduction of talents, and promote the construction of innovation teams. In addition, it can encourage study and exchange with the R&D departments of foreign-funded enterprises to learn their advanced technology and talent training models to effectively improve the level of human capital. Promote the development of regional technological innovation with talents, and improve the efficiency of resource allocation and local innovation capability.

4.2.4 Further expand the level of openness to the outside world

The expansion of trade openness will be accompanied by the expansion of the scale of foreign investment, while the formation of scale effects will lead to greater technology spillover, cutting-edge technology and rich management experience will also enter China, which can provide a basis for scientific and technological innovation. Therefore, in order to attract more foreign investment, we need to reduce trade barriers, increase preferences, optimize the business environment and expand trade convenience to an appropriate extent. Formulate appropriate policies to attract foreign investment and give full play to the role of foreign investment in promoting the efficiency of innovation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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