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Research on the Impact of FDI on the Efficiency of technological innovation in Manufacturing Industry Based on VAR Model and Computer Software

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Abstract

In recent years, with the rapid growth of China's national economy, China has absorbed a large number of foreign capital investment, which has a huge impact on China's manufacturing technology innovation. With the technological innovation (hereinafter referred to as TI) of Manufacturing Industry (hereinafter referred to as MI), China's traditional MI is facing more and more pressure of economic transformation. Therefore, we need to constantly change the mode of development and social specialization. FDI can enhance the technological capability of MI through technology spillover (hereinafter referred to as TS), which will give full play to the characteristics of knowledge intensive and technology intensive. In the process of industrial integration, TI will promote the efficiency of related industries, especially the MI. First of all, this paper analyzes the mechanism of the impact of FDI on industrial TI ability. Then, through DEA model, this paper calculates the relevant indicators of manufacturing efficiency. Finally, this paper analyzes the impact of FDI on the TI efficiency of MI by VAR model.

Keywords: *VAR model, DEA model, FDI, TI efficiency, MI;*

1. Introduction

In 2017, the total output value of China's MI was about 4.5 trillion US dollars, accounting for 33% of the world's share[1].Although China's MI has been developing rapidly, there are still many disadvantages. For example, the main advantages of the rapid development of China's MI are labor cost and large-scale resource investment. This low-cost advantage does not have long-term sustainability[2]. With the rising cost of land, raw materials, labor and other resources, China's MI will face great pressure.

FDI technology absorptive capacity and TS effect are the ability of a country to produce dynamic II by acquiring, absorbing, transforming and utilizing the technology of the branches of multinational companies in the country[3]. The technology absorptive capacity and TS effect of FDI is one of the important capabilities that a country must possess to realize technological progress, especially in developing countries[4]

In the increasingly fierce international competition situation, we must improve the ability of Independent innovation (hereinafter referred to as II), which is the key to change the mode of economic growth and social development[5]. II is an inevitable choice for China to move towards developed countries. According to the current situation in China, TI needs strong technical support, sustained R&D investment and strong risk resistance ability. At the same time, FDI technology absorptive capacity and TS effect have a huge impact[6]. By improving the technical efficiency and competitiveness of the downstream MI, we can accelerate the industrial upgrading.

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2. Research on related concepts

2.1. Concept of FDI

According to IMF, FDI refers to the investment behavior of one country's investors who use their capital for the production or operation of other countries and control certain operation rights. Therefore, FDI is a long-term relationship between resident entities of one country and enterprises of another country, which will enjoy lasting benefits and control. Generally speaking, foreign direct investment mainly includes: wholly foreign-owned enterprises, Sino foreign cooperative enterprises, Sino foreign joint ventures and cooperative development[7].

2.2. The way of using FDI in China's MI

With the continuous development of China's national economy, China has entered the level of medium developed countries. FDI has gradually changed from export-oriented to market-oriented. At present, China's MI mainly uses FDI in four forms, which will play an important role in different industries[8]. The way in which China's MI uses FDI is shown in Table 1.

Table 1. How China's MI uses FDI.

Form	Characteristic	Foreign control
Totally in shape type	1. High technical content 2. The main parts are imported . Foreign businessmen take advantage of China's human, land and cost advantages 4. The products face the international market	New technology components, R&D, brands, international marketing, marketing network
OEM production type	1. The product technology is relatively mature 2. Take advantage of China's manufacturing capacity, low labor costs and other cost advantages 3. Made in China and sold abroad	Brand, market network
Skill seeking type	1. R&D in China Some scattered and specialized core technologies may be mastered by China 3. The market is outside	Overall technology, market network
Market seeking	1. High technical wood content Foreign investors have not bypassed the barriers the switching tax barriers, 3. The purpose is to occupy the market	R&D of core technical components and brands

3. The way of FDI to realize technological progress

3.1. Introducing technology through FDI

According to the law of knowledge spillover, the less developed countries obtain more advanced mature technology from developed countries through technology trade and technology transfer, which will meet the demand of advanced technology of underdeveloped countries[9].At the same time, they can narrow the technological distance with developed countries. Through the introduction of technology, the underdeveloped countries can obtain many advantages, such as saving a lot of time of technology development (hereinafter referred to as TD), shortening the cycle of TD, reducing the cost of technology R&D, obtaining cost advantage, reducing the risk of TD, improving dynamic

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comparative advantage, etc., which will improve the competitiveness of product market[10].

3.2. Improve independent TI through independent R&D

Independent R&D can get rid of the technology dependence on the home country. By relying on the power of the host country, enterprises can carry out TI, which will make enterprises not be passive users of advanced technology in their home countries. There are two modes of independent R&D innovation,namely imitation innovation and first innovation. Imitation innovation is a way for the company to analyze the innovative technology, and then master the core technical secrets of the first innovation through observation and learning, and improve and improve it. This innovation mode has many advantages, such as reducing the uncertainty of technological development, saving manpower and material consumption, expanding market share, etc[11]. However, there are also many shortcomings in imitation innovation, such as focusing on market innovation, ignoring major technical basic research, and lack of long-term planning. Taking the lead in innovation is a fundamental and pioneering innovation, which is a new market and TD. Taking the lead in innovation will make huge profits once it is successfully developed. It must have strong scientific and technological foundation, rich innovation experience, anti risk ability and economic strength. At the same time, taking the lead in innovation will also have the problems of high risk and high cost[12].

3.3. TS

TS is the externality of technology diffusion (hereinafter referred to as TD), which is a way of TD. TD refers to the way that technology moves from one place to another. Technology transfer is the voluntary and active diffusion of R&D firms[13]. TS is a kind of TD which does not come from the subjective will of R&D firms. TS is a kind of externality. There are three ways to realize technological progress in TS. First, the TS of Industry Association. TS can be realized through industrial linkage, which will achieve technological progress[14]. Second, TS of market competition[15].

4. Evaluation of TI efficiency in MI

4.1. Index selection

4.1.1. Selection of evaluation index in R&D stage

In the R&D stage of MI, this paper selects input index and output index, as shown in Table 2.

Table 2. Input output indicators of R&D stage.

Primary indicators	Secondary indicators	Company
Input index	Full time equivalent of R&D personnel	Person / year
	Internal expenditure of R&D funds	Ten thousand yuan
Output indicators	No. of patent applications	Piece
	No. of valid invention patents	Piece

4.1.2. Selection of evaluation index in transformation stage

In the transformation stage of MI, this paper selects input index and output index, as shown in Table 3.

Table 3. The input-output index of the transformation stage.

Primary indicators	Secondary indicators	Company
Input index	No. of valid invention patents	Piece
	New product development expenditure	Ten thousand yuan

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Output indicators	Sales revenue of new products	Ten thousand yuan
	No. of new product development projects	Individual

4.2. DEA model

The first important model of DEA is CCR model, which was proposed by Charnes in 1978. DEA model is a way to extend the engineering efficiency to the relative efficiency evaluation of multi input and multi output systems, which provides a feasible method and effective tool for the relative efficiency evaluation of DMUs.

There are n decision units $DMU_i(i=1,2,3...,n)$. Each decision unit has input of type m and output of type s. x_{ij} is the j-th decision unit to the i-th. y_{rj} is the j-th decision unit to the r-th. So, we can get the Equation 1.

$$x_{ij}>0,\ x_j=\left(x_{1j},x_{2j},...,x_{mj},\right),\ j=1,2,3,...,n$$
$$y_{rj}>0,\ y_j=\left(y_{1j},y_{2j},...,y_{mj},\right)^T,\ j=1,2,3,...,n \quad (1)$$

Then, we can set v_i as a weight for the first input, u_r is a weight to the output in r. So, we can get the Equation 2.

$$v=(v_1,v_2,...,v_m)^T$$
$$u=(u_1,u_2,...,u_m)^T \quad (2)$$

So, we can get the efficiency evaluation index in the unit j-th, which is shown as follows Equation 3.

$$h_j=\left(\sum_{r=1}^{s}u_r y_{rj}\right)\Big/\left(\sum_{i=1}^{m}v_i x_{ij}\right) \quad (3)$$

For h_j, we can always choose the weight coefficients v and μ, and we will get $h_j\le 1, j=1,2,...,n$.

When evaluating the efficiency of the j_0, we should take the weight coefficient v and μ as variables, take the efficiency index of the j_0 as the goal. When we take the efficiency index as the constraint, we can get the CCR model, as shown in formula 4.

$$P_{CCR}=\begin{cases}\max\dfrac{\mu^T y_{j_0}}{v^T x_{j_0}}=V_P, v\ge 0,\mu\ge 0\\ s.t.\dfrac{\mu^T y_j}{v^T x_j}\le 1,\ j=1,2,...,n\end{cases} \quad (4)$$

We can let ε be a non-Archimedean infinitesimal, x_{ij} is the j-th decision-making unit to the i-th, y_{rj} is the j-th decision-making unit to the r-th. Among them, we can get the formula 5.

$$x_{ij}>0; y_{rj}>0; i=1,2,3,...,m; r=1,2,3,...,s;\ j=1,2,3,...,n$$
$$x_j=\left(x_{1j},x_{2j},...,x_{mj},\right)^T,\ j=1,2,3,...,n$$
$$y_j=\left(y_{1j},y_{2j},...,y_{mj},\right)^T,\ j=1,2,3,...,n$$
$$\min\left\lfloor\theta-\varepsilon(\hat{e}^T s^- +e^T s^+)\right\rfloor \quad (5)$$

So, we can get the formula 6.

$$s.t.\begin{cases}\sum_{j=1}^{n}x_j\lambda_j+s^-=\theta x_0,\\ \sum_{j=1}^{n}y_j\lambda_j-s^+=y_0,\\ \lambda_j\ge 0,\ j=1,2,...,n\\ s^-\ge 0, s^+\ge 0\end{cases} \quad (6)$$

Among them, $\hat{e}^T=(1,1,...,1)\in E^m; e^T=(1,1,...,1)\in E^m$, λ_j,s^-,s^+,θ is the parameter to be estimated, λ is the efficiency value of the decision-making unit, s^-,s^+ is the relaxation variable. When the optimal solution of the model is $\lambda^0,s^{-0},s^{+0},\theta^0$, if $\theta^0=1$, then decision unit j_0 is weak DEA effective. If $\theta^0=1$ and $s^{-0}=0,s^{+0}=0$, then decision unit j_0 is DEA

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effective.

4.3. Data processing

Based on the panel data of China's MI from 2009 to 2017 and deap2.1 software, we calculate the innovation input and output efficiency of MI based on DEA model. We get the basic data processing results, as shown in Table 4. Through the analysis of Deap software, we get the comprehensive technical efficiency (hereinafter referred to as CTE), pure technical efficiency(hereinafter referred to as PTE) and scale efficiency (hereinafter referred to as SE). By analyzing the relationship between FDI and the three factors, we can determine the relationship between FDI and TI efficiency of MI.

Table 4. Technical innovation efficiency data.

	FDI(US $100 million)	CTE	PTE	SE
2009	900.33	0.716	0.716	0.97
2010	1057.35	0.876	0.894	0.98
2011	1160.11	0.797	0.849	0.99
2012	1117.16	1	1	1
2013	1175.86	1.091	1.011	1.008
2014	1192.6	0.958	0.974	0.999
2015	1262.7	1.049	1.04	1.008
2016	1260.0	0.977	0.974	1.004
2017	1310.4	0.966	0.972	1.014

5. The FDI on the TI based on VAR model

5.1. Stability test

Through Eviews software, we get the unit root energy test. And the results are shown in Table 5, the values are greater than the critical value of 5%, which indicates the existence of unit roots. Therefore, the original variable sequence is not stationary. After the first-order difference, it is still not uniformly stationary. However, after the second-order difference, the original variable values are less than 5% of the critical value, which meets the conditions of cointegration test.

Table 5. Unit root test results.

	Prob.*	Conclusion		Prob.*	Conclusion		Prob.*	Conclusion
ln(PDI)	0.1088	Instability	Δln(PDI)	0.10011	Instability	ΔΔln(PDI)	0.0487	Stability
ln(CTE)	0.1350	Instability	Δln(CTE)	0.0268	Stability	ΔΔln(CTE)	0.0227	Stability
ln(PTE)	0.2630	Instability	Δln(PTE)	0.0104	Stability	ΔΔln(PTE)	0.0008	Stability
ln(SE)	0.1394	Instability	Δln(SE)	0.0764	Instability	ΔΔln(SE)	0.0066	Stability

5.2. Granger causality tests

Based on VAR model, this paper tests the causality between PDI and CTE, PTE, SE. Through the establishment of VAR model, this paper tests the original hypothesis. The results are shown in Table 6.

Table 6. The granger causality test.

Null Hypothesis	Obs	F-Statistic	Prob.
CTE does not Granger Cause PDI	7	0.12555	0.8885

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PDI does not Granger Cause CTE		1.87796	0.3475
PTE does not Granger Cause PDI	7	0.11714	0.8951
PDI does not Granger Cause PTE		0.83631	0.5446
SE does not Granger Cause PDI	7	0.70746	0.5857
PDI does not Granger Cause SE		299.637	0.0033

According to table 5, there is a causal relationship between PDI and CTE, and a causal relationship between PDI and PTE.

5.3. The VAR between PDI and CTE

In this paper, Parameter estimation results of variable PDI and CTE is tested, as shown in Table 7.

Table 7. Parameter estimation results of variable between PDI and CTE.

	PDI	CTE		PDI	CTE
PDI(-1)	0.282455	-0.001127	CTE(-1)	116.7517	-0.222645
	(0.81587)	(0.00103)		(331.596)	(0.41971)
	[0.34620]	[-1.09176]		[0.35209]]	[-0.53048
PDI(-2)	0.128578	0.001200	CTE(-2)	120.7717	0.059869
	(0.48949)	(0.00062)		(358.814)	(0.45416)
	[0.26268]	[1.93662]		[0.33659]	[0.13182]
C	510.3893	1.112564			
	(580.700)	(0.73500)			
	[0.87892]	[1.51369]			

After establishing the VAR model, the stability of VAR model is tested, as shown in Figure 1. In VAR model, impulse response function is described in this paper, as shown in Figure 2.

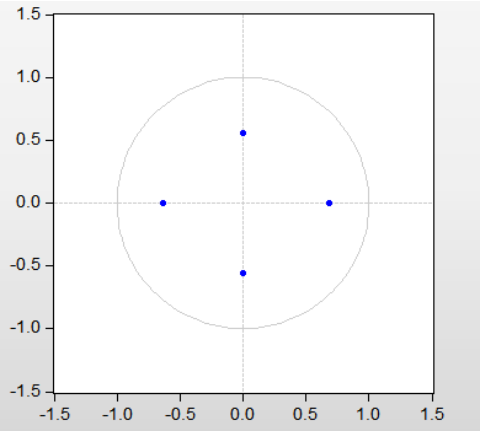

Figure 1. The stability of VAR model between PDI and CTE.

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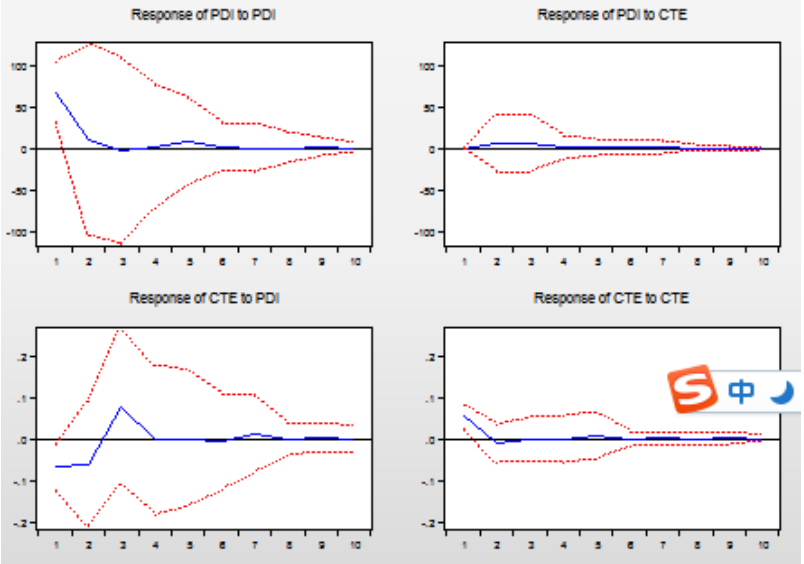

Figure 2. The impulse response function between PDI and CTE.

5.4. The VAR between PDI and PTE

In this paper, Parameter estimation results of variable PDI and PTE is tested, as shown in Table 8.

Table 8. Parameter estimation results of variable between PDI and PTE.

	PDI	CTE		PDI	CTE
PDI(-1)	0.467993 (0.88158) [0.53086]	-0.000690 (0.00074) [-0.93161]	PTE(-1)	261.5914 (549.724) [0.47586]	-0.266096 (0.46165) [-0.57641]
PDI(-2)	0.124144 (0.55943) [0.22191]	0.000545 (0.00047) [1.16083]	PTE(-2)	-38.80757 (587.750) [-0.06603]	0.351947 (0.49358) [0.71305]
C	305.8104 (661.773) [0.46211]	1.102213 (0.55574) [1.98331]			

The stability of VAR model is tested, as shown in Figure 3.

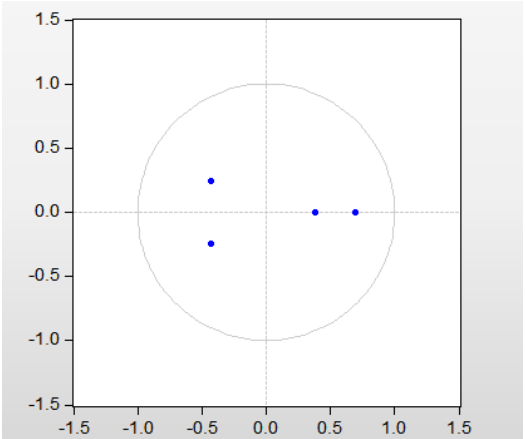

Figure 3. The stability of VAR model between PDI and PTE.

In VAR model, impulse response function is described in this paper, as shown in Figure 4.

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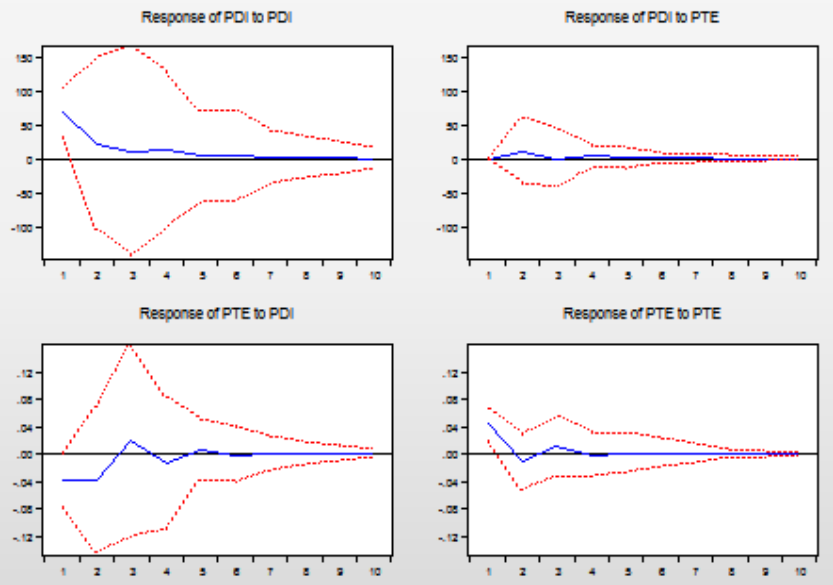

Figure 4. The impulse response function between PDI and PTE.

6. Policies to enhance the TI ability of MI

6.1. Adjust the policy of attracting FDI timely

In the 1980s, China was in a situation of material and capital shortage, and the conditions and environment for attracting FDI were very poor. Therefore, it was right and necessary to implement preferential policies to attract foreign direct investment. However, with the continuous improvement of China's investment environment, more ME and foreign capital flow into China. The preferential policy based on attracting foreign investment is not in harmony with China's economic development, and needs to be adjusted. This adjustment strategy is to gradually dilute the preferential policies for attracting foreign investment, and strengthen the attraction of FDI through the large-span, all-round opening up and the creation and utilization of foreign investment environment, and change the preferential tax policy into the rule-based policy, that is, from the incentive based FDI policy to the rule-based FDI policy.

6.2. Improve the technology content of FDI

In recent years, the government has vigorously supported MI and actively encouraged the entry of foreign capital in these industries, which has played a significant positive role in improving the level of TI. The government should give full play to the advantages of location and characteristic industries, appropriately raise the threshold for foreign investment in traditional labor-intensive industries, put forward higher requirements for technology and quality standards, and impose restrictions on industries or projects with moderate pollution and high energy consumption. Through the introduction of high-quality foreign investment, we can improve the technological content of traditional MI, promote its technological progress, and then improve the level of TI, obtain the core competitiveness of advantageous industries, and improve the competitive advantages of these industries. Finally, we should not give up the development of traditional industries while developing MI, and promote the level of TI.

6.3. Speed up the establishment of a sound enterprise technology innovation mechanism

In order to improve the TI ability of MI, it is necessary to establish a TI system centered on enterprises, so that manufacturing enterprises can become the main body of TI investment, research and development, benefit, decision-making and risk-taking, and the way to strengthen the transformation ability of industrial scientific and technological achievements. In order to improve the driving force of TI of enterprises, it is necessary to

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innovate the incentive mechanism for TI of enterprises, which requires the government to strengthen the protection of intellectual property rights, and the government should give support to enterprises with low TI in terms of financial and tax policies. Third, enterprises should realize secondary innovation on the basis of introduction, learning, observation, absorption and digestion, so as to prevent enterprises from catching up with technology. Fourth, it is necessary to strengthen the production, learning and research alliance between enterprises and scientific research institutes, make full use of the advantages of equipment, talents and technology of scientific research institutions and universities, form a strategic alliance for product joint development, and transform scientific and technological achievements into market advantages of enterprises, so as to form a company centered, scientific research institutes and colleges and universities participate widely, share risks and interests together The system, scientific and standardized mechanism of production, teaching and research. Finally, it is necessary to speed up the construction of social technology innovation service system for the company, shorten the distance between the supply and demand side of scientific and technological achievements, set up a foundation for the development of MI, and promote the development and diffusion of key, common and cutting-edge science and technology in MI.

6.4. Strengthen R&D investment intensity and resource allocation capacity

The government should continue to strengthen the intensity of R&D investment and further enhance the ability of TI. At the same time, domestic enterprises in high-tech service industry and related industries should enhance the resource allocation ability of their organizations, pay attention to the reasonable resource allocation between R&D activities and enterprise operation activities, and avoid excessive R&D. not only does it not promote the improvement of enterprise's technology level, but also improves the technological level of enterprises It hinders the normal operation and development. Scientific research institutions and enterprises should enhance the level of TI, improve the quality of TI, pay attention to the practicability of R&D technology, and make R&D technology achievements. By improving the application technology innovation ability, the innovative technology can be widely applied to enterprises, improve the existing technology level of enterprises, and promote the development of various industries including high-tech service industry.

6.5. Strengthening the embeddedness of multinational enterprises (hereinafter referred to as ME)

As one of the main bodies of TI in China's manufacturing industry, ME promote the technological progress and innovation of local enterprises in the interaction with domestic companies. In order to achieve this goal, it must be based on the localization of R & D of ME. Therefore, in order to improve the positive role of foreign direct investment in promoting technological progress and innovation of manufacturing industry, ME need to take root, blossom and bear fruit in China's manufacturing industry. Only when ME have strong embeddedness can they invest and transfer advanced technology and produce demonstration effect. Therefore, our government should improve the policy of introducing FDI, require ME to invest in MI and set up research and development centers and laboratories, so as to promote the localization of R & D institutions of ME.

7. Conclusion

According to the above DEA model and VAR model, the main influencing factors of FDI on TI efficiency of China's MI include the growth ability of TI, the allocation of TI resources, the development environment of TI and the level of TI research and development. Therefore, we must pass the following aspects: Zeng Jiang's TI efficiency. First, by increasing R&D investment, China can reasonably

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allocate innovation resources. Second, by improving the efficiency of TI, China can enhance the industrial competitiveness. Third, by improving the industrial innovation environment, China can speed up infrastructure construction.

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