Impact of China's Green Finance Development on the Upgrading of Industrial Structure Based on Spatial Panel Model

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Abstract. Due to the spatial liquidity of green finance, the level of green finance in the local area will have an impact on the level of green finance in its neighboring areas; Furthermore, when the level of industrial structure upgrading in a certain region is high, neighboring areas will imitate the level of industrial structure in that region, which will also have an impact on its industrial structure upgrading. Therefore, studying the spatial correlation between regional industrial structure upgrading and green finance is of great significance. This article uses provincial panel data from 2010 to 2021 in China as the research sample. After conducting spatial correlation tests and spatial econometric model selection tests, the dynamic Durbin spatial panel model with bidirectional fixed effects is used to analyze the spatial effects of green finance in industrial structure upgrading. The research results found that in the short term, green finance has significant direct and total effects in industrial structure upgrading, but the indirect effects are not significant. In the long run, the positive direct effect, indirect effect, and total effect of green finance on industrial structure upgrading are significant, indicating that the development of green finance has a significant promoting effect on industrial structure upgrading in all regions in the long run.

Keywords: Green finance; Industrial structure; Panel model

1 INTRODUCTION

Since the reform and opening up, the Chinese economy has flourished, and the relationship between the three domestic industries has also undergone significant changes. With the continuous development of the economy and the upgrading of industrial structure, the service industry has gradually become the dominant industry, and this change has played an important role in the development of the national economy. However, with the upgrading of industrial structure and rapid economic development, environmental pollution has also emerged one after another. At present, environmental pollution remains an important factor affecting the high-quality development of China's economy. In the process of China's economic transformation and upgrading, green de-

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velopment has increasingly become an important path to transform the mode of economic development. Against the backdrop of increasingly strict environmental requirements, industrial structure upgrading still faces many challenges. According to the 2022 report on the development of China's environmental protection industry released by the China Environmental Protection Industry Association, the environmental quality in China urgently needs to be improved, and the demand for environmental governance is difficult to translate into industrial market demand. The environmental protection industry also faces problems such as excessive government investment dependence, inadequate investment return mechanisms, and low participation of social capital and financial institutions. Therefore, promoting economic restructuring and green technology progress has become an inevitable choice for China's low-carbon economic transformation and development, which also puts forward new and higher requirements for the ecological and environmental protection industry.

2 DOMESTIC AND FOREIGN LITERATURE REVIEW

Domestic and foreign scholars have studied the relationship between green finance and industrial structure upgrading. Broberg (2013) found that environmental investment is an effective way to improve environmental quality and promote industrial structure optimization[1]. Chen Weiguang (2011) believes that the imperfect financial system in China has led to a lack of clear promotion of green credit for industrial structure[2]. Liu Xia (2019) believes that green finance plays a positive role in promoting industrial structure optimization. In areas where investment in environmental governance accounts for a close proportion of GDP, the promoting effect of green finance is more significant and can play an important role in the economic development of the province[3]. In addition, Zhang Yunhui (2019) also pointed out that the direct impact of green credit on industrial structure optimization is greater than its indirect impact through technological progress[4].

The agglomeration and division of labor within a region will have an impact on the spatial differentiation effect of industrial structure upgrading. Different regions have formed different industrial agglomeration and division of labor models based on their own resource endowments, market demands, policy environments, and other factors. In addition, economic connections and technological spillovers between different regions can also lead to spatial spillover effects of industrial structure upgrading. The close economic connections formed through trade, investment, and talent mobility have promoted the cross regional flow and diffusion of factors such as technology, knowledge, and information. Meanwhile, Liu Chong et al. (2022) argue that spatial interference and interaction between adjacent regions may also lead to overflow of processing effects. One of the unavoidable problems when using the double difference method is the spatial spillover effect, as the implementation of policies may have an impact on adjacent regions, thereby causing certain interference with the assumption of stable unit treatment variable values[5]. Considering the long time required for industrial structure adjustment, the degree of industrial structure adjustment in this year is still affected by the industrial structure adjustment in the previous year.

Previous studies have made significant contributions to the relationship between green finance and industrial structure upgrading. However, when analyzing the spatial effects of green finance development on industrial structure upgrading, it is necessary to consider the spatial lag term that includes variables in the model. This means that the parameter estimation coefficients of the explanatory variable cannot directly reflect their marginal effects on the dependent variable. This article mainly focuses on in-depth research on these aspects.

3 CONSTRUCTION OF SPATIAL METROLOGY PANEL MODEL AND VARIABLE EXPLANATION

3.1 Construction of Spatial Metrology Panel Model

Considering the spatial spillover effect and the impact of industrial structure itself, this paper introduces a first-order lag term of the dependent variable industrial structure upgrading based on the spatial Durbin model, which corrects the bias of the static spatial panel model and improves the accuracy and reliability of the estimation results. Therefore, this article refers to the study of Shao et al. (2020)[6]to construct a bidirectional fixed effects dynamic Durbin spatial panel model as follows:

$$Y_{it} = \theta_0 + \rho W Y_{it} + \theta_1 Y_{it-1} + \theta_2 X_{it} + \theta_3 W X_{it} + \theta_4 Controls_{it}^3 + \theta_5 W Controls_{it}^3 + \lambda_i + \lambda_t + \varepsilon_{it} \quad (1)$$

In equation (1), W is the spatial weight matrix, i represents the region, t represents the year, ε_{it} represents the random disturbance term in model (5-1). Y_{it} represents the industrial structure upgrading index of region i in year t; ρ is the spatial autocorrelation coefficient; θ_1 is the time lag coefficient of the dependent variable industrial structure upgrading, reflecting the impact of the previous industrial structure upgrading on the current period; X_{it} is the core explanatory variable, representing the level of green finance development in region i in year t; θ_3 is the estimated coefficient of the spatial lag term of the core explanatory variable; $Controls_{it}^3$ is the control variable in model (5-1), controlled for some temporal and individual factors that may cause bias in the estimates presented in this article. These factors include the proportion of R&D investment, fixed assets investment, urban population density, human capital, financial development and other important variables that may affect the upgrading of industrial structure, as well as the individual characteristics of some regions themselves. λ_i is an individual fixed effect. Individual fixed effects were controlled in the model, thereby controlling for all non temporal differences between regions, such as geographical environment, culture, institutions, climate conditions, etc. λ_t is a fixed time effect [7-8]. Controlled for fixed time effects, thus controlling for national trends that do not vary with each region but change over time, such as improvements in the national level of living environment, digital technology, and digital finance.

3.2 Variable Description and Descriptive Statistics

The dependent variable is industrial structure upgrading (Y), measured by the ratio of the added value of the tertiary industry to the added value of the secondary industry using the advanced industrial structure indicator. The core explanatory variable is the level of development of green finance (X). In order to control the impact of regional differences as much as possible and alleviate the bias caused by the results, the model includes control variables that represent the characteristics of fixed assets, finance, technology research and development, urbanization, human capital, and other aspects of each province. It mainly includes fixed assets investment (FIX), urbanization (POP), human capital level (HUM), R&D investment (R&D), and the amount of deposits and loans per unit of GDP (FIN) refers to the amount of deposits and loans per unit of GDP. This study uses China's provincial panel data from 2010 to 2021 as the original research sample, including 30 provinces in China (Xizang, Xizang, Hong Kong, Macao and Taiwan are not included due to the lack of data and data integrity). The data is sourced from the China Statistical Yearbook. The descriptive statistical results of the variables show that the overall values are relatively stable.

4 EMPIRICAL ANALYSIS

4.1 Spatial Correlation Test

The Moran index as an indicator is used to measure spatial correlation. The range of Moran's index values is [-1,1]. If there is a spatial positive correlation between the upgrading of various industrial structures, the Moran's index will be between [0,1]. The closer the Moran index is to 1, the stronger the spatial positive correlation. The positive spatial correlation is mainly reflected in the clustering between regions with high levels of industrial upgrading, as well as the clustering between regions with low levels of industrial upgrading. The following formula is used to calculate the global Moran index.

$$I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} z_i z_j}{S_0 \sum_{i=1}^{n} z_i^2} \tag{2}$$

$z_i = (x_i - \bar{x})$ in equation (2), z_i represents the deviation of variables in region i from their mean values, w_{ij} is the element in the i-th row and j-th column of the spatial weight matrix, S_0 is the set of elements in the spatial weight matrix.

Table 1 shows the results of the global Moran index, where the Z-values are all positive and pass the 10% statistical significance level test. At the same time, the Moran index is all positive, indicating a significant spatial positive correlation in industrial structure upgrading.

Table 1. Global Moran Index Results.

variable	symbol	YEAR	I	z	p-value
Upgrade of industrial structure		2012	0.100	1.806	0.071

	2013	0.119	1.866	0.062
	2014	0.134	2.069	0.039
	2015	0.159	2.476	0.013
	2016	0.179	2.561	0.010
	2017	0.161	2.370	0.018
Y	2018	0.150	2.225	0.026
	2019	0.170	2.392	0.017
	2020	0.168	2.280	0.023
	2021	0.174	2.098	0.036
	2022	0.174	2.283	0.022

From Table 1, it can be seen that the spatial correlation of industrial structure upgrading shows a significant upward trend of fluctuations. This reflects the possibility that industrial structure upgrading is influenced by different factors and there are spatial spillover effects between regions simultaneously. Therefore, this article will further analyze the factors that affect the upgrading of industrial structure and the potential inter regional interaction effects.

4.2 Spatial Spillover Effect Test

(1) Testing the Selection of Spatial Econometric Models

Before analyzing the spatial spillover effects of green finance on industrial structure upgrading, it is necessary to first select a suitable spatial econometric model. Therefore, this article draws on the testing approach of Vegas&Elhorst and uses Hausman's test, individual fixed effects, time fixed effects, and double fixed effects selection tests, LM, LR, and Wald's tests, as shown in Table 2. The test results indicate that the Hausman test rejects the null hypothesis of selecting random effects at a significance level of 1%, therefore it is recommended to use a fixed effects model. Subsequently, selective tests of individual fixed effects, time fixed effects, and bidirectional fixed effects showed that the individual time bidirectional fixed effects model outperformed other models.

Table 2. Testing of spatial econometric model selection.

Inspection method	statistics	p-value
Hausman	144.68	0.0000
ind nested in Both	42.68	0.0002
time nested in Both	107.85	0.0000
LM-Error	0.517	0.472
Robust LM-Error	9.702	0.002
LM- Lag	9.417	0.002
Robust LM-Lag	18.603	0.000
LR- SAR-SDM	28.99	0.0001
LR-SEM-SDM	25.40	0.0003
Wald test (SDM vs SAR)	15.21	0.0187
Wald test(SDM vs SEM)	12.80	0.0463

Therefore, taking into account the above results, this article adopts the individual time bidirectional fixed effects spatial Durbin model to analyze the spatial effects of green finance on industrial structure upgrading.

(2) Regression Results of Spatial Econometric Models

Table 3 shows the results of decomposing the short-term and long-term effects of the explanatory and control variables. In the short term, the promotion of industrial structure upgrading by green finance can be mainly divided into direct effects, indirect effects, and total effects, with coefficients of 1.202, -0.004, and 1.198, respectively. The coefficients of direct effects and total effects have undergone a statistical significance test at the 1% level, indicating that in the short term, green finance has a significant promoting effect on industrial structure upgrading overall. In the long run, green finance has positive direct effects, indirect effects, and overall effects on industrial structure upgrading. This indicates that the development of green finance has a significant promoting effect on the upgrading of industrial structure in all regions in the long term.

Table 3. Direct effects, indirect effects, and total effects.

variable	symbol	short-term effect			Long-term effect		
		direct effect	indirect effect	Total effect	direct effect	indirect effect	Total effect
green finance	X	1.202*** (29.93)	-0.004 (-0.37)	1.198*** (28.93)	0.713*** (10.07)	1.138*** (22.82)	1.851*** (26.96)
R&D investment proportion	$R\&D$	91.220*** (20.59)	2.788 (0.84)	94.008*** (66.89)	69.745*** (17.10)	75.519*** (42.90)	145.264*** (50.29)
Unit GDP deposit and loan amount	FIN	0.126*** (8.78)	0.011 (0.87)	0.137*** (18.98)	0.132*** (18.36)	0.080*** (9.44)	0.211*** (18.99)
human capital	HUM	0.523** (1.98)	-0.232 (-0.86)	0.291*** (15.34)	-0.846*** (-14.57)	1.296*** (26.23)	0.450*** (14.93)
urban population density	POP	-0.469*** (-34.19)	-0.005 (-0.78)	-0.474*** (-45.84)	-0.311*** (-14.44)	-0.421*** (-26.94)	-0.732*** (-40.90)
Fixed assets investment	FIX	-0.551*** (-53.01)	0.005 (0.86)	-0.546*** (-47.67)	-0.313*** (-11.69)	-0.531*** (-32.02)	-0.844*** (-41.08)

Note: The values in parentheses are z values, * p<0.1, * * p<0.05, * * * p<0.01

5 RESEARCH CONCLUSION

With the emergence of green finance, the green industry has gained more financing channels and preferential policies. These policies can reduce the financing costs of green enterprises, promote the rapid development of the green industry, and thereby drive the overall upgrading of the regional industrial structure. With the rapid development and growth of green industries, the demand for energy-saving technologies and environmental protection equipment is gradually increasing, and the driving effect of this demand on related industries and industries in other regions is becoming increasingly evident. At the same time, the successful experience and preferential policies of local green finance development will also attract green industries and enterprises from other regions to imitate, further expanding the scale and influence of green industries, and promoting the upgrading of the entire regional industrial structure. The analysis using spatial econometric models reveals that the total effect reflects the comprehensive effect of direct and indirect effects, and the direct and indirect effects of green finance interact with each other. The number and scale of green industries and enterprises continue to expand, forming a strong scale effect, which further accelerates the upgrading and optimization of industrial structure.

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