

Research on the Impact of Green Finance on High-Quality Development in the Manufacturing Sector

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Abstract

Under increasing environmental pressure and carbon neutrality objectives, this paper analyzes the effect of green finance on high-quality manufacturing development. Using Chinese firm-level panel data from 2011 to 2024 and fixed-effects estimation, the results show that green finance significantly promotes manufacturing development by easing corporate financing constraints. Environmental regulation positively moderates this relationship, and the effects exhibit heterogeneity across ownership structures and regions. These findings suggest the need to improve green finance policies and standards, promote regionally coordinated green finance development, strengthen green information disclosure and environmental risk management, and enhance manufacturing firms' green awareness and sustainable development capacity.

Keywords

Green Finance; High-quality Development of Manufacturing; Financing Constraints; Environmental Regulations.

1. Introduction

As climate-related risks intensify and sustainability objectives gain prominence worldwide, green finance has been widely recognized as an effective approach to integrating economic development with ecological considerations. As climate-related challenges continue to intensify and sustainability objectives gain prominence, green finance has emerged as an important instrument for aligning economic expansion with environmental sustainability. Although China's green finance system has continued to mature, with green loan balances exceeding 30 trillion yuan and providing strong support for green manufacturing, the manufacturing sector still faces challenges in achieving high-quality development, including a high concentration of energy-intensive industries, insufficient green technology investment, and financing constraints. The current supply of green financial resources has not yet fully aligned with the demands of industrial upgrading. While existing studies recognize the positive role of green finance, the underlying mechanisms and heterogeneous effects across regions and enterprises remain underexplored. In response, this paper examines the transmission pathways of green finance in promoting high-quality manufacturing development, analyzes the moderating impact of environmental regulation, and considers heterogeneity among firms to inform policy refinement.

2. Literature Review

2.1. The Economic Impact of Green Finance

Green finance is found to be an important driver of improvements in the quality and sustainability of economic development. Empirical evidence from economies adopting green finance confirms its effectiveness in energy conservation and pollution reduction (Aboul-Dahab

et al., 2021)[1]. Studies based on Chinese provincial data further show that green finance plays a facilitating role in the greening process of the manufacturing sector by reducing emissions and improving efficiency (An Yong et al., 2025)[3].

2.2. Factors Influencing High-Quality Development in Manufacturing

Prior research has explored the factors shaping high-quality manufacturing development using a variety of analytical perspectives, such as technological progress, industrial policy interventions, environmental governance, and the application of digital technologies. Technological advancement has been shown to improve labor productivity and facilitate manufacturing upgrading (Varumca et al., 2009)[2]. Moreover, environmental regulation, as an important policy tool, contributes to high-quality manufacturing development by phasing out highly polluting and inefficient firms while simultaneously stimulating R&D investment and innovative activities (Huang Yi et al., 2023)[9].

2.3. Green Finance and High-Quality Development in Manufacturing

Although a growing body of literature has examined the role of green finance in manufacturing development, studies explicitly addressing high-quality development remain relatively scarce. Existing evidence suggests that green finance strengthens manufacturing resilience in light of carbon peaking and carbon neutrality policy objectives, while also enhancing green competitiveness by facilitating industrial restructuring and technological upgrading (Chai Zhengmeng et al., 2024; Sun Yingjie and Lin Chun, 2023)[4,11]. However, most studies emphasize overall effects, with limited systematic analysis of the mechanisms driving high-quality manufacturing development.

3. Theoretical Background and Hypothesis Development

3.1. Direct Effect

Green finance reallocates capital toward green manufacturing through market-based mechanisms, lowering financing costs while restricting high-pollution industries. By incorporating environmental performance into credit assessments, it encourages firms to strengthen environmental disclosure and invest in technological R&D, thereby promoting structural optimization, technological upgrading, and high-quality manufacturing development. Accordingly, the following hypothesis is formulated:

H1: Green finance significantly promotes high-quality development within the manufacturing industry.

3.2. The Mediating Effect of Financing Constraints

Green finance provides manufacturing firms with stable and cost-efficient sustained funding obtained through green financial instruments, including green credit and green bonds, thereby broadening and improving their financing channels. Meanwhile, dedicated funds and risk-sharing mechanisms reduce uncertainty, thus facilitating greater R&D spending by firms and upgrade equipment, thereby improving efficiency and competitiveness and promoting high-quality manufacturing development. On this basis, we advance the following hypothesis:

H2: Financing constraints serve as a mediating channel through which green finance promotes high-quality development in the manufacturing sector.

3.3. The Modulating Effects of Environmental Regulations

Environmental regulation functions as an important external factor that conditions the impact of green finance on high-quality development in the manufacturing sector. Through policy guidance and market access constraints, it directs green financial resources toward environmentally responsible firms and incentivizes technological innovation. Stronger

regulatory intensity amplifies the catalytic effect of green finance, creating a synergistic mechanism that accelerates the green transformation and upgrading of manufacturing. In light of the above analysis, the following hypothesis is advanced:

H3: Environmental regulations positively moderate the role played by green finance on the high-quality development of the manufacturing sector.

4. Research Design

4.1. Data Sources

This study assembles firm-level panel data for Chinese listed manufacturing companies over the period 2011–2024. The sample is screened by removing ST, *ST, and PT firms, deleting observations with missing values in key variables, and applying 1% winsorization to all continuous variables to reduce the influence of extreme values. Measures of high-quality manufacturing development are obtained from the China National Research Data Service (CNRDS). The green finance index is constructed based on data from the China Statistical Yearbook of Science and Technology, the China Statistical Yearbook of Energy, and the China Financial Yearbook. Firm-level control variables and financial information are drawn from the China Securities Market and Accounting Research (CSMAR) database.

4.2. Variable Definition

(1)Dependent variable

Table 1. Manufacturing High-Quality Growth Index

Overall Indicator	Dimensional Metrics	Primary Indicator	Second-level indicators	attribute
High-quality development	Innovative Development	Innovation Investment	Proportion of R&D personnel	+
			Ratio of R&D spending to operating revenue	+
		Innovative Achievements	Number of patents granted in a given year	+
				+
	Coordinated Development	Equity Structure Alignment	Equity Concentration	+
		Personnel Structure Alignment	Proportion of Independent Directors	+
			Is it two positions and one	-
	Green Development	Sustainable Development Capacity	ESG Composite Score	+
	Operational Performance	Open Development	Overseas Revenue Share	+
		Market Position	Accounts Receivable Turnover Ratio	-
		Profitability	Management Expense Ratio	-
			Financial Expense Ratio	-
			Return on Equity	+
			Selling Expense Ratio	-
			Net Profit Margin	+
		Operational Efficiency	Total Asset Turnover Ratio	+
			Inventory Turnover	+
			Current Asset Turnover	+
			Fixed Asset Turnover	+
		Sustainable Development	Operating Revenue Growth Rate	+
			Year-on-year growth in operating cash flow per share	+
			Sustainable growth rate	+
	Shared Development	Capacity for Promoting Common Prosperity	Corporate Common Prosperity Score	+

The dependent variable is high-quality manufacturing development (MHD). Following Feng Yongqi et al. (2024) and Zhang Yue et al. (2024), and guided by the new development philosophy, a composite index is constructed using the entropy weight method, encompassing five dimensions: innovative, coordinated, green, operational, and shared development[7,12]. For details, see Table 1.

(2) Explanatory variable

Building on prior studies (Meng Weifu et al., 2025), a Green Finance Development Index (GF) is developed in this study, covering seven key components: green credit, green investment, green insurance, green bonds, green support, green funds, and green equity[10]. Detailed descriptions of the indicators are provided in Table 2.

Table 2. Green Finance Development Level

Indicator	Definition	Calculation Method
Green Credit	Share of Environmental Protection Projects in Credit	Total Environmental Protection Project Loans in the Province / Total Loans in the Province
Green Investment	Environmental pollution control spending relative to GDP	Environmental governance investment as a percentage of GDP
Green Insurance	The extent of environmental pollution liability insurance coverage	Environmental Pollution Liability Insurance Premium Income / Total Premium Income
Green Bonds	Development level of green bonds	Ratio of green bond issuance to total bond issuance
Green Support	Budget share of environmental protection expenditures	Ratio of fiscal environmental protection spending to general budget expenditures
Green Fund	Share of green funds	Share of green funds' market value in total fund market value
Green Rights	Green Rights Development Depth	Total Value of Carbon Trading, Energy Consumption Rights Trading, and Pollution Emission Trading/Equity Market Transactions

(3) Mediating Variables and Moderating Variables

① Mediating variable

The degree of corporate financing constraints can be indirectly reflected through several key corporate financial indicators. Drawing upon the research of Wei Zhihua et al. (2014), the KZ Index is constructed using a sample of Chinese listed companies to measure the level of financing constraints^[13]. The specific construction steps are as follows: First, classify each year across the entire sample based on net operating cash flow/previous period total assets ($CF_{i,t}/Asset_{i,t-1}$), cash dividends/previous period total assets ($DIV_{i,t}/Asset_{i,t-1}$), cash holdings/previous period total assets ($CASH_{i,t}/Asset_{i,t-1}$), debt-to-asset ratio ($LEV_{i,t}$) and Tobin's Q ($TobinQ_{i,t}$). If $CF_{i,t}/Asset_{i,t-1}$ below the median, then $KZ_1=1$, otherwise 0; If $DIV_{i,t}/Asset_{i,t-1}$ below the median, then $KZ_2=1$, otherwise 0; If $CASH_{i,t}/Asset_{i,t-1}$ below the median, then $KZ_3=1$, otherwise 0; If $LEV_{i,t}$ above the median, then $KZ_4=1$, otherwise 0; If $TobinQ_{i,t}$ above the median, then $KZ_5=1$, otherwise 0. Second, calculate the KZ index, where $KZ=KZ_1+KZ_2+KZ_3+KZ_4+KZ_5$. Then, using ordered logistic regression, we regress the KZ index as the dependent variable against $CF_{i,t}/Asset_{i,t-1}$, $DIV_{i,t}/Asset_{i,t-1}$, $CASH_{i,t}/Asset_{i,t-1}$, $LEV_{i,t}$ and $TobinQ_{i,t}$ estimating the regression coefficients for each variable. Finally, using the estimated results from the aforementioned regression model, the KZ index for each listed company's financing constraints

can be calculated. An increase in the KZ index suggests that a listed company is subject to stronger financing constraints.

②Control variable

Following Chen Shiyi et al. (2021), environmental regulation is proxied by the share of “environmental protection”-related terms in local government work reports, calculated as their frequency relative to the total word count [5].

(4) Control variables

Building on existing research on the relationship between green finance and high-quality development in manufacturing sector and considering data availability, this study controls for other relevant factors, as reported in Table 3.

Table 3. Control Variable Definitions and Descriptions

Control variables	Definition
Enterprise Scale	Natural logarithm of total assets plus one
Enterprise Development Potential	(Current Period Net Profit - Net Profit for the Same Period Last Year) / Net Profit for the Same Period Last Year
Corporate Cash Flow	Enterprise Free Cash Flow / Total Assets
Nature of Property Rights	Property ownership status is 1 for state-owned, 0 for others
Company Age	Natural logarithm of the company's years in operation
Regional Economic Conditions	Natural logarithm of per capita GDP
Industrial Structure	Secondary and Tertiary Industry Output Value Share
Fixed Asset Investment Ratio	Total Fixed Asset Investment / GDP

4.3. Model Setup

First, a fixed-effects panel model is employed to examine how green finance influences the high-quality development of manufacturing firms:

$$MHD I_{i,t} = \alpha_0 + \alpha_1 GF_{p,t} + \sum Controls + \sum Firm + \sum Year + \sum Province + \varepsilon_{i,t} \quad (1)$$

Here, i denotes an enterprise, t denotes the year, and $MHD I_{i,t}$ denotes the quality-oriented development level of manufacturing firm i in year t . $GF_{p,t}$ indicates the degree of green finance development in region p during year t . Controls represent a set of control variables. Firm, Year, and Province indicate firm-, year-, and province-level fixed effects, respectively. α_1 is the key coefficient of interest in this study. A significantly positive α_1 indicates that improvements are driven by green finance in the degree of high-quality development of manufacturing.

Second, to test whether financing constraints mediate the linkage between green finance and high-quality development in the manufacturing sector, this paper builds upon the baseline regression model. First, we construct a regression model of green finance on financing constraints:

$$FC_{i,t} = \beta_0 + \beta_1 GF_{p,t} + \sum Controls + \sum Firm + \sum Year + \sum Province + \varepsilon_{i,t} \quad (2)$$

Then, construct a regression model for green finance and financing constraints with respect to high-quality development in manufacturing:

$$MHDI_{i,t} = \gamma_0 + \gamma_1 GF_{p,t} + \gamma_2 FC_{i,t} + \sum Controls + \sum Firm + \sum Year + \sum Province + \varepsilon_{i,t} \quad (3)$$

Here, $FC_{i,t}$ denotes the degree of financing constraints. Other model parameters are consistent with those in the baseline model. If β_1 is significantly negative, it indicates that green finance significantly alleviates financing constraints faced by manufacturing firms. If both γ_1 and γ_2 are statistically significant and the absolute value of γ_1 is smaller than that of α_1 , financing constraints partially mediate how green finance influences high-quality development in the manufacturing sector. If γ_1 is insignificant while γ_2 is significant, financing constraints serve as a full mediator.

Finally, to assess whether environmental regulation moderates the effect of green finance on high-quality development in the manufacturing sector, this study augments the baseline model by introducing an interaction term between green finance and environmental regulation, thereby specifying the following moderation model.:

$$MHDI_{i,t} = \delta_0 + \delta_1 GF_{p,t} + \delta_2 Envir_{p,t} + \delta_3 GF_{p,t} * Envir_{p,t} + \sum Controls + \sum Firm + \sum Year + \sum Province + \varepsilon_{i,t} \quad (4)$$

Here, $Envir_{p,t}$ denotes the intensity of environmental regulation, and $GF_{p,t} * Envir_{p,t}$ is specified as the interaction of green finance with environmental regulation. Other variable definitions are consistent with the baseline model. δ_3 is the key coefficient of interest in this study. A significantly positive δ_3 indicates that environmental regulation exerts a positive moderating effect on the relationship linking green finance to high-quality manufacturing development.

5. Empirical Findings and Analysis

5.1. Descriptive Statistics

Table 4 reports the descriptive statistics of the key variables used in this study. The Manufacturing High-Quality Development Index (MHDI) has an average value of about 0.126 and a standard deviation of 0.067, reflecting pronounced regional variation in the level of manufacturing development quality. The Green Finance Development Index (GF) shows a mean of 0.593 with a standard deviation of 0.24, indicating that green finance development remains uneven and generally at a relatively modest level across Chinese provinces.

Table 4. Descriptive Statistics of Variables

Variable	Symbol	Sample size	mean	Std.Dev	Min	Median	Max
High-quality Manufacturing Development	MHDI	35821	0.126	0.067	0	0.147	0.203
Green Finance	GF	35821	0.593	0.24	0.035	0.63	0.967
Enterprise Scale	Size	35821	21.865	1.086	19.738	21.722	25.476
Enterprise Development Potential	Develop	35821	0.043	0.057	-0.204	0.042	0.224
Corporate Cash Flow	Cash	35821	0.049	0.061	-0.145	0.047	0.241
Company Age	Age	35821	1.879	0.91	0	1.946	3.367
Regional Economic Conditions	Economic	35821	8.6646	6.1884	0	8.7089	20.2341
Industrial Structure	Structure	35821	0.748	0.397	0	0.956	1
Fixed Asset Investment Ratio	Fixed	35821	0.615	0.613	0	0.461	3.243

5.2. Basic Regression Analysis

The baseline regression results are reported in Table 5. Column (1) presents the univariate regression without controlling for firm, year, or province fixed effects, where the coefficient of green finance is positive and statistically significant, suggesting a strong association between green finance and high-quality manufacturing development. As shown in Column (2), after further accounting for firm, year, and province fixed effects, green finance continues to exert a significantly positive effect on high-quality manufacturing development at the 1% significance level.

Columns (3) and (4) introduce control variables, with Column (3) excluding fixed effects and Column (4) incorporating firm, year, and province fixed effects. The results in both specifications consistently indicate that green finance significantly promotes high-quality manufacturing development. Overall, these findings demonstrate that improvements in green finance play a substantial role in advancing high-quality development in the manufacturing sector, thereby providing empirical support for Hypothesis H1.

Table 5. Benchmark Regression Test

	(1)	(2)	(3)	(4)
	MHDI	MHDI	MHDI	MHDI
GF	0.108*** (79.051)	0.343*** (140.785)	0.017*** (15.815)	0.025*** (12.496)
Size	—	—	0.009*** (43.151)	0.008*** (28.006)
ROA	—	—	0.047*** (11.972)	0.035*** (11.824)
Cashflow	—	—	0.040*** (11.265)	0.036*** (14.365)
ListAge	—	—	0.001* (2.319)	0.002*** (7.340)
Economic	—	—	0.000*** (10.012)	0.000*** (25.026)
Structure	—	—	0.114*** (134.433)	0.116*** (185.978)
Fixed	—	—	0.012*** (32.207)	0.011*** (28.542)
Firm	N	Y	N	Y
Year	N	Y	N	Y
Province	N	Y	N	Y
_cons	0.062*** (70.770)	-0.077*** (-53.030)	-0.183*** (-42.653)	-0.178*** (-30.709)
N	35821	35350	35821	35350
adjr2	0.1485	0.5943	0.7049	0.8970

Notes: t-statistics are presented in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Coefficients of the main variables are reported to three decimal places when fractional; otherwise, values are rounded to three decimal places.

5.3. Robustness Test

To examine the robustness of the benchmark results, several alternative specifications are employed. First, following Huang Bo et al. (2023), total factor productivity (TFP) is used as an

alternative measure of high-quality manufacturing development, calculated using both the OP and LP methods[8]. As reported in Column (1) of Table 6, green finance remains significantly positive under both TFP_OP and TFP_LP, indicating that higher levels of green finance enhance enterprise productivity. Second, consistent with Cui Jie et al. (2025), green credit is used to replace the green finance indicator[6]. The results in Column (2) show that green credit continues to exert a significant positive effect on high-quality manufacturing development. Third, to account for potential dynamic and lagged effects, one- and two-period lags of green finance are introduced into the baseline model. As reported in Column (3) of Table 6, the coefficients for the lagged terms continue to be significantly positive. Overall, these findings confirm the robustness of the baseline results.

Table 6. Robustness Tests

Variable	(1)		(2)	(3)	
	Replace indicators for high-quality enterprise development		Replace green finance indicators	Lagged Explanatory Variable	
	TFP_OP	TFP_LP			
GF	0.357*** (11.830)	0.208*** (7.252)	0.008*** (28.511)	— —	— —
L.GF	— —	— —	— —	0.025*** (10.931)	— —
L2.GF	— —	— —	— —	— —	0.002*** (3.106)
Control variables	Y	Y	Y	Y	Y
Firm	Y	Y	Y	Y	Y
Year	Y	Y	Y	Y	Y
Province	Y	Y	Y	Y	Y
_cons	-3.064*** (-36.322)	-4.948*** (-61.903)	-0.179*** (-30.875)	-0.179*** (-26.894)	-0.171*** (-23.405)
observed value	32524	32524	35350	30212	26599
Adj.R ²	0.8546	0.9141	0.8969	0.8921	0.8853

5.4. Mechanism Verification

(1)Mediation Effect Analysis

The mediation analysis reported in Table 7 indicates that green finance significantly alleviates financing constraints, which subsequently enhances high-quality development in the manufacturing sector. This finding confirms that the positive effect of green finance on high-quality manufacturing development operates partly through the mitigation of external financing constraints. Thus, Hypothesis H2 is supported.

(2)Moderation Effect Analysis

Environmental regulation plays a significant moderating role in the relationship between green finance and high-quality development in the manufacturing sector. Results in Column (2) indicate that the interaction term of green finance and environmental regulation is positive and statistically significant, confirming a positive moderating effect and supporting Hypothesis H3.

Table 7. Testing for Mediating and Moderating Effects

Variable	(1)		(2)
	Mediation effect		Modulating effect
	FC	MHDI	
GF	-0.070*** (-9.670)	0.017*** (6.607)	0.038*** (14.304)
FC	—	-0.010*** (-5.763)	—
Envir	—	—	6.077*** (14.007)
GF*Envir	—	—	5.132*** (19.551)
Control variables	Y	Y	Y
Firm	Y	Y	Y
Year	Y	Y	Y
Province	Y	Y	Y
observed value	32224	27328	33362
Adj.R ²	0.6061	0.8895	0.8893

6. Conclusion and Implications

The empirical analysis indicates that green finance (GF) exerts a statistically significant and positive impact on the high-quality development of the manufacturing sector (MHDI), thereby supporting Hypothesis H1. By enhancing the efficiency of financial resource allocation and directing capital toward environmentally friendly industries and low-carbon initiatives, green finance provides critical support for the sector's green transformation. Robustness checks consistently uphold these results, demonstrating their reliability and sustainability. In addition, green finance indirectly fosters high-quality manufacturing development by alleviating corporate financing constraints, confirming Hypothesis H2. Environmental regulations further strengthen the resource allocation effects of green finance through signaling and incentive mechanisms, validating Hypothesis H3. Collectively, the mediating role of financing constraints and the moderating influence of environmental regulation constitute the primary channels through which green finance promotes high-quality development in the manufacturing sector.

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