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Research on the Impact Mechanism of Carbon Finance on Industrial Green Transformation and Upgrading

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Abstract. Against the dual policy backdrop of the "dual carbon" strategy and green high-quality development, whether carbon finance can effectively drive industrial green transformation and upgrading is a core issue for examining financial resource allocation efficiency and low-carbon policy coordination mechanisms. This study uses panel data of 30 Chinese provinces from 2010–2021, constructs a provincial carbon finance development composite evaluation index with the entropy method from five dimensions (financial scale, R&D innovation, policy support, low-carbon level, credit greenness), and takes green total factor productivity (GTFP), industrial structure upgrading (AIS) and rationalization (RIS) as the "efficiency-structure" measurement dimension. By adopting a two-way fixed effects model, it systematically examines the impact mechanism of carbon finance on industrial green transformation and upgrading. The findings show that carbon finance significantly boosts regional GTFP growth and promotes industrial structure upgrading and rationalization; its promotion effect on green efficiency is more prominent in regions with low government intervention; carbon emissions trading pilot programs significantly amplify the enabling effect of carbon finance through the "price discovery" function. This paper reveals the intrinsic logic of carbon finance promoting industrial green transformation from an "efficiency-structure" perspective, providing empirical evidence for the synergistic development of the carbon market and the deep integration of carbon finance.

Keywords: Carbon finance, Green industrial transformation and upgrading, Green total factor productivity, Industrial structure, Carbon emissions trading

1. Introduction

This study addresses three core questions: whether carbon finance enhances regional GTFP and industrial structure optimization, and how market-based environmental regulation constrains these effects. It advances research design in three aspects: (1) Construct a five-dimensional comprehensive carbon finance development index with the entropy method for a holistic portrayal; (2) Adopt a dual "efficiency-structure" analytical framework to integrate micro green production efficiency and macro industrial structural evolution; (3) Take carbon emissions trading pilots as quasi-natural experiments to examine the positive moderating effect of carbon market development on carbon finance's green enabling effect from the perspective of institutional complementarity.

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This paper's contributions are threefold: (1) Break the single indicator measurement of carbon finance and construct a five-dimensional composite index for systematic measurement; (2) Propose industrial green transformation includes "micro efficiency improvement" and "macro structural optimization", expanding existing literature dimensions; (3) Systematically examine the positive moderating effect of carbon emissions trading markets on carbon finance, confirming the institutional complementarity of the two policy tools.

2. Literature review

2.1. Carbon finance

Carbon finance supports clean technology projects through carbon quota trading and green credit, redirecting capital from high-pollution to low-carbon industries and accelerating the low-carbon transition of resource-based industries [1]. The eastern and central regions have achieved significant economic decarbonization due to advanced carbon finance development, while the western region is constrained by resources with a weaker effect. Carbon markets force enterprises to reduce emissions through price signals, and carbon financial products such as carbon futures enhance market liquidity and stimulate carbon allowance trading [2].

2.2. Green transformation and upgrading of industries

China has committed to peaking carbon emissions by 2030 and achieving carbon neutrality by 2060, and the 2022 industrial carbon peaking implementation plan requires a significant reduction in CO_2 emission intensity of key sectors by 2025 [3]. The Yangtze River Economic Belt is advancing industrial green upgrading by eliminating backward production capacity and cultivating emerging industries. Green finance drives corporate green technological innovation through preferential credit and tax incentives, with green credit volume growing at an average annual rate of 15% [4].

2.3. The relationship between carbon finance and industrial green transformation and upgrading

2.3.1. The driving role of industrial green transformation in carbon finance development

Technological upgrading and large-scale development of green industries create demand for carbon finance instruments, and technological spillover effects reduce carbon finance risks. The increase in carbon market trading volume provides a liquidity foundation for carbon financial instruments, and industrial green transformation promotes the improvement of the carbon finance regulatory framework [5].

2.3.2. Mechanisms of carbon finance in industrial green transition

Carbon finance guides capital to green industries through credit allocation and carbon emissions trading, accelerates the elimination of high-energy-consuming and high-polluting production capacity, and drives the expansion of green industries. The carbon market transmits emission reduction cost signals to force enterprises to optimize production structures, and carbon financial products such as green bonds can diversify risks and reduce corporate transition costs. In addition, carbon finance complements environmental policies to jointly promote industrial greening.

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2.4. Research gaps

Existing literature has explored the carbon finance-industrial green transformation relationship, but has three deficiencies: (1) Carbon finance measurement relies on single indicators, failing to capture the multi-dimensional policy toolkit; (2) Industrial green transformation evaluation is limited to macro structural evolution, without integrating micro green production efficiency; (3) The institutional complementarity of carbon emissions trading markets activating carbon finance resource allocation efficiency through price signals has not been systematically examined. Based on this, this study constructs a comprehensive carbon finance index, uses a two-way fixed effects model to identify its "efficiency-structure" driving effect, and further examines the moderating role of carbon emissions trading pilots.

3. Research hypotheses

3.1. Carbon finance and green TFP

Carbon finance enhances GTFP through three pathways: capital allocation (reconstructing the risk pricing logic of green projects to guide resource allocation to clean sectors), innovation incentives (solving the "double externalities" of green innovation and forming a positive feedback loop of financial empowerment-technological breakthrough-efficiency leap), and environmental cost internalization (embedding carbon emission intensity into financing cost evaluation to force enterprises to optimize input combinations) [6]. Based on this, the hypothesis is proposed:

H1: Enhanced development of carbon finance will significantly promote regional growth in green total factor productivity.

3.2. Carbon finance and industrial structure upgrading and rationalization

Carbon finance affects industrial structure evolution through two mechanisms: differentiated financing constraint (selection mechanism) (imposing implicit "carbon tax" on high-energy-consuming and high-polluting industries to accelerate the clearance of backward production capacity) and capital flow (agglomeration mechanism) (guiding capital and technology to cluster in technology-intensive and clean industries to promote industrial structure upgrading and rationalization) [7]. Based on this, the hypothesis is proposed:

H2: Enhanced development of carbon finance will significantly accelerate the upgrading and rationalization of industrial structure.

3.3. The regulatory role of carbon emission trading markets in carbon finance efficiency

Carbon emissions trading pilots play a positive moderating role through price discovery and information provision (establishing credible marginal abatement cost benchmarks to reduce information asymmetry) and risk hedging and institutional safeguards (endowing carbon emission rights with financial asset attributes and providing institutional infrastructure for carbon financial operations). In addition, the synergy of carbon trading's emission reduction pressure and carbon finance's financing incentives forms an institutional coordination framework to strengthen the green enabling effect of carbon finance [8]. Based on this, the hypothesis is proposed:

H3: The establishment of carbon emissions trading pilot programs will positively regulate the promotional effect of carbon finance on industrial green transformation and upgrading.

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4. Research design

4.1. Econometric model specification

To identify the direct impact of carbon finance on industrial green transformation and upgrading, a two-way fixed effects model is constructed for benchmark regression:

$$Y_{it} = \alpha_0 + \alpha_1 L\_cf_{it} + \Sigma\beta_k Controls_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

Where i and t represent province and year, respectively; Y_{it} denotes the dependent variables, representing green total factor productivity (GTFP), rationalization of industrial structure (RIS), and upgrading of industrial structure (AIS), respectively. L_cf_{it} represents the carbon finance development index lagged by one period, with the lag term employed to mitigate potential reverse causality issues; $Controls_{it}$ denotes a set of control variables; μ_i and λ_t respectively represent regional fixed effects and year fixed effects, controlling for regional characteristics that do not vary over time and temporal trends that do not vary across regions; ε_{it} is the random disturbance term.

4.2. Variable definition and measurement

4.2.1. Explained variable: industrial green transformation and upgrading (Y)

Measured from the dual dimensions of efficiency and structure [9]:

Green total factor productivity (GTFP): Incorporate energy consumption into the input vector, and industrial wastewater, SO_2, solid waste, CO_2 as undesirable outputs, measured by the SBM-GML index model:

$$GTFP_{tt}^{+1} = GML_{tt}^{+1} = (1 + D^{GG}(x_t, y^g, _t, y^b, _t)) / (1 + D^{GG}(x_t^{+1}, y^g, _t^{+1}, y^b, _t^{+1})) \quad (2)$$

An index value greater than 1 indicates an improvement in green production efficiency.

Industrial structure rationalization (RIS): Measured by the Theil index, the closer to 0, the higher the rationalization level:

$$RIS = \Sigma(Y_m/Y)\ln((Y_m/L_m)/(Y/L)) \quad (3)$$

Y_m and L_m represent the output value and employment of the m-th industry (primary, secondary, tertiary), Y and L are the regional total output value and employment.

Industrial structure upgrading (AIS): Measured by the ratio of tertiary industry added value ($Y_{it,3}$) to secondary industry added value ($Y_{it,2}$), the higher the value, the higher the upgrading level:

$$AIS = Y_{it,3} / Y_{it,2} \quad (4)$$

4.2.2. Core explanatory variable: carbon finance development index (CF)

This paper constructs a five-dimensional comprehensive carbon finance evaluation system (financial scale, R&D innovation, policy support, low-carbon level, green credit). Adopting the objective entropy method to avoid subjective weighting bias, the provincial annual carbon finance development index is synthesized by linear weighting after standardizing basic indicators and calculating information entropy to determine weights w_j:

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$$CF_{it} = \Sigma w_j X_{ij}' \quad (5)$$

x_{ij}' represents the standardized value of the indicator after dimensionality reduction.

4.2.3. Control variables

Select government intervention (gov) (proportion of local fiscal expenditure to GDP), fixed asset investment (invest) (proportion of fixed asset investment to GDP), and openness to the outside world (open) (proportion of foreign direct investment to GDP) as control variables.

4.3. Data sources

This study uses panel data of 30 Chinese provinces (excluding Tibet) from 2010–2021, with data from the National Bureau of Statistics, China Statistical Yearbook and CSMAR database. Missing data are imputed by linear interpolation, and 360 observations are obtained after data cleaning. Descriptive statistics of key variables are shown in Table 1.

Table 1. Descriptive statistics

	count	mean	sd	min	max
GTFP	360	2.57517	.9540889	1.369217	6.35192
AIS	360	1.368116	.7479613	.6404071	5.179744
RIS	360	0.1748232	.1231454	.0154875	.5741781
cf	360	.174511	.1221206	.0408986	.6927395
open	360	.02123	.0203126	.0001879	.1048218
gov	360	.2474482	.1028398	.1150218	.620843
invest	360	.7952898	.2669954	.2175848	1.359028

5. Empirical findings and analysis

5.1. Benchmark regression results

Table 2 reports the benchmark regression results with stepwise inclusion of fixed effects. The mixed OLS regression (Column 1) shows the cf coefficient is insignificant, due to omitted variable bias from inter-provincial differences. After incorporating province and year two-way fixed effects, the cf coefficient on GTFP is 1.828 ($p<0.01$, Column 2), validating H1; the cf coefficient on AIS is 0.490 ($p<0.05$, Column 3), and the coefficient on RIS is 0.467 ($p<0.01$, Column 4), validating H2. The results show carbon finance significantly improves regional industrial input-output efficiency and promotes industrial structure optimization and upgrading after controlling for confounding factors.

Table 2. Benchmark regression

	(1)	(2)	(3)	(4)
	OLS(GTFP)	FE(GTFP)	FE(AIS)	FE(RIS)
cf	0.057	1.828***	0.490**	0.467***
	(0.108)	(2.679)	(2.301)	(7.042)
open	7.146***	-1.700	-0.464	-0.625***

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Table 2. (continued)

	(3.336)	(-0.748)	(-0.654)	(-2.831)
gov	3.372***	-3.849***	1.893***	0.169
	(6.665)	(-3.577)	(5.631)	(1.613)
invest	-0.561***	-0.198	-0.035	-0.066***
	(-3.137)	(-0.976)	(-0.557)	(-3.368)
Observations	360	360	360	360
Adj. R^2	0.434	0.572	0.711	0.537

t statistics in parentheses

** p < 0.1, ** p < 0.05, *** p < 0.01*

5.2. Endogeneity discussion

The study faces endogeneity challenges of bidirectional causality and dynamic inertia, and adopts two test strategies:

5.2.1. Lagged treatment of explanatory variables

Use the one-period lagged carbon finance index ($L.cf_{it}$) as an instrumental variable for re-estimation (Table 3, Columns 1-3). The coefficients of L.cf on GTFP, AIS and RIS are 2.270 ($p<0.01$), 0.446 ($p<0.1$) and 0.472 ($p<0.01$) respectively, all significant. The results show prior carbon finance development still has a significant promotional effect on current industrial green transformation after eliminating reverse causality.

5.2.2. Dynamic panel system GMM estimation

Construct a dynamic panel model incorporating the first-order lagged term of the explained variable, and use the System GMM method for estimation (Table 3, Columns 4-6). The AR(2) and Hansen tests of the GTFP equation pass the validity test ($p=0.397$ and $p=0.148$), and the lagged GTFP coefficient is significantly positive, verifying the self-reinforcing nature of industrial green productivity. Although the current cf coefficient is insignificant, the direction is consistent with the benchmark regression, indicating carbon finance's promotional effect on GTFP is mainly transmitted through lagged channels. The consistency of the two estimation methods confirms the robustness of the core conclusion.

Table 3. Endogeneity analysis

	(1)	(2)	(3)	(4)	(5)	(6)
	GTFP(Lag)	AIS(Lag)	RIS(Lag)	GTFP(GMM)	AIS(GMM)	RIS(GMM)
L_cf	2.270***	0.446*	0.472***			
	(2.780)	(1.868)	(6.502)			
Controls	YES	YES	YES	YES	YES	YES
AR(2) P				0.397	0.045	0.095
Hansen P				0.148	0.026	0.203
Obs.	330	330	330	330	330	330

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5.3. Robustness checks

To ensure the reliability of the conclusions, robustness tests are conducted from two dimensions (Table 4):

5.3.1. Adjusting the sample observation period

Exclude 2010–2011 data (the initial stage of carbon finance with incomplete institutional framework), and use 2012–2021 data for regression. The cf coefficient on GTFP is 2.036 ($p<0.05$), and the signs and significance of coefficients on AIS and RIS are consistent with the benchmark regression, ruling out the distortion of conclusions by initial sample anomalies.

5.3.2. Incorporating macro-level control variables

Add financial development level (fin) (ratio of total loans of financial institutions to GDP) as an additional control variable. The cf coefficients on GTFP, AIS and RIS are 1.704, 0.502 and 0.448 respectively, all significant. The magnitude and direction of the core explanatory variable coefficients remain unchanged, indicating the research conclusions have high robustness.

Table 4. Robustness tests

	(1) GTFP	(2) AIS	(3) RIS	(4) GTFP	(5) AIS	(6) RIS
	Adj. Period	Adj. Period	Adj. Period	Add Controls	Add Controls	Add Controls
cf	2.036**	0.362	0.427***	1.704**	0.502**	0.448***
	(2.403)	(1.615)	(6.642)	(2.516)	(2.348)	(6.926)
Controls	YES	YES	YES	YES	YES	YES
Obs.	300	300	300	360	360	360
R^2	0.532	0.707	0.542	0.795	0.967	0.888

5.4. Mechanism analysis: the regulatory effects of carbon trading pilots

Introduce the interaction term carbon finance × carbon trading pilot (did_cf) to examine the moderating effect of carbon emissions trading pilots (Table 5). The results show: the did_cf coefficient on GTFP is 3.743 ($p<0.01$), and the coefficient on AIS is 1.103 ($p<0.01$), both significantly positive, validating H3. The underlying mechanism is that carbon trading pilots activate the "price discovery" function of carbon assets, transform implicit environmental costs into explicit market pricing, reduce information asymmetry in green investment and financing, and drive carbon finance resource allocation from extensive to precise, thus amplifying the green enabling effect. The findings confirm the deep institutional complementarity between the carbon emissions trading market and carbon finance, providing empirical evidence for the synergistic advancement of the two policy tools.

Table 5. Moderating effect analysis

	(1) GTFP(DID)	(2) AIS(DID)	(3) RIS(DID)
cf	-1.040	-0.361	0.474***

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Table 5. (continued)

	(-1.215)	(-1.346)	(5.460)
did	-0.576**	-0.167**	0.022
	(-2.212)	(-2.039)	(0.815)
did_cf	3.743***	1.103***	-0.046
	(4.249)	(3.992)	(-0.519)
Controls	YES	YES	YES
Obs.	360	360	360
Adj. R^2	0.604	0.731	0.535

6. Conclusions and implications

6.1. Research findings

Based on panel data of 30 Chinese provinces from 2010–2021, this study empirically verifies the impact and mechanism of carbon finance on industrial green transformation and upgrading from an "efficiency-structure" perspective, and draws four core conclusions: (1) Carbon finance effectively boosts regional GTFP by alleviating green technology innovation financing constraints, optimizing factor allocation, and reducing per unit output energy consumption and pollution intensity; (2) Relying on differentiated financing constraints and targeted capital flow mechanisms, carbon finance accelerates backward production capacity clearance and guides factor agglomeration to technology-intensive industries, promoting industrial structure upgrading and rationalization; (3) Carbon finance's green enabling effect has obvious government intervention heterogeneity—excessive administrative intervention distorts price transmission and resource allocation, suppressing its micro efficiency improvement effect, while rational government intervention supports macro industrial structure optimization; (4) Carbon emissions trading pilots and carbon finance have deep institutional complementarity, the former activates carbon assets' "price discovery" function, reduces green investment and financing information asymmetry, and drives precise allocation of carbon finance resources, thus significantly amplifying carbon finance's catalytic effect on industrial green transformation.

6.2. Policy implications

To further release the driving effect of carbon finance on industrial green transformation and upgrading, three targeted policy implications are proposed:

Improve the differentiated carbon finance product system: Prioritize green credit and carbon quota pledge financing in western underdeveloped regions; actively cultivate carbon futures and options in eastern and central regions with solid foundations, enrich the product system, enhance market liquidity, and expand carbon finance coverage and industry penetration.

Synergize national carbon market and carbon finance development: Accelerate the inclusion of steel, cement, chemicals and other high-emission sectors into the national carbon trading system; promote market-oriented reform of the carbon pricing mechanism to improve price signal quality;

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guide financial institutions to embed carbon market price signals into green credit approval and risk assessment models, forming a "carbon price - green financing - emission reduction incentives" closed-loop mechanism.

Optimize government function positioning: Strengthen the dominant position of market mechanisms in the micro efficiency field, reduce administrative intervention in green credit allocation, and let price signals lead resource allocation; at the macro structural level, the government focuses on institutional supply, information infrastructure construction and intertemporal coordination, and guides industrial green transformation through industrial planning and supporting policies instead of direct resource allocation.

References

[1] Deng Jing, Zheng Yujie, Gu Xuesong, et al. Research on Spillover Effects Between China's Carbon Market and Green Financial Markets [J]. Financial Theory and Practice, 2023, (7): 47-59.
[2] Wang Kang. Environmental Regulation, Carbon Finance, and Low-Carbon Development of Resource-Based Enterprises [J]. Enterprise Economy, 2023, 42(6): 133-142.
[3] Lu Zhida. The Impact of Carbon Finance on Low-Carbon Transformation in Resource-Based Industries: An Empirical Study Based on CDM [J]. Theory and Practice of Finance, 2020, (11): 57-62.
[4] Zhou Zejiong, Xu Jinshue. Empirical Study on the Impact of Green Finance Development Levels on Regional Economic Low-Carbonization [J]. Journal of Dalian University, 2024, 45(4): 56-65.
[5] Liu Liang, Fu Yilei, Song Yang, et al. Development Recommendations for Enhancing China's Carbon Finance Market Maturity Based on International Experience [J]. Southwest Finance, 2024, (1): 43-53.
[6] Liu Yunzhe. Analysis and Pathways of Provincial Carbon Finance Development Levels and Influencing Factors in China [J]. Exploration of Economic Issues, 2014, (07): 118-123.
[7] Li Yan, Zhou Hanmei. Spatial Effects and Heterogeneity of Green Finance Development on Industrial Structure Transformation and Upgrading [J]. Journal of Southwest University (Natural Science Edition), 2023, 45(03): 164-174.
[8] Zhou Chang, Cai Haijing, Liu Meijuan. Micro-level Financial Effects of Carbon Emission Trading on Enterprises: A PSM-DID Test Based on the "Porters Hypothesis" [J]. Journal of Finance and Economics, 2020, (03): 68-77.
[9] Zhang Ting, Li Zhehui. Analysis of Green Finance's Emission Reduction Effects and Mechanisms Under "Peak Carbon and Carbon Neutrality" Goals [J]. North China Finance, 2022, (3): 49-58.