INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 15, Issue 2, (2025) E-ISSN: 2222-6990

Threshold Effect of Environmental Regulation in Green Finance - Promoted High - Quality Economic Development——Evidence from 282 Cities in Mainland China

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To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v15-i2/24790 DOI:10.6007/IJARBSS/v15-i2/24790

Published Date: 23 February 2025

Abstract

High-quality economic development is an important goal in global sustainable development efforts. After experiencing rapid growth, China faces both economic and environmental challenges. Green finance, which integrates environmental and financial elements, is crucial for high-quality economic transformation, which promotes industrial upgrading and transition to low-carbon. Previous studies have mainly explored the linear relationship between the two, but neglected the non-linear impacts. As a key policy tool, environmental regulation influences business activities and regional development patterns, potentially altering the role of green finance in high-quality economic development. Therefore, this paper explores the threshold effect of environmental regulation in green finance-Promoted high-quality economic development using data from 282 cities in China. The results of the study show that there is indeed a single threshold value, and the effect of green finance becomes more obvious when this threshold value is crossed. Therefore, investment in and regulation of environmental pollution control should be appropriately increased.

Keywords: Green Finance, High-Quality Economic Development, Environmental Regulation, Threshold Effect

Introduction

In the global pursuit of sustainable development, high-quality economic development (HQED) is a universal goal. China, like many countries, grapples with the dual imperatives of economic expansion and environmental stewardship. Decades of rapid growth have bolstered national strength but also led to resource strains and environmental degradation. Green finance, an innovative blend of environmental and financial elements, is pivotal for high-quality economic transformation. By channelling capital towards green sectors, it drives

industrial upgrading and a shift towards a low - carbon economy.Therefore, the relationship between green finance and HQED has become an important area of research(Gao et al., 2023; Wang & Wang, 2022).

However, its impact on economic development is not independent. Previous studies have neglected the non-linear relationship between the two.Environmental regulation, as an important policy tool for the government to guide and constrain the environmental behaviour of economic agents, not only directly affects the production decisions and innovation activities of enterprises (Trevlopoulos et al., 2021), but also shapes the industrial structure and development model of the region to a certain extent (Chen et al., 2020; Li & Liu, 2023). It may change the intensity and direction of the role of green finance in the high-quality development of the economy.

Given this, researching the threshold effect of environmental regulation in green finance - led HQED is crucial. Understanding the optimal threshold can enrich academic theory and guide the government in formulating effective policies for sustainable growth. In this paper, data from 282 cities and prefectures in mainland China will be used as the research sample for the threshold test, aiming to provide a more in-depth and accurate analysis of the relationship between environmental regulation, green finance, and HQED.

Theoretical Analysis and Hypothesis

Relevant Theory

The traditional economic view is that coercive environmental regulation internalizes firms' environmental costs and increases their production costs, thus discouraging economic growth. However in the early 1990s, Harvard University's Porter and his collaborators argued that appropriate environmental regulation could incentivize firms to develop and adopt eco-innovations, thereby establishing a competitive advantage for national firms in green markets, which became known as the Porter Hypothesis (Porter, 1996).

The reasons for this include:(a) environmental regulation can make firms aware of the inefficiency of resource use and point to possible technological improvements; (b) environmental regulation can raise environmental awareness;(c) environmental regulation can reduce investment uncertainty; (d) environmental regulation can put pressure on firms to innovate and develop; and (f) environmental regulation can change the traditional competitive environment (Porter & Linde, 1995). In other words, environmental management can "force" enterprises to realize the economic benefits of eco-innovation.

With the exploration of the interrelationship between the types of eco-innovation, its performance, and its influencing factors, it has been gradually realized that Porter's Hypothesis logically consists of two links: the first topic concerns the correlation between environmental regulation and eco-innovation, in which appropriate environmental regulation stimulates the eco-innovation of enterprises; and the second is the relationship between eco-innovation and the competitiveness of enterprises (Kemp & Arundel, 1998).

It is worth noting that the "Porter's Hypothesis" of innovative behavior applies only to innovative behavior under scientifically designed environmental regulations, so environmental policy should not only focus on end-of-pipe pollution but also on pollution

control during the production process. In the choice of policy instruments, it is necessary to use a combination of various types of environmental regulatory policies to make up for the shortcomings of a particular type of environmental regulation (Jaffe & Palmer, 1997; Lanoie et al., 2008).

Later, (Jaffe & Palmer, 1997) subdivided the Porter's hypothesis into the Weak-Porter's hypothesis and the Strong-Porter's hypothesis. The Weak-Porter's hypothesis argues that environmental rules have the potential to promote particular forms of technological progress, but that it is uncertain whether innovative activity leads to improved firm performance due to cost effects. The Strong-Porter's hypothesis goes beyond the profit-maximisation framework and argues that environmental policy shocks can broaden firms' thinking and stimulate innovation and improvement.

Hypothesis

Combining the “negative externality” of ecological pollution and the theory of market failure in economics, it is impossible to achieve Pareto optimality by relying only on the market mechanism for resource allocation, and it is necessary to rely on government intervention, that is, the corresponding environmental regulation to ensure the rational allocation of resources. At the same time, GTI has a “positive externality”, enterprises in the GTI investment, high risk, no external stimulus to carry out GTI enthusiasm is low. Therefore, the government needs environmental regulation to limit the polluting behaviour of enterprises and urge them to carry out green technological innovation through “command and control” and “market incentives”.

Regarding the impact of environmental regulation on GTI, the following views have been developed: (a) Traditional neoclassical economics argues that environmental regulation, as a regulatory pressure, will increase the costs of firms, thus crowding out productive investment and hindering the development of corporate GTI (Ramanathan & Samuel, 1998). (b) Porter's hypothesis, contrary to neoclassical economics, argues that environmental regulation has an ‘innovation compensation’ effect. It can promote green technological reforms in high-pollution and high-energy-consumption enterprises to improve productivity and product quality (Berrone et al., 2013).

Therefore, some scholars have suggested that the impact of environmental regulation is related to its intensity (Li et al., 2022). As the intensity of environmental regulation continues to rise, there is a threshold of environmental regulation intensity at which firms will engage in green technological innovations for the sake of longevity when the environmental costs are moderate (Li & Li, 2019; Ouyang et al., 2019).

Based on this, this study proposes Hypothesis: environmental regulation has a threshold effect on the relationship between green finance and HQED.

Research Design

Sample Selection and Data Source

In order to enhance the precision of the study and better capture the spatial spillover effect. Combined with the availability of data, this study selects 282 cities out of 334 cities in China. These cities include cover the eastern, central, and western regions of China, and are highly representative. Among them, the data are derived from from the China Urban

Statistical Yearbook, WIND database, CSMAR database, and statistical annual reports of prefecture-level cities. On this basis, the index smoothing method is used to estimate the missing data. The data years selected for this study are 2011-2022. this is because over the past 10 years, China has paid particular attention to green finance and the high-quality development of its economy, and has introduced a number of proactive policies.

Variables Definition

(1) Independent Variable: High-quality Economic Development

Although total factor productivity has become the consensus of many scholars as an important factor for the sustainability of economic growth (Jumbri & Managi, 2020; Sato et al., 2018; Wang et al., 2021), due to the volatility of measurement and the unidimensionality, it is obviously not enough to meet the research needs by using it only as an evaluation index for HQED. Therefore, more and more scholars measure the level of HQED through a multi-dimensional indicator system. Based on the relevant literature (Zeng et al., 2019; Zhao et al., 2020) and the data available at the city level, this study comprehensively evaluates the HQED Level from five dimensions. These include industrial structure, inclusive TFP, technological innovation, Resident's living level and ecological environment. The indicators' composition is presented in Table 1.

(2) Dependent Variable: Green Finance

The Guiding Opinions on Building a Green Financial System issued by the PBOC are of great significance to building a green financial system. The Opinions propose it is proposed to vigorously develop green credit, green investment, green fund, green bond, green insurance and equity trading.Referring to Chai et al. (2024) this study will construct a green financial indicator system from these seven aspects.The indicators' composition is presented in Table 2.

(3) Threshold Variable: Environmental Regulation

Environmental regulation comprises the policy and mandatory measures adopted by the government to ensure economic development while taking into account the ecological environment (Dasgupta & Stiglitz, 1980).Considering the availability of data at the municipal level, this study adopts the proportion of industrial pollution control investment to industrial added value as a measure of environmental regulation. The amount of investment in industrial pollution control intuitively reflects the scale and strength of the funds invested by the region in the industrial sector to deal with the pollution problem, while the value added of industry reflects the new value created by industrial production. The ratio of the two can accurately measure the relative number of resources invested in pollution control in industrial economic activities, thus effectively characterising the intensity and effectiveness of environmental regulation.

(4) Control Variables

HQED can be affected by many factors. Therefore, this paper introduces the Degree of Government Intervention (GOV), Urbanisation Level (URB), Employment Structure (PLO), Infrastructure Level (INF), Market Size (MARKE), GDP Growth Rate (GDPG) as control variables.Table 1 System of Indicators for Economic Quality Development Level

Level 1 Indicators	Level 2 Indicators	Level 3 Indicators	Indicators Meaning	Indicator Properties
High-quality economic development (HQED)	Industrial structure	Advanced industrial structure	Tertiary sector output/secondary sector output	+
		Rationalisation of industrial structure	Tyrell's index measured by 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	SO_2 removal rate	SO2 removal/ SO2 production	+
		Comprehensive industrial solid waste utilisation rate	Comprehensive utilisation 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	+

Table 2
System of Indicators for Green Finance

Level 1 Indicators	Level 2 Indicators	Level 3 Indicators	Indicators Meaning	Indicator Properties
Green finance (GF)	Green Credit	Proportion of green credit projects	Total green project credit/total credit	+
	Green Investment	Percentage of investment in environmental pollution control in GDP	Investment in environmental pollution control/GDP	+
	Green Insurance	Degree of promotion of environmental pollution liability insurance	Environmental pollution liability insurance income/total premium income	+
	Green Bond	Degree of green bond development	Total green bond issuance/total bond issuance	+
	Green Support	Percentage of fiscal energy-saving and environmental protection expenditure	Fiscal energy-saving and environmental protection expenditure/fiscal general budget expenditure	+
	Green Fund	Percentage of green funds	Total market value of green funds/total market value of all funds	+
	Green Equity	Degree of development of green equity	Total carbon trading / Total equity market transactions	-

Sources: Li et al. (2020);Wang and Guo (2022);Zeng et al. (2014)Model Specification

Based on Hansen (1999) threshold model, this study selects ER as the threshold variable to explore in depth the influence of studying the level of GF on HQED. The results of the study not only help to understand the complex relationship between green finance and HQED, but also provide a scientific basis for optimising GF policies and environmental regulation policies. Based on this, this paper constructs the following regression model:

$$Y_{it} = \beta_0 X_{1it} + \beta_1 X_{2it} I(q_{it} \le \gamma) + \beta_2 X_{2it} I(q_{it} > \gamma) + \varepsilon_{it} \quad (1.1)$$

In the formula (1.1), Y_{it} is the explanatory variable, which is set as HQED in this study, where i represents cities and t represents time; X_{1it} represents the control variables except X_{2it} that have obvious influence on the explanatory variables; X_{2it} is the main explanatory variable, which refers to the level of GF in this research; q_{it} represents the threshold variable, which is the environmental regulation in this study, and γ represents the estimated threshold, $\beta_1$is the coefficient of control variables, $\beta_1$and $\beta_1$are the coefficients of threshold variables in different intervals. And I is the indicator function. 1 is assigned when the condition in the corresponding bracket is true, and the value of 0 when the condition is not valid. $\varepsilon_{it}$is the random disturbance term.

To produce estimates for each parameter, the squared residuals can be summed for any given threshold value γ. The best threshold value should minimize the SSR (γ) within all the residual sums of squares, i.e.:

$$\gamma_1 = \arg\min_{\gamma_1} e_i(\gamma_1) \quad (1.2)$$

The observation that satisfies formula (1.2) is the threshold value. The next step is to ensure the scientific validity of the model and the reliability of the conclusions by testing for significance and truthfulness. The following original hypotheses are tested for the presence of the threshold effect:

$$H_0: \beta 1 = \beta 2 \quad (1.3)$$

If this original hypothesis holds, there is no threshold effect. Then γ taking any value has no effect on the model, so the parameter γ is not identifiable. If the original hypothesis does not hold, then there is:

$$H_0: \beta 1 \neq \beta 2 \quad (1.4)$$

If the first hypothesis is disproven, then a threshold effect is considered to exist. Next the threshold can be tested and the confidence interval for the threshold can then be determined. At this point, the likelihood ratio test LR statistic is used:

$$LR = \frac{S_0 - S_1(\gamma)}{\gamma^2} \quad (1.5)$$

In the formula (1.5), S0 represents the sum of squares of the residuals under the original hypothesis H0. The study concludes by constructing the p-value through the Bootstrap method suggested by Hansen (1999), and after determining that a variable has a "threshold effect", and the test is then expanded by the likelihood ratio statistic to determine its threshold confidence interval.

Empirical Analysis

Entropy Weight Method

(1) Green Finance: Then, this study utilizes ArcGIS software to map the spatial distribution of green finance in 282 municipalities across China in 2011, 2016, and 2022. And the green finance index is divided into three levels: low (<0.3), medium (0.3-0.45) and high (>0.45). The specific distribution characteristics are shown in Figure 1.

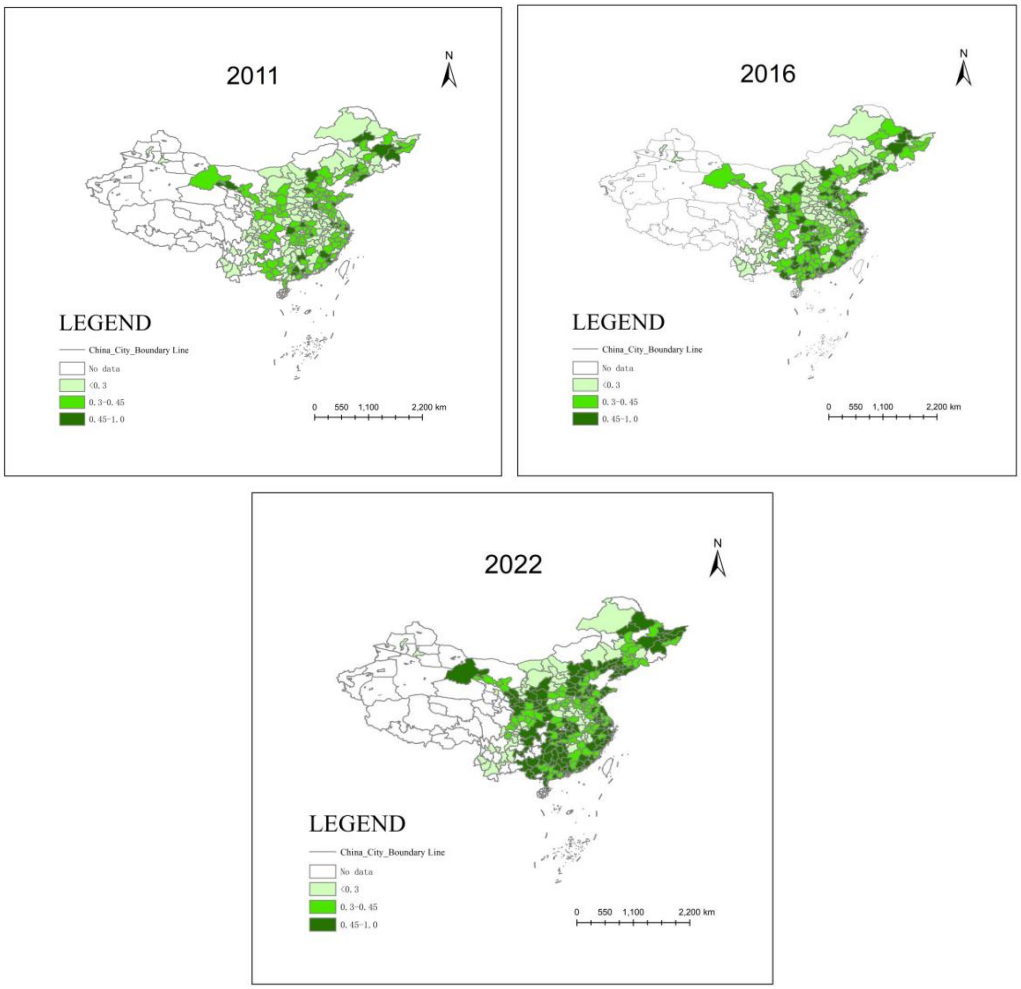

Figure 1 Changes in the Spatial Distribution of Green Finance Levels, 2011, 2016, 2022

On the whole, green finance shows obvious spatial agglomeration. The better-developed regions are mainly concentrated in the eastern coast. These regions include Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang and cities. Green finance level in the western region and part of the central region is relatively low, especially in Nei mengu, Yunnan, Anhui and other provinces and cities that have been at a lower level in these three years.

In 2011, the development of green finance in most regions was at a medium or low level, with relatively small differences among regions. Only a few scattered individual cities have green finance indexes above 0.45. By analysing the raw data, it is found that the green credit and green support indexes of Harbin and Shenyang are particularly prominent, which may be related to the active low-carbon transformation of traditional industrial bases (Zhang & Qian, 2011). Guangzhou, Shenzhen, and Shanghai, the most economically and financially active cities, have led green finance in China.

From 2011 to 2016, the level of green finance development in the eastern coastal regions has increased significantly, with more regions becoming darker in colour, which indicates that these regions have achieved significant development in green finance during these five years. Some provinces in the central region have also improved their level of green

finance, such as Henan and Hubei. In the western region, although the overall level is still low, there has been a small improvement, such as in parts of Sichuan, Shanxi and other provinces.

Between 2016 and 2022, green finance level in the country has increased significantly, with high-level cities increasing from 58 in 2016 to 128 in 2022. Among them, the eastern region continues to maintain the leading position in green finance. The dark-coloured region further expands with a clear state of aggregation, which is closely related to regional economic development. Green finance level in the central region has further improved, with more regions entering the 0.3-0.45 or even 0.45-1 range, but the level of green finance in resource-dependent Henan and Shanxi still lags behind the national level. Some regions in the western region, such as Chongqing and Guizhou, have also gradually become darker in colour, but there remains a wide gap in comparison with the east.

Green finance in China shows obvious spatial agglomeration. The eastern coastal regions are more developed in green finance, while the western and some central regions are relatively backward. From 2011 to 2022, the overall level of green finance in China has been rising. Although the central and western regions have made progress, there is still a large gap compared with the eastern region.

(2)Economic Quality Development Level:These three figures show the spatial distribution of China's HQED index in 2011, 2016 and 2022.

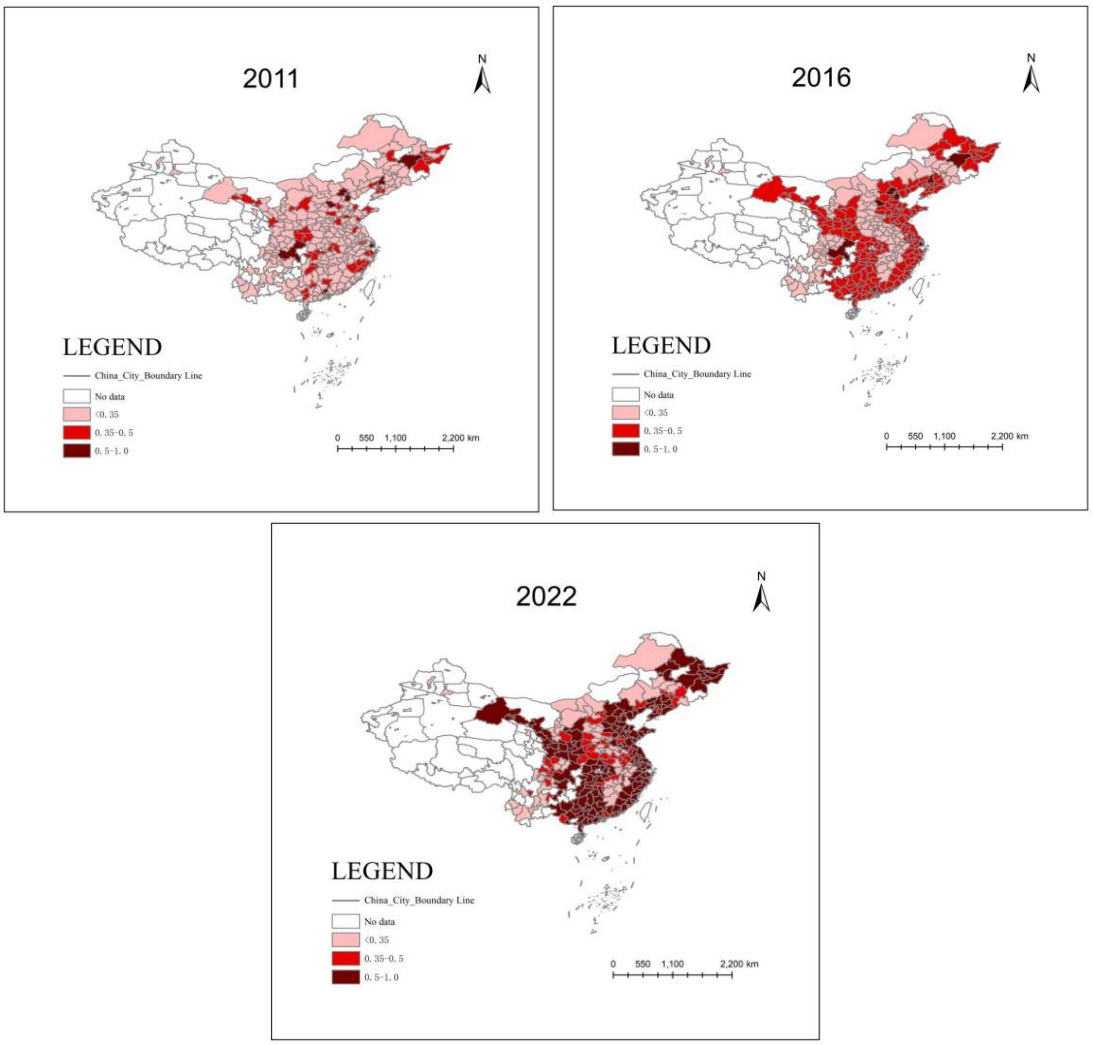

Figure 2 Spatial Distribution of HQED Level

In 2011, the level of high-quality development of China's economy was generally low. There were only nine regions with indices above 0.5, of which only Harbin and Chongqing were located in the central and western regions, while the others belonged to the eastern region. Harbin is a large industrial city with a strong economy; Chongqing, as an important city in Southwest China, had already begun its industrial restructuring before 2011 (Liu et al., 2013), transforming from traditional labour-intensive industries to high-end manufacturing.And the country has a number of policy support for Chongqing, which has promoted the development of the regional economy. In the eastern region, the Yangtze River Delta (including Shanghai, Jiangsu and Zhejiang) and the Pearl River Delta (Guangdong) have higher economic quality development indexes. These regions are economically developed and have a more optimised industrial structure, and thus have outstanding performance in economic.

Compared with 2011, the index of HQED of all regions in China has improved to some extent in 2016. In particular, the eastern coastal regions and some central regions gradually improved to a medium level. For example, the Beijing-Tianjin-Hebei region strengthened its regional co-development and promoted industrial upgrading and innovation during this

period (Ye & Mao, 2019), resulting in a significant improvement in the HQED index. Despite the overall improvement, the gap between the eastern and western regions still exists. The western region is still dominated by light pink (<0.35). Among them, Zhangye, Pingliang and other cities in Gansu are more prominent among western cities in terms of HQED. 2016 is the year when the “Belt and Road”construction is in the stage of deepening, and Gansu, as an important province in the “Belt and Road” initiative (Lachininskii et al., 2024), has received key support from the national policy in terms of foreign trade and other aspects.

By 2022, China's eastern regions are expanding their development advantages, and even some central regions are beginning to show more deep red areas, indicating that China has achieved extensive results in promoting HQED. This has a lot to do with the fact that after China put forward the strategy of HQED in 2017, many cities have made breakthroughs in industrial transformation and scientific and technological innovation, such as Hunan and Hubei. The western region has also seen some development over the past 11 years, with increasing number of cities with a HQED index above 0.35. But there is still more room for development compared to the eastern region.

Correlation Analysis

Prior to spatial measurement, correlation analyses were conducted in this study to obtain a preliminary insight into the relationship among the variables, details of which are given in the Table 3.Table 3 Correlation Results of Variables

	HQED	GF	GOV	URB	PLO	JCS	MARKE	ECO
HQED	1							
GF	0.814***	1						
GOV	0.092***	0.030*	1					
URB	0.315***	0.228***	0.030*	1				
PLO	0.079***	0.0180	0.231***	-0.184***	1			
JCS	-0.078***	-0.058***	0.124***	-0.127***	0.220***	1		
MARKE	0.173***	0.169***	0.0250	0.121***	-0.0250	0.030*	1	
ECO	-0.224***	-0.170***	-0.137***	-0.235***	-0.177***	-0.128***	-0.201***	1

The results show that there are different degrees of correlation between the variables. First, GF is significantly and positively correlated with HQED at the 1% level with a regression coefficient of 0.814. The correlation results show that the better the development of green finance, the higher the level of HQED. Regarding the control variables, HQED was positively correlated with GOV, URB, PLO and MARKE. On the contrary, HQED is negatively correlated with ECO and JCS.

Threshold Effect Test

The first step is to test the number of thresholds. In the study, the intensity of environmental regulation is used as the threshold variable. And STATA 18.0 software is employed to estimate the single-threshold and double -threshold effects respectively. After 500 times of Bootstrap repeated sampling, the regression test results are obtained and presented in Table 4. The regression model only passes the significance test of 1 % under a single threshold.

Table 4
Threshold Number Test

Threshold	Bootstrap	F-value	P-value	1%	5%	10%
Single	500	36.96	0.0040	20.1291	24.7343	31.9319
Double	500	13.90	0.1520	15.8730	19.0321	26.6532

Therefore, this study adopts the single-threshold regression model for regression. These results in Table 5 reveal that under the regulation of environmental regulation intensity, the impact of green finance on HQED increases in a stepped manner. When the environmental regulation intensity is lower than 0.0537, an increase in the green finance level is conducive to promoting HQED. The impact coefficient is significant, reaching 0.083. After crossing this threshold, the positive effect of the green finance becomes more pronounced. The impact coefficient significantly rises to 0.118.From this result, it can be seen that China's current environmental regulation intensity is more reasonable, there is no “crowding out effect” (Hottenrott & Rexhäuser, 2015) due to excessive environmental regulation intensity, and the “innovation compensation effect”(Borsatto & Bazani, 2021) is more obvious.

Table 5
Threshold Regression Results

Variables	Coefficient	t	95% Confidence Interval
GF（≤0.0537）	0.0830***	9.11	（0.0651 ,0.1008）
	(0.00911)		
GF（>0.0537）	0.118***	12.41	（0.0991 ,0.1364）
	(0.00949)		
GOV	0.0449***	14.44	（0.0388 ,0.0510）
	(0.00311)		
URB	0.251***	20.54	（0.2272,0.2752）
	(0.0122)		
PLO	0.121***	17.49	（0.1069 ,0.1340）
	(0.00689)		
INF	0.00796***	3.16	（0.0030 ,0.0129）
	(0.00252)		
MARKE	-0.00647	-0.71	（-0.0244 ,0.0115）

	(0.00917)		
ECO	-0.00216***	-12.61	（-0.0024 ,-0.0018）
	(0.000171)		
Observations	3,384		
Number of id	282		
R-squared	0.590		

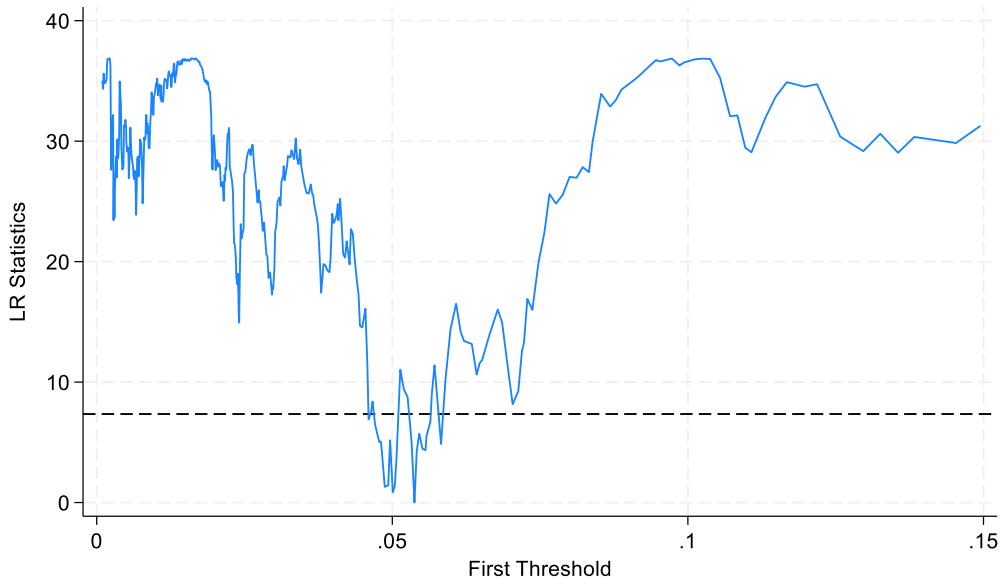

Figure 3 Distribution of LR statistics for single threshold effects

At lower levels of environmental regulation intensity (below 0.0537), the role of green finance is significant but the effect is relatively limited (the impact coefficient is 0.083). This may be due to the fact that in the case of weak environmental regulation, the demand and reliance of enterprises on green finance is low (Ren et al., 2018), and the role of green finance is more reflected in supporting a few environmental protection projects or enterprises.

As environmental regulation intensity rises above the threshold of 0.0537, the effect of green finance in promoting HQED becomes more obvious, with the impact coefficient rising to 0.118. This is mainly because stricter environmental regulation prompts enterprises to seek green transformation more actively (Liu et al., 2021). Under the higher intensity of environmental regulations, enterprises face greater pressure on environmental compliance costs. Green finance has become an important channel for enterprises to obtain funds, which can provide stronger financial support for their green transformation (Falcone, 2020). In addition, with the rising intensity of environmental regulation, the demand for green products and services from the whole society may also increase. Green finance can better guide the flow of resources to the green industry and promote the prosperity of the green industry, thus giving a greater impetus to the HQED.This phenomenon is consistent with Porter's hypothesis that appropriate environmental regulation can stimulate firms' incentives to innovate, thereby increasing economic efficiency and competitiveness (Porter & Linde, 1995).

From the above results, it is clear that environmental regulation in most Chinese cities brings about an "innovation compensation" effect. It can promote green technological reforms in highly polluting and energy-consuming firms, thus increasing productivity and product quality. Considering that when the intensity of environmental regulation crosses the threshold value of 0.0537, the effect of green finance in promoting HQED becomes more obvious. For regions with a lower intensity of environmental regulation, governments should appropriately increase investment in and regulation of environmental pollution control. At the same time, policymakers should dynamically adjust the intensity of environmental regulations and green financial policies according to the stage of economic development and environmental objectives in order to achieve optimal results.

Robustness Test

To ensure the reliability and validity of the findings, this study conducted a robustness test through two methods of varying the sample size. The results are in Table 6, (2) (3) columns.

The first method is to exclude special cities (Li et al., 2023), China's municipalities and sub-provincial cities have certain economic characteristics. Municipalities directly under the central government and sub-provincial cities have a higher administrative level and often have unique advantages in policy making, resource allocation, and financial support. This leads to the fact that the data of municipalities and sub-provincial cities are often much higher than other cities in some economic indicators, which may become outliers in the data. Therefore, this study re-runs the regression analyses after excluding the 4 municipalities and 15 sub-provincial cities. Column (2) of Table 6 indicates that the values and significance of the regression coefficients are only slightly different from the original results (1) after excluding the special city samples, and the robustness and scientific validity of the model is verified.

The second method is to shrink the tail of the data. Considering the effects of extreme values, all samples in this paper are sorted according to the level of HQED from high to low. The data less than 1% and more than 99% quantile are alternatively trimmed with values of 1% and 99%, respectively, and regression analyses are conducted based on this. The regression coefficients in Table 4.20 column (3) are not much different from the base regression, again proving that the empirical results are relatively robust.

Table 6
Robustness Test Result for Threshold Effects

Variables	（1）	（2）	（3）
GF（≤0.0537）	0.0830***	0.0713***	0.0759***
	(0.00911)	(0.00922)	(0.00897)
GF（>0.0537）	0.118***	0.108***	0.108***
	(0.00949)	(0.00948)	(0.00936)
GOV	0.0449***	0.0512***	0.0478***
	(0.00311)	(0.00377)	(0.00325)
URB	0.251***	0.272***	0.238***
	(0.0122)	(0.0123)	(0.0123)
PLO	0.121***	0.104***	0.123***
	(0.00689)	(0.00681)	(0.00698)
INF	0.00796***	0.00677***	0.00746***

	(0.00252)	(0.00252)	(0.00250)
MARKE	-0.00647	-0.000937	-0.0150
	(0.00917)	(0.00905)	(0.00942)
ECO	-0.00216***	-0.00192***	-0.00282***
	(0.000171)	(0.000168)	(0.000200)
Constant	0.102***	0.0917***	0.119***
	(0.00785)	(0.00761)	(0.00841)
Observations	3,384	3,156	3,384
Number of id	282	263	282
R-squared	0.590	0.592	0.605

Endogeneity Test

There may be a two-way causal relationship between green finance and HQED. In addition, there are more factors affecting the high economic development level, including institutional factors, international factors, economic factors etc., and there may be omitted variables in the model. Considering all of the above factors may cause endogeneity problems, this study conducts endogeneity tests through the following two instrumental variables.

In this study, we refer to the related study by Zhang et al. (2024) and choose green finance with a one-period lag as an instrumental variable to estimate the model. The instrumental variable needs to be uncorrelated with the disturbance term while highly correlated with the explanatory variables. From column (1) in Table 7, green finance with a one-period lag is closely related to the current explanatory variable green finance. Moreover, green finance with a one - period lag does not directly affect the explanatory variables and is uncorrelated with the disturbance term, thus satisfying the condition of instrumental variables. As shown in Table 1.7, the regression coefficient of green finance on the level of HQED is still significantly positive, which indicates that after the endogeneity problem is dealt with, the promotion effect of green finance on HQED is still significant. Meanwhile, after the test of weak instrumental variables, the F value is 3639.34, which is obviously greater than 10, showing that there are no weak instrumental variables, which indicates that the instrumental variables are selected effectively.

Table 7
Regression Results of Green Finance With a One-period Lag

Variables	(1)	(2)
	GF	HQDL
L.GF	0.758***	
	(60.33)	
GF		0.924***
		(66.22)
GOV	-0.003	0.007
	(-0.61)	(1.40)
URB	0.031**	0.072***

	(2.44)	(6.60)
PLO	-0.004	0.048***
	(-0.31)	(4.51)
INF	-0.008*	-0.007*
	(-1.91)	(-1.94)
MARKE	0.046***	-0.007
	(2.96)	(-0.50)
ECO	0.000	-0.000
	(0.22)	(-0.54)
Constant	0.052***	-0.030**
	(3.39)	(-2.31)
Observations	3,102	
R-squared	0.637	
Weak IV test	3639.34***	

Conclusions and Discussion

Considering that the promotion effect of green finance on HQED may be regulated and constrained by many external factors, thus there is a non-linear relationship.Therefore, this study introduces environmental regulation as a threshold variable.As shown by the single-threshold regression model, if the environmental regulation intensity is less than 0.0537,the impact coefficient is significant at 0.083.After crossing this threshold, the effect of the green finance on the HQED is more obvious, and the impact coefficient is significantly increased to 0.118. This result verifies the correctness of hypothesis . It suggests that environmental regulation in most Chinese cities brings there is an “innovation compensation” effect. Therefore, in order to improve the effectiveness of green finance, investment in and regulation of environmental pollution control should be appropriately increased.

Policy Implications and Recommendations

First, the empirical results demonstrate that green finance can effectively drive HQED. Consequently, China ought to continuously enhance its green financial system and reinforce relevant policy support. To begin with, a unified green financial standard system needs to be established. This system serves as the foundation and criterion for a series of green financial operations, including those related to green industries, green financial instruments, and corporate information disclosure. Simultaneously, governments should stimulate the development of green financial intermediaries and establish a multi-industry coordination mechanism for green finance.

Second, the threshold effect shows that the strength of environmental regulations has a significant impact on the role of green finance. Environmental policies, then, by setting stringent environmental standards and regulatory requirements, can prompt enterprises to increase green inputs, thereby creating more projects that are eligible for green financial support. Therefore, green finance policies need to be introduced in concert with

environmental policies. According to the empirical results, China should further increase its investment in environmental pollution control and strengthen environmental regulation and enforcement.

In the dimension of capital investment, governments at all levels should make environmental pollution control a key item to be safeguarded in their fiscal budgets. On the one hand, the central government should co-ordinate the establishment of special funds for environmental pollution control; on the other hand, local governments should actively broaden fund-raising channels, explore the issuance of green municipal bonds, and attract social capital to participate in environmental control projects.

At the level of regulation and enforcement, it is necessary to promote green technological innovation and internalise the cost of environmental pollution by strengthening environmental enforcement and improving technical standards. For example, we can appropriately raise the standard of sewage charges, levy a pollution tax and develop a tradable pollution licence system. By increasing the intensity of environmental regulation, the government, financial institutions and enterprises will be guided to form a common point of interest, prompting all three to take the initiative to assume the responsibility of spreading the concept of green consumption, and promoting the formation of HQED.

Contributions of the Study

This study makes important contributions at both the theoretical and practical levels. Theoretically, this study breaks the limitations of the research on the linear relationship between green finance and HQED, and innovatively explores the threshold effect of environmental regulation. Revealing the complex non-linear connection between the three can provide new perspectives for subsequent theoretical research. In practice, the study concludes that there exists a single threshold for green finance to promote HQED, which provides a quantitative basis for the government to formulate green finance and environmental regulation policies, and helps precise control. Moreover, this study proposes to increase the investment and regulation of environmental pollution control appropriately, which can help to improve the effect of green finance and achieve the goal of sustainable development.

References

Berrone, P., Fosfuri, A., Gelabert, L., & Gomez-Mejia, L. R. (2013). Necessity as the mother of 'green'inventions: Institutional pressures and environmental innovations. *Strategic Management Journal, 34*(8), 891-909.

Borsatto, J. M. L. S., & Bazani, C. L. (2021). Green innovation and environmental regulations: A systematic review of international academic works. *Environmental Science and Pollution Research*, 1-18.

Chai, Z. M., Deng, Y. T., & Han, X. F. (2024). The mechanism and effect research of green finance enhancing the resilience of manufacturing industry. *Journal of Central South University(Social Sciences), 30*(02), 114-130.

Chen, L., Ye, W., Huo, C., & James, K. (2020). Environmental regulations, the industrial structure, and high-quality regional economic development: Evidence from China. *Land, 9*(12), 517.

Dasgupta, P., & Stiglitz, J. (1980). Uncertainty, industrial structure, and the speed of R&D. *The Bell Journal of Economics*, 1-28.

Falcone, P. M. (2020). Environmental regulation and green investments: The role of green finance. *International Journal of Green Economics, 14*(2), 159-173.

Gao, J., Wu, D., Xiao, Q., Randhawa, A., Liu, Q., & Zhang, T. (2023). Green finance, environmental pollution and high-quality economic development—a study based on China's provincial panel data. *Environmental Science and Pollution Research, 30*(11), 31954-31976.

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. *Journal of econometrics, 93*(2), 345-368.

Hottenrott, H., & Rexhäuser, S. (2015). Policy-induced environmental technology and inventive efforts: is there a crowding out? *Industry and Innovation, 22*(5), 375-401.

Jaffe, A. B., & Palmer, K. (1997). Environmental regulation and innovation: a panel data study. *Review of economics and statistics, 79*(4), 610-619.

Jumbri, I. A., & Managi, S. (2020). Inclusive wealth with total factor productivity: global sustainability measurement. *Global Sustainability, 3*, e5.

Kemp, R., & Arundel, A. (1998). Survey indicators for environmental innovation.

Lachininskii, S., Liu, Z., & Solodilov, V. (2024). The reorientation of the economy of the Gansu region within the framework of the One belt—One road project implementation. *Pskov Journal of Regional Studies*(2), 26-41.

Lanoie, P., Patry, M., & Lajeunesse, R. (2008). Environmental regulation and productivity: Testing the porter hypothesis. *Journal of productivity analysis, 30*, 121-128.

Li, G., Gao, D., & Li, Y. (2022). Dynamic environmental regulation threshold effect of technical progress on green total factor energy efficiency: evidence from China. *Environmental Science and Pollution Research, 29*(6), 8804-8815.

Li, H., & Li, B. (2019). The threshold effect of environmental regulation on the green transition of the industrial economy in China. *Economic research-Ekonomska istraživanja, 32*(1), 3128-3143.

Li, Y., Hu, H. Y., & Li, H. (2020). Empirical Analysis of the Impact of Green Credit on the Upgrading of China's Industrial Structure: Based on Chinese Provincial Panel Data *Journals*(1), 37-43.

Li, Y., & Liu, W. (2023). Spatial effects of environmental regulation on high-quality economic development: From the perspective of industrial upgrading. *Frontiers in Public Health, 11*, 1099887.

Li, Z., Zhang, Y., & Zhao, Z. (2023). Digital Economy and Industrial Green Transformation——Mediation Effect and Threshold Effect Based on Scientific and Technological Innovation. *Journal of Industrial Technological Economics, 42*(10), 3-16.

Liu, W., Huang, Z., & Ibrahim, A. M. (2013). The Path Dependence of Industry Structure Adjustment in Chongqing: Central Government Political Decision. *Asian Economic and Financial Review, 3*(8), 978.

Liu, Y., Wang, A., & Wu, Y. (2021). Environmental regulation and green innovation: Evidence from China's new environmental protection law. *Journal of cleaner production, 297*, 126698.

Ouyang, X., Shao, Q., Zhu, X., He, Q., Xiang, C., & Wei, G. (2019). Environmental regulation, economic growth and air pollution: Panel threshold analysis for OECD countries. *Science of The Total Environment, 657*, 234-241.

Porter, M. (1996). America's green strategy. *Business and the environment: a reader, 33*, 1072.

Porter, M. E., & Linde, C. V. D. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of economic perspectives, 9*(4), 97-118.

Ramanathan, A., & Samuel, A. (1998). Financial Liberalisation and Economic Development: The Theory and Experience. *The Indian Economic Journal, 46*(1), 20-29.

Ren, S., Li, X., Yuan, B., Li, D., & Chen, X. (2018). The effects of three types of environmental regulation on eco-efficiency: A cross-region analysis in China. *Journal of cleaner production, 173*, 245-255.

Sato, M., Tanaka, K., & Managi, S. (2018). Inclusive wealth, total factor productivity, and sustainability: an empirical analysis. *Environmental Economics and Policy Studies, 20*, 741-757.

Trevlopoulos, N. S., Tsalis, T. A., Evangelinos, K. I., Tsagarakis, K. P., Vatalis, K. I., & Nikolaou, I. E. (2021). The influence of environmental regulations on business innovation, intellectual capital, environmental and economic performance. *Environment Systems and Decisions, 41*, 163-178.

Wang, M. L., Pang, S., Hmani, I., Hmani, I., Li, C., & He, Z. (2021). Towards sustainable development: How does technological innovation drive the increase in green total factor productivity? *Sustainable Development, 29*(1), 217-227.

Wang, R., & Wang, F. (2022). Exploring the role of green finance and energy development towards high-quality economic development: application of spatial Durbin model and intermediary effect model. *International Journal of Environmental Research and Public Health, 19*(14), 8875.

Wang, Y. Q., & Guo, Q. (2022). Research on the Coordination and Development of Green Finance and Industrial Green Development in the Yangtze River Economic Belt. *Journal of Hohai University(Philosophy and Social Sciences), 24*(2), 53-59.

Ye, T. L., & Mao, R. C. (2019). Coordinated Industrial Development of the Beijing-Tianjin-Hebei Region: An Analysis Based on Enterprise Big Data. *Analysis of the Development of Beijing (2018)*, 261-280.

Zeng, X. W., Liu, Y. W., Man, M. J., & Shen, Q. L. (2014). Measurement Analysis of the Development Level of China's Green Finance. *Journal of China Executive Leadership Academy Yan'an*(6), 112-121.

Zeng, Y., Han, F., & Liu, J. F. (2019). Does the Agglomeration of Producer Services Promote the Quality of Urban Economic Growth? . *The Journal of Quantitative & Technical Economics, 36*(05), 83-100.

Zhang, W., & Qian, X. Y. (2011). China Science and Technology Information. *中国科技信息* (14), 214.

Zhang, Y., Zhang, J., & Liu, Y. (2024). Does green finance promote the improvement of regional eco-efficiency? Direct and spillover effects. *Frontiers in Environmental Science, 12*, 1506734.

Zhao, T., Zhang, Z., & Liang, S. K. (2020). Digital Economy, Entrepreneurship, and High-Quality Economic Development:Empirical Evidence from Urban China. *Management World, 36*(10), 65-76.