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Original Research

Has Green Credit Promoted High-Quality Economic Development? Evidence from China

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Abstract

The government and academic community have widespread concerns about how China utilizes financial resources to direct credit allocation and achieve high-quality economic development, especially under the dual pressures of resource constraints and environmental challenges. Analyzing panel data from 30 Chinese provinces from 2008 to 2020, this paper constructs evaluation indicators of high-quality economic development and aims to explore the impact of green credit on such development. The study concludes that green credit significantly contributes to high-quality economic development. This effect varies based on regional location, bank competition levels, the development quality of intermediary organizations, and local government debt pressure. In terms of mechanisms, the advancement of green technology, industrial structure upgrading, and energy consumption structure adjustment emerge as key transmission mechanisms. The findings underscore the importance of actively promoting green credit, steadily increasing green finance initiatives, and skillfully directing capital flows toward resource- and technology-efficient, environmentally-friendly businesses. This approach is essential to accelerate the shift in the economic development model and foster the growth of a green economy.

Keywords: green credit, economic quality development, intermediation effect, heterogeneity analysis

Introduction

For a long time, China has relied on an unsophisticated, resource-intensive development model to achieve rapid economic growth, leading to significant environmental challenges. The current strategic goal of China's economic development focuses on enhancing the greening of the existing economic system to realize both green and high-quality economic growth. Achieving this requires not only the implementation of comprehensive environmental remediation measures but also the use of financial tools to modify the foundational incentive structure for resource allocation. Green finance offers a range of investment and financing solutions to address environmental issues and is essential for promoting economic growth and environmental quality control, as well as for setting the groundwork for upcoming industrial optimization and transformation [1, 2].

Green credit, a key element of green finance, is essential to China's bank-centered financial system. In 2012, the former China Banking Regulatory Commission (CBRC) formally endorsed the Green Credit Standard, establishing the policy framework for green credit. These guidelines aim to steer capital towards

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projects that promote energy conservation, emission reduction, and other eco-friendly initiatives, thereby strategically advancing green credit. The banking sector and other financial institutions are tasked with limiting credit investment in industries characterized by high energy consumption, high pollution, and excess capacity, the "two high and one leftover" sectors [3, 4]. Concurrently, they are encouraged to enhance credit support for eco-friendly enterprises, integrating considerations of environmental protection and resource conservation into the financial industry's evaluative and decision-making processes. This strategic deployment of credit resources directs societal funds towards industries with lower energy consumption and superior environmental protection, counteracting environmental degradation and addressing ecological shortfalls, paving the way for sustainable economic development [5, 6].

Current research on green credit is concentrated on two primary aspects. At the micro level, scholars have observed that green credit policies effectively restrict the financing scope of heavily polluting companies, significantly escalating their financing costs and terms. This, in turn, curtails their polluting activities. Concurrently, these policies have been shown to alleviate financing constraints and reduce costs for environmentally friendly firms [7, 8], influencing their investment decisions [9, 10] and inputs in technology research and development [11, 12]. Wang et al. [10] demonstrate that green credit policies considerably diminish capital investments in energy-intensive businesses, though debates persist regarding their impact on operational efficiency [13, 14]. Moreover, some academics highlight the significant influence of green credit policies on commercial banks' operational choices as issuers of clean loans. Opinions diverge on whether these policies foster improved bank development [15, 16]. One perspective suggests that in light of growing global environmental regulations, financial institutions should integrate environmental risks into their social responsibility and risk management strategies. It is believed that banks will refine their risk management approaches and credit structures under green credit implementation, thereby reducing non-performing loans [17, 18]. Alternatively, the ineffective implementation of green credit policies and insufficient policy support, attributed to corporate inaction and government leniency, impede green credit's growth in China [19].

At the macro level, scholars note that post-implementation of green credit, financial institutions decrease loans to highly polluting companies. This restricts their production and investment, consequently lowering pollutant emissions and aiding environmental improvement [20, 21]. Additionally, some scholars point out that green credit policies promote industrial upgrading [22], strengthen technological innovation [23], improve energy efficiency [24], and realize the green development of the economy [25]. However, there are assertions that green credit might hinder economic growth rather than improve environmental quality [26].

According to the literature currently in publication, while some researchers have focused on how green credit policies affect business decisions, environmental pollution, and green energy efficiency, they have rarely examined how these policies affect high-quality economic development, which has a wider range of implications and is more consistent with China's current strategic goal of economic development than green economic development. Furthermore, without the backing of governmental, financial, and legal control, neither the advancement of green credit policies nor the accomplishment of the objective of superior economic development can be difficult to achieve. The reasons are: First, the way local governments behave will have a big impact on how well the green credit policy is implemented. This is because they are the ones who directly promote and carry out local economic policies, and their actions have a direct impact on the local economy and environmental performance. Second, China's financial system contains credit and financial mismatches, which result in inefficient investments and a decline in business productivity. As the foundation of the financial system, the banking sector plays a crucial role in directing credit money, therefore it's imperative to distribute credit fairly and fund high-efficiency projects that cut pollution. Finally, the main means of financial development of synergistic green credit is through the configuration and guidance of green funds. However, this requires a lot of interdisciplinary, professional intermediary organizations to offer technical support, including environmental risk assessment, green asset assessment, and green credit assessment. As a result, the local financial market environment and the intermediary organization can have a direct impact on how efficiently credit funds are allocated for green credit. Therefore, the effectiveness of green credit cannot be accurately assessed without taking into account the above factors.

This paper makes the following incremental contributions: (1) Total factor productivity, or green total factor productivity, has been utilized by previous researchers as a stand-in for high-quality economic growth. This is a limited perspective that deviates greatly from the Chinese government's present strategic aims for high-quality development. Therefore, this article uses the definition of high-quality economic development provided by the Chinese government, evaluating it according to five criteria: innovation, coordination, greenness, openness, and sharing. This strategy extends the research focus on green credit and superior economic development while addressing the drawbacks of utilizing a single indicator. (2) The paper explores the role of green credit in fostering high-quality economic development from both theoretical and empirical perspectives, uncovering three critical mechanisms: green technological advancement, industrial upgrading, and energy consumption structure transformation. This expands the research horizon of green credit studies. (3) Beyond regional heterogeneity

analysis, this research also examines the heterogeneous effects of green credit from perspectives such as government debt levels, banking competition, and the completeness of market intermediary laws. This enables a better understanding of the external constraints on the implementation of green credit, offering more targeted policy options for the Chinese government to expedite economic transformation.

Theoretical Analysis and Research Hypotheses

By June 2023, China's green credit balance reached an impressive 25 trillion yuan, establishing it as a crucial component of the green economy [27] and one of China's most essential green tools [28]. With a focus on resource conservation and environmental protection, green credit influences credit allocation within the banking sector, lowering financing costs for green industries and reshaping sectors like industrial, energy, and transport. This promotes green industrial transformation and high-quality economic growth [20]. According to Hu et al. [12], green credit policies, through credit constraints on polluting enterprises, encourage technological advancements and product innovation, leading to green transitions. Zhang et al. [27] argue that these policies redirect financial resources towards R&D and innovation in green sectors, thereby stimulating economic development through green transformation. Conversely, green credit policies encourage financial institutions to adopt a 'green layout' in their credit distribution, easing funding constraints for eco-friendly enterprises and fostering clean projects or green innovation. This strategy strengthens green technological innovation, boosts energy efficiency, and improves operational performance, contributing to green transformation [23]. Based on this understanding, the first hypothesis (H1) is proposed:

H1: Green Credit Can Effectively Promote High-Quality Economic Development.

Green credit policies, integrating environmental considerations into credit decisions, aim to promote economic green transformation through the judicious allocation of credit resources. On one hand, these policies curtail loans to high-polluting enterprises, increase their loan rates, and hike interest charges, thus raising the financing costs of production. Faced with high pollution costs, companies must rely on green technological innovation to mitigate environmental risks and reduce pollution expenses [12]. On the other hand, green credit policies enhance support for environmentally friendly enterprises by lowering their loan rates and increasing financing, easing their funding constraints. This allows eco-friendly enterprises to allocate more funds towards R&D, advancing green technology [11, 23]. Building on these insights, the second hypothesis (H2) is formulated:

H2: Green Credit Achieves High-Quality Economic Development by Promoting Green.

Technological Innovation

Green credit plays a vital role in fostering industrial structure upgrading by reshaping the ecosystem of green industry, manufacturing, and consumption, and directing capital towards environmentally friendly sectors using financial tools [28]. Its mechanism for promoting industrial transformation includes three key aspects: Firstly, the capital flow mechanism utilizes innovative financial instruments in environmental finance to redirect funds towards green industries, thereby triggering restructuring and shifting investments from high-energy-consuming and polluting industries to environmentally friendly ones [22]. Secondly, the industry integration mechanism uses the modern financial market to gather capital for the integration of green industries, creating economies of scale, breaking down industry barriers, and enhancing the long-term competitiveness of these sectors [29, 30]. Thirdly, the policy guidance mechanism involves green policies strategically limiting credit to high-energy-consuming industries while encouraging the growth of eco-friendly sectors, facilitating the transition to a green economy. Based on these insights, the paper proposes the following hypothesis:

H3: Green Credit Realizes High-Quality Economic Development by Achieving Industrial.

Structure Upgrading

Green credit policy, by promoting green consumption from the demand side, aims to address the environmental crisis. Increasing public awareness of green consumption can change consumer preferences and stimulate green industry development through market supply and demand. Firstly, by appropriately guiding public opinion, the public will develop greater concern for environmental issues and support energy conservation and emission reduction, thus enhancing public green awareness and increasing the use of clean energy. Secondly, the policy actively promotes green consumption and the widespread use of green products and technologies, altering the energy consumption patterns of enterprises and individuals, and promoting the development of clean energy. Building on these insights, the second hypothesis (H4) is formulated:

H4: Green credit realizes high-quality economic development by restructuring energy consumption.

Experimental Procedures

Basic Model

To explore the relationship between green credit and high-quality economic development, the following regression model was built for this study:

$$HD_{it} = \partial + \alpha \mathrm{GC}_{it} + \beta \vec{X} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

The level of the index of high-quality economic development in i province in year t is represented by the explanatory variable HD_{it} in the equation (1); the GC_{it} is Green $credit_{it}$; $\vec{X}$ denotes a set of control variables; i denotes any of the 30 provinces in China; t denotes the sample interval, 2008 - 2020, and δ_t, μ_i and ε_{it} denote time effects, individual effects, and random disturbance terms, separately.

Variables

(1) High-quality Economic Development (HD): Since numerous factors contribute to high-quality economic development, including social coordination, ecology and environment, the structure and efficiency of economic growth, and more, the index's creation must be thorough and meticulous. Total factor productivity has generally been used in previous research as an indication of the quality of economic growth [31]. Total factor productivity, which disregards energy inputs and environmental considerations, is insufficient to depict the quality of economic development, even though it can describe the efficiency of economic development more fully. Green Total Factor Productivity, which takes energy and environmental inputs into account, has since been selected by academics as a high-quality development evaluation indicator [32, 33]. However, Green Total Factor Productivity remains extremely limited and biased, unable to fully capture the core of high-quality economic development even after taking energy inputs and environmental outputs into account. To address the problems of economic, social, and environmental development as well as the transition to sustainable development, the 193 member states of the United Nations formally established 17 Sustainable Development Goals in 2015. Countries are also introducing their sustainability rating systems based on this objective. Some examples of these are the National Welfare Evaluation System in Germany [34], the Sustainable Development Evaluation System in the European Union [35], and the New Economy Evaluation System in the United States [36]. The importance of high-quality economic growth varies slightly throughout countries, though, as each has a different degree of economic development and resource endowment. An objective collection of indicators is needed to determine the state of development of a country [37].

The Chinese government defines high-quality development as one that successfully meets the population's growing need for a higher standard of living. The definition states that coordination is an endogenous trait, openness is a critical path, green is a universal form, sharing is a fundamental objective, and innovation is the main engine. The "Five Development Concepts," which include all facets of China's social and economic development, are currently widely used as a foundation for scientific evaluations of the quality of the growth in the new millennium and for conducting scientific assessments of the growth's quality. Thus, the five development concepts are utilized to determine the level of HD. Table 1 lists the relevant indicators. The weighted values in this work are derived using the objective weighting approach, and the model is computed as follows:

1. Normalize each index's data as follows:

$$X_{ij}^{'} = \begin{cases} \dfrac{x_{ij} - min\left(x_{ij}\right)}{max\left(x_{ij}\right) - min\left(x_{ij}\right)} \left(\text{If } x_{ij} \text{ is a positive indicator}\right) \\ \dfrac{max\left(x_{ij}\right) - x_{ij}}{max\left(x_{ij}\right) - min\left(x_{ij}\right)} \left(\text{If } x_{ij} \text{ is a negative indicator}\right) \end{cases}$$

Where x_{ij} and $X_{ij}^{'}$ represent the province I and dimension J Index indices before and following normalization, respectively.

2. Determine the information entropy:

$$P_{ij} = X_{ij}^{'} / \sum_{i=1}^{n} X_{ij}$$

And

$$H_j = \frac{1}{LN\left(n\right)} \sum_{i=1}^{n} P_{ij} * LN\left(P_{ij}\right)$$

Where P_{ij} represents the province I feature weight for dimension j.

3. Weighting of measurement indicators:

$$W_j = \left(1 - H_j\right) / \sum_{j=1}^{m} (1 - H_j \right)$$

(2) Green Credit (GC): Provincial-level data is not available in the current green credit ratio, which only publishes information from 21 big banks. The industrial pollution control investment's "bank loan data" are only counted up until 2010, which is out of alignment with the paper's sample period. After careful consideration, this paper uses the Guo et al. study [38] as a basis and chooses the interest expense ratio of non-six high energy-consuming industries to gauge the extent of green credit because, in the first place, changes in China's industrial interest expense are correlated with loan sizes, and interest rates in the country's banking sector do not differ significantly. Second, the primary objective of green credit policy is to enhance lending support for businesses that promote environmental protection. This indicator shows the credit support for green industries and environmental protection, which is more consistent with the policy's objective.

Table 1. Indicator system for measuring high-quality economic development.

Primary Indicators	Secondary Indicators	Calculation Methodology	Indicator Properties
Innovation	R&D expenditure intensity	R&D expenditure/GDP	+
	Number of patent applications	Total number of patent applications/year-end population	+
	Degree in technology market development	Technology market turnover/GDP	+
	GDP growth rate	GDP growth speed	+
Coordination	Demand structure	Total retail sales of social consumer goods / GDP	+
	Urban-rural structure	Urbanization rate	+
	Industry structure	Primary sector*1 + Secondary sector *2 + Tertiary sector *3	+
	Urban-rural income gap	Urban disposable income/rural disposable income	-
Green	Energy consumption per unit of GDP	Combined energy consumption / GDP	-
	Greening area of built-up area	Greening coverage of built-up areas	+
	Unit output wastewater discharge degree	Wastewater emissions/GDP	-
	Unit output wastewater discharge degree	Sulfur dioxide emissions/GDP	-
Open	The level of opening to the outside world	Total imports and exports/GDP	+
	Export contribution	(Exports - Imports)/GDP	+
	Actual Utilization of Foreign Investment	Actual Utilization of Foreign Investment/GDP	+
	Actual amount of foreign investment	External real investment/GDP	+
Share	Infrastructure level	Number of road miles /10000	+
	Medical level	Number of medical beds/10000	+
	Development Sharing	Resident income growth rate/GDP growth rate	+
	Urban and rural consumption	Urban consumption expenditure/rural consumption expenditure	-
	Education Level	The proportion of students enrolled in institutes of general higher education	+

(3) Mediating Variables: Green technological innovation (Gti) is expressed using the number of green patent applications by 10,000 people. Industrial structure upgrading (Uis) is expressed using the ratio of the output value of the third sector to the second sector. Energy consumption structure (Ecs) is expressed as the proportion of clean energy consumption.

Other control variables: Government intervention (Gov): The government may provide a wide range of public goods and services with positive externalities and remedy different market failures with the resources already at its disposal. This will encourage private investment and economic progress. Yet, over-expansion of the government may also have the unintended consequence of creating a "crowding out" effect, which can lower the effectiveness of administrative services, put undue strain on the budget, and ultimately result in an inadequate supply of public goods and services, which lowers total factor productivity. In this study the government's fiscal expenditure as a percentage of GDP. The degree of industrialization (Di): The traditional industrial system is an important driver for realizing China's economic development, but it is also considered an important source of environmental pollution, which is expressed in this paper using the ratio of industrial value added to GDP. Level of environmental regulation (ER): Environmental regulation has the potential to raise business operating expenses and lower productivity, both of which are detrimental to economic expansion. However, environmental regulations also encourage technological innovation by businesses, which not only helps to offset the costs associated with regulations but also boosts the competitiveness of those businesses by leveraging technological advancements brought about by technological innovation. This study builds the environmental regulation evaluation index based on Shen and Liu (2012) [39]. Level of economic development (Lnrgdp): The environmental Kuznets curve shows that environmental pollution follows an inverted "U" curve with the level of economic development, i.e., as the income level increases, the level of environmental pollution rises to a certain level

and then improves. Therefore, in this paper, we add the main and square terms of the level of economic development to examine this relationship.

Data Source

This research used publicly accessible data sources, including the National Bureau of Statistics, China Statistical Yearbook, and China Environmental Statistical Yearbook, to gather panel data for 30 randomly chosen Chinese provinces and cities between 2008 and 2020, taking into account the study's representativeness and data accessibility. 2008 is recognized as the study's beginning year because the idea of green credit was first proposed in 2007.

Results and Discussion

Benchmark Regression Analysis

In academic research, fixed-effect models are commonly used to address constant and unobservable endogeneity. The Hausman test was also applied to the models in this study. Due to its relevance in empirical analysis, a two-way fixed effects model accounting for both time and regional variables was used for analysis in this paper's future studies.

The results of this investigation, which used stepwise regression, are shown in Table 2 and show that the coefficient of GC is significantly positive. This suggests that increasing green credit enhances the economy's level of high-quality development. Green credit encourages environmentally conscious growth in businesses by increasing their environmental awareness [8], and directs investment towards low-energy and pollutant-consuming enterprises, thereby supporting high-quality economic development through optimal financial asset allocation [16]. Additionally, the financial regulation introduced by green credit propels businesses towards environmental consciousness, aiding in production efficiency and technological advancement.

The regression findings for the control variables are also displayed in Table 2. The negative regression coefficient of -0.058 for government intervention suggests that excessive intervention distorts resource allocation and hinders green development. China's GDP-based performance appraisal system fosters intergovernmental competition, often leading to relaxed environmental regulations. The negative coefficient of Di implies that heightened industrialization impedes high-quality economic development. Environmental regulation, with a regression coefficient of 0.032, shows that government action can limit businesses' production behaviors, encouraging them to invest in pollution

Table 2. Baseline regression results.

	(1)	(2)	(3)	(4)	(5)
GC	0.062***	0.062***	0.063***	0.060***	0.080***
	(0.017)	(0.018)	(0.018)	(0.018)	(0.017)
Gov		-0.006	-0.007	-0.019	-0.058**
		(0.024)	(0.025)	(0.025)	(0.026)
Di			-0.032	-0.035	-0.023
			(0.040)	(0.040)	(0.044)
ER				0.023*	0.032***
				(0.012)	(0.012)
Lnrgdp					0.080***
					(0.021)
$Lnrgdp^2$					-0.018***
					(0.005)
cons	0.199***	0.200***	0.185***	0.186***	0.183***
	(0.008)	(0.011)	(0.022)	(0.022)	(0.021)
Time fixed	Yes	Yes	Yes	Yes	Yes
Individual fixed	Yes	Yes	Yes	Yes	Yes
N	390	390	390	390	390
R^2	0.541	0.541	0.542	0.547	0.596

Note: Standard errors in parentheses, ***p<0.01; **p<0.05; *p<0.1.

control measures, and thus advancing high-quality economic development. The coefficients of Lnrgdp and Lnrgdp^2, at 0.080 and -0.018 respectively, suggest an inverted U-shaped relationship. Issues such as income disparity, uncoordinated urban-rural development, illogical industrial structure, and severe environmental pollution, which contradict high-quality economic development, indicate the need for structural and mechanism adjustments in China's economic development.

Mechanism Testing

Drawing on the aforementioned theoretical works, this paper employs a mediated effects model to demonstrate the importance of green credit channels by drawing on Baron and Kenny's (1986) [40] study. Equation (1) serves as the foundation for the introduction of Equations (2) and (3).

$$M_{it} = \partial_1 + \alpha_1 GC_{it} + \beta \vec{X} + \mu_i + \delta_t + \varepsilon_{it} \quad (2)$$

$$HD_{it} = \partial_2 + \alpha_2 GC_{it} + \rho_0 M_{it} + \beta \vec{X} + \mu_i + \delta_t + \varepsilon_{it} \quad (3)$$

Where M_{it} is the mediating variable, if α in Equation (1) is significant, α_0 in Equation (2) is significant, and ρ_0 in Equation (3) is significant, it means that the mediating effect is significant. In the meantime, Table 3 displays the regression findings. If α_1 is significant at the same time, it indicates a partial mediating impact; if not, it indicates a full mediating effect.

Column (1) of Table 3 examines the overall impact of GC, aligning with the findings in Column

Table 3. Mechanism tests.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HD	Gti	HD	Uis	HD	Ecs	HD
GC	0.080***	3.499***	0.043**	0.457***	0.069***	0.135***	0.061***
	(0.017)	(0.370)	(0.019)	(0.087)	(0.018)	(0.015)	(0.020)
Gti			0.011***				
			(0.003)				
Uis					0.022*		
					(0.012)		
Ecs							0.143**
							(0.070)
Gov	-0.058**	1.375**	-0.073***	0.205	-0.054**	0.012	-0.060**
	(0.026)	(0.563)	(0.026)	(0.132)	(0.026)	(0.022)	(0.026)
Di	-0.017	4.271***	-0.063	-2.895***	-0.080	0.153***	-0.039
	(0.042)	(0.919)	(0.043)	(0.216)	(0.054)	(0.036)	(0.044)
ER	0.031***	1.953***	0.0100	0.606***	0.045***	0.045***	0.025**
	(0.012)	(0.254)	(0.013)	(0.060)	(0.014)	(0.010)	(0.012)
Lnrgdp	0.078***	-2.455***	0.104***	-0.654***	0.063***	-0.072***	0.088***
	(0.020)	(0.432)	(0.021)	(0.102)	(0.021)	(0.017)	(0.021)
Lnrgdp^2	-0.019***	1.142***	-0.031***	0.060**	-0.017***	0.021***	-0.022***
	(0.005)	(0.103)	(0.006)	(0.024)	(0.005)	(0.004)	(0.005)
cons	0.181***	-2.861***	0.211***	2.146***	0.227***	-0.061***	0.189***
	(0.020)	(0.425)	(0.021)	(0.100)	(0.032)	(0.017)	(0.020)
Time fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	390	390	390	390	390	390	390
R^2	0.596	0.760	0.617	0.897	0.601	0.610	0.599

Note: Standard errors in parentheses, ***p<0.01; **p<0.05; *p<0.1.

(5) of Table 2, as detailed above. In Column (2), the regression coefficient of GC on Gti is significant at 3.499, indicating that green credit notably promotes green technology innovation. Column 3's results, with significant coefficients of 0.043 for GC and 0.011 for Gti, indicate a partial mediation effect. On one hand, green credit policy increases financing costs for businesses, reduces loan amounts for "two high and one leftover" industries, imposes punitive high-interest rates, and compels polluting businesses to adopt greener practices. On the other hand, it necessitates greater support for the low-carbon green economy, reducing financial barriers for environmentally friendly businesses, thereby enhancing their ability to invest in technological R&D, and advancing green technology [23].

In Columns (4) and (5), the positive coefficients on GC and Uis suggest that industrial structure upgrading is an intermediate mechanism of green finance. Green finance restricts the financing access of "two high" industries, compelling them to modernize and adopt environmentally friendly practices while directing industries towards green environmental protection through capital investments [22].

In Column (6), the significantly positive coefficient of 0.135 for GC indicates that GC influences Ecs. In Column (7), the regression coefficients of GC and Ecs, respectively, are significant at 0.061 and 0.143, highlighting that energy consumption structure is an intermediary mechanism. Green credit policies have increased public environmental awareness, promoted individual green consumption, and supported the adoption and popularization of low-carbon, eco-friendly technology and products, such as new energy vehicles and green housing. Additionally, these policies have enabled industrial businesses to undertake energy-saving renovations, foster the development and use of renewable energy, and transform the energy consumption structure towards a low-carbon, environmentally friendly model.

Heterogeneity Analysis

Regional Heterogeneity

Based on the regression results presented in Table 4, it can be inferred that the central and western regions are more impacted by green credit, since the GC coefficient in Column (2) is significant at 0.037 but is insignificant in the regression results for the eastern region. This disparity is attributable to the Eastern region's economy previously being dominated by secondary industries, where traditional industries often prioritize economic growth at the expense of the environment. In contrast, China's current green credit policy primarily focuses on supporting green projects, predominantly in low-carbon industries. Additionally, the eastern region's over-investment in traditional industries hinders their transformation, rendering green credit less effective for promoting green development there. Consequently, green financing in the Eastern region has a limited impact on promoting green growth. The industrial landscape of the Central-Western areas, with their relative emphasis on agriculture and animal husbandry, creates a conducive environment for green industry growth.

Heterogeneity in the Level of Bank Competition

In China, where indirect financing is predominant and bank credit is a crucial financing source for firms, bank competition reflects the extent of regional financial development. A competitive banking environment impacts bank behavior, with increased competition easing corporate financing constraints, promoting innovation, and boosting productivity. Variations in regional banking competition levels may lead to different outcomes, and this paper further examines whether green credit policy effects are influenced by regional banking competition levels. This is analyzed in two subsamples: regions with strong and weak competition. Financial license information from banking institutions is sourced from the China Banking and Insurance Regulatory Commission, excluding policy banks, credit unions, rural cooperative banks, and other financial institutions due to their policy-oriented role. The calculation of the bank's competition level is as follows:

$$HHI = \sum_{K=1}^{K} (Branch_k / Total_{Branch})^2$$

where $Branch_k$ represents the number of branches of Bank K, and $Total_{Branch}$ is the total number of commercial bank branches in the area. A higher HHI value, ranging from 0 to 1, indicates less competitive banking in the area.

Table 4 (Columns (3) and (4)) shows that areas with less bank competition have higher regression coefficients, suggesting that corporate financing constraints are typically stricter in these regions, especially for green businesses. Green credit in these areas facilitates green innovation by alleviating financial constraints. Conversely, stronger bank competition, indicated by more business financing avenues and a comprehensive financial system, results in relatively fewer incentives and constraints in green credit policy implementation. To optimize the role of green finance in high-quality development, future policy formulation and implementation should include rigorous review and monitoring of the credit resources in the financial sector.

Differences in Market Intermediary Organization and Legal System Environment

The primary function of green credit is to guide the allocation of green funds, a process requiring technical expertise from professional organizations in disciplines such as risk assessment, green asset evaluation, and green credit rating. Consequently,

well-developed regional market intermediaries, like accounting firms and credit rating agencies, enhance green credit fund allocation by providing essential support services to financial institutions.

In this study, "the development of market intermediary organizations and the legal environment" is used as a measure. Regions are categorized based on the median value of the calendar year. Provinces above the current year's sample median are considered to have a "good intermediary organization and institutional environment," while those below are deemed to have a "poor intermediary organization and institutional environment."

Regression results from Table 4 (Columns (5) and (6)) indicate that regions with better-developed intermediary and market organizations, as opposed to less developed ones, exhibit significant positive regression coefficients for green credit. This suggests that green credit funds are more effectively allocated in regions with stronger institutional environments and intermediary organizations, facilitating the channeling of funds to environmentally friendly businesses and encouraging corporate green innovation, thereby promoting high-quality economic development.

Heterogeneity in Local Government Debt Levels

Green credit is a primary mechanism through which governments use financial leverage to encourage environmental protection behavior, primarily implemented by regional commercial banks. These banks, often state-owned enterprises with local government equity participation, are closely linked to local governments. Over-indebtedness of local governments can strain local bank credit funds, leading to increased interest rates and bank funding costs, thereby reducing enterprise loan costs and debt financing scale, and decelerating overall bank credit, impacting liquidity creation.

Furthermore, increasing local government debt intensifies the pressure for economic development and reliance on "two high and one leftover" businesses, limiting the effectiveness of green credit policies. Therefore, this paper uses the local government debt ratio, drawing from Lv's research [41], to represent the pressure of local government debt. The study finds that the regression coefficient in areas with low local government debt is 0.070, while it is not significant in areas with higher government debt. This suggests that in regions with higher local government debt

Table 4. Analysis of heterogeneity.

	Geographical location		Bank competition		Intermediary organizations		Government debt	
	East	Midwest	High	Low	High	Low	High	Low
GC	0.010	0.037*	0.045*	0.056***	0.012	0.039*	0.029	0.070***
	(0.035)	(0.020)	(0.031)	(0.018)	(0.026)	(0.020)	(0.032)	(0.023)
Gov	0.274***	-0.065***	-0.070***	-0.001	-0.103	-0.041*	-0.017	-0.029
	(0.090)	(0.024)	(0.020)	(0.055)	(0.067)	(0.022)	(0.078)	(0.031)
DI	0.359***	-0.118***	-0.094**	0.151	-0.018	-0.129***	-0.066	0.034
	(0.131)	(0.041)	(0.036)	(0.095)	(0.070)	(0.043)	(0.085)	(0.054)
ER	-0.008	-0.006	-0.022	0.059***	0.090***	-0.009	0.015	0.048***
	(0.018)	(0.021)	(0.015)	(0.020)	(0.017)	(0.015)	(0.038)	(0.015)
Lnrgdp	-0.131**	0.093***	0.061***	0.0410	0.0370	0.042*	0.146***	0.035
	(0.054)	(0.024)	(0.020)	(0.041)	(0.029)	(0.023)	(0.034)	(0.028)
$Lnrgdp^2$	0.009	-0.004	0.003	-0.025***	-0.043***	-0.014**	-0.033***	-0.011
	(0.011)	(0.006)	(0.005)	(0.008)	(0.007)	(0.007)	(0.007)	(0.008)
cons	0.238***	0.209***	0.207***	0.161***	0.285***	0.224***	0.168***	0.187***
	(0.061)	(0.021)	(0.018)	(0.041)	(0.034)	(0.021)	(0.034)	(0.026)
Time fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	143	247	196	194	196	194	196	194
R^2	0.480	0.790	0.849	0.513	0.801	0.504	0.790	0.605

Note: Standard errors in parentheses, ***p<0.01; **p<0.05; *p<0.1.

and economic growth pressure, the "punitive" effect of green credit policy on the debt financing of "two highs and one leftover" enterprises is diminished, weakening the policy's implementation impact.

Robustness Test

(1) Excluding municipalities: The empirical analysis is re-conducted excluding municipalities under the central government, owing to their distinct status from other provinces. (2) Addressing anomalies: The study addresses potential anomalies by recalculating with a 5% shrinkage procedure. Table 5 shows a significantly positive regression coefficient, underscoring green credit's strong impact on high-quality economic development. (3) Following Min and Hua [42], control variables are lagged by one period to address potential endogeneity. (4) Addressing potential omitted variables: The study further employs the system-generalized method of moments estimation (SYS-GMM) to resolve potential endogeneity issues. Table 5's Column (4) presents the regression results. Sargan's test validates the instrumental variables, with the AR(1) p-value less than 0.1, and the AR(2) p-value greater than 0.1, affirming model validity. (5) This study employs the green credit development from the previous period as an instrumental variable. The development of green credit in the previous period influences the current period's green credit development through the ratchet effect, thereby impacting HD. Importantly, this approach ensures that the high-quality economic development in the current period does not affect the historical green credit development in the previous period, effectively addressing the issue of endogeneity. The endogeneity test and regression results associated with Column (5) in Table 5 indicate that the results are robust.

Table 5. Robustness test.

	(1)	(2)	(3)	(4)	(5)
GC	0.050**	0.128***	0.058***	0.011***	0.085***
	(0.020)	(0.029)	(0.015)	(0.002)	(0.018)
L.HD				0.952***	
				(0.025)	
Gov	-0.052**	-0.050*	-0.017	-0.005	-0.062**
	(0.026)	(0.030)	(0.032)	(0.005)	(0.026)
Di	-0.104**	-0.028	-0.121***	0.063***	0.048
	(0.043)	(0.043)	(0.038)	(0.017)	(0.045)
ER	-0.017	0.029**	0.005	0.023***	0.021
	(0.015)	(0.011)	(0.020)	(0.005)	(0.014)
Lnrgdp	0.130***	0.123***	0.144***	0.036***	0.077***
	(0.024)	(0.022)	(0.013)	(0.004)	(0.022)
$Lnrgdp^2$	-0.019***	-0.019***	-0.026***	-0.014***	-0.021***
	(0.005)	(0.005)	(0.005)	(0.002)	(0.005)
cons	0.194***	0.198***	0.187***	0.032***	0.155***
	(0.021)	(0.046)	(0.018)	(0.007)	(0.020)
Kleibergen-Paap rk LM					96.480***[0.000]
Kleibergen-Paap rk Wald F					121.359{16.38}
AR(1)				0.027***	
AR(2)				0.184	
Sargan test				0.554	
Time fixed	Yes	Yes	Yes	Yes	Yes
Individual fixed	Yes	Yes	Yes	Yes	Yes

Notes: ① ***, **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively; ② values in () are standard errors, values in [ ] are P values of the corresponding statistics, and values in { } are critical values at the 10% level of the Stock-Yogo test.

Conclusions

China's economy is undergoing a significant transition, making achieving high-quality economic growth a major challenge for the government, and green credit will be key to this. Utilizing panel data from 2008 to 2020 across 30 Chinese provinces, this paper explores the impact of green credit on high-quality economic development. The study reveals a significant contribution of green credit to high-quality economic development, with this enhancement being more pronounced in Midwest regions, areas with weaker bank competition, regions with superior legal and intermediary organizations, and areas with lower local government debt levels. Mechanism tests indicate that the intermediate channels through which green credit operates include green technology innovation, industrial structure upgrading, and transformation of energy consumption structures. This study empirically and theoretically supports the use of financial tools by the government for synchronized economic and environmental development.

Policy Implication

Firstly, prioritizing the implementation of green credit policy, developing a robust green financial system, and efficiently guiding credit and financial structures to allocate funds to environmentally conscious businesses are crucial initial steps for all regions. While green credit in China is taking shape, challenges such as longer profit cycles and higher risks deter banks from engaging in green credit activities. Local governments should assume risks, regulate the market, and reward innovation to actively encourage commercial banks' participation in green financing.

Secondly, enhancing green credit promotion necessitates clearly defining the roles and responsibilities of governments, banks, and firms. Integrating green development criteria into local governments' economic development evaluations, ensuring consistent and stable policy implementation, proactively mitigating and managing local debt risks, and avoiding direct intervention in credit allocation due to financial and employment pressures are essential to prevent efficiency losses. Concurrently, strengthening green credit-related institutional arrangements and capacity building, such as developing intermediary organizations and institutions, is critical for supervising and evaluating enterprises, reducing credit risk, and realizing green economic development.

Thirdly, tailoring development plans to regional specificities is crucial to optimize the advantages of green finance legislation and policy change. Supporting economic transformation towards green, resource-efficient, and environmentally protective practices through policy initiatives will smooth out the role of green credit, change the economic development mode, and guide enterprises toward green technological innovation. By developing green consumption concepts, systems, and platforms, enterprises, and the public can shift to green consumption patterns, fostering long-term green consumption habits and establishing a society-wide green consumption environment.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of Interests

The authors declare that they have no competing interests.

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