Proceedings of ICMRED 2025 symposium: Analyzing the Impact of Governmental Environmental Attention on Enterprises' ESG Performance
DOI: 10.54254/2754-1169/2025.MUR22315

The Impact of Carbon Trading Price Volatility on the Financial Risk of Manufacturing Enterprises--A Study Based on Listed Companies in China

Liren Wang[1,a,*]

[1]*School of Public Economics and Administration, Shanghai University of Finance and Economics, Shanghai, 200433, China*
a. rainw47@outlook.com
**corresponding author*

Abstract: In the context of the global active response to climate change and the continuous development and improvement of the carbon trading market, the manufacturing industry is increasingly linked to financial risk. Theoretically, the fluctuation of the carbon trading price affects the cost of enterprises and the competitive situation in the market, which in turn affects the financial risk. The empirical evidence is based on the sample of 1107 listed companies in the manufacturing industry from 2014 to 2021, and the regression model is constructed, and the results show that carbon trading price volatility is significantly positively correlated with the financial risk of manufacturing enterprises. The heterogeneity test finds that state-owned enterprises and large-scale enterprises are more affected by carbon price volatility on financial risk, and the difference in this effect among enterprises with different R&D investment intensity is not significant. After replacing the regression model and the robustness test of the reduced-tail treatment, the results are reliable.

Keywords: China's carbon trading market, carbon price volatility, manufacturing enterprises, financial risk, listed companies

1. Introduction

As environmental problems have intensified in recent years, countries have been actively reducing carbon emissions, and China has also been taking action. As of the end of July 2024, the turnover and volume of transactions were sizable and covered a huge amount of carbon dioxide emissions, making China the largest carbon market in the world.

In the context of the global green and low-carbon transition, the sustainable development of the manufacturing industry faces both opportunities and challenges, and is closely linked to financial risks. The transformation and upgrading of the manufacturing industry requires a large amount of funds, and poor financing can easily lead to financial risks; at the same time, financial market volatility also affects the costs and returns of enterprises. Relevant state departments of China have also issued documents emphasizing the promotion of financial resources to the advanced manufacturing sector.

At present, the attention of the academic and practical communities to issues related to the manufacturing industry and carbon trading has risen, but there are still deficiencies. Existing research

DOI: 10.54254/2754-1169/2025.MUR22315

has mostly focused on the macro impact of carbon trading on enterprises, with less research on the impact of carbon trading price volatility on the micro-financial risk decisions of enterprises, especially manufacturing enterprises, and a lack of empirical research within China.

This study focuses on the impact of carbon trading price volatility on the financial risk of manufacturing enterprises, and whether there is a difference between different enterprises when facing carbon price volatility. On the theoretical side, the study helps to enrich the relevant empirical research results. On the practical side, the study provides a basis for enterprises to formulate financial plans and for the government to improve its policies, which will help the manufacturing industry develop green and innovatively and the economy to develop sustainably.

2. Theoretical Analysis and Research Hypothesis

Lianghu Wang found that China has a relatively low level of high-quality development in the manufacturing industry by studying China's carbon emissions trading pilot policy (CETP), and CETP significantly improves the level of high-quality development of the manufacturing industry, but there is a certain lag in the effect of the policy [1]. Reading the literature, we found that the impact of carbon price volatility on manufacturing enterprises is attracting much attention [2].

From the point of view of enterprise cost, the fluctuation of carbon trading price is directly related to the carbon emission cost of manufacturing enterprises. Many studies have shown that changes in carbon price significantly affect the cost structure of enterprises. For example, Chen Fang and Li Xinrou proposed that the carbon price level directly affects the investment and operation costs and income level of enterprises [3]. Zeng Lin also believes that the carbon price will increase the transaction costs of enterprises. Especially in energy-intensive manufacturing enterprises, such as iron and steel, the chemical industry, carbon emission costs account for a larger proportion of the total cost, and carbon price fluctuations on their cost impact are more obvious [4]. Lu Qin further pointed out that the instability of the cost triggers the enterprise capital liquidity risk, increases the pressure of debt servicing, and increase the risk of capital chain breakage, which in turn affects the financial stability of enterprises [5].

Analyzing from the market competition dimension, the coping ability of different enterprises to carbon trading price fluctuations varies significantly. Cheng et al. indicated that factors such as enterprise scale and technology level affect their ability to cope with carbon price fluctuations, and enterprises with weaker technological innovation abilities have limited adjustment ability and intensified financial risks in the face of carbon price fluctuations[6]. Zhang et al. found that market mechanisms and policy differences can lead to different carbon price fluctuations, which in turn make different enterprises face different levels of risk challenges [7].

Based on the above theoretical analysis, this study proposes the hypothesis that the increased price volatility of carbon trading will increase the financial risk of manufacturing companies.

3. Empirical Research Design

3.1. Model Building

In this paper, the research hypothesis is established by building model (1) as a study of the impact of carbon price volatility on the financial risk of manufacturing firms if β_1 is significantly positive.

$$\mathrm{Finlev}_{I,t} = \beta_0 + \beta_1 \mathrm{CPV}_{I,t} + \beta_2 \sum \mathrm{Controls}_{I,t} + \varepsilon_{I,t} \quad (1)$$

DOI: 10.54254/2754-1169/2025.MUR22315

3.2. Indicator Selection

This study selects the financial asset-liability ratio (Finlev) of manufacturing companies to measure the financial risk of companies. Referring to the measure of carbon price volatility in related studies, this paper takes the daily volume as the weight and the daily transaction price as the basis, and calculates the average annual growth rate of each year during 2014-2021 as the indicator of carbon price volatility (CPV) [8-9]. In order to eliminate the influence of factors other than the core explanatory variables, the control variables selected in this study are enterprise size (Size), operating income growth rate (Growth), the proportion of shares held by the largest shareholder (Top1), research and development investment intensity (RD), and whether it is a state-owned enterprise (SOE), of which SOE is a dummy variable; if it is a state-owned enterprise, then SOE=1, if it is a non-state-owned enterprise, then SOE = 0.

3.3. Data Sources and Descriptive Statistics

The explanatory variable CPV is calculated based on the carbon trading price data of China's national carbon trading market database for the period of 2014-2021, and all other variables are collected and processed from the annual reports of China's domestically listed manufacturing firms, which amount to 1,107 firms.

Table 1: Descriptive Statistics of Research Variables for Listed Manufacturing Companies

Variables	Obs	Mean	Std.dev	Min	Max
id	7,749	240695.5	262346.7	12	900953
years	7,749	2018	2.00129	2015	2021
Lev	7,749	.4212599	.2098925	.009779	2.848743
Finlev	7,749	.4165648	.2387461	0	.961629
CPV	7,749	.1091763	.2175469	-.2664188	.4326112
Size	7,749	22.31471	1.199152	17.38817	27.547
Growth	7,749	.4783501	12.35135	-2.874917	760.5805
Topl	7,749	32.01236	13.79037	2.79	89.99
RD	7,749	4.48969	4.326416	0	110.9
SOE	7,749	.3232675	.4677541	0	1

Through descriptive statistics, it can be seen that the observed values of all variables are 7749, and the mean value of Finlev is 0.4165648, with a standard deviation of 0.2387461, taking values ranging from 0 to 0.961629, with significant differences. The mean value of CPV is 0.1091763, with a standard deviation of 0.2175469, taking values ranging from -0.2664188 to 0.4326112, with a certain degree of volatility. Because the core variable CPV differs from Finlev and other variables in terms of magnitude, subsequent regression analyses will use Z-score to eliminate this effect and bring the data closer to normal distribution, thus improving the reliability of the regression analysis. Model (2) is presented here for later analysis.

$$z\_Finlev_{i,t} = \beta_0 + \beta_1 z\_CPV_{i,t} + \beta_2 \sum z\_Controls_{i,t} + \varepsilon_{i,t} \quad (2)$$

DOI: 10.54254/2754-1169/2025.MUR22315

4. Analysis of Empirical Results

4.1. Preliminary Analysis

Before conducting the empirical regression, this paper plots the relationship between carbon trading price volatility and financial risk indicators of manufacturing companies. The fitted line in Figure 1 shows that there is a positive correlation between carbon trading price volatility and the level of corporate financial risk, which is consistent with the theoretical expectations of the research hypothesis in this paper, thus providing preliminary evidence for this research hypothesis.

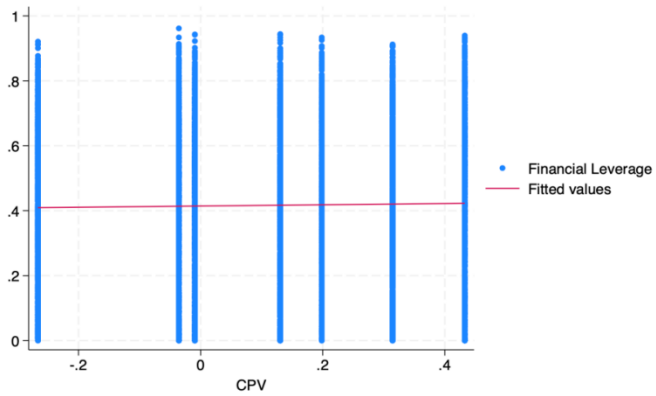

Figure 1: Preliminary analysis diagram

4.2. Correlation Test

The average value of variance inflation factor VIF in this study is 1.06, which is much lower than 5, and the whole indicates that there is no serious multicollinearity problem among the independent variables in the model, and the variables in the regression model are relatively independent, and their respective influences on the explanatory variables can be more clearly identified and estimated.

4.3. Benchmark Regression

After the Hausman test for fixed effects and random effects selection, the original hypothesis of "the disturbance term is not related to the explanatory variables" is strongly rejected, so this paper adopts the fixed effects model for regression. In this study, individual fixed effects and time-fixed effects are taken into account, while cluster robust standard errors are used to reduce model errors.

Table 2: Benchmark Regression Results

	(1)	(2)	(3)
VARIABALES	z_Finlev	z_Finlev	z_Finlev
z_CPV	0.0239**	0.0935***	
	(0. 00843)	(0.0116)	
z_Size		0.478***	0.478***
		(0.0563)	(0.0563)
z_Growth		-0.00619***	-0.00619***
		(0.00149)	(0.00149)
z_Topl		-0.0322	-0.0322
		(0.0318)	(0.0318)
Z_RD		0.0777***	0.0777***

DOI: 10.54254/2754-1169/2025.MUR22315

Table 2: (continued).

		(0.0168)	(0.0168)
SOE		-0.126*	-0.126*
		(0.0680)	(0.0680)
Constants	-0.00557	0.0573**	0.196***
	(0.00892)	(0.0242)	(0.0303)
Individual Fixed Effects	Controlled	Controlled	Controlled
Time Fixed Effects	Controlled	Controlled	Controlled
Observations	7749	7749	7749
R-squared	0.004	0.060	0.060

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Table 2 shows the regression results of the association between the degree of carbon price volatility and the financial risk of manufacturing companies. Column (1) shows the regression results when no control variables are included; column (2) incorporates control variables such as firm size (Size), growth rate of operating income (Growth), proportion of shares held by the first largest shareholder (Top1), research and development investment intensity (RD), and whether or not it is a state-owned enterprise (SOE); and column (3) examines the relationship between the control variables and the explained variables separately.

From the regression results, the association between the explanatory variables and the explained variables is significantly positive at a 1% significance level. The correlation coefficient is 0.0239 when the control variables are not added, which indicates that the degree of volatility of carbon emissions trading price is significantly and positively related to the financial risk of manufacturing enterprises. After adding the control variables, the positive relationship is still significant at a 1% level and the correlation coefficient becomes 0.0935, which indicates that the significant positive relationship between the volatility of carbon emissions trading price and the financial risk of manufacturing enterprises still exists after taking into account a number of factors that may affect the value of enterprises. As far as the control variables are concerned, except for the proportion of shares held by the largest shareholder, which has no significant effect on enterprise value, all other control variables are significantly associated with the financial risk of manufacturing enterprises. This result strongly supports the research hypothesis that there is a significant positive relationship between the level of financial risk and the degree of carbon price volatility of listed manufacturing companies.

4.4. Heterogeneity Test

The previous benchmark regressions provide a lot of empirical evidence on the relationship between carbon price volatility and the financial risk of manufacturing firms, but the starting point of this examination focuses on the overall level and ignores the heterogeneity in different scenarios. In this paper, we examine the heterogeneous response of financial risk of manufacturing firms to carbon price volatility from the three dimensions of property rights, firm size, and R&D investment intensity according to the relevant literature [10-11].

The approach is as follows:(1) Nature of property rights. The cross multiplier of SOE and z_CPV is chosen as the focus of interest in this section. (2) Firm size. Generate the dummy variable Sizegroup, which defines the firm as a large-scale company if z_Size>0 and Sizegroup takes the value of 1. If z_Size<0, the firm is defined as a small-scale company and Sizegroup takes the value of 0. Select the cross-multiplication term of the dummy variable Sizegroup with z_CPV as the focus of attention in this part. (3) R&D investment. Generate the dummy variable RDgroup, if z_RD>0, then define the

DOI: 10.54254/2754-1169/2025.MUR22315

enterprise as a large R&D investment company, RDgroup takes the value of 1. If z_RD<0 then define the enterprise as a small R&D investment company, and RDgroup takes the value of 0. Select the cross-multiplication term between the dummy variable RDgroup and z_CPV as the focus of attention in this part.

Table 3: Heterogeneity Test Results

	(1)Nature of Property Rights	(2)Firm Size	(3)R&D Investment
VARIABALES	z_Finlev	z_Finlev	z_Finlev
z_CPV*SOE	0.0220**		
	(0.0105)		
Z_CPV*Sizegroup		0.0249**	
		(0.0106)	
z_CPV*RDgroup			-0.00473
			(0.0115)
z_CPV	0.0856***	0.0831***	0.0952***
	(0.0128)	(0.0126)	(0.0123)
z_Size	0.476***	0.482***	0.478***
	(0.0565)	(0.0564)	(0.0563)
z_Growth	-0.00625***	-0.00597***	-0.00624***
	(0.00143)	(0.00148)	(0.00149)
z_Topl	-0.0294	-0.0316	-0.0321
	(0.0319)	(0.0318)	(0.0318)
z_RD	0.0775***	0.0778***	0.0776**
	(0.0168)	(0.0169)	(0.0168)
SOE	-0.122*	-0.128*	-0.126*
	(0.0682)	(0.0680)	(0.0680)
Constants	0.0568**	0.0624**	0.0571**
	(0.0243)	(0.0243)	(0.0243)
Individual Fixed Effects	Controlled	Controlled	Controlled
Time Fixed Effects	Controlled	Controlled	Controlled
Observations	7749	7749	7749
R-squared	0.060	0.061	0.060

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Table 3 reports the regression results for the different heterogeneity tests. The results in column 1 show that for SOEs, an increase in the price volatility of carbon credits leads to an additional increase in corporate financial risk on top of the effect of carbon price volatility itself. The results in column 2 indicate that for large-scale firms, corporate financial risk is greater than the effect of carbon price volatility itself. Column 3 shows that there is insufficient evidence in the current study to support significant heterogeneity in the impact of carbon price volatility on corporate financial risk across firms with different levels of R&D investment.

4.5. Robustness Test

To ensure the reliability of the findings, this study conducted a robustness test, which was carried out in terms of replacing the regression model and shrinking the tails. The first column regression replaces the original fixed effects model with OLS regression. Under the OLS regression, the core explanatory

DOI: 10.54254/2754-1169/2025.MUR22315

variable carbon price volatility is significantly positive at the 1% significance level, indicating that carbon trading price volatility is still significantly positively correlated with the financial risk of manufacturing companies, which is consistent with the results of the benchmark regression and suggests that the research findings have a certain degree of stability under different regression models. The second column of regression is tailed to reduce the impact of extreme values on the financial asset-liability ratio data of manufacturing enterprises. After the treatment, the z_CPV coefficient is positively correlated at the same 1% significance level and close to the benchmark regression coefficient. This indicates that the extreme values do not substantially interfere with the findings of the study, and the relationship between the core variables remains robust after the process. Combining the results of the two columns of regression, the positive correlation between carbon trading price volatility and financial risk of manufacturing enterprises still exists after replacing the regression model and shrinking the tail treatment, which indicates that the conclusions of this study have good robustness.

Table 4: Robustness Test Results

	(1)Replacement of OLS regression	(2)Shrinking tails
VARIABALES	z_Finlev	z_Finlev
z_CPV	0.0458***	0.0929***
	(0.0111)	(0.0116)
z_Size	0.252**	0.477***
	(0.0118)	(0.0560)
z_Growth	-0.00414	-0.00622***
	(0.0110)	(0.00147)
z_Topl	-0.133***	-0.0331
	(0.0113)	(0.0317)
Z_RD	-0.0113	0.0779***
	(0.0111)	(0.0167)
SOE	-0.113***	-0.126*
	(0.0249)	(0.0679)
Constants	-0.0365***	0.0558***
	(0.0136)	(0.0242)
Individual Fixed Effects	Uncontrolled	Controlled
Time Fixed Effects	Uncontrolled	Controlled
Observations	7749	7749
R-squared	0.065	0.060

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

5. Conclusion

This study focuses on the impact of carbon trading price volatility on the financial risk of manufacturing enterprises, and the comprehensive theoretical and empirical analyses lead to the following key conclusions: First, carbon trading price volatility is significantly positively correlated with the financial risk of manufacturing enterprises, and the relationship remains robust even after controlling for a variety of factors, such as enterprise size and operating income growth rate. Second, there are obvious heterogeneous impacts. When the carbon trading price fluctuates, state-owned enterprises and large-scale enterprises are more significantly affected in terms of financial risks. However, for enterprises with different R&D investment intensities, the differences in the impact of

DOI: 10.54254/2754-1169/2025.MUR22315

carbon trading price volatility on financial risks are not significant. Third, the reliability of the research results is further verified by replacing the regression model with the shrinking-tail treatment for the robustness test. This study also has certain shortcomings. The sample only covers 1107 listed manufacturing companies from 2014 to 2021, which is a limited time span and sample size and may not fully reflect the complex market situation. Future research can expand the sample scope to include more unlisted companies and longer time series data; it can also analyze the specific transmission path of carbon trading price volatility affecting the financial risk of enterprises, as well as the reasons for the heterogeneity of different enterprises, so as to provide a more accurate decision-making basis for enterprises and the government.

References

[1] *Wang, L., et al.(2022). Does environmental regulation promote the high-quality development of manufacturing? A quasi-natural experiment based on China's carbon emission trading pilot scheme. trading pilot scheme. Socio-Economic Planning Sciences, 81, 101216. https://doi.org/10.1016/j.seps.2021.101216*

[2] *Wei, Z.J.(2023). A study on the impact of carbon emission right price volatility on the value of manufacturing listed companies. China Forestry Economics, 05, 84-89. doi:10.13691/j.cnki.cn23-1539/f.2023.05.012.*

[3] *Chen F., Li, X. R.. (2024). Research on the influence of carbon trading price on enterprise low carbon technology innovation. Market Outlook, 06, 46-48.*

[4] *Zeng, L., et al. (2021). The impact of carbon trading price on corporate innovation: An empirical study based on Chinese listed companies. Shanghai Finance, 11, 61-70. doi:10.13910/j.cnki.shjr.2021.11.006.*

[5] *Lu Q. (2025). Exploration of cost control in financial management of manufacturing enterprises. Market Modernization 04, 186-188. doi:10.14013/j.cnki.scxdh.2025.04.038.*

[6] *Cheng, X. X.,et al. (2025). Research on the relationship between digital transformation and green technology innovation in manufacturing industry. Journal of Industrial Technological Economics, 01,115-121.*

[7] *Zhang J., et al. (2018). Research on price volatility in China's carbon emissions trading market - Data analysis based on trading prices in pilot carbon emissions markets in six cities including Shenzhen, Beijing and Shanghai. Price: Theory & Practice, 01, 57-60. doi:10.19851/j.cnki.cn11-1010/f.2018.01.015.*

[8] *Trinks, A., Mulder, M., & Scholtens, B. (2022). External carbon costs and internal carbon pricing. Renewable and Sustainable Energy Reviews, 168, 112780. https://doi.org/10.1016/j.rser.2022. 112780*

[9] *Ding, D. (2022). The impacts of carbon pricing on the electricity market in Japan. Humanities and Social Sciences Communications, 9, 353. https://doi.org/10.1057/s41599-022-01360-9*

[10] *Wei, C., et al. (2014). Financial ecosystem and corporate financing constraints-an empirical study based on Chinese listed companies. Accounting Research, 05, 73-80,95.*

[11] *Lin, Y.F.,Li, Y.J. (2001). Development of Small and Medium-sized Financial Institutions and Financing of Small and Medium-sized Enterprises. Economic Research Journal, 01,10-18,53-93.*