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RESEARCH ARTICLE

The Impact of Green Finance on High-quality Development of Economy in China—Based on Spatial Spillover Effect

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ABSTRACT

In the context of the rapid expansion of the Chinese economy and the prominent contradiction with the environmental carrying capacity, green finance plays a pivotal role in promoting high-quality economic growth. This research investigates the influence of green finance on China's economic growth by analyzing 282 prefecture-level cities in China. Firstly, the study evaluates the level of green finance and the degree of high-quality economic development in these cities. Secondly, the spatial econometric model is utilized to analyze the direct effect and spatial effect of green finance on the quality of economic development. Finally, policy suggestions are implemented to strengthen regional coordination and achieve green and coordinated development. The results indicate significant differences in the scale of green finance and the quality of economic development among regions; green finance has direct and spatial spillover effects on promoting economic development.

INTRODUCTION

Since 1978, China's economic growth rate has drawn worldwide attention, and it has rapidly ascended to be the second-largest economy globally. According to the data from the National Bureau of Statistics of China, China's Gross Domestic Product (GDP) reached 129 trillion yuan in 2023, representing an increase of 2.7% compared to the previous year. The total GDP has increased nearly 45 times compared to 1992. Nevertheless, this is closely associated with China's early extensive economic growth pattern.

In the context where the contradiction between the rapid economic growth of China and the environmental carrying capacity has become increasingly prominent. The "13th Five-Year Plan" released in 2016 proposed the new development concepts of "innovation, coordination, green, openness, and sharing," and it was suggested that the Chinese economy should achieve "High-Quality Economy Development (HQED)" in line with these characteristics. Against this backdrop, green finance was put forward as an emerging financial paradigm. In 2016, the People's Bank of China issued the "Guiding Opinions on Constructing a Green Financial System ."This document emphasized the significant role of green finance in facilitating China's transition to low-carbon practices and promoting high-quality economic development. Consequently, in recent years, China has made progressive advancements in the green financial system by strengthening the overall framework of green finance and providing institutional policy guidance.

Nevertheless, numerous problems remain to be solved between green finance and HQED. First, the spatial effect of green finance on HQED has not been clarified. Judging from the actual circumstances and the empirical research findings of numerous scholars, green finance does indeed contribute to the quality of regional economic development (Han et al., 2023; Wang, R. & Wang, 2022; Yang, 2023).

Their findings indicate that green finance can effectively restrain local high-pollution resource-based industries and direct funds to green ecological environment applications, eventually achieving the ultimate objective of HQED (Gao et al., 2023; Romi, 2024). This only stops at the study of direct effects.

Second, China is an extensive country with a vast expanse of land, and these regions are characterized by strong industrial linkages and high population mobility (Chen et al., 2022; Jam et al., 2010). According to the theory of spatial interaction, the knowledge spillover resulting from the co-agglomeration of different industries will influence adjacent regions due to geographical spatial proximity (Ding et al., 2022). Population flow across different regions brings resources such as capital, information, and technology. It can lead to the redistribution of production factors and ultimately bring about higher productivity (De Haas, 2010). The current status of regional economic development in China and related theories have affirmed that traditional local effect research is no longer adequate.

Third, a comprehensive study on whether and how regional green finance exerts positive spatial spillover effects is currently lacking. For example, can regions with a higher level of green finance development drive high-quality economic growth in neighboring areas? What are the scope and intensity of such spatial spillovers? These research gaps will affect the overall assessment of the green finance situation in the Hong Kong High Center, thereby influencing the formulation of related policies.

Therefore, 282 cities were selected in this study for empirical analysis and evaluated the green finance level and the extent of high-quality economic development of these Chinese cities. Furthermore, a spatial econometric model was utilized to analyze the direct and spatial effects of green finance on the quality of economic development. It provides a scientific basis for formulating regional cooperation strategies and coordinated development policies from a spatial perspective.

Theoretical Analysis and Hypothesis

Relevant Theory

This study explores the spillover effects of green finance on high-quality economic development based on the theory of new economic geography. New economic geography concerns the geographical distribution, spatial pattern, and spatial evolution of production and economic activities. New economic geographers Krugman and Fujita represent the entire scope of economic activities as an interdependent entity, emphasizing the spatial interaction of economic activities.

Krugman (1992) suggested that uneven development among regions is often observable in reality. To better account for this phenomenon, in addition to the incremental scale effect, economics needs to focus on three factors: labor market share, the supply of intermediate products, and knowledge spillover.

Fujita et al. (2001) employed the term "spatial economy" to denote the research that connects geography with the "new trade theory," which encompasses increasing returns to scale. They classified the spatial economic models of that era into three parts: regional, urban, and international. All these three models regard the spatial distribution of economic activities as a balance between two forces: centripetal forces and centrifugal forces. Centripetal forces mainly originate from production linkages, market sharing, and knowledge spillovers, while centrifugal forces mainly derive from the immobility of production factors, transportation costs, and congestion effects.

Hypothesis

In China, HQED is guided by the new development concepts of "innovation, coordination, green development, openness, and sharing." In combination with the functions of the financial system proposed by Levine (2005), green finance can facilitate economic development by realizing these concepts.

Firstly, green finance can furnish financing channels for enterprises' innovative activities (Hossain et al., 2024) and provide risk management support for high-risk green technological innovations (Stricker et al., 2022). Secondly, green finance can facilitate integrating and upgrading industrial structures to realize coordinated development (Xu et al., 2024). This will compel high-pollution and high-energy-consuming enterprises to research green technology and promote green transformation and upgrading (Cai et al., 2023; (Chen et al., 2022; Jam et al., 2013). Thirdly, green finance mitigates the environmental damage caused by the operation of high-pollution enterprises, channels financial resources towards cleaner manufacturing, and ultimately accomplishes green economic development (Zhang et al., 2021). Green finance is also beneficial for promoting the development of an open economy (Liu & Wu, 2023). As the global market favors environmentally friendly products, implementing green finance policies is conducive to stimulating more exports of green products and attracting more international green capital investment.

As an innovative financial modality, green finance's operation and promotion are likewise dependent on comprehensive factors such as the economy and geography. The geographical spillover effect of green finance development on the Hong Kong-Macao Economic Corridor predominantly manifests in industrial agglomeration and regional policies.

On the one hand, guided by green finance, the core lies in the formation of green industrial clusters initially. Simultaneously, it will stimulate the flow of raw materials, technologies, funds, and other resources in the surrounding areas. Eventually, a green industrial cluster effect will be formed, propelling the development of surrounding cities (He F. et al., 2024). Aggregating green industries is conducive to forming a green industrial chain, ultimately attaining scale effects and facilitating the economic development of surrounding regions (Guo & Chen, 2024). On the other hand, the disparities in regional policies also exert an influence on the development level of green finance in different regions. The Chinese government has taken the lead in promoting the construction of green finance. The proposition of regional policies creates a favorable ambiance for the development of local environmental protection enterprises and has a chain reaction in surrounding areas (Lv et al., 2024). Therefore, green finance can advance the interconnection and gradual development of the national green finance market, generating larger-scale economic benefits (Li et al., 2023). Based on theoretical analysis, this study proposes the following hypothesis:

H1: Green finance has both direct spillover effects and spatial spillover effects on promoting HQED.

METHODOLOGY

Sample Selection and Data Source

In light of the availability of data, this study selects 282 cities from among 334 cities in China to enhance the precision of the study and better capture the spatial spillover effect. These cities encompass China's eastern, central, and western regions and are highly representative. The data are derived from the China Urban Statistical Yearbook, the WIND database, the CSMAR database, and the statistical annual reports of prefecture-level cities. On this basis, the index smoothing method is employed to estimate the missing data. The data years chosen for this study are from 2011 to 2022. This is because, in 2007, China's State Environmental Protection Administration (SEPA) issued the "Opinions on Implementing Environmental Protection Policies to Prevent Credit Risks," which was the first time that the utilization of financial instruments to support environmental protection was proposed. Considering the delay in policy implementation, the analysis commences from 2011. The timeliness of secondary data depends on the publication of databases and statistical yearbooks. As of the time of data analysis for this study, only city-level data up to 2022 had been officially made public. To ensure the completeness of the data, the endpoint is set at 2022.

Variables Definition

Independent Variable: High-Quality Economic Development Level (HQED)

Although total factor productivity, as an important factor for the sustainability of economic growth, has reached a consensus among numerous studies (Jumbri & Managi, 2020; Sato et al., 2018; Wang, M. L. et al., 2021), owing to its measurement volatility and one-dimensionality, merely taking it as an evaluation index for HQED is inadequate to fulfill the research requirements. Hence, many scholars have resorted to multi-dimensional indicator systems to gauge the level of HQED. Based on relevant literature and the available data at the urban level, this study conducts a comprehensive evaluation of the level of HQED from five dimensions (Zeng Y. et al., 2019; Zhao et al., 2020; Akash et al., 2023). These factors encompass industrial structure, inclusive total factor productivity, technological innovation, the living standards of residents, and the ecological environment. The composition of the indicators is presented in Table 1.

Dependent Variable: Green Finance

The "Guiding Opinions on Constructing a Green Financial System" issued by the People's Bank of China are significant for establishing a green financial system. The "Opinions" suggest vigorous efforts should be made to develop green credit, green investment, green funds, green bonds, green insurance, and green equity trading. Concerning Chai et al. (2024), this study establishes a green financial indicator system from these seven aspects. The composition of the indicators is presented in Table 2.

Control Variables

Many factors can affect HQED. Therefore, this paper introduces the Degree of Government Intervention (GOV), Urbanisation Level (URB), Employment Structure (PLO), Infrastructure Level (INF), Market Size (MARKE), and GDP Growth Rate (GDPG) as control variables.

Model Specification

The spatial model established in this research is as follows:

$$\mathbf{EQDL_{it} = \alpha_0 + \rho W_{ij} EQDL_{it} + \alpha_1 GF_{it} + \gamma control_{it} + \mu W_{ij} GF_{it} + \varphi W_{ij} control_{it} + \varepsilon_{it}} \quad (1)$$

In (1), i denotes city i, t denotes time, $EQDL_{it}$ denotes HQED, GF_{it} denotes green financial development, $control_{it}$ denotes control variables, W_{ij} denotes the spatial weight matrix, ρ represents the coefficients of spatial autoregression, $\rho W_{ij} EQDL_{it}$ represents the spatial correlation of the level of HQED of the explanatory variable, μ denotes the coefficient of the spatial effect of the primary explanatory variable, φ represents the coefficients of the spatial effect of the influence of control variables on the HQED, and ε_{it} denotes the error term.

Table 1. Indicator for Economic Quality Development Level

Indicator Name	Sub-indicator Name	Tertiary Indicator Name	Description
Economic Quality Development Level (HQED)	Industrial structure	Advanced industrial structure	Tertiary sector output/secondary sector output
		Rationalization of industrial structure	Tyrell's index measures the ratio of the number of persons employed and the value of output among the three industries.
		Proportion of productive services	Number of employees in productive services/Number of urban employees
	Equity and efficiency	Inclusive TFP	Inclusive TFP Index
	Technological innovation	Technological Innovation	Innovation Index
	Ecological environment	SO2 removal rate	SO2 removal/ SO2 production
		Comprehensive industrial solid waste utilization rate	Comprehensive utilization of industrial solid waste/production of industrial solid waste
		PM2.5	PM2.5 Index
	Resident's living level	GDP/Urban Resident Population	GDP/Urban Resident Population
		Per capita education expenditure	Total education expenditure/urban resident population
		Number of hospital beds per capita	Number of hospital beds/Urban resident population

Sources: Zhao et al. (2020)

Table 2. Indicator for Green Finance

Indicator Name	Sub-indicator Name	Tertiary Indicator Name	Description
Green finance (GF)	Green Credit	Proportion of green credit projects	Ratio of total green project credit to total credit
	Green Investment	Percentage of investment in environmental pollution control in GDP	Investment in environmental pollution control divided by GDP
	Green Insurance	Degree of promotion of environmental pollution liability insurance	Income from environmental pollution liability insurance over total premium income
	Green Bond	Degree of green bond development	The ratio of total green bond issuance to total bond issuance
	Green Support	Percentage of fiscal expenditure on energy conservation and environmental protection	Fiscal expenditure on energy conservation and environmental protection compared to fiscal general budget expenditure
	Green Fund	Percentage of green funds	The ratio of the total market value of green funds to the total market value of all funds
	Green Equity	Development degree of green equity	The ratio of total carbon trading volume to total equity market transactions

Sources: Zeng, X. W. et al. (2014)

EMPIRICAL RESULTS AND ANALYSIS

Entropy Weight Method

Green Finance: In this study, the entropy weight method is adopted to construct a green finance indicator based on seven third-level indicators. According to the weights of each indicator, the green finance development index of 282 cities is ultimately measured. Based on the measured outcomes, the changing trends of the green finance development levels of the entire country and the three regions over the period from 2011 to 2022 are depicted. The specific trends are presented in Figure 1.

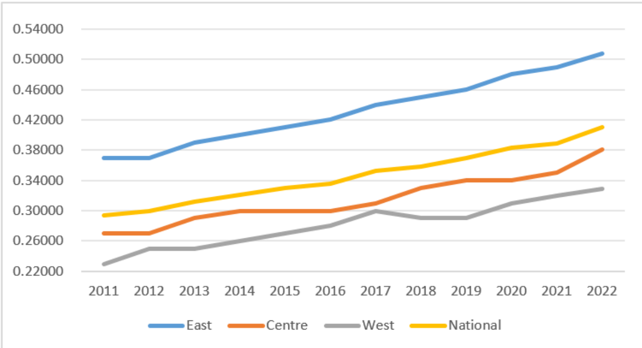

Figure 1. Green Finance Level in the East, Centre, West, and national

Overall, during this entire period, the level of green finance has shown a consistent upward trajectory. Specifically, in 2022, it witnessed a 39.7% growth when compared to the level in 2021. Moreover, the growth rate is relatively stable, averaging 3.3 % annually. Among them, 2016-2017 saw significantly faster growth because, in 2016, the Guidance on Building a Green Financial System was issued. This document lays a good foundation for the full speed-up of green finance. The growth rate of the country's green finance development slowed down in 2020-2021 due to the COVID-19 epidemic. After a short period of impact, China's economy gradually recovered in 2021, and the green finance level in 2021-2022 again showed significant growth, from 0.38 to 0.41, an increase of up to 5.7 %.

During this period, the level of green finance exhibited a continuous upward trajectory. On January 1, 2021, January 1, 2022, it increased by 3.3%. Notably, the growth rate accelerated significantly from 2016 to 2017, as the "Guiding Opinions on Building a Green Financial System" was released in 2016. This document laid a favorable foundation for green finance's all-around and accelerated development. Affected by the COVID-19 pandemic, the growth rate of green finance decelerated from 2020 to 2021. After a short-lived shock, the Chinese economy gradually recuperated in 2021, and the level of green finance witnessed remarkable growth again from 2021 to 2022, rising from 0.38 to 0.41, with an increase as high as 5.7%.

HQED: Similar to the green finance measurement method, this study provides a comprehensive HQED assessment from five perspectives. The weights of each indicator are determined by the entropy value method, and finally, the HQED index of cities is derived.

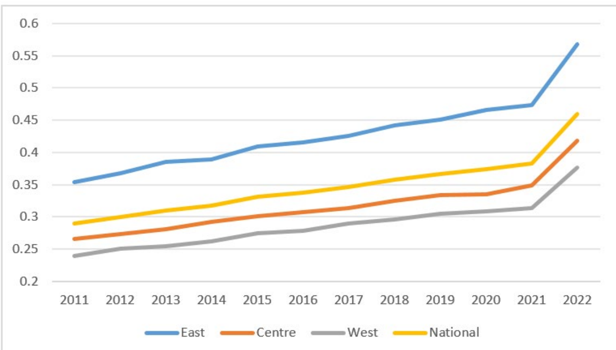

Figure 2. HQED Level in the East, Centre, West, and national

Overall, the HQED index in the eastern, central, and western regions of China and the entire country witnessed a stable upward trend from 2011 to 2022. The growth rate accelerated more conspicuously in 2021 and 2022, which was closely associated with China's economic recovery after the COVID-19 pandemic. The most remarkable growth was observed in the eastern region, attaining 19.1%.

From a regional perspective, the HQED index in the eastern region was significantly higher than the national average. On the other hand, the central region was lower than the national average, following the same overall growth trend as the country. Meanwhile, the western region consistently remained at the lowest level.

The HQED index reflects that all regions across the country have maintained a favorable growth trend, yet considerable disparities exist in the levels of development.

Descriptive Statistics

In this study, there are a total of 3384 sample data. In order to understand the data as a whole, descriptive statistics were analyzed for the main variables. As shown in Table 3.

The HQED variable's mean is 0.348, with a standard deviation (SD) of 0.125. The 10th percentile (p10) is 0.203, and the 90th percentile (p90) is 0.469, indicating that most data points are closely clustered around the mean. This suggests a relatively narrow dispersion in the levels of high-quality economic development across regions. The GF variable's mean is 0.346, with a standard deviation of 0.140. The 10th percentile (p10) is 0.158, and the 90th percentile (p90) is 0.517. Compared to HQED, the higher standard deviation for GF indicates greater variability in the level of green finance among cities.

Table 3. Descriptive Statistics for Key Variables

Variables	N	Mean	SD	p10	p90
HQED	3384	0.348	0.125	0.203	0.469
GF	3384	0.346	0.140	0.158	0.517
GOV	3384	0.314	0.301	0.134	0.513
URB	3384	0.570	0.150	0.392	0.783
PLO	3384	0.568	0.156	0.373	0.764
INF	3384	0.499	0.0790	0.444	0.524
MARKE	3384	0.384	0.111	0.254	0.525
ECO	3384	7.633	4.028	3.100	12.70

Note: p10 represents the 10th percentile

Spatial Autocorrelation

This study utilizes STATA 18.0 software to measure the Moran index of global green finance and HQED. The results indicate that from 2011 to 2022, the levels of green finance and HQED in China were at the 1% significance level and have positive values. This suggests that an increase in the level of green finance and HQED in a particular city has a significant positive impact on surrounding cities. Therefore, selecting a spatial econometric model to empirically analyze the spatial effects of green finance and the green economy is advisable.

Table 4. The global Moran Index of the level of green finance

Year	Moran Index	Year	Moran Index
2011	0.073***	2017	0.073***
2012	0.088***	2018	0.071***
2013	0.087***	2019	0.081***

2014	0.074***	2020	0.075***
2015	0.067***	2021	0.077***
2016	0.075***	2022	0.081***

Note:***means p < 0.01.

Table 5 The global Moran Index of the level of HQED

Year	Moran Index	Year	Moran Index
2011	0.081***	2017	0.079***
2012	0.081***	2018	0.084***
2013	0.086***	2019	0.082***
2014	0.085***	2020	0.085***
2015	0.083***	2021	0.085***
2016	0.088***	2022	0.085***

Note:***means p < 0.01.

Stationarity Test

Unit Root Test

In this study, the Levin, Lin, and Chu (LLC) test is used to check the stability of the data before the regression analysis to prevent the emergence of pseudo-regression. ' Table 6 displays the outcomes.

Table 6. Unit root test result

Variable	Adjusted t*	P-value
QUL1	-20.8690	0.0000
GF	-25.7188	0.0000
URB	-32.3338	0.0000
PLO	-53.2404	0.0000
JCS	-29.2273	0.0000
MARKE	-15.2464	0.0000
ECO	-38.9122	0.0000

The results presented in Table 7 indicate that the values of the adjusted t-statistics for all the variables are significant at the 1% level, thereby rejecting the hypothesis regarding the existence of a unit root. Therefore, it can be proved that the variables in the model are all stationary series.

Cointegration Test

This study then conducted the Pedroni test for cointegration to test the data's cointegration relationship, and the results are shown in Table 4.5.

Table 7 Pedroni Cointegration test results

	Statistic	P-value
Modified Phillips–Perron t	28.0092	0.0000
Phillips–Perron t	-59.7745	0.0000
Augmented Dickey-Fuller t	-48.2650	0.0000

As the table shows, all the statistics are significant at the 1% level; hence, the original hypothesis can be rejected. That is, it is considered that a cointegration relationship exists among the panel data, and the variables maintain a long-run equilibrium.

Multicollinearity Test

In this study, Variance Inflation Factor (VIF) method is conducted to perform the multicollinearity test and the outcomes are presented in Table 8.

Table 8. VIF for each variable

Variable	VIF	1/VIF
ECO	1.190	0.841
URB	1.190	0.843
PLO	1.180	0.847
GF	1.090	0.913
JCS	1.090	0.920
GOV	1.080	0.929
MARKE	1.070	0.935
Mean VIF	1.130	

The VIF values of the other variables are relatively low, ranging from 1.0 to 1.5. Meanwhile, the mean value of VIF is 1.130, which is less than 5. This means that there is no serious multicollinearity problem among the variables.

Spatial Panel Model Selection

In order to select more appropriate spatial measurement models, the Lagrange Multiplier (LM) test, the Great Likelihood Ratio (LR) test and the Wald test need to be performed sequentially.

Table 9 Spatial measurement model selection test

Test Type	Indicator	Statistics	P-value
LM	Moran's I	17.448	0.000
	LM-error	260.852	0.000
	Robust-LM-error	134.009	0.000
	LM-lag	265.523	0.000
	Robust-LM-lag	138.681	0.000
LR	LR-spatial-error	85.96	0.000
	LR-spatial-lag	77.15	0.000
Wald	Wald-spatial-error	248.84	0.000
	Wald-spatial-lag	113.96	0.000

Table 9 presents the outcomes of the tests that utilized the geographic distance weight matrix. Firstly, the P-values for the LM-lag, Robust LM-lag, LM-error, and Robust LM-error tests are all zero. This finding implies that when selecting a model in this study, the spatial lag and the spatial error terms must be considered. The spatial Durbin model (SDM) emerges as a viable candidate, given that it incorporates these two crucial effects. Hence, it is initially decided to adopt the SDM for further analysis. Further, conducting a Likelihood Ratio (LR) test on the Durbin model (SDM) is essential. The results show that both LR-Spatial-lag and LR-Spatial_error pass the 1% significance level test, indicating that the SDM model cannot be transformed into the spatial lag model (SAR) and spatial error model (SEM); finally, Wald-Spatia_lag and Wald-Spatia_error also pass the 1% significance level test, and therefore, this paper chooses to establish an SDM to carry out empirical research.

Spatial Durbin Model Test Results

This study refers to the the approach of LeSage and Pace (2009) and carries out partial differentiation of the variables in the SDM to decompose the spatial effect of green finance on HQED into the direct effect, indirect effect,, and total effect (as shown in Table 10).

Table 10 Estimation results of SDM

Variables	Direct	Indirect	Total
GF	0.589***	1.797***	2.386***
	(0.00996)	(0.329)	(0.327)
GOV	0.00152	0.230***	0.231***
	(0.00349)	(0.0692)	(0.0694)
URB	0.0999***	-0.778***	-0.678***
	(0.0104)	(0.172)	(0.170)
PLO	0.0535***	-0.409***	-0.356***
	(0.0101)	(0.133)	(0.131)
INF	-0.00951**	0.0479	0.0384
	(0.00386)	(0.0370)	(0.0368)
MARKE	0.0221**	-0.381***	-0.359***
	(0.0112)	(0.137)	(0.138)
GDPR	-0.0001	-0.0115***	-0.0116***
	(0.000380)	(0.00322)	(0.00311)
Observations	3,384		
R-squared	0.660		
Number of id	282		

Note：*** p<0.01, ** p<0.05, * p<0.1

As shown in Table 10, the direct effect coefficient of green finance is 0.589. This coefficient passes the significance test at the 1% level, indicating that in the development process, green finance significantly contributes to the local economy's high-quality development. This direct impact may be related to the following reasons.

Firstly, green finance can provide financing channels for corporate innovative activities(Hossain et al., 2024) and risk management support for risky green technological innovation (Stricker et al., 2022). Green finance continues to enhance economic and social benefits by directing more capital to green industries and livelihood projects (Li et al., 2023).

Secondly, green finance can improve industrial structure (Xu et al., 2024). Companies must commit to innovative green production technologies if they want to receive financial support for green finance. Through this active pursuit, they can ultimately drive the process of green transformation and upgrading. Industrial upgrading can support sustainable development over the long run. (Cai et al., 2023).

Thirdly, green finance directs the flow of financial resources towards cleaner production by curbing environmental degradation caused by the business activities of highly polluting enterprises. This can ultimately lead to green economic development, guaranteeing the sustainability and efficiency of economic growth (Li et al., 2023).

Finally, green finance can also improve the population's living standards by promoting balanced regional development (Lee & Lee, 2022). Green finance can guide the flow of capital to regions with less developed economies but abundant natural resources to develop green industries. For example, in some remote mountainous areas, green finance supports the local development of eco-agriculture, eco-tourism, and other green industries. This protects the local ecological environment while increasing local residents' employment opportunities and incomes. Ultimately, it has helped to narrow the gap with developed regions.

The indirect effect coefficient of green finance amounts to 1.797 and has successfully passed the test at the 1% significance level. This outcome is highly significant as it clearly reveals that green finance plays a pivotal role in enhancing the HQED level of neighboring cities. To put it differently, for every 1% increase in the regional development level of green finance, the level of rural revitalization in the surrounding areas will ascend by 1.797%. Through comparison, it is discovered that the indirect influence on the region is greater than the direct one. This indirect effect might be associated with the following reasons.

Firstly, developing green finance can encourage the integration of green industries and form the agglomeration effect of green industries (Saeedi & Ashraf, 2024). This helps to create a green industrial chain that ultimately achieves economies of scale and promotes the development of the economy of the neighboring regions (He, Z. et al., 2022).

Secondly, regional policies have the same impact on the spatial distribution of green finance. The Chinese government plays a pivotal role in advancing the development of green finance (Wang, C. et al., 2023), and the proposal of regional policies creates a favorable atmosphere for the development of local environmental protection enterprises and has a chain effect on the neighboring regions. Ultimately, it promotes the interconnection and gradual development of green financial markets around the country, creating larger-scale economic benefits (Li et al., 2023).

Finally, when a region achieves good results due to the development of green finance, neighboring cities can learn from its advanced experience or copy the implementation of relevant policies. Eventually, the relatively backward neighboring cities will be driven to improve the quality of economic development (Li et al., 2023).

By comparing the coefficients of indirect effect and direct effect, this study found that the level of green financial development has a more significant effect on the level of HQED in neighboring cities. Therefore, neighboring cities should actively coordinate interregional green finance policy needs with core cities, establish a cross-regional green finance cooperation platform, and promote interregional flows of green capital, technology, and talent.

Robustness Test

The geographic weight matrix has a significant impact on the spatial econometric model's regression outcomes. (Tiefelsdorf et al., 1999). This study uses the methodology of Ye et al. (2018) to confirm the analytical results' robustness and chooses Binary Weight, Economic Distance Spatial Weight Matrix to replace the original Distance Decay Weight to re-register the model. The economic eigenvalue of the Economic Distance Spatial Weight Matrix is chosen to measure the average value of GDP per capita from 2011 to 2022. Table 11 shows that green finance's direct and indirect impacts on HQED exhibit a significantly positive impact under any given matrix. The result is fully consistent with the results obtained from the original regression analyses. In other words, it affirms the dependability and credibility of the estimates obtained from the spatial Durbin model.

Table 11. Robustness test results (substitution space matrix)

Variables	Binary weight			Matrix of spatial weights for economic distance		
	Direct	Indirect	Total	Direct	Indirect	Total
GF	0.534***	0.310***	0.843***	0.562***	0.608***	1.170***
	(0.0102)	(0.0178)	(0.0161)	(0.0103)	(0.0495)	(0.0459)
GOV	0.00181	0.0194**	0.0212**	0.00233	-0.0333	-0.0310
	(0.00337)	(0.00857)	(0.00922)	(0.00343)	(0.0238)	(0.0242)
URB	0.107***	-0.0103	0.0962***	0.0984***	-0.316***	-0.218***
	(0.00960)	(0.0166)	(0.0196)	(0.00986)	(0.0496)	(0.0500)
PLO	0.0703***	0.000295	0.0706***	0.0557***	-0.0576	-0.00190
	(0.00963)	(0.0156)	(0.0181)	(0.00994)	(0.0422)	(0.0419)
JCS	-0.00506	-0.0196***	-0.0247***	-0.00364	-0.0323***	-0.0360***
	(0.00370)	(0.00557)	(0.00605)	(0.00392)	(0.0119)	(0.0115)
MARKE	0.0148	0.0395**	0.0543***	-0.00317	0.0198	0.0166
	(0.0110)	(0.0195)	(0.0186)	(0.0115)	(0.0460)	(0.0463)
ECO	-0.000567	0.00180***	0.00124**	-0.000465	0.000278	-0.000187
	(0.000354)	(0.000585)	(0.000608)	(0.000370)	(0.00111)	(0.00108)
Observations	3,384			3,384		
R-squared	0.727			0.702		
Number of id	282			282		

Endogeneity Test

Lagged explanatory variables are often used as instrumental variables (IV) to address endogeneity issues in empirical studies (Bellemare et al., 2017). In this study, the first-order lag term of the HQED index was again regressed on the spatial Durbin model. Table 12 displays the results. After using the lagged one-period data, the coefficient of the direct effect of green finance on HQED is 0.590, and the coefficient of the indirect effect is 1.678. This is very close to the original regression results, showing that the validation results of this study are reliable and scientific.

Table 12 Endogeneity test regression results

Variables	Direct	Indirect	Total
GF	0.589***	1.797***	2.386***
	(0.00996)	(0.329)	(0.327)
GOV	0.00152	0.230***	0.231***
	(0.00349)	(0.0692)	(0.0694)
URB	0.0999***	-0.778***	-0.678***
	(0.0104)	(0.172)	(0.170)
PLO	0.0535***	-0.409***	-0.356***
	(0.0101)	(0.133)	(0.131)
INF	-0.00951**	0.0479	0.0384
	(0.00386)	(0.0370)	(0.0368)
MARKE	0.0221**	-0.381***	-0.359***
	(0.0112)	(0.137)	(0.138)
GDPR	-0.0001	-0.0115***	-0.0116***
	(0.000380)	(0.00322)	(0.00311)
Observations	3,384		
R-squared	0.660		
Number of id	282		

Note：*** p<0.01, ** p<0.05, * p<0.1

CONCLUSIONS AND DISCUSSION

This study uses the spatial Durbin model to conduct regression analysis on the relevant data of 282 prefecture-level cities. Besides, this study found a wide gap between the level of green finance and HQED in various regions of China. Further, regression results show that the direct effect coefficient of green finance is 0.589, and the indirect effect coefficient is 1.797, and all of them pass the 1% significance level test. It indicates that green finance has a significant contribution to the HQED of both the city and the neighboring cities in the process of development. This conclusion verifies the correctness of the hypothesis. It is worth noting that the coefficient of indirect impact is higher, which indicates that the spillover effect brought about by the development of green finance is vast, far exceeding the effect brought about by its direct financial support to individual enterprises and cities. Therefore, it is necessary to strengthen the links between regions to maximize the spatial spillover effects of green finance.

Policy Implications and Recommendations

Firstly, empirical findings indicate that green finance can facilitate the development of HQED. Consequently, China should persist in perfecting the green finance system and reinforcing relevant policy support. For example, China should establish a unified standard system for green finance. It serves as the basis and norm for a series of green finance operations encompassing green industries, green financial tools, and enterprise information disclosure. Simultaneously, the government should encourage the development of green finance intermediary institutions and establish a multi-industry coordination mechanism for green finance.

Secondly, each region should formulate green financial development goals based on its development characteristics. Empirical evidence demonstrates that the role of green finance in promoting HQED is regionally heterogeneous. Therefore, each region should combine its resource endowment, geographical location, and other factors to formulate a green financial development strategy in line with its characteristics.

Finally, regional policy coordination should be enhanced to achieve green and coordinated development. Green finance has a significant spatial spillover effect on high-quality economic development. All regions should strengthen policy exchanges, and regions with developed green finance should give full play to their exemplary role in driving less developed regions. Besides, an information-sharing platform should be established to reduce information asymmetry among enterprises in different regions and promote healthy competition among green enterprises. In optimizing industrial layout, each region should systematically plan green industrial clusters based on its own resource endowment and comparative advantages. Core cities can drive surrounding cities to participate in various industrial chain links, achieving regional green and coordinated development.

Limitations

Despite the rigor of the research design, several limitations are inherent in this study. Firstly, the quality of the data in this research is circumscribed by numerous factors. For instance, some prefecture-level cities' relevant statistics of green finance are either lacking or inconsistent in statistical caliber. Particularly in the early stages, the data of certain nascent green finance operations are not completely encompassed in the statistical system, which might lead to certain measurement biases. Secondly, from the perspective of variable measurement, the adoption of relevant indicators might not be all-encompassing. This is because the measurement criteria for variables such as green finance and HQED have not been standardized, and the availability of data from prefecture-level cities also requires consideration. Finally, this study focuses on the urban level and adopts a macroscopic perspective without considering the influence on enterprises' investment and consumption behaviors. This also offers a broader scope for further research in the future.

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