Environmental Technology Effect of Two-way FDI Interactive Development in China

Mengqi Gong

Wuhan Institute of Technology

Zhe You (✉ youzhe@wit.edu.cn)

Wuhan Institute of Technology

Jinhua Cheng

China University of Geosciences

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Abstract

This paper examines the impact of the interactive development of inward foreign direct investment and outward foreign direct investment (two-way FDI) on regional environmental technology by using data from 30 provinces and cities in China from 2004 to 2017. To overcome the possible endogeneity problem of the model, the system generalized moment estimation method (system GMM) is used to estimate the model. The results show the following: First, two-way FDI could inhibit the progress of regional environmental technology. Second, the results of the regional heterogeneity test show that the development of two-way FDI interaction promotes the environmental technology in the eastern region, but inhibits the environmental technology in the central and western regions of China. Third, the heterogeneity test results of two-way FDI interactive development degree show that the two-way FDI interactive development in China promotes environmental technology in high-interactive areas, but inhibits environmental technology in low-interactive areas. Finally, the results of the phased heterogeneity test show that as China's two-way FDI interactive development gradually increases, its inhibitory effect on regional environmental technology gradually declines. Therefore, it is believed that in the future, China should further strengthen inward foreign direct investment and outward foreign direct investment, realize the benign interaction of two-way FDI, and finally promote the progress of regional environmental technology.

Introduction

Since 1978, China's economy is booming. However, the investment development model of "three to one supplement (processing supplied materials, assembly supplied parts, processing supplied samples and compensation trade)" and "two ends outside (It refers to the export-oriented economic form in which raw materials come from abroad and products are sold abroad)" has inevitably brought tremendous pressure on China's resources and environment (Gong et al. 2019). The report of the Nineteenth National Congress also points out that pollution control is the key to future economic development, and emphasizes that green technology innovation will become new economic growth point. Therefore, the importance of guiding environmental technology upgrading to improve environmental quality can not be ignored (Ganda 2019; Irandoust 2016). The improvement of environmental technology mainly comes from two aspects, one is the increase in domestic R&D inputs (Jiao et al, 2018), another is the introduction of exogenous techniques (Zhou et al, 2019; Dong et al, 2019). Due to the large gap between China's environmental technology level and developed countries (Piperopoulos, 2018), access to foreign advanced technology through technology spillover is an important way to promote China's environmental technology progress (Yang et al. 2016). In general, a number of developing countries expect technology spillover and technology transfer through bilateral investment (Muhammad et al. 2019). As a major bilateral investment country, China's flows and stocks of inward foreign direct investment (IFDI) and outward foreign direct investment (OFDI) both show a simultaneous growth trend (Figure 1), and the interactive relationship between them has become a new feature of economic development in China (Dunning 1981). Investment development path theory also points out that IFDI will promote OFDI

development through technology spillover effects (Yao et al. 2016). With the improvement of a country's economic development level, the interaction effect of its bilateral investment will also gradually rise. Are there interaction effects between two-way FDI in China? If it exists, how can we scientifically guide the interactive development of two-way FDI and enhance its international technology spillover effect to promote China's regional environmental technology? Answering the above questions will help to improve China's environmental technology on the basis of promoting China's two-way FDI interactive development.

From the existing research, there are abundant studies based on the effects of IFDI on environmental technology. Some studies suggest that IFDI, as an important engine of economic growth, not only conducive to the growth of employment in the host country, but also promotes the improvement of production technology and environmental technology in the host country (Demena and Afesorgbor 2020). Zhu et al. believed that since foreign enterprises have more advanced technology, IFDI is conducive to the improvement of environmental technology in the host country (Zhu et al. 2016). Yuan and Xiang analyzed the data of China's manufacturing industry from 2003 to 2014 and found that IFDI would promote the environmental technological progress of China's manufacturing industry through technology spillover effect (Yuan and Xiang 2018). Demena and Afesorgbor also reached a similar conclusion that IFDI will promote the environmental technology progress of the host country through technology spillover effect because it has cleaner production technology. Qiu et al.(2021) investigates the impact of IFDI on environmental technology of the industrial sectors in 30 provinces in China, and found that IFDI exerts a "pollution heaven" effect on environmental technology in eastern and central China. Yu et al.(2021) studies the impact of IFDI on environmental technology based on the data of 285 Chinese cities from 2003 to 2017. The result shows that IFDI plays a positive role in promoting environmental technology in high-high and high-low cluster cities. However, some scholars believe that the environmental technology effect of IFDI is not obvious (Zhu and Bang, 2007), because if the introduced IFDI is resource seeking rather than bringing advanced technology, it may inhibit environmental technology and increase regional environmental load (Ai et al. 2015).

Existing research have paid less attention on OFDI's impact on the environmental technology of the home country. In general, OFDI is considered as a key factor in promoting technological upgrading in enterprises (Cheng and Yang 2017; Buckley 2018). Through OFDI in technology intensive and knowledge intensive countries, enterprises can promote their technological progress through reverse technology spillover effect (Chen et al. 2012; Cozza et al. 2015), and further improve the company's environmental technology (Yang et al. 2013). Li et al.(2016), Cheng and Yang (2017) believe that through outward foreign direct investment, enterprises are conducive to the integration of tangible and intangible assets of subsidiaries in the host country, and finally promote the improvement of environmental technology in the home country through reverse technology spillover effect. Through the analysis of panel data from 30 provinces and cities in China, Zhou et al. (2019) also found that the OFDI of China will promote the increase of environmental technology, but there is a large heterogeneity among the provinces.

By organizing the existing literature, it can be found that scholars based on international direct investment technology spillover effect analysis are unidirectional, and their theoretical paradigm and empirical research are carried out separately. Less literature take the impact of IFDI and OFDI coordinated development on environmental technology into consideration. Under the condition of open economy, both IFDI and OFDI are important forms for a country to participate in international economic activities. At present, the coordinated development situation between the two is becoming more and more obvious. This will affect a country's environmental technology to a certain extent. Therefore, the impact of one-way analysis IFDI or OFDI on regional environmental technology progress is easy to cause inconsistency of estimation results, which leads to large deviation of estimation results. The main contribution of this paper is that: Firstly, the impact of coordinated development of two-way FDI on China's technological progress deep dive into the environmental technology level. Secondly, incorporating IFDI and OFDI into the same analysis framework, systematically sorted out the mechanism of the two-way FDI coordinated development affecting regional environmental technological progress. Thirdly, the regional heterogeneity of the two-way FDI interactive development affecting environmental technology has been proved empirically.

Model Setting And Data Description

3.1. Model setting

For the purpose of systematically investigating the impact of China's two-way FDI interaction development on regional environmental technology, limited to the integrity and availability of data, this paper selects the data of 30 provinces and cities except Hong Kong, Taiwan, Macao and Tibet for empirical analysis from 2004 to 2017, and sets the measurement model as follows (Qiu et al. 2021):

$$\ln tec_{it} = \alpha_0 + \alpha_1 \ln tec_{it-1} + \alpha_2 \ln IDFDI_{it} + \alpha_3 X_{it} + \mu_i + \nu_t + \varepsilon_{it}$$

1

Where i and t denote Chinese province and time (year). $\ln tec_{it}$ represents the environmental technology. Because environmental technology may have temporal summation, lagged $\ln tec_{it}$ is introduced. $\ln IDFDI_{it}$ represents the two-way FDI interactive development degree. X_{it} represents other variables that affect regional environmental technology, including domestic R&D investment ($\ln RD_{it}$), human capital ($\ln H_{it}$), environmental regulation ($\ln ERS_{it}$), trade openness ($\ln TR_{it}$), regional economic development level ($\ln GDP_{it}$) and factor intensity ($\ln KL_{it}$).

3.2. Data description

3.2.1 Environmental Technology

The current widely used environmental technology measurement method mainly through the decomposition of SBM (Slacks-based model) to obtain environmental efficiency values. However, Song

and Wang pointed out that environmental efficiency is affected by both environmental technology and environmental regulations (Song and Wang 2013). Therefore, using environmental efficiency indicators to replace environmental technology will lead to unreliable estimation results. This paper draws lessons from Zhang and Jiang (2014), He (2006). First of all, China is regarded as a region A, which can be defined as:

$$plu_{A,t} = W_{A,t} / Y_{A,t}$$

2

Among them, $W_{A,t}$ represents China's pollution emissions in year t, expressed in terms of total carbon emissions. $Y_{A,t}$ represents China's GDP in year t. Therefore, the national pollution emission intensity $plu_{A,0}$ in the base period can be regarded as a technical benchmark. Then, the theoretical value of pollution emission can be expressed as:

$$W_{i,t} = plu_{A,0} * Y_{i,t}$$

3

The ratio of the theoretical value to the actual value of the regional pollution emission is defined as the regional environmental technological progress index:

$$tec_{i,t} = W_{i,t} / W_{i,t}$$

4

If $tec_{i,t} > 1$, it means that the actual pollution emission in the area is lower than the theoretical value of pollution emission under the reference technology level, that is to say, the environmental technology in the area is higher than the reference technology level. The larger the index, the higher the regional environmental technology level.

3.2.2 The degree of interactive development of two-way FDI

IFDI data comes from the China Statistical Yearbook, and OFDI data comes from the Statistical Bulletin of China's OFDI.

This paper uses the coupling coordination function (Li et al. 2021) to measure the degree of interaction of two-way FDI. The formula is as follows:

$$IDFDI_{it} = \left[C_{it}(IO) * \frac{IFDI_{it} + OFDI_{it}}{2} \right]^{\frac{1}{2}} = \left\{ \frac{IFDI_{it} * OFDI_{it}}{[(IFDI_{it} + OFDI_{it}) / 2]} \right\}^{\frac{1}{2}}$$

5

$C_{it}(IO) = IFDI_{it} * OFDI_{it} / (\alpha IFDI_{it} + \beta OFDI_{it})^\gamma$. Among them, $IFDI_{it}$ and $OFDI_{it}$ represents the IFDI and OFDI flow of each province in the t period, and α and β represents the weights of IFDI and OFDI respectively. Since the synchronization between the introduction of IFDI and the OFDI of each province in China is becoming more and more obvious at this stage, the value of the set sum is 0.5. At the same time, the adjustment coefficient γ is set to 2.

3.2.3 Other control variables

Domestic R&D investment ($\ln RD_{it}$), this paper uses the regional R&D funds internal expenditure measurement, the data from the statistical yearbooks of the provinces. Human capital ($\ln H_{it}$), this paper draws on the method of Barro and Lee and measures the stock of human capital by the average years of education of the labor force (Barro and Lee 1993). The data on the education level of employees in various regions comes from the "China Labor Statistics Yearbook". The environmental regulation ($\ln ERS_{it}$) is measured by the total investment in environmental pollution control in each region, and the data is from the National Bureau of statistics. Trade openness ($\ln TR_{it}$), using the proportion of the total import and export trade of each region in GDP to measure. The data is from China Statistical Yearbook. Regional economic development level ($\ln GDP_{it}$),using regional GDP to measure. The GDP data of each province comes from the Statistical Yearbook of China. The factor intensity ($\ln KL_{it}$) is measured by the ratio of fixed capital stock to the number of employees at the end of the year, in which the fixed capital stock in each region is calculated by the perpetual inventory method.

3.2.4 Descriptive statistics

The descriptive statistics of the data are as follows:

Table 1
Descriptive statistics

Variable	obs	Mean	Std. Dev.	Min	Max
Intec _{i,t-1}	420	1.0611	1.1505	-1.7273	5.4246
lnIDFDI _{it}	420	1.9390	0.9485	-1.2833	4.1083
lnRD _{it}	420	11.6378	1.4421	7.5858	15.3659
lnH _{it}	420	2.2106	0.1237	1.8656	2.5944
lnERS _{it}	420	4.5578	0.9469	1.6294	6.9626
lnTR _{it}	420	-1.6855	0.9864	-4.0892	0.5873
lnGDP _{it}	420	8.9742	0.9339	6.1444	10.9288
lnKL _{it}	420	8.6899	0.6036	7.2196	10.0746

Empirical Analysis

4.1. Benchmark regression

To overcome the possible endogeneity problem of the model, the system generalized moment estimation method (system GMM) is used to estimate the model. In the view of the fact that the generalized moment estimation method can be divided into one-step GMM and two-step GMM (two-step), the data is analyzed by one-step GMM method, which is mainly due to the two-step method estimated standard deviation existence downward bias, although the bias will be reduced after some correction, but this will lead to the unreliable approximate distribution of two-step GMM estimators to some extent (Bond 2002). The results are shown in model 3 and model 4 in Table 1 as a comparison, and the estimation results of static equation are given. The results are shown in model 1 and model 2 in Table 2.

Table 2
Environmental technology effects of two-way FDI interactive development.

	Model 1	Model 2	Model 3	Model 4
	FE	IV-FE	SYS-GMM	SYS-GMM
Intec _{i,t-1}			1.4670*** (0.1994)	1.0806*** (0.0902)
lnIDFDI _{it}	-0.0575*** (0.0220)	-0.1901** (0.0827)	-0.7998* (0.4449)	-0.4524*** (0.1457)
lnRD _{it}	0.3134*** (0.0712)	0.2897*** (0.0846)		0.0345** (0.0142)
lnH _{it}	-1.5480*** (0.3705)	-2.2852*** (0.4103)		0.4161 (0.2551)
lnERS _{it}	-0.2033*** (0.0529)	-0.2033*** (0.0587)		-0.0038 (0.0578)
lnTR _{it}	-0.0282 (0.0610)	-0.0144 (0.0707)		0.0938** (0.0428)
lnGDP _{it}	2.1692*** (0.1758)	2.6286*** (0.2589)		0.2409*** (0.0756)
lnKL _{it}	-0.0546 (0.0808)	0.0031 (0.0995)		0.2915*** (0.0959)
cons _	-16.9362*** (0.6880)	-18.8838*** (1.0190)	4.6170* (2.4982)	-3.0018*** (1.1127)
R square	0.8734	0.8443		
F value	377.32 [0.000]	35.81 [0.000]		

Note :1.*,**,*** indicate significant at the level of 10%, 5%, and 1%, respectively; 2. FE represent fixed effect estimation, IV-FE tool variable method estimation for fixed effect, SYS-GMM represent system GMM estimation; 3.The standard error of the estimated coefficient is shown in parentheses, and the P value of the statistics shown in square brackets. 4. The Arellano-Bond test for AR (1) and AR (2) show first-order serial correlation and no second-order serial correlation. The P value of sargan test is greater than 0.1, there is no problem of over-identification.

	Model 1	Model 2	Model 3	Model 4
AR(1)			-2.12 [0.034]	-3.51 [0.000]
AR(2)			0.46 [0.646]	-0.06 [0.952]
Sargan			0.55 [0.458]	2.00 [0.157]
Note :1.*,**,*** indicate significant at the level of 10%, 5%, and 1%, respectively; 2. FE represent fixed effect estimation, IV-FE tool variable method estimation for fixed effect, SYS-GMM represent system GMM estimation; 3.The standard error of the estimated coefficient is shown in parentheses, and the P value of the statistics shown in square brackets. 4. The Arellano-Bond test for AR (1) and AR (2) show first-order serial correlation and no second-order serial correlation. The P value of sargan test is greater than 0.1, there is no problem of over-identification.				

It can be seen from the regression results that, first, the impact of environmental technology on the current environmental technology is positive, and all of them have passed the test at the level of 1%, indicating that the progress of environmental technology has a certain cumulative nature.

Second, the degree of two-way FDI interaction will inhibit the progress of China's environmental technology. The reasons are as follows: First of all, the IFDI introduced by China in the past are mainly resource-seeking, rather than technical IFDI, and resource-seeking IFDI are mainly marginal industries that fail to meet the environmental regulation standards of their home countries. These foreign-funded enterprises are bound to bring a lot of energy consumption while putting China's environment into production as a cheap factor. In the case of clear definition of property rights, pollution emissions need a certain cost. Therefore, in the case of competition between enterprises, foreign enterprises are unlikely to transfer their core environmental technology to the host country. Secondly, China's goal of OFDI technology acquisition is not clear, and the goal of investing in developing countries is still to access natural resources and use their cheap labor to occupy the market, which leads to less significant technology spillover effects. At the same time, the theory of appropriate technology shows that some advanced technologies in developed countries are mostly tailored to them, and their technology spillover effects only affect countries or regions with similar technologies (Lin and Jin 2011). Therefore, when the technology gap between China and host countries is too large, its OFDI to developed countries can not play a positive role. Therefore, in this long-term extensive growth model, the degree of interaction between IFDI and OFDI is very limited, which inhibits China's environmental and technological progress.

Third, from other control variables: The impact of R&D on environmental technology is positive, indicating that the improvement of R&D investment will promote the progress of environmental technology. The impact of human capital on environmental technological progress is negative. This may be due to the dislocation of human resource allocation caused by the expansion of college enrollment and the high-educated labor enters a position that can be filled by low-educated labor, thereby inhibiting the progress

of environmental technology (Wang and Hu 2013). Environmental regulation will restrain the progress of environmental technology in the region (Lin and Xu 2019), the reason is that the rise of environmental regulation increases the cost of emission reduction, so it will inhibit the enterprise environmental technology in the short term. The degree of regional trade openness will promote environmental technological progress (Jin et al. 2019). The increase of regional economic development level will promote the improvement of environmental technology. Factor intensity will promote regional environmental technological progress, indicating that the higher the degree of capital intensity of enterprises, the more conducive to promote enterprise environmental technological innovation, this conclusion is consistent with Wan, which holds that capital deepening is conducive to promoting the progress of green technology level and technical efficiency of the industry (Wan and Zhu 2013).

4.2. Heterogeneity analysis

4.2.1. Regional Heterogeneity Analysis

Since there are great differences in the energy structure, economic development level and the degree of two-way FDI interaction development in various provinces, cities and autonomous regions of China, the environmental and technological effects of two-way FDI interaction development from a national perspective may be ignored. Therefore, this paper further divides China into three regions East, Central and West, and estimates the model by systematic GMM method, as shown in Table 3.

Table 3
Environmental technology effects of two-way FDI interactive development in the subregion.

	East	Central	West
	SYS-GMM	SYS-GMM	SYS-GMM
$Intec_{i,t-1}$	1.1376*** (0.0562)	0.7730*** (0.0468)	0.7092*** (0.1469)
$lnIDFDI_{it}$	0.3543* (0.1946)	-0.1166* (0.0681)	-0.0563* (0.0325)
cons _	-2.7778* (1.5170)	-3.1034*** (1.1946)	-4.4943 (1.9089)
Control variables	Yes	Yes	Yes
AR(1)	-4.34 [0.000]	-2.23 [0.026]	-4.42 [0.000]
AR(2)	0.03 [0.976]	1.41 [0.160]	-0.51 [0.611]
Sargan	1.23 [0.268]	1.15 [0.284]	1.27 [0.260]
<p>note :1.*,**,*** indicate significant at the levels of 10%, 5% and 1%, respectively; 2. SYS-GMM indicate the system GMM estimate; 3. the standard error of the estimation coefficient is shown in parentheses, and the P value of the statistics shown in square brackets. 4. The Arellano-Bond test for AR (1) and AR (2) show first-order serial correlation and no second-order serial correlation. The P value of sargan test is greater than 0.1, there is no problem of over-identification.</p>			

According to the regression results in Table 3, it can be found that, first of all, the influence of environmental technology in the delayed phase on the current environmental technology is positive, but this positive effect is the largest in the eastern region, the second in the central region and the smallest in the western region. This may be related to the level of regional economic development and its own environmental technology.

Secondly, the interactive development of two-way FDI only has a significant positive effect on the environmental technology in the eastern region. Every 1% increase in the interactive development of two-way FDI will promote a 0.3543% increase in the regional environmental technology level. The reason is that the scale of IFDI and OFDI in eastern region is relatively large, and as some industries in eastern region gradually shift to the central and western regions, the eastern region pays more attention to high-quality regional economic development and tends to introducing green and high-tech IFDI. At the same time, OFDI has greater initiative. From the perspective of technological innovation incentives, the level of human resources and R&D capabilities in the eastern region is relatively high, and it has a high degree of

marketization, which can make better use of the cutting-edge technologies that OFDI can access for secondary innovation. Therefore, in the process of “going out”, the eastern region is more inclined to develop technology-seeking OFDI. This high-quality development of IFDI and OFDI will promote each other, and ultimately form the role of interactive development of IFDI and OFDI to effectively promote regional environmental technology progress.

Thirdly, the impact of $\ln\text{IFDI}_{it}$ on the environmental technology in the central and western regions is significantly negative. For every 1% increase in $\ln\text{IFDI}_{it}$, the environmental technology level in the central region decreases by 0.1166%, and the environmental technology level in the western region decreases by 0.0563%. The reason is that, on the one hand, China's central and western regions not only undertake the industrial transfer of the eastern region, but also introduce IFDI based on resource seeking. These enterprises are not conducive to the progress of environmental technology. On the other hand, due to the low level of regional economic development, the scale of OFDI is relatively small, and the flow to the region is mainly developing countries, which is not conducive to the progress of regional environmental technology. Therefore, $\ln\text{IFDI}_{it}$ in the central and western regions will inhibit the progress of regional environmental technology.

4.2.2. Heterogeneity analysis of score interactive development degree

To systematically analyze the impact of different two-way FDI interactive development degrees on environmental technology, this paper further classifies 30 provinces and cities in China into high-interactive development degree group and low-interactive development degree group. If the average two-way FDI interactive development degree is higher than the overall average of two-way interactive development degree in China, the region is divided into high-interactive development degree group and vice versa, and the regression results are shown in Table 4.

Table 4
Heterogeneity Analysis of the Development Degree of Two-way FDI Interaction.

	High Interactive Development	Low Interactive Development
	SYS-GMM	SYS-GMM
$Intec_{i,t-1}$	1.1954*** (0.0496)	0.8036*** (0.0576)
$lnIDFDI_{it}$	0.1547** (0.0762)	-0.0569** (0.0260)
cons _	1.9976** (0.9260)	-2.8144** (1.1769)
Control variables	Yes	Yes
AR(1)	-6.48 [0.000]	-3.10 [0.002]
AR(2)	1.18 [0.237]	-0.82 [0.410]
Sargan	1.63 [0.202]	3.37 [0.185]
<p>note :1.*,**,*** indicate significant at the levels of 10%, 5% and 1%, respectively; 2. SYS-GMM indicate the system GMM estimate; 3. the standard error of the estimation coefficient is shown in parentheses, and the P value of the statistics shown in square brackets. 4. The Arellano-Bond test for AR (1) and AR (2) show first-order serial correlation and no second-order serial correlation. The P value of sargan test is greater than 0.1, there is no problem of over-identification.</p>		

The regression results in Table 4 show that, first of all, the delayed phase of environmental technology will promote the current high interactive development area of environmental technology. Because of this, the economic level of the two-way FDI high interactive development area is relatively high, and the economic development level determines the regional environmental technology to a certain extent. Secondly, the promotion effect of two-way FDI interaction development on regional environmental technology only occurs in areas with high degree of interactive development. At this time, the degree of two-way FDI interaction development increases by 1 percentage point, and the regional environmental technology will rise by 0.1547 percentage points. For the low interactive development area, the degree of two-way FDI interaction development will significantly inhibit the regional environmental technology, and passed the test at the significant level of 5%. The reason is that in areas with high degree of two-way FDI interaction development, the scale and structure of its IFDI and OFDI are relatively reasonable. It will promote the rise of environmental technology.

4.2.3. Phased Heterogeneity Test

To systematically analyze whether there are differences in the impact of two-way FDI interactive development level on China's environmental technology in different stages, this paper takes the 2008 financial crisis as the time node. The impact of two-way FDI interactive development on China's environmental technology in 2004-2008 and 2009-2017 is investigated. The results are shown in Table 5.

Table 5
Environmental Technology Effects of Phased Two-way FDI Interactive Development.

	2004-2008	2009-2017
	SYS-GMM	SYS-GMM
Intec _{i,t-1}	1.5227*** (0.1474)	1.1078*** (0.0578)
lnIDFDI _{it}	-0.2157** (0.0866)	-0.0592* (0.0355)
cons _	0.3552 (1.0615)	-0.6376 (1.0221)
Control variables	Yes	Yes
AR(1)	-2.15 [0.032]	-8.58 [0.000]
AR(2)	-1.64 [0.102]	0.38 [0.703]
Sargan	0.05 [0.818]	1.20 [0.274]
note :1.*,**,*** indicate significant at the levels of 10%, 5% and 1%, respectively; 2. SYS-GMM indicate the system GMM estimate; 3. the standard error of the estimation coefficient is shown in parentheses, and the P value of the statistics shown in square brackets. 4. The Arellano-Bond test for AR (1) and AR (2) show first-order serial correlation and no second-order serial correlation. The P value of sargan test is greater than 0.1, there is no problem of over-identification.		

Table 5 shows that, China's two-way FDI interactive development level has inhibited environmental technology during 2004-2008, and passed the test at a significant level of 5%. At this point, for every one percentage point increase in the level of two-way FDI coordinated development, it will lead to a decrease of 0.2157 percentage points in environmental technology in the region. Between 2009 and 2017, China's level of two-way FDI interaction increases by one percentage point, It will lead to a decrease of 0.0592 percentage points in regional environmental technology. It shows that, during the sample period, China's two-way FDI interactive development level of environmental technology gradually decreased. The reason

is that, in recent years, on the basis of increased IFDI and OFDI, keeping adjusting the IFDI and OFDI structures, which effectively promotes the level of interaction between the two, and finally promote the reduction of its negative impact on environmental technology

4.3. Robustness test

To verify the robustness of the results in Table 2, this paper uses IFDI stock and OFDI stock to replace IFDI flow and OFDI flow variables, and recalculates the degree of interactive development of two-way FDI in various regions, and carries out regression analysis. The results are shown in Table 6. It can be found that the coefficient size, symbol and significance level of the variables do not change significantly. Therefore, the regression results in Table 2 are considered to be robust.

Table 6
Robustness test.

	SYS-GMM	SYS-GMM
Intec _{i,t-1}	0.7944*** (0.0416)	1.0376*** (0.0130)
lnIDFDI _{it}	-0.0162** (0.0079)	-0.0313** (0.0154)
cons _	-0.5812*** (0.0730)	0.1052*** (0.0251)
Control variables	Yes	No
AR(1)	-5.23 [0.000]	-4.08 [0.000]
AR(2)	-0.89 [0.373]	-0.19 [0.851]
Sargan test	29.81 [0.155]	29.89 [0.319]

note :1.*,**,*** indicate significant at the levels of 10%, 5% and 1%, respectively; 2. SYS-GMM indicate the system GMM estimate; 3. the standard error of the estimation coefficient is shown in parentheses, and the P value of the statistics shown in square brackets. 4. The Arellano-Bond test for AR (1) and AR (2) show first-order serial correlation and no second-order serial correlation. The P value of sargan test is greater than 0.1, there is no problem of over-identification.

Conclusions And Policy Recommendations

Based on the data of 30 provinces, cities and autonomous regions in China from 2004 to 2017, this paper empirically tests the influence of two-way FDI interactive development level on the progress of environmental technology, and analyzes the heterogeneity from the angles of region, degree of interactive development, time stage and so on. First, the interactive development of two-way FDI in China inhibits the progress of regional environmental technology. Second, from the perspective of regional heterogeneity, the development of two-way FDI interaction promotes the environmental technology in the eastern region, but inhibits the environmental technology in the central and western regions. Third, from the heterogeneity of the degree of development of two-way FDI interaction, the interactive development of two-way FDI will promote the environmental technology in high interactive development areas, but will inhibit the environmental technology in low interactive development areas. Fourthly, from the point of view of stage heterogeneity, with the increasing degree of development of two-way FDI interaction in China, the inhibitory effect of two-way FDI interaction development on regional environmental technology has decreased.

Although this study has drawn rich conclusions, it also has certain limitations. Limited by the availability of data, the empirical analysis data used in this study is panel data from 30 provinces and cities in China. If data on prefecture-level cities or double-digit industry data in China can be further collected, this study will be more targeted. Therefore, if we can break through the limitation of data availability in the future, we can conduct further in-depth research on China's prefecture-level city data or specific industry data, which will help formulate more specific policy recommendations, and this research can also be used as an effective reference.

In summary, this paper puts forward the following policy recommendations:

First, the continuous introduction of IFDI is an important way to develop the economy in the future and promote the progress of environmental technology. China's previous strategy of "exchange market for technology" is an inevitable choice under the condition of economic backwardness. Although it has brought rapid development to China's economy, on the one hand, the technology exchanged is not advanced core technology. On the other hand, a large IFDI inflow has brought great pressure to China's resources and environment, seriously inhibiting the sustainable development of China's economy. Therefore, under the background that China's economy has entered a new state of "the three period superimposed" (Growth rate shifting period, Painful period of structural adjustment, Digestion period of early stimulus policy) and the environmental quality problems are prominent, the formulation of investment policy should be combined with this background, and the introduction of environmental technology should be strengthened through the introduction IFDI. Encourage Sino foreign joint ventures and strengthen technical cooperation

Second, Since OFDI has greater initiative, it can strengthen the scale of OFDI in the future and accelerate the pace of enterprises "going out". For the central and western regions, the OFDI scale and technology-seeking OFDI is relatively small. Therefore, adjusting the structure of OFDI and increasing the scale of OFDI is one of the important channels for strengthening environmental technology in the central and

western regions in the future. As for the eastern region, although it has a relatively large OFDI scale, the eastern region should focus on developing acquisition-oriented OFDI and strengthen investment in countries with higher environmental technology levels to promote the home country environmental technology progress through the reverse technology spillover effect of OFDI.

Third, strengthen the level of interactive development between two-way FDI. On the IFDI side, we should make clear the purpose of attracting investment, focus on introducing foreign capital with high technology level, and pay attention to the spillover effect of IFDI environmental technology, so as to slow down the emission reduction cost of domestic enterprises and improve their competitiveness, thus promoting their OFDI. On the OFDI side, we should focus on multi-oriented investment motivation, pay attention to mutual benefit and win-win with the host country, promote the progress of environmental technology in the home country through reverse technology spillover effect, and enhance the overall economic strength of the home country. Then introduce more high-tech IFDI, to form a benign interaction between IFDI and OFDI, and ultimately promote environmental technology.

Declarations

Author Contributions: M.G. designed the study, analyzed the data, and wrote the manuscript. Z.Y. collected the data and coordinated the data analysis. J.C. revised the manuscript. All authors have read and agreed to the published version of the manuscript.

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Figures

(a) Flow Trends of Two-way FDI in China

(b) Stock Trends of Two-way FDI in China

Figure 1

Flow and Stock Trends of Two-way FDI in China.