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Research Article

Does Fiscal Mechanism Affect the Promotion of Outward Foreign Direct Investment in Green Innovation?

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This study aims to investigate the driving mechanisms behind outward foreign direct investment (OFDI) on regional green total factor innovation efficiency (GTFIE), focusing specifically on the external fiscal factor perspective. We measured the GTFIE using the super slacks-based model and established a threshold model using financial agglomeration and fiscal decentralization as moderating variables for empirical analysis. The findings indicate that the level of GTFIE in China is relatively low, with an average value of only 0.588 in the sample provinces. It is worth noting that there is a serious imbalance in China's regional green innovation development. The eastern region has an average GTFIE of 0.886 and is home to nine of the top ten GTFIE provinces. Moreover, regional financial factors exert a substantial moderating impact on the spillover of OFDI. OFDI exhibits a significant dual threshold effect on GTFIE under external fiscal moderation. Specifically, with an increase in the degree of financial agglomeration, the relationship between OFDI and GTFIE changes from being insignificant to a significant positive correlation, with a gradient enhancement. Meanwhile, the relationship between them exhibits an "inverted U-shaped" nonlinear dynamic pattern under fiscal decentralization moderation.

1. Introduction

While global economic growth has slowed down due to COVID-19, China's GDP exceeded 110 trillion yuan in 2021, accounting for 18.5% of the world's total economic, becoming the main source of world economic growth. However, the mode of economic growth with high input and high energy consumption is accompanied by serious environmental pollution and resource depletion [1]. In 2005, China became the world's largest carbon emitter, with the "double carbon" goal proposed, China has achieved some achievements in carbon reduction, but the climate problem is still serious. Obviously, achieving economic growth at the cost of environmental pollution is not conducive to the healthy and stable development of China's economy, the current urgent need to adopt new technology and kinetic energy to achieve green, low-carbon, circulation, and sustainable development. In 2015, the Chinese government proposed that innovation is the primary driving force of development, and green is a necessary condition for development. Adhering to the path of green and low-carbon innovation is an inevitable choice for win-win economic and ecological outcomes. Green innovation is an extension of traditional innovation, which is a collection of new technologies, products, and systems that can reduce pollution [2]. Specifically, green innovation should include nontechnical innovation in the management process and technological innovation in the product process. Green technology innovation is the combination of technology and ecology, which providing social value by reducing pollution and carbon emissions [3]. It mainly covers technology in clean energy, environmental protection, and low-carbon production, which reduce costs by minimizing raw materials, reducing energy consumption and improving efficiency. At the same time, the economic growth of green technology innovation is reflected primarily in improving quality, and this qualitative change can in turn drive growth of quantity. With the academic research, the goal of green technology innovation needs to further improve the ecological, social and human survival and development benefits on the basis of improving economic benefits. Therefore, green technology innovation will become a new engine for sustainable economic and environmental development throughout the world and an important metric to evaluate ecological development [4–6].

Green innovation is committed to pursue the maximum benefits of economic development and environmental protection and has gradually become the core of the development strategy of the international community. About 76% of EU enterprises have implemented green innovation development strategies as early as 2006 [7], and some developed countries such as the United States and Japan have also achieved certain results on the road of exploring green innovation strategies. Faced with issues such as resource overutilization and industrial structural imbalance, China officially implemented the "green innovation strategy" in 2012. The role of green innovation in low-carbon development has gradually been attached importance by the government, and began to explore ways to improve green innovation. In 2019, the Chinese government released the policy "Guiding Opinions on Constructing a Market-Oriented Green Technology Innovation System," which, for the first time, proposed that China should expand two-way openness in green technology innovation, actively introduce, digest, and absorb international advanced green technology, encourage domestic enterprises to "go global," and promote China's green innovation.

Academia has begun to explore green innovation from various perspectives, including promoting industrial transformation, strengthening environmental regulations, and improving human capital levels [8–10]. From the perspective of outward foreign direct investment (OFDI), numerous studies have confirmed that OFDI is the driving force of green technology innovation and proposed that OFDI is the primary way for domestic enterprises to "go global." OFDI can not only help domestic enterprises optimize resource allocation but also obtain reverse technology spillover effect by absorbing leading technology and experience from host countries [11]. Bai et al. [12] found that Chinese manufacturing enterprises can effectively learn from foreign innovation experience and obtain valuable reverse spillover effects through OFDI channels, thus promoting the green innovation development of the parent company [12]. OFDI has emerged as a vital channel for developing countries to enhance their scientific and technological capabilities, and has played a critical role in facilitating China's transition towards a green and high-quality development path. China's OFDI flow reached $178.82 billion in 2021, ranking second globally, as reported by the Ministry of Commerce. At the same time, the "Guidelines for Green Development of Foreign Investment Cooperation" clearly states the need to promote green technology innovation in outwards foreign investment cooperation and work together with host countries to build a low-carbon and environmentally friendly world, further emphasizing the importance of OFDI in China's green innovation path.

Green innovation differs from general innovation and its dual externalities of "green" and "innovation" often result in overly flexible innovation subjects and limited supervision and constraints, necessitating government intervention to correct them [13]. The implementation of macroeconomic policies for ecological management in both developed and developing countries is beneficial to global sustainable development [14]. However, while the intervention of macroeconomic policies can curtail environmental pollution of enterprises in the short term, long-term regulations may increase the costs of innovation and reduce enterprises' competitiveness in the market. In the process of "go global," it is particularly important to realize green development through long-term and stable incentive mechanisms. Financial system can be a long-term effective control means to correct enterprises' green innovation behavior. It has been shown that enterprises in regions with better financial system development are also more willing to engage in green and low-carbon production [15]. However, external economic factors, especially fiscal support and financial structure, can also affect the reverse driving effect of OFDI to a certain extent [16].

Therefore, this research explores the complex relationship and underlying mechanism between OFDI and green innovation from the perspective of external fiscal control, using provincial data in China. Our study makes two significant contributions. First, we construct the super slacks-based measure (Super-SBM) model to accurately measure provincial green total factor innovation efficiency (GTFIE), which solves the slack bias caused by the traditional DEA model not considering undesired output, and provides accurate reference for the implementation of policies. Second, we introduce a threshold regression model to creatively explore the heterogeneous impact of OFDI on regional GTFIE from the perspectives of financial agglomeration and fiscal decentralization, filling a gap in empirical evidence. In short, this paper provides important insights into the spillover effects of green innovation through OFDI and reveals the mechanism of regional collaborative development of green innovation, which can be useful for policy implementation.

2. Literature Review

Green innovation involves transforming products, production processes, and other processes in ways that reduce environmental pollution and promote sustainable development [17]. GTFIE is a measure of the output-to-input ratio of innovation activities under environmental constraints. It is a crucial index for measuring innovation achievement that combines green technology with innovation level [18]. Scholars typically use Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) to evaluate input and output to measure the GTFIE. However, SFA has the limitation of single output, while DEA considers the whole input-output process of green technology innovation. But the conventional DEA models are radial models that do not capture the relaxation and improvement between the current state of the evaluated unit and the desired target value, leading to certain limitations. Tone [19] developed a Super-SBM model based on the modified slack variable [19]. The nonradial and nonangular characteristics of this model can effectively overcome the aforementioned limitations.

Numerous studies have demonstrated that OFDI can directly or indirectly enhance the development of GTFIE in home countries. Branstetter's [20] study concluded that OFDI promotes technological innovation in both host and home countries [20]. Similarly, Gong et al. [21] found that OFDI facilitates enterprises' green innovation efficiency through the effect of scale and resource allocation [21]. In a study of Japan and the United States, Pantulu and Poon [22] observed that multinational enterprises' investment in developed countries can result in reverse innovation spillover in various fields such as high-level manufacturing, biomedicine and information networks, leading to increased technological innovation in their home countries [22]. Nevertheless, certain scholars have presented a counterargument, contending that OFDI does not have a substantial influence on the advancement of green innovation [23], and may even inhibit domestic green innovation. For example, Alazzawi [24] found that countries with low technological level can obtain advanced technology through OFDI reverse spillovers. However, due to the need for improved domestic capacity to absorb, transform and utilize advanced technologies, OFDI is negatively associated with the green innovation of the home country [24].

It should be emphasized that the relationship between OFDI and green innovation may not be straightforward linear, and external constraints can influence will affect the driving effect of OFDI on regional green innovation, leading to threshold characteristics [25]. According to Dai et al. [26], the impact of OFDI on green innovation is significantly affected by the threshold of environmental regulation [26]. Furthermore, regulatory factors such as economic growth and independent innovation capacity can affect the reverse green spillover effect of OFDI [27, 28]. However, there is a relatively limited amount of research on the mechanism between them in terms of external fund thresholds, such as financial agglomeration and fiscal decentralization. According to Xie et al. [29], OFDI provides home countries with opportunities for green innovation by acquiring advanced production technology and experience from abroad. However, external financial constraints, such as the financial environment and fiscal system of the home country, can somewhat influence the reverse green innovation spillover of OFDI [29]. On the one hand, companies need financial support from the financial sector to obtain reverse technology spillovers during the outward investment process [30]. On the other hand, government support plays a crucial role in promoting OFDI in developing countries [31]. Moreover, moderate decentralization and financial incentive policies can improve resource allocation efficiency, raise public service standards, and encourage enterprises to invest overseas for greater development. Therefore, this study incorporates two moderating variables, financial agglomeration and fiscal decentralization, into the research framework of OFDI and green innovation. It aims to investigate the driving mechanism behind the spillover effects of OFDI on green innovation, which is of certain theoretical and practical significance.

3. Theoretical Analysis and Hypothesis Development

OFDI has emerged as an important component of China's economy and is poised to play a vital role in promoting green innovation development [32]. Most scholars have affirmed that the spillover of OFDI can significantly improve the green technology level of the home country and can effectively promote the green innovation efficiency of the home country [33, 34]. Theoretically, OFDI can obtain the market of the host country and better avoid technical barriers of the host country compared with traditional international trade [35]. OFDI can directly or indirectly promote the development of green technology and innovation capability of the home country through technology transfer, experience learning, and information exchange [36–38]. Multinational enterprises actively carry out overseas investment to absorb and integrate tangible and intangible assets into the parent company, which promotes the great improvement of the economy, management, and production efficiency of the home country. Therefore, the following hypotheses are proposed:

> H1: Overall, OFDI can significantly promote the development of green innovation in China.

As is well known, technology spillover is not entirely unconditional and unrestricted and is generally subject to multiagent and multifactor intervention. For instance, technology protection in host countries, as well as human capital, technological capacity, and government support in home countries, all affect spillover effects [39]. Among them, the financial situation of the home country is also one of the key factors affecting spillover.

The financial system can provide diverse support for green innovation in enterprises, while regional financial development may lead to financial agglomeration. Kindleberger [40] was the first to analyze the reasons for the existence of financial agglomeration using Adam Smith's theory of economies of scale. He believed that financial agglomeration can help enterprises maintain the balance of working capital and provide convenience for investment and financing [40]. Unlike general innovation, green innovation has higher requirements in terms of complexity, uncertainty, and exploration direction [41]. During the development process, green innovation requires greater support from production factors such as capital, human labor, and knowledge. The externalities of financial agglomeration can provide a foundation and abundant resources to meet these requirements [42, 43]. Several studies have shown that financial agglomeration can promote the development of green innovation [44, 45]. According to Wu et al. [46], the spatial agglomeration of financial institutions can create a favorable financing environment for enterprises, which is more conducive to absorb international green technology spillovers [46]. The higher the degree of financial agglomeration, the greater the opportunity to obtain relevant support and improve learning conditions, thereby promoting the demonstration effect in OFDI spillover. Conversely, regions with a low degree of financial agglomeration fail to provide sufficient guarantees for learning and imitating green technologies, introducing and cultivating talents, and procuring advanced equipment, which hinders the release of positive spillover effects of OFDI. Therefore, financial agglomeration will affect the relationship between OFDI and green innovation to a certain extent. Based on this, the following research hypotheses are proposed:

> H2: The impact of OFDI on green innovation is moderated by financial agglomeration, and the impact exhibits significant threshold characteristics.

The rapid development of China's OFDI is mainly due to effective government support and policy incentives [47]. Fiscal decentralization affects the reverse spillover of regional OFDI through local government competition and economic supervision behavior, and is an important external force of China's OFDI [48, 49]. At the same time, fiscal decentralization also determines the degree of participation of local governments in green innovation activities [50]. In theory, fiscal decentralization enables local governments to have more financial power, which provides them with greater freedom to allocate and choose how funds are spent. One possible scenario is that local governments prioritize green innovation development, increase the scale of OFDI, acquire environmental protection technologies, and improve the efficiency of resource allocation and utilization. Another possibility is that local governments remain focused on economic development and increasing fiscal revenue, while neglecting environmental pollution and resource consumption, hindering local green and sustainable development. Therefore, further empirical research is required to investigate the regulatory role of fiscal decentralization in both OFDI and green innovation. Accordingly, this study proposes the following hypotheses:

> H3: The impact of OFDI on green innovation is moderated by fiscal decentralization, and the impact exhibits significant threshold characteristics.

4. Study Design

4.1. Construction of a Super-SBM Model. We begin by computing the level of regional green innovation development using GTFIE. However, the traditional DEA model suffers from radial and angle problems, making it challenging to accurately represent efficiency. Consequently, we conducted a comprehensive analysis of the interplay between input, output, and environmental pollution constraints, while also accounting for possible slack issues in efficiency assessment. Drawing on Tone's [19] research, we developed a Super-SBM model to evaluate provincial GTFIE as follows:

Assuming the system comprises n decision units, each with three input vectors X, desired output Y^a and undesired output Y^b and $X \in R^m$, $Y^a \in R^{w_1}$, $Y^b \in R^{w_2}$, the matrix is defined as:

$$\begin{aligned} \mathbf{X} &= \left[x_1, \cdots, x_n\right] \in R^{m\times n}, \\ \mathbf{Y}^a &= \left[{y_1}^a, \cdots, {y_n}^a\right] \in R^{w_1\times n}, \\ \mathbf{Y}^b &= \left[{y_1}^b, \cdots, {y_n}^b\right] \in R^{w_2\times n}. \end{aligned} \tag{1}$$

Let μ be the density vector, representing the input factor weights. When $\sum_{k=1}^{n} u_k = 1$ returns to scale that is variable, the efficiency value of input-output calculation will be significantly different. Accordingly, the setting model is as follows:

$$\theta = \min \frac{1 - (1/m)\sum_{i=1}^{m} w_1^- / x_{i0}}{1 + (1/w_1 + w_2)\left(\sum_{r=1}^{w_1} {w_r}^a / y_{r0} + \sum_{l=1}^{w_2} {w_l}^b / y_{l0}\right)},$$
$$\text{s.t.} \begin{cases} x_0 = X\mu + w^-, \\ {y_0}^a = Y^a \mu + w^a, \\ {y_0}^b = Y^b \mu + w^b, \\ w^- \geq 0, w^a \geq 0, w^b \geq 0, \mu \geq 0. \end{cases} \tag{2}$$

The slack variables for input, desired output, and undesired output are represented by w^-, w^α, and w^b, respectively, and are strictly and monotonically decreasing. The target efficiency value is denoted by θ, where $0 \leq \theta \leq 1$.

4.2. Construction of the Threshold Model. In order to explore the potential heterogeneous change law between the two more objectively, we implemented the threshold effect test. This paper employs Hansen's [51] method and establishes a multiple threshold model with GTFIE as the explanatory variable, which was used to discusses the dynamic effects of OFDI on GTFIE under the moderation of financial agglomeration and fiscal decentralization [51]. The formula is as follows: formula (3) discusses the linear relationship between OFDI and GTFIE, and formula (4) is the threshold model after adding moderating variables to explore the nonlinear effect between OFDI and GTFIE.

$$\text{GTFIE}_{i,t} = \alpha + \beta \text{OFDI}_{i,t} + \sum \theta X_{i,t} + \mu_i + \eta_t + \varepsilon_{i,t}, \tag{3}$$

$$\begin{aligned} \text{GTFIE}_{i,t} = \alpha &+ \beta_1 \text{OFDI}_{i,t} \cdot I\left(r_{i,t} \leq \gamma_1\right) + \beta_2 \text{OFDI}_{i,t} \cdot I\left(\gamma_1 < r_{i,t} \leq \gamma_2\right) + \cdots \\ &+ \beta_n \text{OFDI}_{i,t} \cdot I\left(\gamma_{n-1} < r_{i,t} \leq \gamma_n\right) + \beta_{n+1} \text{OFDI}_{i,t} \cdot I\left(r_{i,t} > \gamma_n\right) \\ &+ \sum \theta X_{i,t} + \mu_i + \eta_t + \varepsilon_{i,t}, \end{aligned} \tag{4}$$

where i represents the region and t represent year, GTFIE stands for green total factor innovation efficiency, OFDI stands for outwards foreign direct investment index, r represents the threshold variable, n represents the number of thresholds, γ represents the threshold value to be calculated, X represents the control variable that affects the GTFIE, $I(\cdot)$ as an indicator function, when meet the expression in parentheses, values are 1, otherwise 0; α, β, and θ are the coefficients of each variable, μ and η denote the individual and time effects of the sample cross section, respectively, and ε denotes the error term.

4.3. Variable Description. The explained variable GTFIE is green total factor innovation efficiency. This paper measures the GTFIE of Chinese provinces using the Super-SBM model, which assesses the GTFIE of each province based on three dimensions: input, desired output, and undesired output. The input indicators selected for this study include personnel and capital inputs [52]. Personnel input is measured by the number of employees in each province, while capital input is measured by R&D capital stock based on 2011 and calculated using the perpetual inventory method at a depreciation rate of 9.6%. Additionally, the total provincial energy consumption is converted to standard coal to represent the energy consumption of green innovation activity. Given that green patents better reflect innovation output [53], GDP and green patent application numbers are used to represent desired output, while carbon dioxide emissions, sulfur dioxide emissions, wastewater and solid waste emissions to represent undesired output.

The explanatory variable OFDI is outward foreign direct investment. Currently, officially released OFDI data at the provincial level can be divided into two types: stock and flow. However, due to the irregular volatility of the flow data, they cannot accurately reflect the long-term cumulative effect of OFDI. Therefore, the stock data of OFDI are first selected for research, and converted the OFDI stock data of each province into RMB units based on the average exchange rate over the years. In addition, the ratio of OFDI stock data of each province to GDP of the same period was used to represent the data. A higher value of the variable indicates a larger scale of OFDI in the province.

The threshold variable FA and FD is financial agglomeration and fiscal decentralization. As location quotient can well eliminate financial scale differences among regions, this paper uses location quotient index to represent the degree of financial agglomeration in China's provinces. The formula is as follows:

$$FA_{it} = \frac{q_{it}/p_{it}}{q_t/p_t}, \quad (5)$$

where FA_{it} represents the location quotient value of the financial industry in province i in year t. If FA_{it} is greater than 1, it indicates the existence of agglomeration phenomenon, and the greater the value, the greater the degree of financial agglomeration in this province. q_{it} is the financial added value of province i in year t, p_{it} is the GDP of province i in year t, q_t is the national financial added value in year t, p_t is the GDP in year t.

In addition, the ratio of fiscal revenue and total expenditure within the provincial budget is used to characterize the level of fiscal decentralization.

The following control variables were selected to ensure the reliability of the model results: Industrial structure optimization (variable ISO) can drive the expansion and subdivision of the market and then affect the diffusion and spillover of technology within the region, which is expressed by the output value ratio of tertiary industry to secondary industry. R&D capital input (variable RDI) expressed as the natural logarithm of provincial per capita R&D expenditure. Over time, a region's investment in R&D activities can enhance its present innovation capacity. Foreign direct investment (variable FDI) represents the total amount of FDI as a ratio of the GDP during the same period. This serves as a crucial avenue for sharing technology and information. Human capital (variable HC) reflects the overall talent quality in a region. Long-term and stable improvements in human capital levels can significantly enhance green innovation ability, providing a crucial foundation for regional green innovation development and transformation. HC can be measured through logarithmic processing of the average number of college and university students per 100,000 population. For descriptions and measurement methods of financial agglomeration (variable FA) and fiscal decentralization (variable FD), please refer to the threshold variable interpretation above. All variable information are presented in Table 1.

4.4. Data Sources. Firstly, the study selected panel data from 30 Chinese provinces for quantitative analysis between 2011 and 2020 (excluding Tibet, Hong Kong, Macao, and Taiwan). Descriptive statistics for all variables are presented in Table 2.

5. Results and Discussion

5.1. GTFIE Results and Analysis. Figure 1 illustrates that the GTFIE level in different regions of China was relatively low from 2011 to 2020, with an average provincial GTFIE of only 0.588. This indicates that China still has a long way to go in transitioning from extensive development to green-intensive development. Specifically, only five provinces—Beijing, Shanghai, Guangdong, Jiangsu, and Zhejiang—achieved efficiency values above 1.000. It is worth noting that nine out of the top ten provinces are located in the eastern region, contributing to an average GTFIE of 0.886, 0.503, and 0.353 for the eastern, central, and western regions, respectively.

Figure 2 indicates a gradual decrease in GTFIE values from east to west, with central and western provinces significantly falling behind eastern provinces. Moreover, the southern provinces exhibit better green innovation development compared to the northern provinces. These findings highlight a significant regional imbalance in China's green innovation development, with the central and western regions considerably trailing the eastern regions. Consequently, promoting coordinated development will emerge as a crucial task for China's pursuit of high-quality development.

Table 1: Interpretation and measurement of each variable.

Variable	Implication	Type	Measurement method
GTFIE	Green total factor innovation efficiency	Explained variable	Super-SBM model
OFDI	Outwards foreign direct investment	Explanatory variable	The ratio of OFDI stock data to GDP
FA	Financial agglomeration	Threshold variables Control variables	Location quotient index
FD	Fiscal decentralization	Threshold variables Control variables	The ratio of fiscal revenue and total expenditure within the provincial budget
ISO	Industrial structure optimization	Control variables	The ratio of the output value of tertiary to secondary industry
RDI	R&D capital input	Control variables	The natural logarithm of R&D expenditure per capita
FDI	Foreign direct investment	Control variables	The ratio of the total amount of FDI to GDP
HC	Human capital	Control variables	The natural logarithm of the average number of college students per 100,000 population

Note. Data sources include the China Statistical Yearbook, China Statistical Yearbook of Science and Technology, CSMAR database, China Statistical Yearbook of Energy, provincial statistical yearbooks, and the official websites of the National Bureau of Statistics and the Ministry of Commerce of China.

Table 2: Descriptive statistics of variables.

Variable	Obs	Mean	Std. dev.	Min	Max
GTFIE	300	0.588	0.322	0.186	1.256
OFDI	300	0.269	1.014	0.000	9.721
FA	300	0.953	0.393	0.418	2.389
FD	300	0.647	0.205	0.241	1.825
ISO	300	3.162	1.687	1.230	5.220
RDI	300	1.882	1.064	0.743	4.525
FDI	300	0.021	0.019	0.000	0.121
HC	300	7.837	0.285	6.989	8.632

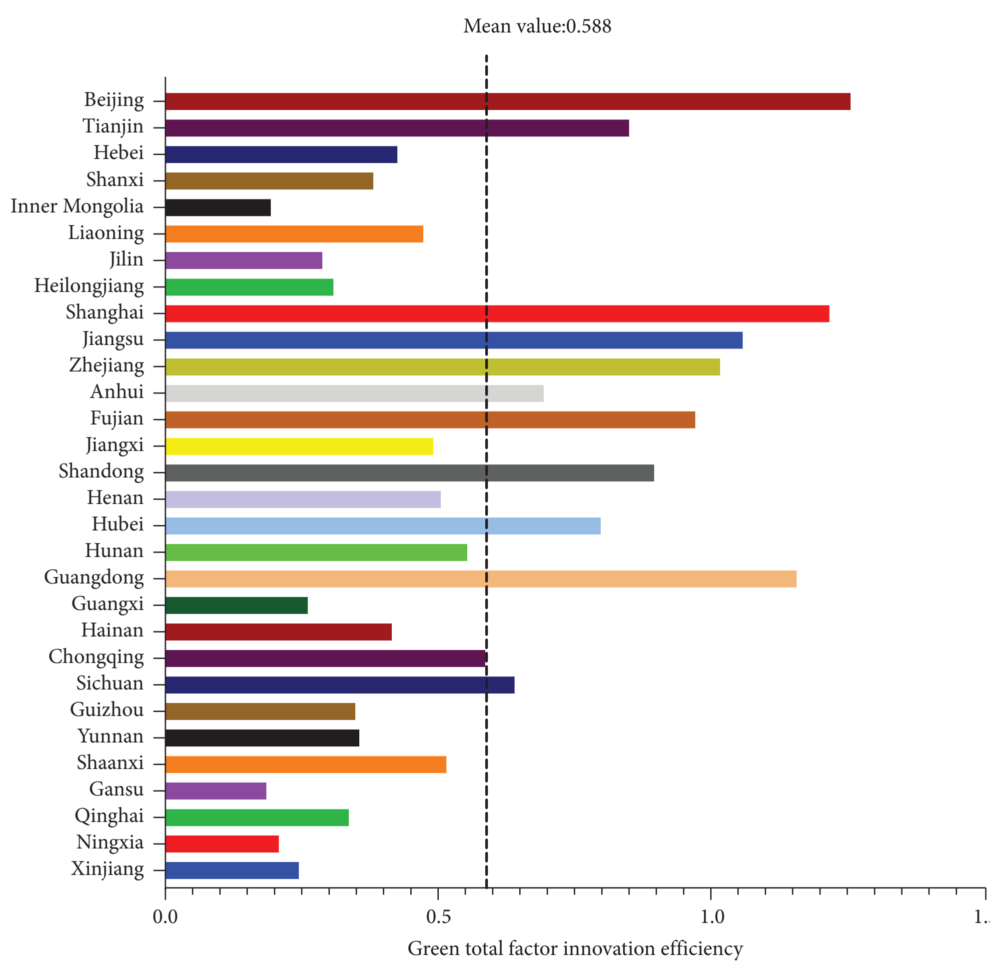

Figure 1: The GTFIE average levels in China by province.

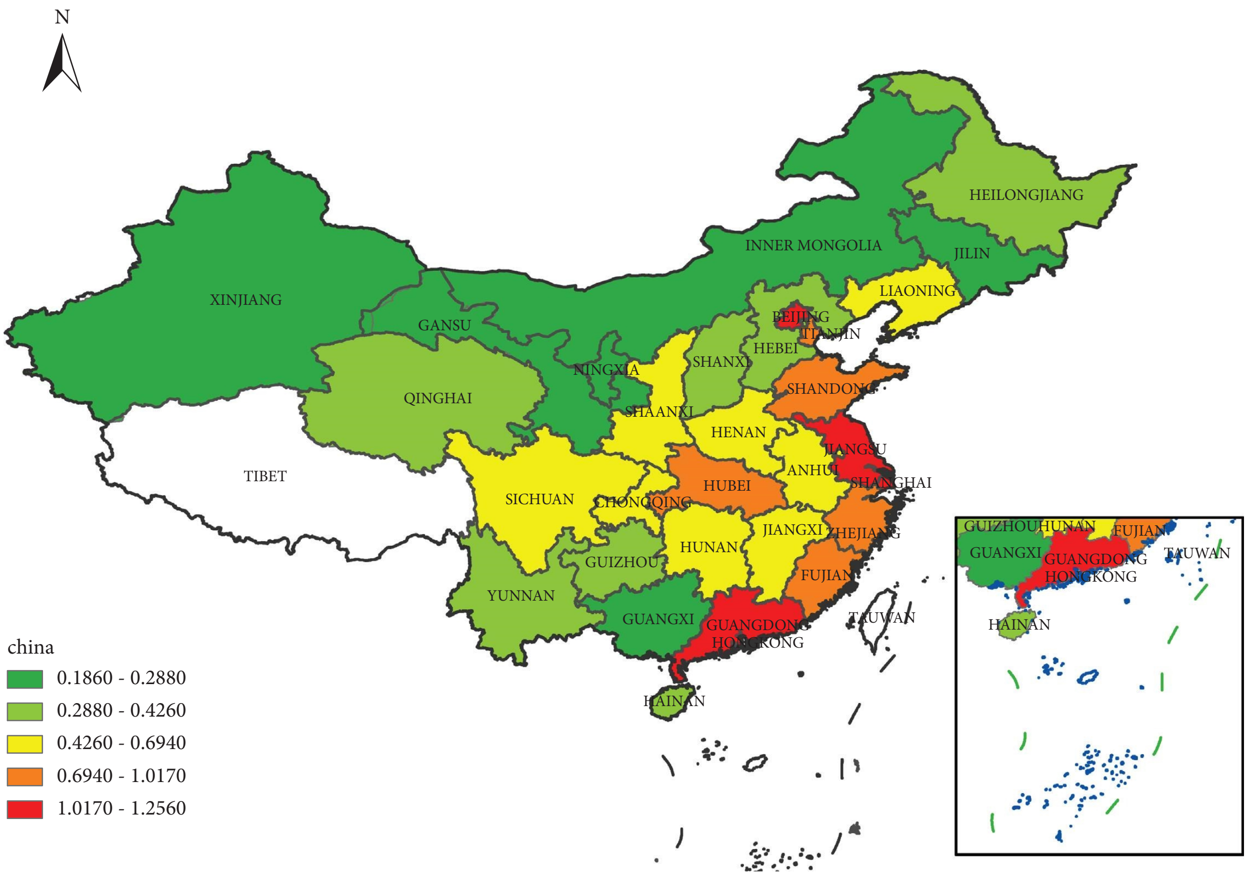

Figure 2: Regional distribution of GTFIE in China.

Beijing, Shanghai, and Guangdong ranked the top three provinces with average GTFIE values of 1.256, 1.218, and 1.158, respectively. Conversely, Ningxia, Inner Mongolia, and Gansu ranked at the bottom. Represented by Beijing and Shanghai, the eastern provinces possess exemplary resource conditions, advanced industrial structures, abundant talent reserves, and robust technological prowess, serving as the primary driving force behind China's efforts toward low-carbon and efficient development. The ten provinces ranking lowest in the GTFIE rankings are all located in the western and central regions. Despite certain provinces in central and western China possessing abundant natural resources, they exhibit relatively weak economic foundations and low GDP. What's more, incomplete infrastructure, remote geographical locations from economically developed provinces in the east, difficulties in attracting exceptional talents and introducing advanced technology, and low innovation vitality have collectively contributed to the consistently low efficiency values. It is noteworthy that resource-rich provinces like Inner Mongolia, Liaoning, Shanxi, Xinjiang, and Heilongjiang tend to exhibit lower GTFIE values. These provinces are characterized by the dominance of heavy polluting industries in regional economic development, resulting in intensive energy consumption and high levels of pollution emissions. Moreover, their innovation drive is hindered by the prevailing development model. Consequently, there is an urgent need to transform the current development model, gradually facilitate the transformation and upgrading of industrial structures, enhance investment in technology research and development, expedite the phasing out of high-polluting industries, and strive towards achieving green innovation and high-quality development.

5.2. Data Stationarity Test. First, we performed unit root tests on the panel data using ADF-Fisher, PP-Fisher, LLC, and IPS methods to confirm data stationarity. The results indicate that the first difference of each variable passed the significance test at least at the 1% level. Therefore, the null hypothesis of unit root was rejected, and all data were stationary. Second, to verify the long-term and stable relationship between variables, we conducted Pedroni and Kao tests to examine the panel cointegration relationship. The results are presented in Table 3.

The p value of 0.000 for each test statistic in Table 3 indicates rejection of the null hypothesis of "no cointegration relationship" at least at the 1% level. This suggests a stable, long-term relationship between GTFIE and the independent variables, which can be analyzed using panel regression.

5.3. Threshold Test and Analysis. The threshold model was employed to examine the existence of a significant nonlinear relationship between OFDI and GTFIE. Financial agglomeration and fiscal decentralization were selected as the threshold variables to test for a threshold effect and determine the number of thresholds. The test results in Table 4

Table 3: Panel cointegration relationship test.

	Panel V	Panel rho	Panel PP	Panel ADF	Group rho	Group PP	Group ADF	ADF
Pedroni test	15.210 (0.000)	17.673 (0.000)	−15.513 (0.000)	−21.108 (0.000)	−15.143 (0.000)	−9.377 (0.000)	−11.758 (0.000)	
Kao test								12.910 (0.000)

Note. In parentheses is the test p statistic.

Table 4: Threshold effect test results and confidence intervals.

Threshold variable	Threshold number	Threshold value	95% confidence interval	F value	P value	Bootstrap number
FA	Single threshold	1.228	[1.097, 1.236]	35.185***	0.000	500
	Double threshold	1.674	[1.615, 1.682]	23.414***	0.003	500
	Triple threshold	1.812	[1.805, 1.826]	0.365	0.246	500
FD	Single threshold	0.588	[0.579, 0.614]	25.874***	0.000	500
	Double threshold	0.797	[0.765, 0.812]	5.169***	0.002	500
	Triple threshold	0.904	[0.897, 0.925]	0.647	0.406	500

Note: ***The estimated coefficient is significant at 1%. The p value and threshold value are obtained using bootstrap with 500 repeated samples.

indicate that both the single threshold and double threshold models passed the 1% significance test, while the triple threshold model failed. Consequently, this paper adopts the double threshold model for empirical analysis.

5.4. Threshold Regression Results. In Table 5, Model 1 presents the results of the linear regression analysis for OFDI and GTFIE. Model 2 and Model 3 provide threshold empirical results under the moderation of financial agglomeration and fiscal decentralization.

Overall, based on the results of the Model 1 analysis in Table 5, OFDI has a significant positive impact on GTFIE, with a significance of 10%. The result also shows that GTFIE increases by 0.218% for every 1% increase in OFDI. Consequently, we have tested the validity of the first hypotheses. However, based on theoretical analysis, the spillover effect of OFDI on GTFIE may be influenced by financial factors and exhibit nonlinear characteristics. This heterogeneity cannot be adequately explained by linear model analysis alone. Additionally, the results in Table 4 support the existence of a threshold effect, further highlighting the need for empirical analysis that incorporates threshold variables.

The results of Model 2 indicate a significant double threshold effect of financial agglomeration on the relationship between OFDI and GTFIE, with threshold values of 1.228 and 1.674, respectively. When the degree of financial agglomeration is below 1.228 ($FA \leq 1.228$), the coefficient of OFDI is not significant, indicating that the driving effect of OFDI on regional GTFIE is not apparent under the moderation of financial agglomeration. Notably, as the degree of financial agglomeration increases and surpasses the first threshold value of 1.228 ($1.228 < FA \leq 1.674$), the coefficient is 0.261 and significant at 5%, exhibiting a positive promoting effect. The financial agglomeration effectively enhances the driving effect of OFDI, fostering the development of green innovation. When the degree of financial agglomeration exceeds 1.674 ($FA > 1.674$), the coefficient of OFDI on regional GTFIE further increases to 0.508.

The results above indicate the financial agglomeration has a positive nonlinear dynamic effect on the gradient enhancement of GTFIE through OFDI. Specifically, financial agglomeration is the primary driving force behind optimal resource allocation and economic growth promotion. As the degree of spatial agglomeration increases, local industries receive more financial guarantees for innovative research and low-carbon development, which promotes enterprise innovation activities and regional green innovation development. In the initial stage of spatial aggregation, financial institutions and resources are influenced by factors such as personnel, capital, and knowledge level. However, as spatial agglomeration strengthens, the competitive advantage of the financial core area expands, and the "siphon effect" becomes more significant. By absorbing the resources of financial institutions in surrounding areas, adequate financing for local green innovation activities continues to be provided, creating a favorable investment environment for environmentally friendly industries.

What's more, the results of Model 3 indicate a significant double threshold effect of fiscal decentralization on the relationship between OFDI and GTFIE, with threshold values of 0.588 and 0.797, respectively. When the level of fiscal decentralization is below 0.588 ($FD \leq 0.588$), the coefficient is 0.094, significant at the 10%. In this case, OFDI has a positive impact on GTFIE, although the effect is not pronounced. When the fiscal decentralization level is between 0.588 and 0.797 ($0.588 < FD \leq 0.797$), the coefficient increases to 0.435, significant at the 5%, further enhancing the positive effect. However, when the fiscal decentralization level is above 0.797 ($FD > 0.797$), the coefficient decreases to −0.065, significant at the 10%, and the effect of OFDI on GTFIE becomes negative. In conclusion, under the moderation of fiscal decentralization, the relationship between OFDI and GTFIE exhibits an "inverted U-shaped" nonlinear dynamic pattern, with an initial promotion followed by inhibition.

Specifically, excessive fiscal decentralization under "Chinese-style decentralization" not only fails to provide positive incentives in OFDI's driving mechanism for GTFIE, but also has a negative effect. Local governments with a higher degree of fiscal control also face a more difficult target development task, and may neglect activities such as environmental pollution and resource waste in order to prioritize production and safeguard the economy. Under financial pressure and competition, relevant governments have a short-sighted approach to promoting enterprises' green innovation R&D, which weakens the positive effect of OFDI on green innovation activities.

Furthermore, the regression results of the model show that except for industrial structure optimization, other control variables have a positive correlation with GTFIE. This indicates that improving the levels of R&D capital investment, foreign direct investment, and human capital can positively contribute to regional GTFIE. It should be

Table 5: Panel threshold regression results.

Variables	Model 1 Linear analysis	Model 2 Threshold variable FA	Model 3 Threshold variable FD
ISO	0.073* (1.221)	0.046 (0.513)	0.079 (0.424)
RDI	0.063*** (4.130)	0.048*** (4.981)	0.055*** (5.244)
FDI	0.234* (1.346)	0.262** (1.986)	0.297* (1.382)
HC	0.122*** (3.875)	0.134*** (4.285)	0.145*** (3.633)
FA	0.191*** (5.371)	0.205*** (6.431)	0.185*** (6.785)
FD	0.109 (0.548)	0.147 (0.709)	0.079 (0.359)
OFDI	0.218* (1.462)		
OFDI·(FA ≤ 1.228)		0.091 (0.766)	
OFDI·(1.228 < FA ≤ 1.674)		0.261** (2.236)	
OFDI·(FA > 1.674)		0.508*** (3.508)	
OFDI·(FD ≤ 0.588)			0.094* (1.179)
OFDI·(0.588 < FD ≤ 0.797)			0.435** (2.348)
OFDI·(FD > 0.797)			−0.065* (−1.108)
Individual effect	Yes	Yes	Yes
Time effect	Yes	Yes	Yes
Adjusted R^2	0.345	0.510	0.501

Note. *, **, ***The estimated coefficients are significant at 10%, 5%, and 1%, respectively. In parentheses is the t-value.

Table 6: Robustness test results.

Variables	(1) One-period lagged variable	(2) Add control variable	(3) Replace FA proxy variables	(4) Replace FD proxy variables
FA threshold test/threshold number	Significant/double	Significant/double	Significant/double	—
FD threshold test/threshold number	Significant/double	Significant/double	—	Significant/double
Resident income (RI)	—	Significant	—	—
Openness (OP)	—	Significant	—	—
Individual effects	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.403	0.512	0.466	0.459
Observation	270	300	300	300

noted that the regional industrial structure has no significant effect on green innovation efficiency, and the current model requires further optimization and upgrading of the industrial structure.

5.5. Robustness Test. To ensure the stability of threshold regression results, the model's robustness was tested. The results of the test are presented in Table 6.

(1) Considering the lag effect of variables. The variables were assigned one-period lagged values, and used to recalculate the model. The results indicate that the double threshold effect of financial agglomeration and fiscal decentralization remains significant, with moderating mechanisms aligning with previous results. While the coefficients and significance of control variables were slightly altered, these changes did not impact the primary conclusions of this study.

(2) Adding explanatory variables. We introduced two control variables, resident income (RI) and openness (OP), to mitigate estimation bias caused by missing dependent variables in the model. Resident income was represented by the logarithm of per capita GDP for each province, while openness was represented by the proportion of trade volume in GDP for each province. These variables were added to the model for recalculation. The results indicate that the threshold results remained robust, with moderating mechanisms aligning with previous findings. While the coefficients and significance of control variables were slightly altered, these changes did not impact the primary conclusions of this study.

(3) Substitution of financial agglomeration variables. We substituted the financial agglomeration variables with the Herfindahl index to measure the financial agglomeration of provinces. Our findings suggest that financial agglomeration still moderates the impact of OFDI on GTFIE, with the t-value of OFDI slightly decreasing in each interval. However, the moderating mechanism remained consistent with the previous findings, and did not affect the main conclusions of this study.

(4) Substitution of fiscal decentralization variables. We replaced the fiscal decentralization variables with a comprehensive evaluation index system, which calculates the fiscal decentralization of provinces based on institutional, social, and managerial decentralization. Our findings suggest that fiscal decentralization still

moderates the impact of OFDI on GTFIE, with the t-value of OFDI slightly decreasing in each interval. However, the moderating mechanism remained consistent with the previous findings, and did not affect the main conclusions of this study.

The four aforementioned robustness tests provide stronger support for the reliability and robustness of the threshold model results presented in this paper.

6. Conclusions

This study examines the effect of OFDI on green innovation across 30 provinces in China from 2011 to 2020. Additionally, it adopts a dual perspective of financial agglomeration and fiscal decentralization to account for external economic influences and constructs a nonlinear panel threshold model.

The study concludes that China's green innovation development level is relatively low, with an average GTFIE score of 0.588, indicating significant potential for improvement. The GTFIE values of Beijing, Shanghai, and other eastern provinces are significantly higher than those in central and western provinces. On average, the eastern region has the highest efficiency value of 0.886. Additionally, the study identifies a significant double threshold effect of financial agglomeration in the relationship between OFDI and regional GTFIE. The two threshold values of financial agglomeration are 1.228 and 1.674, respectively, and OFDI exhibits a positive nonlinear effect of "gradient" enhancement on GTFIE.

Furthermore, the research reveals a significant double threshold effect of fiscal decentralization in the impact of regional OFDI on GTFIE, with threshold values of 0.588 and 0.797. Under fiscal decentralization moderation, the impact of OFDI on GTFIE exhibits an "inverted U-shaped" nonlinear dynamic pattern, initially promoting and then inhibiting growth. OFDI has the most robust driving and incentive effect on regional GTFIE when fiscal decentralization is within the range of [0.588, 0.797]. It should be noted that neither too high nor too low fiscal autonomy can most effectively stimulate the green innovation spillover effect of OFDI.

Based on these findings, the study proposes policy recommendations for improving green total factors innovation efficiency in China.

First, to ensure the long-term and sustained reverse spillover effect of OFDI on regional innovation development, it is crucial to implement investment strategies that are tailored to local conditions to address imbalances in GTFIE across regions. This can be achieved by conducting reverse gradient OFDI investments in areas with lower economic levels, promoting reverse technology spillover through independent selection and learning of advanced technology and experience from the host country to influence green innovation activities. Moreover, encouraging regions with better economic levels to engage in direct OFDI can facilitate the transfer and upgrading of pollution-emitting enterprises, ultimately reducing pollution.

Second, it is crucial to actively support the digital development of regional financial agglomerations, improve the service capacity and capital allocation efficiency of local financial industries, channel more financial funds towards low-carbon and environmentally friendly industries, and provide financial guarantees and information support for enterprises going global. It is essential to recognize the long-term benefits of OFDI by enterprises, prevent short-sighted behavior by local governments focused solely on production, and create a conducive environment for enterprises' outward foreign trade. Local governments with greater financial power should be aware of the great responsibility to protecting resources and the environment, managing pollution consumption, and gradually improve their performance evaluation systems to avoid hindering green innovation activities with high emission standards.

Third, it is important to focus on adjusting the industrial structure, research and development capital, foreign direct investment, and human capital development in a coordinated manner, actively and effectively implement green innovation activities, optimize the use of foreign investment structure, establish strict and standardized foreign investment introduction environment standards and related systems, strengthen the education and introduction of core technical talents to promote the long-term sustainable development of green innovation in our country.

This study examines the nonlinear relationship between OFDI and provincial green innovation in China, focusing on the regulation of external financial factors. It also explores the threshold moderating mechanism of financial agglomeration and fiscal decentralization, which is significant for promoting China's green innovation development and stimulating the spillover effect of OFDI. However, there are limitations to consider in this study, and studies can further explore the following aspects:

Firstly, considering a more comprehensive description of external financial factors. While this paper examines financial agglomeration and fiscal decentralization as moderating mechanisms, it is essential to acknowledge that these are just two aspects of financial factors. China's financial system is highly complex, potentially offering numerous pathways and distinct impact mechanisms for spillover effects. Thus, it is crucial to provide a more detailed and comprehensive analysis of financial factors in future research. Additionally, in evaluating the regional fiscal level in the future, factors like the proportion of the financial service industry, digital finance, and the fiscal development index should be considered to ensure a more comprehensive assessment.

Secondly, examining the output performance and capacity utilization of green innovation. Specifically, this paper focuses on the total factor productivity of green innovation, which has certain theoretical value for promoting regional green innovation development. It is worth noting that recent literature has suggested various methods for assessing green innovation, such as plant capacity utilization (PCU) and green patents. PCU quantifies the ratio of actual output to potential production capacity [54], which helps assess the potential for economic growth and pollution control, thereby reflecting regional green and sustainable development. Additionally, green patents signify outcomes of green innovation, although they have received limited attention in past research.

Finally, exploring the influence of COVID-19 on the green innovation spillover effect of OFDI. The COVID-19 epidemic has significantly impacted global outward investment and economic environment. It is worthwhile to further investigate the impact of this pressure on green innovation, and the potential changes of the relationship between OFDI and green innovation.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Xiao Lei was responsible for methodology and research design, and writing the paper. Yuanyuan Xie was responsible for data collection and processing. Xianfeng Chen revised the original draft.

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References

[1] Z. Chen, Y. Zhang, H. Wang, X. Ouyang, and Y. Xie, "Can green credit policy promote low-carbon technology Innovation?" *Journal of Cleaner Production*, vol. 359, Article ID 132061, 2022.

[2] R. V. Berkel, "Eco-Innovation: opportunities for advancing waste prevention," *International Journal of Environmental Technology and Management*, vol. 7, no. 5/6, pp. 527–550, 2007.

[3] F. Castellacci and C. M. Lie, "A taxonomy of green innovators: empirical evidence from South Korea," *Journal of Cleaner Production*, vol. 143, pp. 1036–1047, 2017.

[4] S. Zhang, "Looking to the future: innovation-driven green development," *Green Energy & Environment*, vol. 2, pp. 1-2, 2017.

[5] W. Fan, X. Dong, H. Wei et al., "Is it true that the longer the extended industrial chain, the better the circular agriculture? A case study of circular agriculture industry company in Fuqing, Fujian," *Journal of Cleaner Production*, vol. 189, pp. 718–728, 2018.

[6] J. J. Kozuch and J. J. Kozuch, "Clean tech intellectual property: eco-marks, green patents, and green innovation," *Journal of Fuel Cell Science and Technology*, vol. 9, no. 2, Article ID 26501, 2012.

[7] R. Kiani Mavi and N. Kiani Mavi, "National eco-innovation analysis with big data: a common-weights model for dynamic DEA," *Technological Forecasting and Social Change*, vol. 162, Article ID 120369, 2021.

[8] M. R. Marvel and G. T. Lumpkin, "Technology entrepreneurs' human capital and its effects on innovation radicalness," *Entrepreneurship Theory and Practice*, vol. 31, no. 6, pp. 807–828, 2007.

[9] N. Wu and Z. K. Liu, "Higher education development, technological innovation and industrial structure upgrade," *Technological Forecasting and Social Change*, vol. 162, Article ID 120400, 2021.

[10] J. Zhang, L. Kang, H. Li, P. Ballesteros-Pérez, M. Skitmore, and J. Zuo, "The impact of environmental regulations on urban Green innovation efficiency: the case of Xi'an," *Sustainable Cities and Society*, vol. 57, Article ID 102123, 2020.

[11] A. A. Amighini, R. Rabellotti, and M. Sanfilippo, "Outward FDI from developing country MNEs as a channel for technological catch-up," *Seoul Journal of Economics*, vol. 23, pp. 1–22, 2010.

[12] Y. Bai, Q. Qian, J. Jiao, L. Li, F. Li, and R. Yang, "Can environmental innovation benefit from outward foreign direct investment to developed countries? Evidence from Chinese manufacturing enterprises," *Environmental Science & Pollution Research*, vol. 27, no. 12, pp. 13790–13808, 2020.

[13] W. Chen, L. Pan, C. Lin, M. Zhao, T. Li, and X. Wei, "Efficiency evaluation of green technology innovation of China's industrial enterprises based on SBM model and EBM model," *Mathematical Problems in Engineering*, vol. 2021, Article ID 6653474, 11 pages, 2021.

[14] Z. Li, K. Ning, J. Chen et al., "Soil and water conservation effects driven by the implementation of ecological restoration projects: evidence from the red soil hilly region of China in the last three decades," *Journal of Cleaner Production*, vol. 260, Article ID 121109, 2020.

[15] Z. Li, G. Liao, Z. Wang, and Z. Huang, "Green loan and subsidy for promoting clean production innovation," *Journal of Cleaner Production*, vol. 187, pp. 421–431, 2018.

[16] Z. Han, X. Li, Z. Yan, and K. Zhong, "Interaction and spatial effects of green technology innovation and financial agglomeration: empirical evidence from China under the goal of "double carbon"," *Frontiers of Environmental Science*, vol. 10, Article ID 984815, 2022.

[17] H. Lin, S. X. Zeng, H. Y. Ma, G. Y. Qi, and V. W. Y. Tam, "Can political capital drive corporate green innovation? Lessons from China," *Journal of Cleaner Production*, vol. 64, pp. 63–72, 2014.

[18] Z. Yang, S. Tauseef Ali, F. Ali, Z. Sarwar, and M. A. Khan, "Outward foreign direct investment and corporate green innovation: an institutional pressure perspective," *South African Journal of Business Management*, vol. 51, pp. 1–12, 2020.

[19] K. Tone, "A slacks-based measure of efficiency in data envelopment analysis," *European Journal of Operational Research*, vol. 130, no. 3, pp. 498–509, 2001.

[20] L. Branstetter, "Is foreign direct investment a channel of knowledge spillovers? Evidence from Japan's FDI in the United States," *Journal of International Economics*, vol. 68, no. 2, pp. 325–344, 2006.

[21] X. Gong, M. Li, and H. Zhang, "Has OFDI promoted industrial enterprises' green innovation efficiency in China: empirical research based on agglomeration economic effect," *The Journal of International Trade*, vol. 11, pp. 127–137, 2017.

[22] J. Pantulu and J. P. H. Poon, "Foreign direct investment and international trade: evidence from the US and Japan," *Journal of Economic Geography*, vol. 3, pp. 241–259, 2003.

[23] M. Bu and M. Wagner, "Racing to the bottom and racing to the top: the crucial role of firm characteristics in foreign direct investment choices," *Journal of International Business Studies*, vol. 47, no. 9, pp. 1032–1057, 2016.

[24] S. Alazzawi, "Innovation, productivity and foreign direct investment-induced R&D spillovers," *Journal of International Trade & Economic Development*, vol. 21, no. 5, pp. 615–653, 2012.

[25] Y. Zhou, J. Jiang, B. Ye, and B. Hou, "Green spillovers of outward foreign direct investment on home countries: evidence from China's province-level data," *Journal of Cleaner Production*, vol. 215, pp. 829–844, 2019.

[26] L. Dai, X. Mu, C. C. Lee, and W. Liu, "The impact of outward foreign direct investment on green innovation: the threshold effect of environmental regulation," *Environmental Science & Pollution Research*, vol. 28, no. 26, pp. 34868–34884, 2021.

[27] S. Ren, Y. Hao, and H. Wu, "The role of outward foreign direct investment (OFDI) on green total factor energy efficiency: does institutional quality matters? Evidence from China," *Resources Policy*, vol. 76, Article ID 102587, 2022.

[28] X. Wang, L. Wang, S. Wang, F. Fan, and X. Ye, "Marketisation as a channel of international technology diffusion and green total factor productivity: research on the spillover effect from China's first-tier cities," *Technology Analysis & Strategic Management*, vol. 33, no. 5, pp. 491–504, 2021.

[29] R. Xie, W. Fu, S. Yao, and Q. Zhang, "Effects of financial agglomeration on green total factor productivity in Chinese cities: insights from an empirical spatial Durbin model," *Energy Economics*, vol. 101, Article ID 105449, 2021.

[30] A. Hao, J. Tan, Z. Ren, and Z. Zhang, "A spatial empirical examination of the relationship between agglomeration and green total-factor productivity in the context of the carbon emission peak," *Frontiers of Environmental Science*, vol. 10, Article ID 829160, 2022.

[31] Y. Luo, Q. Xue, and B. Han, "How emerging market governments promote outward FDI: experience from China," *Journal of World Business*, vol. 45, no. 1, pp. 68–79, 2010.

[32] H. Wang and X. Hu, "China's "going-out" strategy and corporate social responsibility: preliminary evidence of a "boomerang effect"," *Journal of Contemporary China*, vol. 26, no. 108, pp. 820–833, 2017.

[33] C. Torrecillas and S. Fernández, "Exports and outward FDI as drivers of eco-innovations. An analysis based on Spanish manufacturing firms," *Journal of Cleaner Production*, vol. 349, Article ID 131243, 2022.

[34] A. Lema and R. Lema, "Technology transfer in the clean development mechanism: insights from wind power," *Global Environmental Change*, vol. 23, no. 1, pp. 301–313, 2013.

[35] Y. Chen and C. C. Lee, "Does technological innovation reduce CO2 emissions? Cross-country evidence," *Journal of Cleaner Production*, vol. 263, Article ID 121550, 2020.

[36] M. A. Desai, C. Foley, and J. R. Hines, "Domestic effects of the foreign activities of us multinationals," *American Economic Journal: Economic Policy*, vol. 1, pp. 181–203, 2009.

[37] V. Z. Chen, J. Li, and D. M. Shapiro, "International reverse spillover effects on parent firms: evidences from emerging-market MNEs in developed markets," *European Management Journal*, vol. 30, no. 3, pp. 204–218, 2012.

[38] J. P. Pradhan and N. Singh, "Outward fdi and knowledge flows: a study of the Indian automotive sector," *International Journal of Economics*, vol. 1, 2008.

[39] J. Li, R. Strange, L. Ning, and D. Sutherland, "Outward foreign direct investment and domestic innovation performance: evidence from China," *International Business Review*, vol. 25, no. 5, pp. 1010–1019, 2016.

[40] C. P. Kindleberger, "The formation of financial centers: a study in comparative economic history," *Working Papers*, vol. 5, pp. 3395–3397, 1973.

[41] N. Barbieri, A. Marzucchi, and U. Rizzo, "Knowledge sources and impacts on subsequent inventions: do green technologies differ from non-green ones?" *Research Policy*, vol. 49, no. 2, Article ID 103901, 2020.

[42] Y. Feng, L. Zou, H. Yuan, and L. Dai, "The spatial spillover effects and impact paths of financial agglomeration on green development: evidence from 285 prefecture-level cities in China," *Journal of Cleaner Production*, vol. 340, Article ID 130816, 2022.

[43] Q. Ye and C. Cheng, "Green technological innovation efficiency and financial ecological environment," *Open Journal of Social Sciences*, vol. 07, no. 12, pp. 132–151, 2019.

[44] Y. Wen, M. Zhao, L. Zheng, Y. Yang, and X. Yang, "Impacts of financial agglomeration on technological innovation: a spatial and nonlinear perspective," *Technology Analysis & Strategic Management*, vol. 35, no. 1, pp. 17–29, 2021.

[45] Y. Zheng, S. Chen, and N. Wang, "Does financial agglomeration enhance regional green economy development? Evidence from China," *Green Finance*, vol. 2, pp. 173–196, 2020.

[46] F. Wu, X. Yang, and Y. Chen, "Research on innovative mechanisms of financial agglomeration enabling green coordinated development in the Yangtze River Delta of China," *Heliyon*, vol. 9, no. 3, Article ID 14172, 2023.

[47] P. J. Buckley, L. J. Clegg, A. R. Cross, X. Liu, H. Voss, and P. Zheng, "The determinants of Chinese outward foreign direct investment," *Journal of International Business Studies*, vol. 38, no. 4, pp. 499–518, 2007.

[48] J. Lu, X. Liu, M. Wright, and I. Filatotchev, "International experience and FDI location choices of Chinese firms: the moderating effects of home country government support and host country institutions," *Journal of International Business Studies*, vol. 45, no. 4, pp. 428–449, 2014.

[49] Y. Wang, L. Cheng, H. Wang, and L. Li, "Institutional quality, financial development and OFDI," *Pacific Science Review*, vol. 16, no. 2, pp. 127–132, 2014.

[50] T. Ncanywa and K. Mabusela, "Can financial development influence economic growth: the sub-Saharan 657 analysis?" *Journal of Economic and Financial Studies*, vol. 12, pp. 1–13, 2019.

[51] B. E. Hansen, "Threshold effects in non-dynamic panels: estimation, testing, and inference," *Journal of Econometrics*, vol. 93, no. 2, pp. 345–368, 1999.

[52] C. Liu, X. Gao, W. Ma, and X. Chen, "Research on regional differences and influencing factors of green technology innovation efficiency of China's high-tech industry," *Journal of Computational and Applied Mathematics*, vol. 369, Article ID 112597, 2020.

[53] G. Du, M. Yu, C. Sun, and Z. Han, "Green innovation effect of emission trading policy on pilot areas and neighboring areas: an analysis based on the spatial econometric model," *Energy Policy*, vol. 156, Article ID 112431, 2021.

[54] J. Cai, X. Xu, and T. Yu, "Performance evaluation of resource utilization with environmental externality: evidence from Chinese agriculture," *Journal of Cleaner Production*, vol. 397, Article ID 136561, 2023.