China's OFDI and Green Economy Efficiency - Mediating Effect of Technological Innovation Perspective

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Abstract: We select the data of 30 provinces in China from 2010 to 2020 to construct a panel model to empirically test the impact of OFDI on the level of green economy, and takes technological innovation as the intermediary variable to test the intermediary effect. It is found that OFDI can enhance regional green economy, and technological innovation has a positive mediating effect between OFDI and green economic efficiency. The article puts forward relevant suggestions based on the research results. And we propose that China need to adhere to the "Belt and Road" strategy, bring domestic technology and capital into the international market, and promote joint development and promote the differentiation and efficiency of OFDI.

Keywords: OFDI; green economy efficiency; technological innovation; super-efficient SBM model

1 Introduction

China's rapid economic development in recent years has been accompanied by significant environmental challenges, which underscore the importance of transitioning to a green economy. The rough economic growth pattern has a great negative impact on China's environment. Improving the efficiency of the green economy is not only an essential part of realizing the innovation-driven development strategy but also a necessary way to achieve green development. The green economy, characterized by sustainable and environmentally friendly practices, is crucial for balancing economic growth with ecological preservation. In this context, China's Outward Foreign Direct Investment (OFDI) and its technological innovation level play pivotal roles in shaping the efficiency of the green economy. China insists on opening up to the outside world, and the scale of outward investment has continuously remained at the forefront. Against this background, China's level of technological innovation is constantly improving. We can only propose more efficient strategies to achieve green economic development by correctly understanding the relationship between OFDI, innovation level, and green economic efficiency.

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2 Literature Review

2.1 Green Economic Efficiency

Economic efficiency is a pivotal concept that encapsulates the effectiveness of socio-economic processes. It is defined by the optimal ratio of economic benefits to the costs incurred. However, the impact of environmental pollution was not considered in the initial measurement of economic efficiency. The traditional measure of economic efficiency often overlooked the environmental costs associated with economic activities. With the rapid pace of urbanization and industrialization, environmental issues have reached alarming levels of severity. Consequently, scholars are increasingly advocating for the inclusion of environmental and resource costs in the evaluation of economic growth. Green economic efficiency not only considers the inputs and outputs of GDP but also includes non-desired outputs. There are two main models for calculating green economic efficiency. The first one is the SBM model, which includes the non-expected outputs. Tone proposed the super-efficient SBM model, so the second model for calculating the green economic efficiency is the super-efficient SBM model which includes the non-expected outputs [8] (Tone, 2001). The super-efficient SBM model takes this a step further by addressing the limitation of the traditional SBM model where multiple decision-making units (DMUs) may have the same efficiency score of 1, making it difficult to distinguish their relative performance.

2.2 Relationship between OFDI and Green Economy Efficiency

Most scholars believe that OFDI contributes to green economic efficiency. Suyanto et al., (2012) found that OFDI usually promotes the innovation and upgrading of domestic firms' technology, improving production efficiency by studying Indonesia's apparel and electronics industries. Feng's study concluded that OFDI significantly affects the green innovation efficiency, which concludes that OFDI significantly promotes green innovation efficiency[1](Feng et al., 2018). Ren et al. [6](2022) concluded that OFDI not only has a positive effect on local green economic efficiency but also positively promotes neighboring regions' efficiency by using the spatial Durbin model. He et al., [2](2023) assessed the impact of OFDI on TFP which shows that OFDI has a positive effect on total factor energy efficiency.

At the same time, some scholars believe that OFDI has an inhibitory effect on the green efficiency, and [5] (Potterie & Lichtenberg, 2001) found that only the spillover effect of FDI can promote TFP, but OFDI can not promote its improvement. The divergent findings underscore the complexity of the issue and the need for further research that considers various factors such as the type of industries involved in OFDI, the environmental regulations in both the home and host countries, and the absorptive capacity of the investing firms or countries.

2.3 The Impact Of Technological Innovation on Green Economic Efficiency (GEE)

Liu, YJ explores the relationship between technological innovation and green economic efficiency by using data envelopment analysis to measure GEE with a sample of 278 cities and regions in China. The study concludes that technological innovation can effectively promote green economic efficiency, but its effect is also affected by regional heterogeneity [3](Liu & Dong, 2021). Miao et al. [4](2017) uses data from 2001 to 2015 as the research object and adopts the stochastic frontier analysis, and concludes that green technological innovation affects

resource utilization efficiency and ultimately promotes green efficiency.[7] (Sun et al., 2019) took the energy efficiency of 71 countries as a sample and found that green innovation significantly impacts energy efficiency. Zhang et al. (2023)'s study found that technological innovation can significantly improve energy efficiency.

3 Empirical Analysis

3.1 Measurement of Green Economy Efficiency

Before the specific analysis, it is necessary to measure the indicators of China's green economic efficiency, and for this purpose, the DEA model can be used, which makes use of input indicators and output indicators and applies the method of linear programming to analyze the data. Following this, scholars introduced the SBM model, a non-radial approach that offers enhanced problem-solving capabilities. Subsequent researchers further refined this foundational model by introducing additional constraints, resulting in the development of the super-efficient SBM model. This combined model integrates the advantages of both super-efficiency and the SBM model, providing a comprehensive framework for analysis. In comparison to the general radial DEA models (such as radial BCC/CCR), the super-efficient SBM model offers a broader consideration of factors, making it a superior choice for assessing efficiency.

Specific indicators are selected as follows. We use China's GDP to represent desired outputs, while non-desired outputs are calculated by soot emissions, industrial sulfur dioxide and wastewater emissions.

Inputs are divided into human, material, and resource inputs. Human capital inputs are calculated according to the number of urban units employed at the end of the year, fixed asset investment is used for material capital inputs, and resource inputs are calculated according to the total energy consumption.

3.2 Model Building

$$\ln\mathrm{GTFP}_{it} = \alpha_{it} + \beta_1 \ln OFDI_{it} + \gamma X_{it} + \varepsilon_{it} \tag{1}$$

$$\ln\mathrm{GTFP}_{it} = \alpha_{it} + \beta_1 \ln OFDI_{it} + \beta_2 \mathrm{INN}_{it} + \beta_6 \ln INN_{it} \times \ln OFDI_{it} + \gamma X_{it} + \varepsilon_{it} \tag{2}$$

GTFP_{it}represents the green economy efficiency; INN_{it}represents the innovation level of region i in period t; $OFDI_{it}$ represents the outward foreign direct investment (OFDI) ; X_{it} represents the other relevant control variables; β_1 represents the impact coefficient of the explanatory variables; γ represents the vector of the control variables; α_{it} represents the unobservable inter-region heterogeneity; and ε_{it} defines the random error term.

3.3 Data and Variables

The explanatory variable is the green economic efficiency (GTFP) obtained. The core explanatory variables are selected as OFDI measured by actual outward foreign direct investment (OFDI) of each province respectively; the unit of measurement is USD 10,000, and OFDI is logarithmized.

The control variables selected are resident population (POP) and human capital level (LAB).

The number of local residents measures the resident population; the unit is 10,000. Human capital is assessed by the proportion of individuals pursuing higher education relative to the overall population size.

The above data are from the 2010-2020 Statistical Yearbook and the National Bureau of Statistics (NBS), and the data on OFDI in each province are from the OFDI Bulletin. As shown in table 1.

Table 1. Decriptive statistics.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	min	max	sd	mean
GTFP	330	-0.342	2.057	0.355	0.508
OFDI	330	4.927	14.69	1.644	11.29
IND	330	-0.704	1.667	0.422	0.0189
LAB	330	-4.829	-3.188	0.275	-3.962
POP	330	6.334	9.443	0.742	8.203

3.4 Analysis of Empirical Results

To weaken the covariance, all the raw data are taken as natural logarithms and standardized. In columns (1)-(3) of Table 2, we add control variables step by step, and the coefficient of OFDI is always positive. In column (3), the coefficient of OFDI is 0.129, which indicates that OFDI can significantly enhance the green economy of a region. This situation may be because one of the reasons is that Chinese enterprises, through OFDI, especially investing in countries with higher technological levels, actively learn from the host country's technology, management experience, etc., in participating in the international market, which promotes China's green economy. Secondly, China transfers excess production capacity and certain downstream industries outward, which not only contributes to the economic development of the transferring target countries but also favors the development of China's green economy. Thirdly, according to the classical theory of environmental effects of international trade, OFDI can affect the home country's ecological quality by influencing the home country's industrial structure, which is also conducive to the development of the green economy. In columns (4), by incorporating the squared term of OFDI (OFDI^2) into our analysis, we have uncovered evidence suggesting a non-linear dynamic between OFDI and GTFP.

Table 2. Baseline Regression.

	(1)	(2)	(3)	(4)
VARIABLES	GTFP	GTFP	GTFP	GTFP
OFDI	0.316***	0.364***	0.129*	0.215***
	(0.071)	(0.073)	(0.070)	(0.071)
OFDI2				0.122***
				(0.029)
POP		-0.284**	-0.225*	-0.219*
		(0.125)	(0.128)	(0.123)
LAB			0.757***	0.790***
			(0.074)	(0.073)
Constant	0.000	-0.000	0.000	-0.122
	(0.125)	(0.119)	(0.123)	(0.122)
Observations	330	330	330	330
Number of province	30	30	30	30

Table 3 reports the mediation effect test for technological innovation (INN), upgrading of the industrial structure (UI) and the environmental regulation (REG). INN is measured by the invention received at the provincial level. UI is measured by ratio of secondary and tertiary industry output. REG is quantified by the proportion of investment allocated to industrial pollution. The coefficient of OFDI in column (1) is 0.345, which indicates that OFDI promotes the technological innovation level of the region. The coefficient of OFDI in column (2) is 0.609 and significant at a 1% level, indicating innovation will significantly promote green economy. Technological innovation (INN) positively mediates the relationship. In the meanwhile, we found that REG has the negative mediating effect. And the mediating effect of UI is not significant.

Table 3. Mediating Test.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	INN	GTFP	REG	GTFP	IND	GTFP
INN		0.609***				
		(0.131)				
REG				-0.187***		
				(0.051)		
IND						-0.021
						(0.056)
OFDI	0.345***	-0.090	0.255***	0.183***	0.106	0.131*
	(0.027)	(0.082)	(0.073)	(0.070)	(0.070)	(0.070)
Constant	√	√	√	√	√	√
Controls	√	√	√	√	√	√
Observations	330	330	330	330	330	330
Number of province	30	30	30	30	30	30

4 Conclusions

4.1 Research Conclusion

Due to the availability of data, we selects the data of 30 provinces in China from 2010 to 2020 and obtains the following conclusions. (1) OFDI can improve regional green economy, and we have uncovered evidence suggesting a non-linear dynamic between OFDI and GTFP (2) The test of mediation effect was carried out and concluded that technological innovation (INN) has a positive mediation effect between OFDI and green economy efficiency. And the environmental regulation (REG) has a negative mediation effect between OFDI and green economy efficiency. The mediating effect of INN is not significant.

4.2 Suggestions for Countermeasures

First, insist on foreign investment to form a deeper pattern of opening up to the outside world and promoting the development of the country's green economy. The empirical analysis shows that OFDI has a significant positive effect on the green economy. Adhere to the "Belt and Road" strategy, bring domestic technology and capital into the international market, and promote joint development. By deepening regional economic integration, resources can be optimally

allocated, and industries can be upgraded within the region. For example, countries within a region can jointly develop clean energy projects, establish transnational green supply chains, and promote the construction of green infrastructure, such as high-speed railways and smart grids. Promote the differentiation and efficiency of OFDI. Enterprises should also consider their own regional and industry differences in their outbound investments. Promote the internationalization of the RMB, deepen cooperation between countries, avoid the wind, and seize the opportunities for mutual benefit and a win-win situation.

Secondly, in light of the salutary intermediary function exerted by INN (Innovation), it becomes imperative for China to amplify its endeavors in the realm of innovation. This necessitates not only the enhancement of original research and development but also the strategic impetus behind the transmutation of theoretical breakthroughs into tangible technological advancements. The country must foster an environment conducive to the proliferation of cutting-edge innovations, ensuring that the fruits of scientific inquiry are effectively harnessed to drive sustainable growth and development. The mediating role of REG is negative, reflecting the fact that China's environmental regulation strategy still needs further improvement and should further develop market-based environmental regulation policies, such as a carbon emissions trading system. Finally, high-quality tertiary industries should be developed to enhance the role of industrial structure upgrading in promoting the development of regional green economy. Finally, China need to focus on the development of service-oriented industries, the nation can effectively augment the catalytic impact of industrial structural optimization on the regional green economy's growth. This approach entails a strategic emphasis on sectors that are not only less resource-intensive but also pivotal in driving a sustainable economic trajectory, thereby reinforcing the region's commitment to ecological sustainability and environmental stewardship.

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