Research on the impact of carbon emission intensity on firm value

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Abstract. In the context of the global push to achieve the "dual carbon" goals (carbon peaking and carbon neutrality), carbon risk, as an emerging and increasingly prominent issue, has attracted widespread attention from all sectors of society. Especially at the corporate level, where companies are critical agents and vehicles for realizing these ambitious objectives, the impact of carbon risks on their financial behavior has become a focal topic of academic research. This paper delves into the impact of corporate carbon emissions on their value, collecting and organizing carbon emission data, stock market data, and financial statements from sample companies from 2003 to 2021. A panel regression model was constructed to study the samples of companies listed on China's A-share market, specifically quantifying and analyzing the impact of corporate carbon emissions on their value through the regression model. Additionally, heterogeneity tests were conducted on high-emission and low-emission industries. The analysis concluded that corporate carbon emission intensity has a significant negative impact on corporate value; the greater the carbon intensity, the lower the corporate value. The heterogeneity tests revealed that, compared to high-emission industries, corporate values in low-emission industries are more significantly negatively affected by carbon intensity. Based on in-depth empirical analysis, this paper offers several policy recommendations to achieve the "dual carbon" goals.

Keywords: Carbon Risk, Carbon Emission Intensity, Corporate Value.

1. Introduction

1.1. Research Background

Scientific evidence demonstrates that climate change has become a severe challenge for societies in the future. Addressing this challenge calls for concerted efforts and joint endeavors from all countries across the globe, a consensus fully reflected at the UN Climate Change Conference held in Paris, France, on November 30, 2015. Centered on two urgent and critical agendas: low-carbon economy and energy conservation & emission reduction, the conference delivered the landmark Paris Agreement. It not only set the grand global target of net-zero greenhouse gas emissions within this century, but also charted a clear roadmap for global climate action, marking a solid and pivotal step forward in the global fight against climate change.

As a major manufacturing country, China inevitably consumed massive amounts of energy during its economic development, leading to rising carbon dioxide emissions. Nevertheless, the Chinese government attaches great importance to carbon emission management and has adopted a series of proactive measures to tackle this challenge. At the 75th Session of the United Nations General Assembly, General Secretary Xi Jinping put forward the goals of peaking carbon dioxide emissions before 2030 and achieving carbon neutrality before 2060. This commitment demonstrates China's firm resolve to address the global challenge of climate change and clarifies the direction for coordinated economic and ecological development. It is both an active response to global climate change and a manifestation of China's responsibility as a major country.

With deepened understanding and widespread implementation of the low-carbon economy concept worldwide, public environmental awareness has grown continuously, driving capital markets to pay close attention to environmental performance. As a result, listed companies' environmental information has become a key factor guiding investors' decision-making. Meanwhile, enterprises

have gradually recognized the importance of enhancing their environmental reputation. By implementing effective emission reduction measures to build an eco-friendly corporate image, firms can not only win market reputation but also boost economic benefits in a rational manner. More fundamentally, carbon emissions are no longer merely an environmental issue but have evolved into an economic concern. Against this backdrop, this paper selects China's A-share listed companies from 2003 to 2021 as research samples to conduct an in-depth investigation into how carbon emissions affect firm value.

1.2. Research Significance

China ranks among the world's largest carbon dioxide emitters and carbon emission reducers [1]. Achieving the Dual Carbon goals remains an arduous long-term task. Amid global efforts to advance the Dual Carbon agenda, carbon risk, an emerging and increasingly prominent issue, has become a focal point for all sectors of society. As understanding of climate change deepens, academic research on the impact of carbon risk on financial markets has developed into a cutting-edge hot topic. However, in-depth studies examining how carbon risk affects firm value remain relatively scarce at the current stage. Given this research gap, this paper carries significant theoretical and practical value.

By reviewing existing literature on carbon risk and firm value, this paper explores their correlation and internal mechanisms, offering valuable insights into how climate change impacts corporate value. In current domestic research evaluating carbon risk's influence on enterprises, scholars generally adopt carbon information disclosure or carbon emission reduction as core research subjects, while few studies utilize actual corporate carbon emission data. To explore carbon risk's impact on firm value more thoroughly, this paper adopts carbon emission intensity as the measurement indicator. In terms of research methodology, this paper not only analyzes the direct impact of carbon risk on firm value, but also conducts heterogeneity analysis across high-emission and low-emission industries. Such analysis helps reveal cross-industry disparities and differentiated strategies for coping with carbon risks. On the basis of clarifying how carbon emission intensity shapes firm value, this study also provides useful references for subsequent scholars to construct and refine carbon risk evaluation systems.

2. Literature Review

2.1. Connotation and Measurement Indicators of Carbon Risk

2.1.1. Connotation of Carbon Riskb

Numerous scholars have defined the connotation of carbon risk in academic research. Lash and Wellington were among the first to categorize six major types of carbon risk: regulatory risk (risks stemming from government restrictions on carbon emissions), physical risk (disruptions to business operations caused by extreme weather events), reputational risk (brand damage arising from corporate environmental violations), legal risk (litigation risks related to carbon emissions), product and technological risk (obsolescence of products and technologies amid stricter environmental standards), and supply chain risk (supply chain disruptions triggered by climate shocks to suppliers)[2].

Subramaniam et al. proposed an alternative five-category classification of carbon risk: strategic risk (long-term corporate strategic disruptions from climate change), operational risk (daily operational hazards arising from environmental issues), compliance risk (cost burdens to meet environmental regulations), reporting risk (costs and efforts required to accurately disclose corporate carbon emissions), and reputational risk (public perceptions of corporate environmental performance)[3].

Gasbarro et al. further expanded the scope of carbon risk, covering regulatory risk, physical climate risk, reputational risk, demand shifts from consumers, product and technological innovation risk, operational uncertainty driven by environmental factors, and financial risk (potential economic losses

from environmental lawsuits)[4]. In summary, carbon risk refers to any corporate risk linked to climate change and fossil fuel consumption that may disrupt business operations [5].

2.1.2. Measurement Indicators of Carbon Risk

Measuring corporate carbon risk is a complex yet vital process, which helps enterprises identify potential climate-related hazards and lays a foundation for academic research.

Most indicators developed by scholars to measure carbon risk rely on disclosed carbon emission data. Bolton and Kacperczyk and Wang et al. adopt total carbon emissions, carbon emission intensity or year-on-year changes in carbon emissions to quantify corporate carbon risk[6,7]. Beyond firm-level data, some scholars evaluate carbon risk using industrial carbon emission benchmarks, enabling horizontal comparison of carbon performance and risk exposure within the same industry[8,9]. Other researchers use carbon efficiency (ratio of target carbon emissions to actual corporate emissions) to measure carbon risk, which quantifies corporate efforts and achievements in emission reduction to assess risk levels[10].

As research on carbon risk deepens, scholars have adopted diversified assessment methods beyond traditional emission data, including composite indices. For instance, Görgen et al. constructed a Brown-Green Score (BGS) integrating data from four comprehensive ESG databases to evaluate corporate carbon risk, offering a multi-dimensional, holistic evaluation framework[11]. Recent climate risk literature also leverages big data and textual analysis: Engle et al. built an innovative climate news index through textual analysis of media outlets such as The Wall Street Journal[12]; Choi et al. constructed an index based on Google search volume to reflect public attention to climate change[13]; Sautner et al. developed a risk exposure index using earnings call transcripts to capture market participants' focus on corporate climate risks and opportunities[14].

2.2. The Impact of Carbon Emissions on Firm Value

A body of literature has explored the correlation between carbon risk and firm value. Li Jinglin and Feng Qiunan argued that enterprises face multiple challenges and risks during low-carbon transition, including regulatory, legal and technological barriers[15]. Most critically, rising emission reduction costs directly impair financial performance and thereby suppress firm value.

Nevertheless, existing research has not reached a unified conclusion on carbon emissions' impact on firm value, due to the dual-sided effects of emission reduction efforts on enterprises. On one hand, cutting carbon emissions enhances sustainable competitive advantages, improving corporate market reputation and long-term value. On the other hand, emission reduction requires massive investment in R&D and technological retrofits, increasing corporate costs and exerting downward pressure on short-term financial performance. This dual mechanism is supported by Gallego-Álvarez et al. and Lewandowski[16,17].

The majority of studies confirm a negative correlation between carbon emissions and firm value across diverse samples and research perspectives. Saka and Oshika studied Japanese enterprises and empirically verified that carbon emission reduction boosts firm value, while transparent carbon disclosure also exerts positive effects[18]. Prakash et al. analyzed S&P 500 firms from 2006 to 2008 and reached identical conclusions, proving that both emission reduction and carbon disclosure transparency benefit corporate valuation[19]. Zhao Yuzhen et al. added that active corporate emission reduction shapes a positive social image, attracts investor attention, boosts investor confidence and elevates firm value[20]. Bai Shixiu et al. conducted grouped regressions and found the positive correlation between carbon reduction and firm value is more significant for non-industrial enterprises than industrial firms[21]. Liu Yongfeng and Zhao Xiaoqin adopted moderation and threshold effect models and found carbon performance positively correlates with financial performance[22]. Liu and Qiao used financial data of Chinese listed firms from 2005 to 2020 and found decarbonization policies reduced the valuation of carbon-intensive enterprises[23]. Choi and Luo analyzed firm data from 28 countries worldwide and confirmed carbon emission levels negatively correlate with firm value after controlling for voluntary carbon disclosure likelihood[24].

A minority of studies argue carbon emissions may positively affect firm value in the short run. Palmer et al. indicated environmental investments increase corporate expenditure and erode profits, meaning emission reduction harms short-term firm value despite environmental benefits, a viewpoint echoed by Busch and Hoffmann[25,26]. Zhou Zhifang et al. studied FTSE 350 UK firms covered by CDP reports and found carbon performance negatively correlates with short-term financial performance[27]. Siddique et al. found carbon disclosure reduces firms' ROA in the short run due to insufficient financial gains to offset disclosure costs, yet generates positive long-term financial outcomes[28]. Fisher-Vanden and Thorburn discovered voluntary greenhouse gas reduction generates negative abnormal stock returns and lowers firm value[29]. Zhang Qiaoliang et al. analyzed 85 S&P 500 firms in 2010 and found carbon emissions and disclosure quality positively impact firm value for low-emission enterprises[30].

2.3. Literature Commentary

A review of literature on carbon emissions and firm value reveals that corporate carbon issues are multi-dimensional and complex. Carbon emissions exert significant impacts on firm value through internal and external channels including regulatory costs, brand reputation and technological innovation. However, existing research has not formed consistent conclusions, with contradictory findings widely documented. Against this research backdrop, this paper draws on prior methodologies to construct carbon risk measurement indicators and investigate how carbon emission intensity affects the value of Chinese listed firms via panel data analysis.

3. Theoretical Analysis and Research Hypotheses

Stakeholder theory emphasizes that corporate operation and management must fully consider the interests of all legitimate individuals or groups connected to the firm (stakeholders). The theory advocates that a firm's core objective extends beyond profit maximization to maximizing the overall interests of all stakeholders. Driven by CDP initiatives and international conventions such as the Kyoto Protocol, corporate attention to carbon reduction has surged; institutional investors' focus on climate risks has grown 18 times over the past decade[31]. This implies corporate strategies must align with social and environmental responsibilities, balancing economic performance and environmental targets[32]. Stakeholder theory thus predicts carbon emissions exert tangible impacts on firm value.

Investor preference theory posits that green assets may outperform high-carbon assets during periods of heightened non-monetary investor preferences or intensified ESG concerns [33]. Ricci and Banterle surveyed Italian retail consumers and found consumer purchasing behavior shifted markedly toward green products after the Paris Agreement, reflecting rising environmental awareness and demand for sustainable consumption[34]. Riedl and Smeets and Hartzmark and Sussman demonstrated socially responsible investors integrate corporate environmental performance into investment decisions, even willing to sacrifice partial expected returns for green assets[35,36]. Bai Shixiu et al. further proposed investors treat corporate greenhouse gas reduction as an intangible asset reflected in stock prices. Based on the above analysis, Hypothesis 1 is proposed:

H1: Corporate carbon emission intensity exerts a negative impact on firm value.

Since the implementation of the 12th Five-Year Plan, China's industrialization process has accelerated dramatically, accompanied by rapid economic expansion and continuous industrial structural optimization. Despite vigorous adjustments to energy mix and energy conservation policies, high-energy-consuming enterprises remain the primary source of carbon emissions, accounting for a dominant share of industrial carbon output due to large production scales and high energy demand.

Bolton and Kacperczyk analyzed U.S. listed firms and found companies with higher total carbon emissions and emission volatility require higher stock returns for investors. Chava showed investors demand higher expected returns for carbon-intensive firms, while lenders charge higher interest rates on bank loans to environmentally exposed enterprises, consistent with Sharfman and Fernando, who argued firms with high carbon footprints and environmental risk exposure face elevated capital

costs[37,38]. Meanwhile, tightening global climate regulations increase corporate compliance expenditures. High-emission firms must invest in R&D and introduction of low-carbon technologies to cut emissions, further raising carbon-related costs and suppressing firm value[39]. Chapple et al. adopted an amended Ohlson valuation model and found carbon-intensive firms suffer a 6.57% market value impairment[40]. Based on the above reasoning, this paper initially infers that carbon emission intensity's negative impact on firm value is more pronounced for high-emission industry firms than low-emission counterparts, leading to Hypothesis 2:

H2: Carbon emission intensity exerts a stronger negative impact on firm value for enterprises in high-emission industries relative to low-emission industries.

4. Research Design

4.1. Sample Selection and Data Sources

This paper selects A-share listed companies traded on the Shanghai and Shenzhen Stock Exchanges as research samples, covering the period 2003–2021. During sample screening, two categories of firms are excluded: (1) financial listed companies; (2) delisted, ST and *ST listed companies.

The final sample contains 31,807 panel observations to examine carbon risk's impact on firm value. All stock market and financial statement data are sourced from the CSMAR database; carbon emission data are extracted from corporate annual reports, social responsibility reports, corporate official websites and environmental authority portals.

4.2. Variable Definition and Model Construction

Firm value constitutes the core dependent variable of this study. Following widely recognized academic standards at home and abroad, Tobin's Q is adopted to measure firm value to ensure rigor and consistency.

Drawing on research hypotheses and literature review, the baseline regression model is constructed as follows:

$$TBQ_{i,t} = \beta_0 + \beta_1 CEI_{i,t} + \beta_2 Controls_{i,t} + \gamma_t + \varphi_i + \varepsilon_{i,t} \quad (1)$$

Significant disparities exist in carbon emissions across industries, stemming from production characteristics, energy consumption structures and technological gaps. To accurately capture such disparities, the model controls for year fixed effects γ_t (to absorb time-varying shocks) and firm fixed effects φ_i (to absorb time-invariant firm and industry heterogeneity).

In Equation (1), TBQ denotes the dependent variable; CEI is the core independent variable; Controls represents a set of control variables, with detailed definitions presented in Table 1.

Table 1. Variable Definitions

Variable Category	Variable Name	Symbol	Definition
Dependent Variable	Firm Value	TBQ	(Market value of equity + Book value of total liabilities) / Book value of total assets
Independent Variable	Carbon Emission Intensity	CEI	Total carbon emissions / Operating revenue
Control Variables	Firm Size	Size	Natural logarithm of total assets
	Leverage Ratio	LEV	Total liabilities / Total assets
	Profitability	ROA	Net profit / Total assets
	Growth Capacity	Growth	Annual asset growth rate
	Largest Shareholder Ownership	Top1	Number of shares held by the largest shareholder / Total outstanding shares
	Board Size	Bsize	Natural logarithm of the number of board directors
	Independent Director Ratio	INDP	Number of independent directors / Total board members
	Listing Age	Age	Natural logarithm of years since IPO

5. Empirical Tests

5.1. Descriptive Statistics of Variables

Descriptive statistics for all major variables are reported in Table 2. To eliminate bias induced by extreme values, all continuous variables are winsorized at the 1st and 99th percentiles.

Table 2. Descriptive Statistics

VARIABLES	N	mean	median	sd	min	max	p25	p75
CE	31,807	0.311	0.075	0.794	0.003	5.733	0.032	0.203
CEI	31,807	0.473	0.430	0.230	0.140	1.688	0.344	0.531
TBQ	31,807	1.904	1.515	1.170	0.870	7.764	1.190	2.145
Size	31,807	12.880	12.660	1.318	10.540	17.000	11.920	13.600
LEV	31,807	0.430	0.428	0.204	0.054	0.887	0.267	0.585
ROA	31,807	0.046	0.042	0.060	-0.180	0.226	0.016	0.077
Growth	31,807	0.202	0.104	0.356	-0.269	2.084	0.019	0.249
Top1	31,807	0.363	0.345	0.152	0.091	0.750	0.244	0.471
Bsize	31,807	2.150	2.197	0.204	1.609	2.708	1.946	2.197
INDP	31,807	0.370	0.333	0.053	0.273	0.571	0.333	0.417
Age	31,807	1.909	2.133	0.958	0.000	3.291	1.290	2.679

CE denotes total carbon emissions (unit: million tons). The average annual carbon emission of sample firms reaches 311,000 tons. The 25th percentile, median and 75th percentile stand at 32,000 tons, 75,000 tons and 203,000 tons respectively, all far below the mean value. This distribution indicates total carbon emissions are highly concentrated among the top 25% highest-emitting firms.

CEI represents carbon emission intensity (tons per ten thousand RMB revenue). Compared with absolute carbon emissions, carbon emission intensity receives greater attention from investors and corporate operators[41]. The sample average carbon emission intensity equals 0.473; adjusted for firm scale, this indicator more accurately reflects corporate carbon risk exposure. The mean and median Tobin's Q (TBQ) stand at 1.904 and 1.515, demonstrating stable overall firm value across the sample period. These statistics lay a foundational reference for subsequent analysis of carbon risk's impact on firm value.

5.2. Analysis of Baseline Regression Results

Table 3 presents regression results under different fixed effect specifications, with year fixed effects included across all models and firm-clustered standard errors reported in parentheses. Columns (1) and (2) control for firm fixed effects; after absorbing firm-level heterogeneity, the coefficient on CEI (carbon emission intensity) equals -0.097 and passes the 1% significance test. Columns (3) and (4) control for industry fixed effects instead. Compared with firm fixed effects, the statistical significance of CEI weakens when only industry fixed effects are included, which implies substantial within-industry firm-level heterogeneity. Unobservable time-invariant firm-specific factors cannot be fully captured by industry fixed effects alone; controlling for firm fixed effects is necessary to accurately estimate carbon emission intensity's impact on firm value.

For control variables, financial leverage, profitability, independent director ratio and listing age show significant positive correlations with firm value, consistent with theoretical expectations. Financial leverage expands corporate capital input via debt financing, enlarges market share, restrains overinvestment through debt covenants, optimizes resource allocation and lifts firm value. Profitability directly reflects market competitiveness and operational performance; high-profit enterprises generate abundant cash flow to fund expansion and R&D innovation, further boosting valuation. Independent directors maintain objective, impartial oversight over major shareholders and management, preventing conduct detrimental to minority shareholders, stabilizing corporate operations and enhancing firm value. Firms with longer listing histories establish mature governance and internal control systems, standardizing operational procedures, mitigating business risks and supporting higher valuation.

Firm size, asset growth rate and largest shareholder ownership exhibit significant negative correlations with Tobin's Q. Excessively large firms face complex decision-making mechanisms and higher transition barriers amid climate shocks, slowing adaptation to market shifts and depressing firm value. Excessively rapid asset expansion leads to inefficient resource allocation, reducing asset turnover and profitability. Concentrated shareholding by the largest shareholder creates insufficient power balance, elevating decision-making bias risks and harming firm value.

The baseline regression results verify Hypothesis 1, confirming carbon emission intensity exerts a significant negative impact on firm value.

Table 3. Baseline Regression of Carbon Emission Intensity and Firm Value

	(1)	(2)	(3)	(4)
	TBQ	TBQ	TBQ	TBQ
CEI	-0.155***	-0.097***	-0.096**	-0.047*
	(0.029)	(0.025)	(0.033)	(0.027)
Size		-0.580***		-0.393***
		(0.029)		(0.024)
LEV		0.381***		0.107
		(0.100)		(0.083)
ROA		4.034***		5.236***
		(0.222)		(0.667)
Growth		-0.130***		-0.216***
		(0.017)		(0.032)
Top1		-0.325**		-0.182**
		(0.107)		(0.072)
Bsize		0.093		0.023
		(0.075)		(0.072)
INDP		0.550**		0.739**
		(0.207)		(0.293)
Age		0.579***		0.279***
		(0.024)		(0.028)
Constant	1.447***	7.179***	1.069***	5.120***
	(0.033)	(0.388)	(0.036)	(0.391)
Year F.E.	Yes	Yes	Yes	Yes
Industry F.E.	No	No	Yes	Yes
Firm F.E.	Yes	Yes	No	No
Observations	31807	31807	31807	31807
Adj. R2	0.190	0.329	0.204	0.368

***, **, * denote statistical significance at the 1%, 5% and 10% levels respectively; standard errors clustered at firm level in parentheses.

5.3. Industrial Heterogeneity Test

Cross-industry disparities in energy types, energy efficiency and production processes generate distinct carbon emission intensity levels. Examining industrial heterogeneity clarifies sectoral differences in carbon risk exposure and facilitates targeted emission reduction policies. Following industrial classification standards from the National Bureau of Statistics, six major high-energy-consuming sectors are categorized as high-emission industries, while all remaining sectors constitute low-emission industries. Grouped regression results are displayed in Table 4.

For low-emission industries, the regression coefficient of CEI on TBQ equals -0.106 and is significant at the 1% level, implying environmental performance strongly supports firm valuation in low-emission sectors. In contrast, the CEI coefficient for high-emission industries stands at -0.022 with a p-value above 0.1, failing to confirm a statistically significant negative relationship between carbon emission intensity and firm value. Comparison of the two groups reveals carbon emission intensity carries significant negative valuation effects only within low-emission industries, with a

larger absolute coefficient magnitude (-0.106 vs. -0.022), demonstrating emission reduction generates greater valuation gains for low-emission enterprises.

This empirical outcome contradicts Hypothesis 2, attributable to divergent investor expectations across sectors. Investors price in elevated carbon risk ex ante for high-emission industry firms, embedding climate hazards into asset valuations in advance. Consequently, marginal increases in carbon emission intensity for high-emission firms trigger minimal investor response, weakening the statistical correlation between CEI and Tobin's Q. Conversely, low-emission enterprises are generally perceived to have sound environmental performance, with investors placing little weight on carbon risk during valuation. A rise in carbon emission intensity for low-emission firms breaks established market expectations, prompting downward revaluation of corporate fundamentals.

Variations in carbon information disclosure quality further explain this result. Chinese enterprises enjoy substantial autonomy over carbon disclosure, leading to incomplete, inconsistent environmental reporting. High-emission firms face stricter regulatory oversight and potential penalties for excessive emissions, creating incentives to withhold full carbon data to avoid sanctions, which distorts empirical estimation.

Table 4. Industrial Heterogeneity Test

	Low-emission Industries		High-emission Industries	
	(1)	(2)	(3)	(4)
	TBQ	TBQ	TBQ	TBQ
CEI	-0.183***	-0.106***	-0.022	-0.022
	(0.032)	(0.029)	(0.067)	(0.053)
Size		-0.572***		-0.621***
		(0.031)		(0.068)
LEV		0.360***		0.396*
		(0.106)		(0.220)
ROA		4.066***		3.767***
		(0.263)		(0.389)
Growth		-0.145***		-0.081*
		(0.019)		(0.043)
Top1		-0.339**		-0.335*
		(0.130)		(0.197)
Bsize		0.164**		0.035
		(0.082)		(0.133)
INDP		0.619**		0.619*
		(0.244)		(0.326)
Age		0.593***		0.540***
		(0.027)		(0.048)
Constant	1.469***	6.922***	1.330***	7.760***
	(0.039)	(0.399)	(0.067)	(0.843)
Year F.E.	Yes	Yes	Yes	Yes
Firm F.E.	Yes	Yes	Yes	Yes
Observations	25448	25448	6359	6359
Adj. R2	0.194	0.323	0.194	0.364

***, **, * denote statistical significance at the 1%, 5% and 10% levels respectively; standard errors clustered at firm level in parentheses.

5.4. Robustness Test

Quantile regression is adopted to verify the robustness of the baseline relationship between carbon emission intensity and firm value, examining CEI's impact across the full distribution of Tobin's Q to confirm consistent negative effects. Table 5 reports quantile regression results at the 10th, 25th, 50th, 75th and 90th percentiles, with year and firm fixed effects included and firm-clustered standard errors reported in parentheses. CEI carries a significantly negative coefficient at all quantiles except the 90th percentile, proving carbon emission intensity suppresses firm value across most valuation

tiers. The insignificant negative coefficient at the 90th percentile (highest-value firms) may stem from superior market positioning, robust profitability and extensive resource networks that offset the adverse valuation impacts of high carbon intensity.

Table 5. Robustness Test: Quantile Regression

	(1)	(2)	(3)	(4)	(5)
Quantile	TBQ	TBQ	TBQ	TBQ	TBQ
	q10	q25	q50	q75	q90
CEI	-0.083***	-0.057***	-0.115***	-0.114***	0.007
	(0.012)	(0.013)	(0.017)	(0.032)	(0.085)
Size	-0.242***	-0.321***	-0.478***	-0.632***	-0.900***
	(0.020)	(0.017)	(0.028)	(0.030)	(0.054)
LEV	0.138***	0.171***	0.093	0.221**	0.311
	(0.033)	(0.040)	(0.069)	(0.111)	(0.258)
ROA	1.529***	1.842***	2.732***	4.429***	6.399***
	(0.117)	(0.113)	(0.128)	(0.209)	(0.417)
Growth	-0.012*	-0.022**	-0.065***	-0.143***	-0.261***
	(0.007)	(0.008)	(0.011)	(0.021)	(0.042)
Top1	-0.126**	-0.240***	-0.376***	-0.642***	-0.905***
	(0.043)	(0.058)	(0.080)	(0.130)	(0.234)
Bsize	0.033	-0.019	0.059	-0.043	-0.101
	(0.027)	(0.033)	(0.054)	(0.079)	(0.143)
INDP	0.299***	0.415***	0.867***	1.315***	2.426***
	(0.079)	(0.095)	(0.173)	(0.286)	(0.676)
Age	0.091***	0.160***	0.333***	0.527***	0.833***
	(0.013)	(0.011)	(0.017)	(0.027)	(0.061)
Year F.E.	Yes	Yes	Yes	Yes	Yes
Firm F.E.	Yes	Yes	Yes	Yes	Yes
Observations	31807	31807	31807	31807	31807

***, **, * denote statistical significance at the 1%, 5% and 10% levels respectively; standard errors clustered at firm level in parentheses.

6. Research Conclusions and Policy Recommendations

6.1. Research Conclusions

This paper takes China's A-share listed companies from 2003 to 2021 as research samples, collects carbon emission, stock market and financial statement data, and adopts panel data analysis to investigate carbon emission intensity's impact on firm value, with grouped regressions for high-emission and low-emission industries. Two core conclusions are drawn: (1) Corporate carbon emission intensity exerts a significant negative impact on firm value. Higher carbon emission intensity corresponds to lower corporate valuation. (2) The negative valuation effect of carbon emission intensity is statistically significant for low-emission industry firms, yet insignificant for firms operating in high-emission industries.

6.2. Policy Recommendations

Global climate warming grows increasingly urgent, carbon emissions attract widespread public attention, and the low-carbon economy concept has gained mainstream recognition. Guided by the Dual Carbon goals, enterprises as market entities play a decisive role in national emission reduction progress. This paper's empirical finding that carbon reduction lifts firm value provides practical support for China's carbon peaking and carbon neutrality agenda and supplies empirical evidence to improve national carbon information disclosure regulations.

Enterprises constitute the core engine of national economic development and the primary source of energy consumption and greenhouse gas emissions, requiring proactive participation in national

energy structure green transformation and low-carbon strategy implementation. At present, corporate awareness and voluntary action on carbon reduction remain insufficient, with emission reduction progress largely driven by mandatory government policies. This study's finding that carbon emission intensity suppresses firm value highlights the long-term value gains of corporate decarbonization; firms must reduce carbon emission intensity to elevate overall market valuation.

Improving energy efficiency significantly cuts corporate energy consumption and total carbon emissions, lowering operational costs and enhancing environmental performance and corporate brand reputation to generate lasting operational and competitive advantages. Carbon management should target not only absolute emission volume but also carbon emission intensity (carbon output per unit revenue). Enterprises must reduce energy consumption and emissions during production while maintaining or boosting production efficiency.

Insufficient carbon information disclosure quality partially explains the insignificant valuation impact of carbon emission intensity within high-emission industries. Incomplete corporate carbon disclosure hinders investors' accurate assessment of intrinsic value and long-term growth prospects, impeding national carbon reduction targets. Amid rising environmental accountability standards, corporate carbon performance has become a critical metric to evaluate operational efficiency and market competitiveness. High-emission firms in particular should voluntarily disclose comprehensive carbon data to accept public oversight, strengthen sustainable emission reduction capacity and secure long-term market competitiveness.

At the national level, standardized carbon information disclosure rules are essential to incentivize transparent voluntary corporate reporting. Comprehensive disclosure frameworks enable informed investment decisions, empower consumers to evaluate corporate environmental responsibility, and strengthen government environmental supervision. Given divergent carbon risk sensitivity across industrial sectors, differentiated disclosure standards should be formulated. Stringent, detailed reporting requirements covering total carbon emissions, reduction measures and carbon trading activities shall apply to high-emission industries. While low-emission sectors generate minimal direct carbon output, their supply chains and product lifecycles create indirect emissions; appropriate disclosure standards shall also be enforced for low-emission enterprises to drive oversight of indirect carbon footprints.

6.3. Research Limitations and Future Prospects

Although this paper yields meaningful empirical findings on carbon emission intensity's impact on firm value, several limitations remain: First, carbon emission data rely entirely on voluntary corporate disclosure, restricting sample size and data quality. Scarce high-emission industry observations may introduce sample bias and undermine result generalizability. China lacks mandatory uniform carbon disclosure requirements, creating barriers to accessing comprehensive, accurate carbon datasets. Future research may expand sample coverage to conduct more representative long-term analysis.

Second, this paper solely adopts carbon emission intensity as a single-dimensional carbon risk metric, failing to incorporate other critical climate hazards such as physical risks triggered by extreme weather and resource scarcity that may impair firm value. Indirect transmission channels including industrial transformation, technological upgrading and market restructuring are also overlooked. Subsequent studies should adopt multi-dimensional carbon risk indicators to comprehensively evaluate climate risks' financial impacts on enterprises.

Finally, this paper only estimates the total effect of carbon emission intensity on firm value, without exploring intermediate transmission channels and underlying mechanisms. Further research into the internal influence pathways will support corporate low-carbon transition and high-quality sustainable development.

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