



Heterogeneous Impact of Green Finance on Carbon Reduction in High-Energy-Consuming Manufacturing under the Dual Carbon Goals

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Abstract: Under the Dual Carbon Goals, high-energy-consuming manufacturing is a core carbon reduction sector. Green finance is a pivotal low-carbon tool for curbing corporate carbon emissions. This paper samples China's listed high-energy-consuming manufacturers, builds a three-level regression model, and tests the green finance index, its sub-tools and green credit mechanism on carbon emissions, analyzes heterogeneity by industry pollution, property right and firm scale. Results confirm green finance's emission reduction effect with significant heterogeneity, providing policy references for the sector's low-carbon transformation.

Keywords: dual carbon goals; green finance; high-energy-consuming manufacturing; carbon emission reduction; heterogeneity

1. Introduction

Carbon peaking and carbon neutrality is China's major national strategy. High-energy-consuming manufacturing, a major carbon emitter, is the key for its achievement. Green finance allocates capital to low-carbon sectors via green credit, investment and funds, acting as a core means for industrial green transformation.^[1]

China's green finance has developed steadily in recent years but its actual effect on high-energy-consuming manufacturing, tool heterogeneity and firm-based performance lack precise empirical tests. Existing studies focus on overall effects with few targeted multi-level analyses, so this paper tests its emission reduction effect via multi-level indicators and conducts three heterogeneity regressions to improve conclusion validity.

2. Theoretical analysis and research hypotheses

Green finance drives corporate carbon reduction through capital allocation, incentive-constraint and technical support effects. It provides low-cost funds for low-carbon projects, and financial institutions push high-energy-consuming firms to reduce emissions via credit restrictions and differentiated interest rates. Green credit has the most prominent emission reduction effect among green financial tools.^[2]

Based on the above, this paper proposes the following hypotheses:

H1: Green finance cuts carbon emissions of high-energy-consuming manufacturers sharply.

H2: Green financial tools show heterogeneous effects, with green credit being the most significant.

H3-H5: The effect is stronger in heavy polluting industries, private firms and large firms.^[3]

3. Research Design

3.1 Sample and Data Sources

This paper samples China's listed high-energy-consuming manufacturers during 2012–2024, excluding ST firms, missing data and outliers to build panel data. The final sample includes 214 firms with 2,782 observations: 1,841 non-heavy polluting, 941 heavy polluting; 1,980 private, 802 state-owned; 1,129 SMEs, 1,653 large firms. Carbon emission data is from social responsibility reports, and other data is from CSMAR.

3.2 Variable Definition

Explained variable: LNCE (natural log of corporate annual carbon emissions).

Core explanatory variables:

1st: GF (Aggregate Green Finance Index)

2nd: GC (Green Credit Proportion), GI (Green Investment), GFD (Green Fund), GB (Green Bond), CF (Carbon Finance), GS (Green Support)

3rd: GIR (Green Project Investment Rate), GDR (Green Credit Default Rate)

Control variables: SIZE (Firm Scale), LEV (Asset-Liability Ratio), CASH (Cash Flow Ratio), ATO (Capital Turnover Rate), HP (Heavy Pollution Dummy), ER (Environmental Rating).

3.3 Model Setting

This paper uses a panel fixed effects model to control individual and time fixed effects, GF replaceable by the 2nd and 3rd regression variables.

$$LNCE_{it} = \alpha_0 + \alpha_1 GF_{it} + \sum \alpha_k Control_{it} + \varepsilon_{it}$$

Heterogeneity analysis is conducted via grouped regression by industry pollution, property right, firm scale.

4. Empirical Results and Analysis

4.1 Descriptive Statistics

Table 1 presents descriptive statistics of main variables. Corporate carbon emissions and green finance development show large variations. All control variables are in a reasonable range without extreme outliers, supporting subsequent regressions.

Table 1. Descriptive Statistics of Main Variables

Variable	Mean	Std.Dev.	Min	Max
LNCE	13.26	1.39	8.2	17.7
GF	0.6	0.22	0.07	0.94
GC	0.1	0.14	0.002	3.5
GB	0.1	0.04	0.01	0.16
GS	0.02	0.006	0.002	0.03
GI	0.05	0.02	0.006	0.08
GFD	0.045	0.02	0.006	0.07
CF	0.05	0.02	0.006	0.08
GIR	0.996	0.002	0.991	0.9997
GDR	0.004	0.002	0.0003	0.009
SIZE	22.2	1.13	19.8	26
LEV	0.4	0.19	0.04	0.91
ATO	0.57	0.34	0.05	2.64
CASH	0.05	0.06	-0.2	0.26
ER	61.5	7.6	33.8	87.8

4.2 Full-sample three-layer regression results

4.2.1 First-level regression

Table 2. First-level regression Results Table

Variable	Coefficient	Prob.
C	-7.75	0.00
GF	-0.16	0.002
SIZE	0.92	0.00
LEV	0.15	0.03
CASH	0.22	0.25
ATO	1.56	0.00
HP	0.06	0.01
ER	-0.005	0.0007
Adj- R^2	0.83	

GF has a sharply negative coefficient (-0.16, p=0.002) at the 1% level, verifying H1 (green finance reduces

carbon emissions). ER is significantly negative, and HP is significantly positive at the 1% level. SIZE, LEV and ATO are significantly positive, while CASH is positive but insignificant, showing heterogeneous impacts of financial characteristics on carbon emissions.

4.2.2 Second-level regression

Table 3. Second-level regression Results Table

Variable	Coefficient	Prob.
C	-7.52	0.00
GC	-0.94	0.00
GFD	10.25	0.04
GI	11.24	0.04
GB	-7.57	0.06
CF	-10.01	0.07
Adj- R^2	0.84	

GC has a sharply negative coefficient (-0.94, $p=0.00$) at the 1% level, proving it the core emission reduction tool and verifying H2. GI and GFD are significantly positive due to long project cycles; GB and CF are significantly negative, in line with expectations. All green financial tools show significant and heterogeneous impacts.^[4]

4.2.3 Third-level regression

Table 4. Third-level regression Results Table

Variable	Coefficient	Prob.
C	-72.8	0.00
GDR	63.7	0.00
GIR	-47.4	0.00
Adj- R^2	0.86	

GIR is significantly negative (higher investment rate reduces emissions), and GDR is significantly positive (higher default rate raises emissions).

The Adj- R^2 of the three regressions are all above 0.8, proving the model's excellent fit and strong explanatory power.

4.3 Heterogeneity Analysis Results

Heterogeneity analysis verifies H3-H5:

① Industrial Pollution: GF is sharply negative for heavy polluting industries (insignificant for non-heavy ones), with green credit having clearer targeting.^[5]

② Property Right: GF is sharply negative for private firms (insignificant for state-owned ones) due to higher marketization.

③ Firm Scale: GF is sharply negative for large firms (insignificant for SMEs) for better financial and technical conditions.

Table 5. Summary of Core Results of Heterogeneous Regression

Grouping Type	Group	Coefficient	Prob.	Adj- R^2
Industrial Pollution Degree	Non-heavy Pollution	-0.08	0.32	0.8
	Heavy Pollution	-0.21	0.001	0.86
Nature of Property Rights	Private Enterprises	-0.20	0.003	0.79
	State-owned Enterprises	-0.14	0.11	0.85
Enterprise Scale	SMEs	-0.12	0.11	0.67
	Large Enterprises	-0.18	0.01	0.78

5. Research Conclusions

This study concludes: ① Aggregate green finance promotes carbon reduction in high-energy-consuming manufacturing sharply, higher development levels cut corporate carbon emissions effectively. ② Green financial tools show heterogeneous effects: green credit is the core, green bonds and carbon finance curb carbon emissions sharply, while green investment and funds show short-term positive correlation with carbon emissions due to cyclical characteristics. ③ Green credit's mechanisms have divergent impacts, highlighting the importance of fund utilization efficiency and risk control. ④ Green finance's carbon reduction effect shows notable heterogeneity, a more prominent effect on heavy polluting, private and large firms.

6. Policy Recommendations

To further leverage green finance's role in carbon reduction of high-energy-consuming manufacturing, the following policy recommendations are put forward: ① Consolidate green credit's leading position, expand its coverage, strengthen precise support for the sector; ② Standardize capital allocation of green investment and funds, accelerate implementation and effectiveness of related projects, exert the long-term emission reduction role of green bonds and carbon finance; ③ Strengthen green credit risk control to cut default rates, improve green project investment efficiency to realize efficient matching between green funds and emission reduction effects; ④ Implement differentiated green finance policies, tilt support towards heavy polluting high-energy-consuming manufacturing, private and large firms to enhance policy targeting.

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References

- [1] Lu H,Wu J,Gong J.Green finance and the synergistic effects of pollution and carbon emission reduction: evidence from China[J].*Environment, Development and Sustainability*,2026:1-25.
- [2] Wang S,Xia N,Yang M, et al.From capital to climate action: assessing the impact of china's green credit initiative on corporate emissions.[J].*Carbon balance and management*,2026.
- [3] Jiang S,Liu X,Hua H, et al.How Does Green Finance Influence Environmental Performance in China: Unveiling the Mechanisms and Regional Heterogeneity[J].*Sustainability*.
- [4] Ma L,Lv X,Shen Z, et al.How green bonds influence corporate environmental behaviour: A heterogeneous analysis[J].*Research in International Business and Finance*,2026,83103290-103290.
- [5] Xu F.Whether the Heavy-Polluting Enterprise in the Green Finance Reform and Innovation Pilot Zones Have Higher Investment Efficiency: Evidence from China.[J].*Frontiers in Economics and Management*,2025,6(3):211-218.

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