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China's Foreign Direct Investments: Do they Promote Domestic Green Technology?

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Abstract

This study systematically analyses the nonlinear relationship between China's outward foreign direct investment (OFDI) and reverse green technological progress (RGTP) using fixed effects (FE) model based on panel data for 31 Chinese provinces from 2001-2020. We find that the link between China's OFDI and RGTP is an inverted U-shaped curve. In addition, environmental regulation and technology gaps all reduce the height of the inverted U-shaped inflection point. Environmental regulation prolongs the "climb" stage while technology gaps compress the "climb" stage of the inverted U-curve relationship significantly. This result is verified in further robustness tests. The four transmission mechanisms of China's OFDI on RGTP play a positive role: these findings may help policymakers to design more flexible and effective OFDI policies.

Keywords: China's OFDI; RGTP; Environmental Regulation; Technology Gap; Transmission Mechanism

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1. Introduction

China's economic growth rate has been above the global average for many years due to its reform and opening up, and its economy aggregate has risen to second place in the world. However, the traditional crude growth model has caused the accelerated depletion and exhaustion of resources, which has led to serious environmental pollution and ecological damage (Sethi et al., 2020; Yu et al., 2023). Thus, China must promote a transformation from the current crude economic development paradigm to a green and low-carbon strategy. Green technological innovation has emerged as a crucial catalyst for driving the much-needed transition toward a more sustainable economy.

The WIPO's report shows that the global ranking of China's innovation index has risen from 35th in 2013 to 11th in 2022 (WIPO, 2022). However, China's technological innovation capacity is still low for the world's second-largest economy. The IEA estimates that 40% of the 2060 Chinese energy sector CO₂ emissions reductions will come from prototype or demonstration technologies (IEA, 2022). The WIPO reports that it has been observed that European, Japanese, American, and Korean patent holders have been given a greater number of green and low-carbon patents abroad compared to their Chinese counterparts. This trend is also reflected in the proportion of foreign patent grants, as depicted in Fig.1. Moreover, according to the CASTED's report, 19.7% of China's green low-carbon technologies have reached the international leading level. 54.4% of them are basically equal to the international average level, and 25.9% of them are still behind the international average. There is still a large gap of 7.3 years between the average level of green and low-carbon technology in China and the

international leading countries (Teng, 2022).

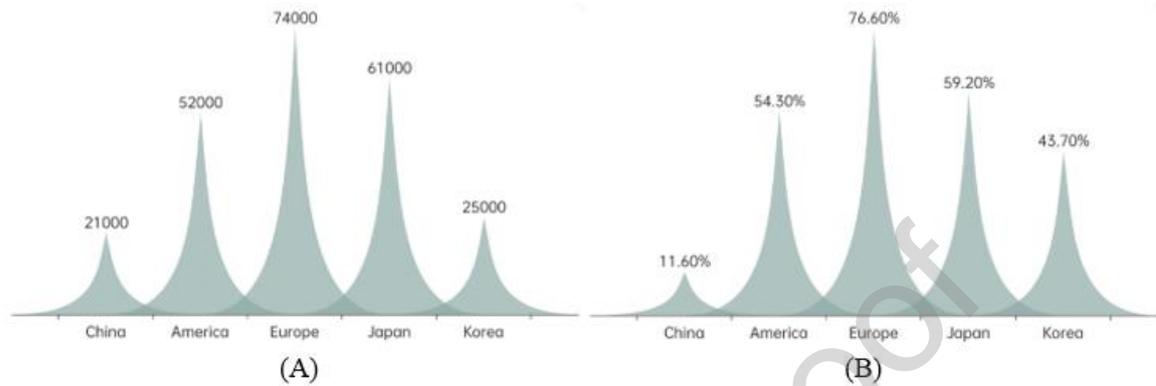


Fig.1. Overseas Green Low-Carbon Cumulative Patent Authorization (A) and Proportion of Overseas Authorization (B) in China, America, Europe, Japan, and Korea (2016-2022).

Obviously, the gap between China and developed countries in green technology exists objectively. OFDI has emerged as a significant avenue for obtaining cutting-edge green technologies from abroad. Thus, with China's tremendous economic growth, the foreign economic policy of large-scale "going out" has become a key characteristic of its open economy. According to World Investment Report 2021, China's OFDI experienced a consistent annual growth rate of over 7% from 2012 to 2020, positioning it as one of the leading three global flows for a period of nine years (UNCTAD, 2021). Over the past 20 years, China's OFDI structure has been progressively optimized, with a growing broad range of investment fields and diversified investment geographies. By 2020, more than 80% of China's OFDI stock was allocated across various sectors, including service, manufacturing, finance, and mining (K. H. Zhang, 2021; Q. Zhang, 2022). According to Wang and Miao (2020), China's OFDI is present in 189 countries and regions worldwide. This accounts for approximately 81.1% of the total number of countries.

A valuable question is raised: has China's rapidly growing OFDI enhanced domestic green technology progress? The existing literature still has mixed effects on the predicted impacts of OFDI and RGTP. These different results stem from differences in investor countries (Weiwei Zhang et al., 2023), different investment motives (H. Liu et al., 2022), etc. It also depends on the indirect-acting factors, such as environmental regulations and the green technology development level (Weiwei Zhang et al., 2023). Thus, OFDI does not automatically boost home country's RGTP. So far, most of the literature has focused on China as the largest FDI inflow country (Deng et al., 2012), ignoring the fact that China's OFDI flows have ranked among the top three globally for ten consecutive years. Specifically, there is a notable absence of adequate focus on the inquiry regarding whether China's OFDI effectively fosters domestic RGTP. This gap provides an impetus for us to study the complex relationship and mechanism of action between China's OFDI and RGTP.

In order to address the aforementioned research questions, this paper utilizes annual data from 31 provinces in China spanning from 2001 to 2020 to construct a FE regression model. The link between China's OFDI and RGTP is confirmed to be an inverted U-shaped curve by the test results. We use environmental regulation and technology gaps as moderating variables of the relationship between OFDI and RGTP, further explore their different impacts on the inflection point height and "climbing" stage of the inverted U-shaped curve. Furthermore, we analyze the four transmission mechanisms of China's OFDI to RGTP.

This paper makes a contribution in three ways. First, we present the relationship between China's OFDI and RGTP as an inverted U-shaped curve. Unlike previous studies (Hao et al.,

2020; Wong et al., 2022), which only explored the linear relationship between China's OFDI and RGTP, this study provides a more complete picture of how China's OFDI affects RGTP. Second, we find that environmental regulation and technology gaps lower the inflection point of China's OFDI and RGTP inverted U-shaped curve. However, the difference is that environmental regulations lengthen the "climb" stage, while the technology gaps significantly compress the "climb" stage. Third, the tests conducted on the transmission mechanism confirm that GDP scale, industrial structure, R&D technology, and capital deepening all steadily play a positive role. These new findings have never been explored in previous studies, which provide a positive implication to policymakers in emerging economies like China.

The paper proceeds. Section 2 reviews literature. In Section 3, the model and variables are introduced. In Section 4, the results are discussed and analyzed. Section 5 analyzes the transmission mechanisms. Section 6 discusses policy implications. Section 7 concludes.

2. Literature review

The reverse technology spillovers of OFDI have been extensively discussed in previous studies (X. Huang & Huang, 2023; Sahoo & Bishnoi, 2021). However, it is worth noting that the existing literature has not yet reached a consensus on this matter.

The first perspective posits that OFDI has the potential to foster technological advancements within the home country. Substantial evidence from technology-lagging countries suggests that reverse investments can learn new knowledge and technologies from developed economies (Fujimori & Sato, 2015; Sahoo & Bishnoi, 2021; Wenyue Zhang et al., 2022). In recent years, emerging economies represented by China have increasingly emphasized direct

investment in developing and less developed countries. Investing in Belt and Road countries can help China improve capacity utilization (Ren & Yang, 2020; Zhou et al., 2019), dissolve excess capacity, and optimize structure, thereby promoting reverse technological progress (Razzaq, Adil, et al., 2021). Xia et al. (2020) confirmed that OFDI can significantly promote reverse technological progress and emphasized the key role of reverse technological progress in economic growth. This is supported by the theory of technological innovation and structural upgrading, as well as the concept known as the "New Flying-Geese Pattern (Jiang et al., 2020a; H. Zhou et al., 2022).

The second argument is that OFDI cannot reverse technological advancement in the native nation. Some scholars insist that OFDI has a crowding-out effect, arguing that OFDI will cause the "off-manufacturing effect" and "siphon effect" in home countries. This can have insignificant or adverse impacts on technological progress in the home countries (Du & Xiao, 2021; Hong et al., 2019; Shaogui, 2020; Xiuwu et al., 2021; Zhou et al., 2019), which ultimately leads to lower economic growth (Hao et al., 2020). In addition, an excessively fast investment process may make it difficult for home country firms to react to quick market demand changes, reversing progress in technology (Jie, 2022; F. Li & Yu, 2020).

Therefore, the relationship between OFDI and RGTP cannot be described simply, which is uncertain. We believe that this may be related to the fact that scholars have overlooked the interval effects of environmental regulations and technology gaps on OFDI and RGTP. A moderate technology gap may be more beneficial for home countries to absorb knowledge, skills, and technology (Hong et al., 2019; Razzaq, An, et al., 2021). Scholars have found that

productivity spillovers from OFDI decrease as the technology gap increases and are no longer significant after reaching a certain threshold (Morales & Moreno, 2020; Razzaq, Adil, et al., 2021). Neoclassicism posits that environmental regulation may increase costs associated with compliance, crowding out investment and limiting the development of reverse technological progress (Ai et al., 2021; L. Liu, Zhao, Zhang, et al., 2021). Zhou et al. (2019) observed that China's OFDI won't have a green spillover unless the environmental regulations index reaches a particular threshold. Therefore, it is possible that environmental regulations and technology gaps have a moderating effect on green technology progress.

By reviewing the relevant literature, we identified several gaps to be filled. The current body of studies pertaining to the influence of OFDI on RGTP remains predominantly focused on the linear relationship framework. The nonlinear link between OFDI and RGTP in the home country is poorly studied. Second, the current literature is mainly based on the RGTP effects of OFDI, but environmental regulations and technology gaps are elements that cannot be ignored. Unfortunately, few studies have focused on environmental regulations and technology gaps in their countries. Finally, the influence mechanisms of OFDI on RGTP have to be further explored and researched, but few scholars have focused on this exciting issue.

3. Model and Variables

3.1 The model

Based on the literature review, four FE models are constructed in this paper. Compared to the ordinary least square (OLS) model, the FE model can better control the individual heterogeneity that does not vary over time and obtain more accurate regression results. In

addition, to minimize the influence of heteroskedasticity, logarithmic transformations were performed for all variables. The models are constructed as follows:

$$\lnrgtp_{it} = \varphi_0 + \varphi_1(\lnofdi_{it})^2 + \varphi_2\lnofdi_{it} + \varphi_3\lncontrol_{it} + \sigma_i + \eta_t + \varepsilon_{it} \quad (1)$$

$$\begin{aligned} \lnrgtp_{it} = & \alpha_0 + \alpha_1(\lnofdi_{it})^2 + \alpha_2\lnofdi_{it} + \alpha_3\lnei_{it} + \alpha_4(\lnofdi_{it})^2 \times \lnei_{it} + \\ & \alpha_5\lnofdi_{it} \times \lnei_{it} + \alpha_6\lncontrol_{it} + \sigma_i + \eta_t + \varepsilon_{it} \end{aligned} \quad (2)$$

$$\begin{aligned} \lnrgtp_{it} = & \beta_0 + \beta_1(\lnofdi_{it})^2 + \beta_2\lnofdi_{it} + \beta_3\lntegap_{it} + \beta_4(\lnofdi_{it})^2 \times \\ & \lntegap_{it} + \beta_5\lnofdi_{it} \times \lntegap_{it} + \beta_6\lncontrol_{it} + \sigma_i + \eta_t + \varepsilon_{it} \end{aligned} \quad (3)$$

$$\begin{aligned} \lnrgtp_{it} = & \gamma_0 + \gamma_1(\lnofdi_{it})^2 + \gamma_2\lnofdi_{it} + \gamma_3\lnei_{it} + \gamma_4(\lnofdi_{it})^2 \times \lnei_{it} + \\ & \gamma_5\lnofdi_{it} \times \lnei_{it} + \gamma_6\lntegap_{it} + \gamma_7(\lnofdi_{it})^2 \times \lntegap_{it} + \gamma_8\lnofdi_{it} \times \\ & \lntegap_{it} + \gamma_9\lncontrol_{it} + \sigma_i + \eta_t + \varepsilon_{it} \end{aligned} \quad (4)$$

Where \lnrgtp denotes the RGTP effect in the provinces. \lnofdi represents OFDI stock of each province. \lnei is environmental regulation and \lntegap is technology gap. \lncontrol expresses the control variable. i and t denote province and time respectively. α_k , β_k , and γ_k represent the estimated coefficients of all independent variables, where $k = 1, \dots, 6$. σ_i , η_t , and ε_{it} are the province effects, time effects, and classical error term, respectively.

3.2 The variables

This study uses 2001-2020 panel data from 31 Chinese provinces. The dependent variable is the RGTP effect, measured by the Global Malmquist-Luenberger (GML) index. Calculating the GML index requires 3 input variables and 2 output variables. Input variables include capital stock, labor force, and energy consumption. The expected output is GDP, and the unexpected output is carbon emission.

The independent variable is the OFDI stock of 31 provinces in China. Environmental regulation and technology gap are moderating variables. Environmental regulation is measured by the investment in environmental governance as a percentage of GDP. The technology gap is measured through the labor productivity gap between America and the provinces, as America is at the forefront of technology. Labor productivity can be calculated by dividing the average annual number of employees by the GDP. The control variables include trade, employed population, patent applications, and the value-added for the secondary industry. The definition of the variables and data sources is reported in Table A1 (in Appendix).

4. Empirical results and analysis

4.1 Inverted U-shaped curve relationship between OFDI and RGTP

Model FE-1 findings in Table 1, the coefficient of $\ln ofdi$ is greater than 0, and the coefficient of $(\ln ofdi)^2$ is less than 0, thus an inverted U-shaped relationship is observed between OFDI and RGTP. The impact mechanism of China's OFDI on RGTP is promotion followed by restraint. This result suggests that it is not better for China to have more OFDI and that blind investment does not produce the expected results. Different from the previous simple linear judgments that OFDI promotes or restrains RGTP (Dai et al., 2021; Feng et al., 2018), the findings in this paper provide richer information to narrow the divergence between them.

In our view, the possible reasons why China's OFDI first promotes and then restrains RGTP are as follows. First, China's strategic resource-seeking and efficiency-seeking investment strategies are mainly used to address the problem of capital accumulation. RGTP can be promoted by divesting relatively disadvantaged "marginal industries" through sharing R&D

costs and divesting peripheral R&D (Y. Chen et al., 2019; X. Li et al., 2021). Second, Chinese incumbent firms face strong rivalry from foreign market-seeking investment, compelling them to innovate. In turn, Chinese firms can obtain reverse green technological spillovers through direct investment in developed countries, thereby reducing their negative impact on the environment. Additionally, with a high-quality economic development strategy and increased green economy awareness, some low-end and energy-intensive industries have reduced or moved to external layouts, which improved RGTP.

However, China's OFDI as a whole is more inclined to seek key strategic resources (Ren & Yang, 2020), resulting in most of capital flowing into resource-intensive or labor-intensive industries in the host country, which does not bring China RGTP (Hao et al., 2020). Besides, due to technological constraints, it is difficult to acquire advanced green technologies through investment in developed countries. Therefore, China's OFDI and RGTP exhibit an inverted U-shaped curve relationship, characterized by initial promotion followed by subsequent restraint.

4.2 Impact of environmental regulation

The coefficient of the model FE-4 $(\ln ofdi)^2 \times \ln ei$ in Table 1 is significantly larger than 0, indicating that the environmental regulation moderates the link between OFDI and RGTP, flattening the inverted U-shaped curve. As shown in Fig.2, the inverted U-shaped curve's inflection point shifts right when environmental regulation is high. This suggests that environmental regulation plays a regulatory role, and that appropriate environmental regulation lengthens the "climb" stage and maintains RGTP in a longer upward range. However, this does not mean that stricter environmental regulation is better, because stricter environmental

regulation reduces the peak of RGTP. It is a new finding of this study that environmental regulation modifies the inverted U-shaped curve relationship between OFDI and RGTP to the right and lowers its inflection point. This provides new policy insights for relevant countries, including China, to promote RGTP through environmental regulation.

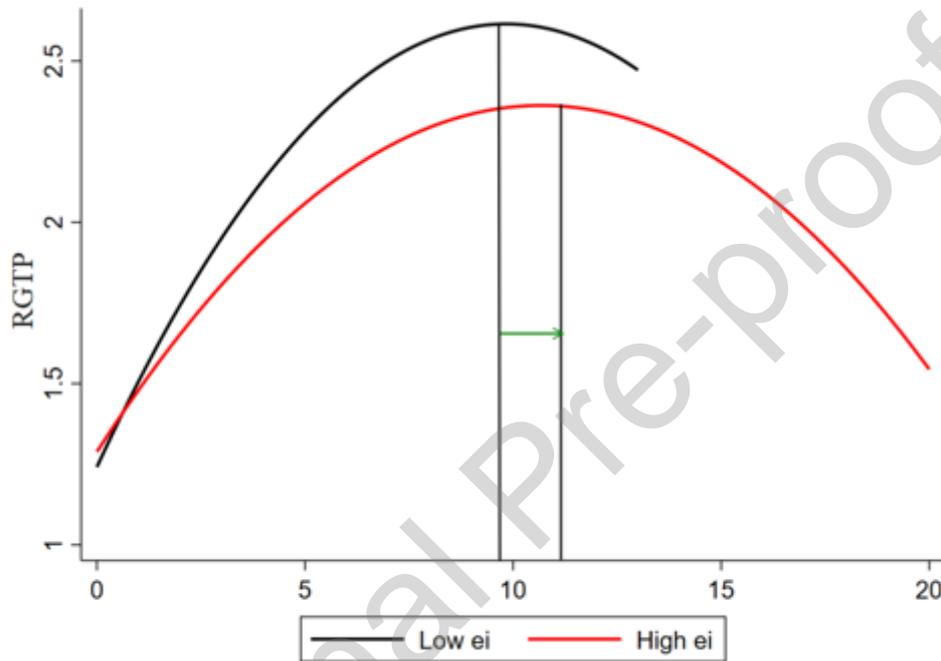


Fig.2. Moderating effect of environmental regulation.

According to environmental regulation's moderating influence, the features that cause the inflection point of the inverted U-shaped curve to right and the height to drop are not immediately apparent. This implies that overly stringent environmental regulation only slightly inhibits RGTP (Feng et al., 2018). The possible reason is that China's environmental regulations mainly are administrative orders, and policy implementation and inspection are too expensive for long-term regulation. Market incentive environmental regulation may cause "environmental rent-seeking," resource factor mismatch, and price distortion due to China's inefficient market

mechanism. These events hinder green technology innovation. Therefore, it is argued that environmental regulation policies and their regulatory practices with moderate intensity can be regarded as a "sieve" that provides sufficient development space for RGTP.

4.3 Impact of the technology gap

Based on the result that the coefficient of the model FE-4 $(\ln of di_{it})^2 \times lntegap$ in Table 1 is significantly greater than 0. This finding suggests that the moderating effect of technology gap flattens the inverted U-shaped curve of OFDI and RGTP. In Fig.3, the inverted U-shaped curve's inflection point shifts right when technology gap is high. The larger the technology gap, the lower the inflection point of the inverted U-shaped curve, and it rapidly shifts left. This is the second new finding obtained from this study. However, the findings may make China, as the investor country, feel somewhat uneasy.

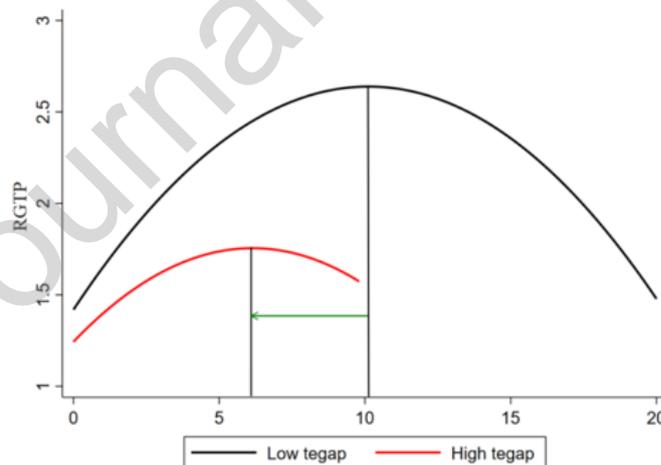


Fig.3. Moderating effect of the technology gap.

First, China's OFDI is likely to be forced to flow to developing countries with relatively small technology gaps. Razzaq, An, et al. (2021) have expressed similar concerns if China, a developing country, can provide technological spillovers for Belt and Road host countries.

Second, China may face more difficulties in breaking through green low-carbon core technologies. By increasing absorption capacity and achieving a more technologically advanced transitional economy, OFDI can bring RGTP to China (Razzaq, An, et al., 2021). However, against the backdrop of the high-end technology blockade initiated by some developed countries, the investor China has two important tasks. The first is to get rid of the strange circle of "introduction-backward-reintroduction-backward again" and the situation of low-end technology locking (Y. Song et al., 2021). The second is to break through green low-carbon core technologies as soon as possible to narrow the technology gap with frontier countries.

It should be emphasized that from Fig.2 and Fig.3, environmental regulation and technological gap lower the inflection point of China's OFDI and RGTP inverted U-shaped curve. The difference is that environmental regulation shifts the inflection point to right, lengthening the "climb" stage, while the technology gap shifts the inflection point to left, shortening the "climb" stage. The results of this study differed from Y. Luo et al. (2021), Hong et al. (2019), and Xie et al. (2017). While they verified the impact of environmental regulation and technology gap on OFDI and RGTP, they found no subtle differences.

4.4 Robustness tests

To verify environmental regulation and technological gap's moderating impacts on China's OFDI and RGTP, we conducted three robustness tests on model FE-4, and the results are shown in the RT-1, RT-2, and RT-3 columns in Table 1.

First, due to the vast data range and potential flaws in older data, 2001–2004 data is deleted first (Table 1 RT-1). Second, railway infrastructure is a major cause of RGTP in several regions

and may alter regression results. Thus, we add railway network density (*lnrail*) (kilometers of railway per 1,000 square kilometers of land area) as a new control variable (RT-2). Finally, OLS regression replaces FE regression for robustness testing (RT-3). The robustness test findings in Table 1 show that variable coefficient sizes do not significantly differ from positive and negative signs. This shows that environmental regulation and technology gap robustly moderate the relationship between China's OFDI and RGTP.

Table 1 Regression and robustness test results.

VARIABLES	(1) FE-1	(2) FE-2	(3) FE-3	(4) FE-4	(5) RT-1	(6) RT-2	(7) RT-3
<i>lnofdi</i>	0.176*** (16.02)	0.204*** (8.62)	0.362*** (17.05)	0.327*** (12.31)	0.327*** (12.31)	0.328*** (12.24)	0.327*** (12.31)
$(lnofdi)^2$	-0.001*** (-14.18)	-0.002*** (-5.77)	-0.002*** (-11.82)	-0.003*** (-10.99)	-0.003*** (-10.99)	-0.003*** (-10.92)	-0.003*** (-10.99)
<i>lnei</i>		0.292*** (4.32)		0.145** (2.52)	0.145** (2.52)	0.153** (2.33)	0.145** (2.52)
$lnofdi \times lnei$		-0.136*** (-2.64)		-0.202*** (-3.93)	-0.202*** (-3.93)	-0.207*** (-3.75)	-0.202*** (-3.93)
$(lnofdi)^2 \times lnei$		0.002*** (3.26)		0.005*** (5.64)	0.005*** (5.64)	0.006*** (5.53)	0.005*** (5.64)
<i>Integap</i>			-0.398*** (-2.91)	-0.366*** (-2.78)	-0.366*** (-2.78)	-0.363*** (-2.74)	-0.366*** (-2.78)
$lnofdi \times Integap$			-0.168*** (-12.96)	-0.132*** (-9.03)	-0.132*** (-9.03)	-0.132*** (-8.75)	-0.132*** (-9.03)
$(lnofdi)^2 \times Integap$			0.010*** (9.32)	0.004** (2.33)	0.004** (2.33)	0.004** (2.24)	0.004** (2.33)
<i>lnrail</i>						-0.028 (-0.27)	
<i>lncontrol</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.287*** (71.56)	1.290*** (71.93)	1.260*** (38.91)	1.260*** (41.36)	1.260*** (41.36)	1.265*** (36.04)	1.105*** (26.22)
R-squared	0.593	0.590	0.724	0.732	0.732	0.732	0.915

Note: *** p<0.01, ** p<0.05, * p<0.1.

5. Further mechanism analysis

5.1 Transmission mechanism model construction

According to Grossman and Krueger (1991), Zhu and Ye (2018), and L. Liu, Zhao, Su, et al. (2021), OFDI may ultimately affect RGTP through the channel effect mechanisms of scale, industrial structure, technology, and capital deepening.

First, the GDP scale effect mechanism. Through OFDI, the advanced technology and R&D resources of foreign firms are absorbed, expanding its production scale and providing financial support for the R&D activities of the home. However, large-scale growth in the home country in the short term occurs mainly in industries with low value-added, energy-intensive and high pollution (Yang & Yu, 2011). This negatively impacts the ecological environment and hinders RGTP. Second, industrial structure effect mechanism. The extensive development model has been solidified to a certain extent due to the relatively large proportion of resource-oriented China's OFDI. This has hindered the rise of emerging industries. In addition, trade growth and reverse technological progress due to OFDI have increased the scale of domestic output, leading to increased energy consumption and pollution emissions. Due to the relatively slow pace of industrial restructuring in China, there is a noticeable lag in RGTP. Third, the R&D technology effects mechanism. China's OFDI is primarily targeted at mergers and acquisitions of firms with advanced production technologies in developed countries (Bai et al., 2020), increasing the production efficiency of the home firms through reverse technological spillovers. However, these positive effects are also somewhat weakened by the transaction and coordination costs incurred in multinational operations. The unfamiliar foreign market environment can cause

firms to assume a "foreign disadvantage" (C. Song et al., 2022), limiting technological cooperation between the investing firms and the host country firms. Finally, the capital deepening effect mechanism. Capital deepening is objective and universal in the process of economic development (Barras, 1986). However, excessive capital deepening exacerbates the overcapacity of resource-based firms and hampers the innovation investment of these firms, ultimately impacting RGTP. China's OFDI tends to promote the rapid development of resource-based firms, which undoubtedly accelerates the capital deepening of resource-based firms. Excessive capital deepening by resource-based firms has inhibited the rise of RGTP in China.

To further test and quantify the above mechanism, this paper adopts the methods of Heckman et al. (2013) and Gelbach (2016) to decompose the mechanism quantitatively, and the formulas are as follows:

$$M_{it} = \lambda_0 + \lambda_1(\ln of di_{it})^2 + \lambda_2 \ln of di_{it} + \lambda_3 Control_{it} + \sigma_i + \eta_t + \varepsilon_{it} \quad (5)$$

$$rgtp_{it} = \theta_0 + \theta_1(\ln of di_{it})^2 + \theta_2 \ln of di_{it} + \theta_3 M_{it} + \theta_4 Control_{it} + \sigma_i + \eta_t + \varepsilon_{it} \quad (6)$$

Where, M are the mediator variables, which are GDP scale, industrial structure, R&D technology and capital deepening. The GDP scale effect ($lngdp$) is measured by GDP. The value-added for the secondary industry is a crucial variable for assessing the industrial structure. Therefore, it is utilized in this section to gauge the impact of the industrial structure ($lnsind$). The R&D technology effect ($lnrd$) is measured in R&D, and the capital deepening effect ($lncp$) is measured in terms of capital stock/labor. Data is from China Statistical Yearbook. Substituting equation (5) into (6) to collate the mediator effect of China's OFDI and RGTP is $ME = \theta_2 + \theta_1 \ln of di + \theta_3(\lambda_2 + \lambda_1 \ln of di)$. This study treats environmental regulation and

technology gap as control variables to mitigate the potential influence of moderating variables on the mediator effect.

5.2 Results analysis of the transmission mechanism

Table 2 presents the regression results pertinent to the four transmission mechanisms.

Table 2. Mechanism regression results

Variables	(1)		(2)		(3)		(4)	
	<i>lngdp</i>	<i>lnrgtp</i>	<i>lnsind</i>	<i>lnrgtp</i>	<i>lnrd</i>	<i>lnrgtp</i>	<i>lncp</i>	<i>lnrgtp</i>
<i>lnofdi</i>	0.197*** (6.07)	0.136*** (12.33)	0.131*** (4.05)	0.143*** (13.16)	0.151*** (4.06)	0.131*** (11.63)	0.388*** (3.51)	0.144*** (12.86)
$(lnofdi)^2$	-0.001*** (-4.06)	-0.001*** (-10.28)	-0.001*** (-2.64)	-0.001*** (-10.91)	-0.001*** (-2.94)	-0.001*** (-9.72)	-0.002*** (-2.68)	-0.001*** (-10.52)
<i>lngdp</i>		0.111*** (5.90)						
<i>lnsind</i>				0.118*** (5.86)				
<i>lnrd</i>						0.040* (1.86)		
<i>lncp</i>								0.020*** (4.30)
<i>Control</i>	YES	YES	YES	YES	YES	YES	YES	YES
Constant	8.977*** (93.89)	0.398** (2.42)	1.377*** (14.49)	1.234*** (33.16)	-3.516*** (-26.93)	1.528*** (16.51)	5.472*** (16.84)	1.248*** (31.38)
R-squared	0.490	0.619	0.445	0.618	0.495	0.557	0.422	0.602

Note: t-statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Bringing in the value of *lnofdi* separately, we get the mediator effect intervals *ME* for the four transmission mechanisms. The intervals for the mediator effects of GDP scale, industry structure, R&D technology, and capital deepening effect are respectively (0.135, 0.158), (0.135, 0.158), (0.114, 0.137), and (0.129, 0.152). It is confirmed that the above four mechanisms are the transmission channels of China's OFDI to RGTP. First, this result aligns with the economic intuition of the scale effect. Large-scale "going out" firms typically have easier access to scarce

resources than their home countries. Over time, these resources will flow back to their home country, ultimately positively affecting RGTP. Second, by shifting these relatively disadvantaged marginal industries, not only can trade barriers be circumvented and pave the way for firms to expand overseas, but it also aids in upgrading China's industrial structure (F. Li & Yu, 2020; X. Li et al., 2021), thus facilitating RGTP. Third, it is worth noting that reverse investment in developed countries can absorb and introduce advanced green technologies. While other forms of OFDI may not primarily focus on technology acquisition, they can still promote green technology innovation. This can be achieved through the transfer of surplus capacity, ensuring a stable supply of resources, and reducing production costs (H. Chen et al., 2020). Finally, this paper provides confirmation that RGTP can be contributed to by capital deepening resulting from China's OFDI, as capital deepening is the primary catalyst for capital-embodied technological progress (Dieppe et al., 2021).

By analyzing the moderating and mediator effects above, we obtain the impact mechanism between China's OFDI and RGTP shown in Fig.4.

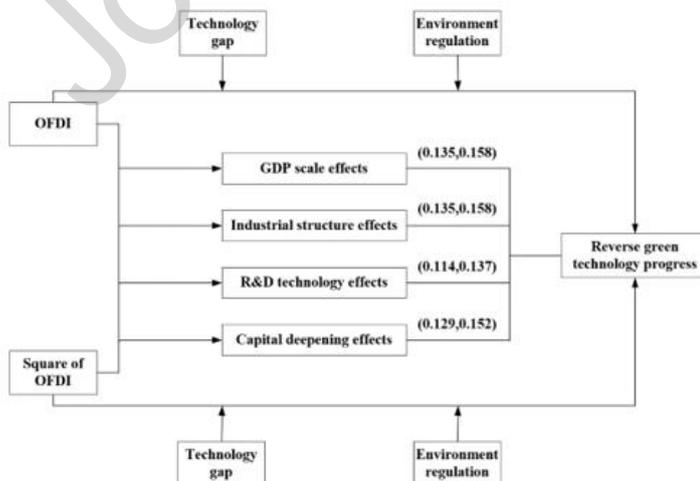


Fig.4. The impact mechanism between Chinese OFDI and RGTP.

6. Policy implications

First, there exists an optimal interval for the China's OFDI on RGTP effect. This finding is a well-intentioned policy reminder that countries such as China should focus on outward investment quality, capital flows, and structural improvements. Currently, tense political relations and the risk of economic decoupling between China and major powers have reversed China's OFDI flows. Therefore, the Chinese government should be more flexible rather than directly confrontational in improving the international investment environment. In addition, along with the expansion of Chinese OFDI in host markets, China's traditionally advantaged manufacturing industries are gradually shifting to low-cost host countries. But this undoubtedly causes environmental pollution. And if not enough advanced and effective technology inevitably causes severe industrial "hollowing out" problems (Hao et al., 2020). The investment motives of strategic resource acquisition and market expansion alone may not bring RGTP to China. However, China should actively establish the perception of being a responsible major country and practice the policy commitment of "win-win cooperation". This is the meaning to improving China's OFDI policy.

Second, moderate environmental regulation and technology gap can help extend the "climbing" stage of the inverted U-shaped curve and increase the height of the inflection point. This finding suggests that interval regulation ideas may have positive policy implications. To this end, the Chinese government should closely monitor the dynamic changes in China's OFDI and RGTP, and optimize and adjust its environmental regulation strategy at the right time. This can unleash as much RGTP as possible and promote China's green innovation to a new level.

The finding that the technology gap has shortened the "climb" stage is noteworthy. It serves as a reminder to countries like China about the importance of continuously enhancing their capacity for independent innovation. Relying solely on importation and imitation will not effectively promote sustainable RGTP (Q. Luo et al., 2019). It should focus on the digestion and absorption of the introduced green technologies to reduce the technology gap and realize the leap of RGTP.

Finally, the results of the transmission mechanism of China's OFDI on RGTP verified in this paper show that the GDP scale effect, industrial structure effect, R&D technology effect, and capital deepening effect can play a positive promotion role. Therefore, it is crucial to adopt a coordinated development approach instead of focusing on one aspect while neglecting others. For example, it is important to avoid neglecting industrial restructuring due to blindly expanding production and export scale. It is also not advisable to mechanically adhere to the principle of "capital-deepening." Excessive or rapid capital deepening, resulting from impulsive investments labelled as "not bad" and blind investments referred to as "flooding" (Lerner & Nanda, 2020; Lin & Xiaoji, 2019), can have a detrimental impact on RGTP. Therefore, improving the "quality" of capital deepening should always be prioritized.

7. Conclusions

This paper examines the nonlinear relationship between China's OFDI and RGTP. We utilize annual data collected from 31 provinces in China, spanning the period from 2001 to 2020. Unlike existing empirical studies, the FE regression model we constructed reveals a relationship between China's OFDI and RGTP that follows an inverted U-shaped curve. The important finding enriches our understanding of China's OFDI and makes an outstanding contribution to

the related research on RGTP. In addition, environmental regulation and technological gap lower the inverted U-shaped curve's inflection point, according to moderating impact tests. The difference is that environmental regulation drives the inflection point to the right, while the technology gap drives the inflection point to the left. These findings provide necessary references for the Chinese government to choose better OFDI policies. Further mechanism tests find that the scale effect and industrial structure effect have the greatest influence among the four transmission mechanisms. These important findings will help guide policymakers to design more flexible and effective OFDI policies.

Appendix

Table A.1: Summary Statistics for All Variables

Variables	Definitions	Sources
<i>lnrgtp</i>	Global Malmquist-Luenberger (GML) index	China Statistical Yearbook
<i>lnofdi</i>	China's OFDI stock	China Foreign Direct Investment Statistical Bulletin
<i>lnei</i>	Environmental pollution control, Total (% of GDP)	China Statistical Yearbook
<i>lntegap</i>	US labor productivity/labor productivity in the Chinese province	China Statistical Yearbook,
<i>lntrade</i>	Trade (% of GDP)	China Statistical Yearbook,
<i>lnwork</i>	Employed population, Total	China Statistical Yearbook,
<i>lnpa</i>	Patent applications	China Statistical Yearbook,

Insind

Secondary industry value added

China Statistical Yearbook,

Reference

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