

The Impact of Green Finance on Corporate Carbon Performance

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Abstract. This paper takes Chinese A-share listed enterprises from 2021 to 2023 as the research object to investigate the effect of green finance on corporate carbon performance. The results show that: First, green finance can significantly improve corporate carbon performance, and this conclusion still holds after multiple robustness tests, including excluding samples from green finance reform and innovation pilot zones, using lagged terms of explanatory variables, and winsorization. Second, from the perspective of the action path, green finance indirectly promotes the improvement of carbon performance by alleviating corporate financing constraints on the one hand and reducing corporate financing costs on the other hand. Third, heterogeneity analysis shows that the carbon performance improvement effect of green finance is significant in non-state-owned enterprises but not obvious in state-owned enterprises; in terms of industry characteristics, this effect is significant in technology-intensive and labor-intensive enterprises, but fails to pass the significance test in asset-intensive enterprises.

Keywords: Green Finance, Carbon Performance, Financing Constraints, Financing Costs

1. Introduction

At present, carbon emission reduction has evolved from an environmental issue into a core proposition affecting the transformation of the economic system. However, constrained by high technological R&D costs and uncertain short-term returns, enterprises often lack endogenous motivation to actively improve carbon performance, and urgently need the guidance and incentives of external mechanisms, among which green finance is a typical representative of this key external force. This raises a series of questions to be solved: Does green finance affect corporate carbon performance? What is the transmission mechanism of this impact? Is there heterogeneity in the impact of green finance on corporate carbon performance? Solving these problems, theoretically, helps to enrich the theoretical connotation in the fields of green finance and corporate environmental responsibility. Practically, the research conclusions can provide references for policymakers to optimize the design of green financial instruments and a basis for enterprise managers to formulate carbon emission reduction strategies.

The marginal contributions of this study are as follows: First, it empirically tests the direct impact of green finance on corporate carbon performance based on enterprise micro-data. Second, it empirically tests the indirect impact paths of green finance on corporate carbon performance from

the perspectives of corporate financing constraints and financing costs respectively. Third, it empirically tests the heterogeneous impact of green finance on corporate carbon performance based on the nature of enterprise property rights and industry characteristics respectively.

2. Literature review

Most studies have confirmed that green finance can effectively improve corporate carbon performance. Liu et al. found based on data from 284 cities that the pilot zone policy significantly improved the synergy level of pollution reduction and carbon reduction through the investment-induced effect and green factor substitution mechanism [1]. Kong et al. extended the research to the agricultural field and found that the development of green finance can achieve the synergistic effect of agricultural pollution reduction and carbon reduction by promoting agricultural technological progress, and there is a significant spatial spillover effect [2]. In terms of action mechanisms and heterogeneity, Nie and Sun pointed out that green innovation and industrial structure optimization are the core paths, and the policy effect is more prominent in non-resource-based cities and cities with a high level of financial development [3]. Some studies have found that policies can affect corporate carbon performance through parallel mediating paths, but the "innovation compensation effect" is still insufficient to offset the "institutional compliance cost" at present [4]. Zhang and Hu pointed out that alleviating financing constraints and promoting technological progress are the key ways for green finance to play its role, and the policy effect is more prominent in resource-based cities and the northwest region of the "Hu Huanyong Line" [5].

However, Zhang et al. observed that corporate carbon performance declined after issuing green bonds, which can be attributed to the long project construction cycle and the short-term performance pressure brought by increased R&D investment [6]. Ma et al. further confirmed that reducing energy intensity is the main mediating mechanism for achieving pollution reduction and carbon reduction, and green finance policies have shown more obvious effects in central and western China and resource-based cities [7]. In addition, Zhao et al. verified using the double machine learning method that policies can achieve synergistic effects by promoting R&D investment, improving the level of green innovation, and promoting the development of digital inclusive finance, which provides new ideas for local governments to optimize green finance practices [8].

3. Research design

3.1. Model specification

To further investigate the internal relationship between green finance and corporate carbon performance, this study sets the following two-way fixed effects model:

$$Carbon_performance_{it} = \alpha_0 + \beta_0 Green_finance_{it} + \sum \gamma_k Control_{it} + \lambda_t + \delta_i + \varepsilon_{it} \quad (1)$$

Where *Carbon_performance*, *Green_finance*, *Controls*, λ_t , δ_i , ε represent corporate carbon performance, green finance, a series of control variables, time fixed effects, individual fixed effects, and error term respectively. α_0 represents the constant term, and β_0 and γ_k represent the coefficients of the variables respectively.

3.2. Variable definition

Regarding the explained variable—carbon performance (*Carbon _ performance*), this study refers to the practice of He et al. and uses the reciprocal of total carbon emissions per million yuan of net sales to measure the level of corporate carbon performance [9].

Regarding the core explanatory variable—green finance (*Green _ finance*), this study constructs a comprehensive evaluation system for green finance and calculates it using the entropy method, which includes seven dimensions. Among them, green credit is measured by the "proportion of credit for environmental protection projects", which is calculated as the ratio of the total credit for environmental protection projects to the total credit of the province; green investment adopts the "proportion of investment in environmental pollution control to GDP", that is, the ratio of investment in environmental pollution control to GDP; green insurance is reflected by the "promotion degree of environmental pollution liability insurance", which is expressed as the ratio of environmental pollution liability insurance income to total premium income; green bonds take the "development degree of green bonds" as an indicator, that is, the ratio of the total issuance of green bonds to the total issuance of all bonds; green support uses the "proportion of fiscal expenditure on environmental protection", which is calculated as the ratio of fiscal expenditure on environmental protection to general fiscal budget expenditure; green funds are measured by the "proportion of green funds", that is, the ratio of the total market value of green funds to the total market value of all funds; the green equity indicator is the "development depth of green equity", which is specifically calculated as the sum of carbon trading, energy use right trading, and emission right trading divided by the total transaction volume of the equity market. This system comprehensively covers the main fields of green finance and provides basic data for subsequent empirical analysis.

Regarding control variables, this study selects a series of control variables from the enterprise level and the macro level respectively, specifically including: (1) Enterprise-level variables: enterprise size (Size), enterprise profitability (ROA), enterprise solvency (Leverage), enterprise liquidity level (Liquidity), enterprise age (Age), board size (Board), executive compensation (Salary), ownership concentration (Top5), price-earnings ratio (PE); (2) Macro-level variables: regional economic development level (GDP), regional industrial structure status (Industry), regional financial development level (Finance).

3.3. Data sources and descriptive statistics

This paper selects Shanghai and Shenzhen A-share listed companies from 2012 to 2023 as the research sample and conducts the following processing: First, exclude enterprises marked as ST, *ST, PT, suspended from listing, terminated from listing, and companies in the financial industry; second, exclude samples with a large amount of missing data; third, match and integrate the data of each variable. In terms of data sources, green finance data comes from the National Bureau of Statistics and statistical yearbooks of various provinces and cities, enterprise-level data comes from the China Stock Market & Accounting Research Database (CSMAR), and macro-level data comes from the Wind Database (Wind). The descriptive statistics results of each variable are shown in Table 1.

Table 1. Descriptive statistics of variables

VarName	Obs	Mean	SD	Min	Max
<i>Carbon_performance</i>	17914	0.791	1.212	-1.357	48.094
<i>Green_finance</i>	24451	0.412	0.101	0.090	0.664
<i>Size</i>	25486	3.093	0.061	2.848	3.357
<i>ROA</i>	25485	0.052	0.061	-0.163	0.171
<i>Leverage</i>	22908	1.172	0.564	0.630	4.947
<i>Liquidity</i>	25457	0.780	2.047	-5.723	8.204
<i>Board</i>	17692	8.331	1.646	0.000	17.000
<i>Salary</i>	17644	0.312	0.376	0.005	1.689
<i>Age</i>	25483	9.213	8.380	0.000	27.000
<i>PE</i>	21658	58.711	86.751	6.843	550.452
<i>Top5</i>	25241	0.483	0.187	0.200	0.991
<i>Industry</i>	25691	55.495	10.550	34.500	84.800
<i>GDP</i>	25691	10.775	0.748	6.565	11.818
<i>Finance</i>	25691	1.702	0.440	0.701	2.998

4. Empirical analysis

4.1. Basic regression analysis

The basic regression results are shown in Table 2. It can be seen that with the addition of control variables at all levels, the regression coefficient of green finance is always significantly positive, which reflects the positive relationship between green finance and corporate carbon performance, indicating that green finance can promote the growth of carbon performance.

Table 2. Basic regression results

VARIABLES	(1)	(2)	(3)	(4)
	Carbon_performance	Carbon_performance	Carbon_performance	Carbon_performance
Green_finance	6.8127*** (40.16)	5.6805*** (32.09)	3.7021*** (24.26)	1.9711*** (9.32)
Size		5.5612*** (19.77)	2.8568*** (9.05)	2.2718*** (7.25)
ROA		-2.3680*** (-8.08)	-0.9407*** (-3.00)	-0.5592* (-1.89)
Leverage		-0.0733*** (-3.90)	-0.1300*** (-5.82)	-0.0833*** (-3.98)
Liquidity		0.0199*** (4.16)	0.0243*** (4.64)	0.0169*** (3.48)
Board			-0.0464*** (-5.53)	-0.0174** (-2.16)

Table 2. (continued)

Salary			0.2471*** (5.14)	0.1864*** (4.01)
Age			0.0296*** (14.01)	0.0220*** (10.52)
PE			0.0002 (1.12)	0.0002* (1.67)
Top5			-0.1614** (-2.11)	-0.0119 (-0.16)
Industry				-0.0509*** (-24.66)
GDP				0.2617*** (10.49)
Finance				1.5633*** (40.06)
Constant	-1.9870*** (-27.08)	-18.5549*** (-21.59)	-9.3773*** (-9.70)	-9.8181*** (-10.20)
Observations	17,910	16,261	11,485	11,485

Note: z-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.

4.2. Robustness analysis

This study conducts a series of robustness tests as follows. First, exclude sample enterprises from green finance reform and innovation pilot zones. Second, use the lagged terms of explanatory variables. Third, exclude extreme values and perform winsorization on all original data at the 2% level. The regression results are shown in columns (1) to (3) of Table 3. The regression coefficient of green finance is still significantly positive, which again indicates that green finance improves corporate carbon performance.

Table 3. Robustness tests

VARIABLE S	(1)	(2)	(3)
	Excluding samples from green finance reform and innovation pilot zones	Using lagged terms of explanatory variables	Excluding extreme values
Green finance	1.9406*** (8.55)		1.1081*** (8.09)
lag_Green finance		2.1828*** (7.17)	
Size	2.3143*** (6.71)	2.8009*** (6.59)	1.9743*** (8.88)
ROA	-0.5395	-0.7788**	-0.8027***

Table 3. (continued)

	(-1.62)	(-2.13)	(-3.62)
Leverage	-0.0804***	-0.0931***	-0.1414***
	(-3.47)	(-3.65)	(-6.66)
Liquidity	0.0158***	0.0214***	0.0177***
	(2.96)	(3.68)	(4.68)
Board	-0.0142	-0.0200*	-0.0152**
	(-1.58)	(-1.91)	(-2.51)
Salary	0.1653***	0.2498***	0.1866***
	(3.25)	(4.07)	(5.70)
Age	0.0205***	0.0246***	0.0170***
	(8.90)	(8.55)	(12.28)
PE	0.0002	0.0003*	0.0002*
	(1.40)	(1.73)	(1.80)
Top5	0.0079	0.0473	-0.0236
	(0.10)	(0.48)	(-0.46)
Industry	-0.0514***	-0.0563***	-0.0394***
	(-23.04)	(-20.00)	(-28.13)
GDP	0.2913***	0.3059***	0.2781***
	(10.70)	(8.64)	(16.24)
Finance	1.6223***	1.7943***	1.3263***
	(36.01)	(35.70)	(48.48)
Constant	-10.3267***	-12.1012***	-8.8665***
	(-9.77)	(-9.24)	(-12.91)
Observations	9,730	8,671	11,485

Note: z-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.

4.3. Mechanism analysis

Furthermore, this study further examines the impact mechanisms from the perspectives of corporate financing constraints and financing costs respectively. Among them, financing cost is measured by the ratio of corporate financial expenses to total liabilities at the end of the period. Financing constraint is measured by the financing constraint index (*SA_index*), and the calculation formula is as follows. Where *Size* represents the natural logarithm of the total asset size of the enterprise, and *Age* represents the operating years of the enterprise.

$$SA = -0.737 \times Size + 0.043 \times Size^2 - 0.040 \times Age \quad (2)$$

The regression results are shown in Table 4. From columns (1) and (2), it can be concluded that green finance improves corporate carbon performance by alleviating corporate financing constraints. From columns (3) and (4), it can be seen that green finance can improve corporate carbon performance by reducing corporate financing costs.

Table 4. Mechanism tests

VARIABLES	(1)	(2)	(3)	(4)
	SA_index	Carbon_performance	Cost	Carbon_performance
Green finance	-0.4453*** (-13.74)	1.8974*** (9.00)	-0.0145* (-1.79)	1.9420*** (9.20)
SA_index		-0.4961*** (-7.85)		
Cost				-2.3638*** (-9.60)
Size	0.1691*** (5.37)	3.0065*** (9.22)	-0.0073 (-0.63)	2.2329*** (7.14)
ROA	0.0864*** (4.41)	-0.5293* (-1.79)	-0.0678*** (-6.39)	-0.7792*** (-2.64)
Leverage	-0.0052*** (-4.00)	-0.0909*** (-4.35)	0.0208*** (28.57)	-0.0336 (-1.56)
Liquidity	-0.0002 (-0.89)	0.0165*** (3.42)	0.0001 (0.51)	0.0169*** (3.49)
Board	0.0028*** (4.60)	-0.0178** (-2.22)	0.0005* (1.79)	-0.0170** (-2.11)
Salary	0.0498*** (14.90)	0.2182*** (4.69)	-0.0201*** (-13.00)	0.1375*** (2.95)
Age	-0.0233*** (-65.27)	0.0111*** (4.42)	0.0004*** (5.28)	0.0225*** (10.78)
PE	0.0001*** (8.71)	0.0003** (2.35)	-0.0001*** (-11.30)	0.0001 (0.61)
Top5	-0.0424*** (-6.98)	0.0034 (0.05)	-0.0038 (-1.41)	-0.0204 (-0.28)
Industry	0.0003 (1.22)	-0.0492*** (-23.82)	0.0006*** (7.55)	-0.0498*** (-24.12)
GDP	-0.0766*** (-18.44)	0.2216*** (8.73)	-0.0011 (-1.20)	0.2591*** (10.40)
Finance	-0.0516*** (-14.29)	1.4912*** (37.33)	-0.0178*** (-12.12)	1.5279*** (39.07)
Constant	-3.0938*** (-31.10)	-13.4239*** (-12.62)	0.0244 (0.68)	-9.6809*** (-10.09)
Observations	14,993	11,485	14,993	11,485

Note: z-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4.4. Heterogeneity analysis

Furthermore, this study examines the heterogeneity from the perspectives of the nature of enterprise property rights and industry characteristics respectively. Columns (1) to (2) of Table 5 show that for non-state-owned enterprises, green finance can significantly improve corporate carbon performance, while for state-owned enterprises, this effect is not significant. From columns (3) to (5), it can be seen that for technology-intensive and labor-intensive enterprises, green finance can significantly improve corporate carbon performance, while for asset-intensive enterprises, this effect is not significant.

Table 5. Heterogeneity tests

VARIABLES	(1)	(2)	(3)	(4)	(5)
	State-owned enterprises	Non-state-owned enterprises	Technology-intensive enterprises	Asset-intensive enterprises	Labor-intensive enterprises
Green finance	0.2596 (1.15)	1.6461*** (7.18)	3.2299*** (9.73)	0.1564 (0.56)	1.5768*** (3.87)
Size	0.8993** (2.45)	2.0634*** (6.06)	2.5414*** (5.26)	2.3242*** (5.01)	1.8624*** (3.10)
ROA	-0.0899 (-0.19)	-0.1529 (-0.54)	-0.9427** (-2.42)	-1.3730*** (-2.80)	0.9069 (1.32)
Leverage	-0.0584** (-2.06)	-0.0817*** (-3.71)	-0.1224*** (-4.35)	-0.0558 (-1.59)	-0.0544 (-1.14)
Liquidity	-0.0108 (-1.39)	0.0306*** (6.42)	0.0290*** (4.52)	-0.0047 (-0.49)	0.0124 (1.23)
Board	-0.0137 (-1.38)	-0.0103 (-1.21)	-0.0080 (-0.72)	-0.0162 (-1.31)	-0.0178 (-1.02)
Salary	-0.1645 (-1.64)	0.1837*** (4.23)	0.1402** (2.35)	0.2855*** (3.40)	0.1055 (0.91)
Age	0.0134*** (5.38)	0.0202*** (8.50)	0.0247*** (7.63)	0.0132*** (4.55)	0.0226*** (5.67)
PE	0.0003 (1.42)	-0.0000 (-0.16)	-0.0001 (-0.41)	0.0001 (0.28)	0.0010*** (2.73)
Top5	-0.1021 (-1.10)	0.1528* (1.96)	0.1234 (1.15)	-0.0449 (-0.40)	-0.1300 (-0.87)
Industry	-0.0375*** (-14.78)	-0.0395*** (-18.12)	-0.0546*** (-18.88)	-0.0426*** (-13.00)	-0.0465*** (-10.88)
GDP	0.3294*** (10.59)	0.1768*** (6.96)	0.1666*** (4.51)	0.3461*** (9.30)	0.2924*** (5.91)
Finance	1.2949*** (20.93)	1.2080*** (31.11)	1.6560*** (31.18)	1.3289*** (21.12)	1.4288*** (16.84)
Constant	-5.7923***	-8.3444***	-10.1364***	-10.1246***	-8.8532***

Table 5. (continued)

	(-5.03)	(-8.01)	(-6.84)	(-7.11)	(-4.78)
Observations	2,912	7,833	5,941	2,250	3,248

5. Conclusion

This paper uses the data of Chinese A-share listed enterprises from 2021 to 2023 to investigate the relationship between green finance and corporate carbon performance. The following three main findings are obtained. First, green finance has a significant positive promoting effect on corporate carbon performance, and the result remains significant after a series of robustness operations such as excluding sample enterprises from green finance reform and innovation pilot zones, using lagged terms of explanatory variables, and excluding extreme values. Second, from the perspective of the transmission mechanism, green finance helps to alleviate corporate financing constraints on the one hand and reduce corporate financing costs on the other hand, thereby indirectly promoting the improvement of corporate carbon performance. Third, heterogeneity analysis shows that the carbon performance improvement effect of green finance is significant in non-state-owned enterprises but not obvious in state-owned enterprises; divided by industry characteristics, this effect is significant in technology-intensive and labor-intensive enterprises, but fails to pass the significance test in asset-intensive enterprises.

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