

Research on Factors Affecting Corporate Carbon Emission Reduction Performance based on TOE Framework

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Abstract

Corporate carbon emission reduction performance is the key driving force for achieving corporate sustainable development, and exploring the factors that affect corporate carbon emissions is the basis for improving corporate carbon performance levels. Based on the TOE theoretical framework, this paper identifies the determinants of corporate carbon performance from three levels: technology, organization, and environment, and establishes a fixed effects model based on panel data. First, descriptive statistics and correlation analysis are conducted, and secondly, robust Finally, an empirical study was conducted on the impact mechanism of industrial enterprises' carbon emission reduction performance from the perspective of regional and life cycle heterogeneity, and the effects of different factors on carbon performance were analyzed.

Keywords

Industrial Enterprises; Carbon Emission Reduction Performance; Influencing Factor.

1. Introduction

As global warming intensifies, carbon emissions have become the focus of corporate attention. Countries are beginning to work together to reduce greenhouse gas emissions, and in fact this has become a necessary goal for companies in terms of environmental performance. Regarding the influencing factors of carbon emission reduction performance, most of the current research focuses on the influencing factors of carbon performance at the macro and meso levels such as countries, regions or industries. A small number of literatures conduct directional research on the enterprise level. In addition, domestic and foreign studies such as green technology are separately explored. There is still a lot of literature on the relationship between one or two influencing factors such as innovation [1], internal characteristics of enterprises [2] or policy media [3] and carbon performance, as well as the intermediaries between the two factors [4, 5], adjustment mechanisms, etc. Empirical research is also extensive, but there is very little literature that considers factors at all levels together. The rest of this article is organized as follows: The third part introduces the framework diagram of driving factors, the fourth part is the data introduction and model, and the fifth part is Empirical Analysis and Results, Section 6 presents the main conclusions of this paper.

2. Models and Data Sources

2.1. Influencing Factor

Based on TOE theory, this paper constructs an analysis framework of factors affecting corporate carbon emission reduction including technical, organizational and environmental levels, as shown in Figure 1, At the technical and organizational levels, an enterprise's carbon performance is mainly affected by intrinsic motivation and subjective efforts, and enterprises can actively control and adjust such factors. For example, companies can improve the level of

green technology innovation, upgrade emission reduction technologies, and optimize organizational structures to improve energy efficiency. However, at the environmental level, most of the conditions that affect corporate carbon performance are uncontrollable external factors. Therefore, facing the environmental dimension, companies may need to adjust their strategies and tactics to adapt to changes, or be forced to make certain changes under pressure. In short, in the process of improving carbon performance, enterprises must not only give full play to their internal motivation and subjective efforts, optimize technical and organizational conditions as much as possible, but also flexibly respond to changes in the external environment, actively adapt to and make full use of these changes. uncontrollable factors to achieve carbon emission reduction and sustainable development goals.

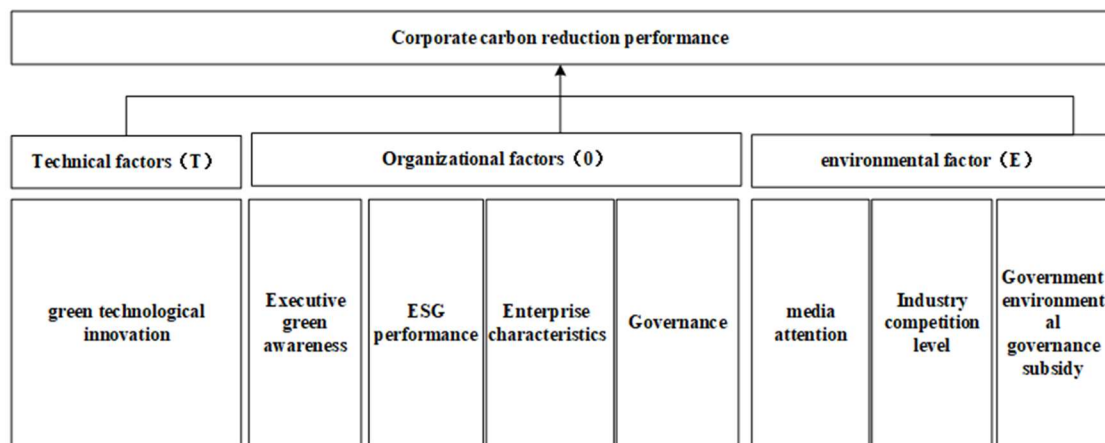


Figure 1. Factors affecting corporate carbon emission reduction performance under the TOE framework

2.2. Sample Selection and Data Sources

This article selects listed companies in China's A-share industrial industry from 2012 to 2022 as the research object. The definition of industrial industry is screened in accordance with the "Industry Classification Guidelines for Listed Companies", covering the production and supply of electricity, heat, gas and water, Mining and manufacturing industries, Finally, a total of 19,021 sample observations were obtained from the data of listed companies in the three major industries. The ESG rating data comes from the ESG rating data released by the Huazheng Index, The media attention data and environmental governance subsidy data come from the CNRDS China Research Data Service Platform. The other listed company data come from the Guotai'an Database(CSMAR). The statistics used software is Stata17.0.

2.3. Model Construction

In order to study the impact mechanism of carbon emission reductions in industrial enterprises, this paper sets the core measurement model as follows:

$$\ln CE_{it} = \beta_0 + \beta_1 X_{1it} + \dots + \beta_2 X_{kit} + Industry_i + year_t + \sigma_{it} \tag{1}$$

Among them, represents $\ln CE_{it}$ the carbon performance index of X_{1it} listed company i in year t, X_{kit} etc. represent the influencing factors of listed company i at the technical level, organizational level, and environmental level in year t. At the same time, this article also controls the possible impact of industry (σ_{it} Industry) and year (Year). represents the random error term.

2.4. Variable Definition

(1) Carbon performance

Referring to the construction of carbon emission indicators by Wang Hao et al. [6], carbon emissions, fossil energy consumption, and electricity heat consumption are manually collected from the social responsibility reports, sustainable development reports, and environmental reports disclosed by companies every year. Carbon emission data are calculated according to the methods issued by the National Development and Reform Commission. Further, referring to the construction of carbon performance indicators by Xu Jinhua et al. [7], this paper takes the natural logarithm of (enterprise operating cost/total carbon emissions of industrial enterprises) and defines it as carbon performance (LnCE). The larger the index, the greater the carbon performance of the enterprise. The higher the level.

(2) Green technology innovation.

Green patented technologies can better reflect green technology innovation capabilities, and the number of technology applications can also demonstrate the immediacy and substantive nature of green technology innovation. This article refers to the research of Xu Jia and Cui Jingbo [1] to measure corporate green technology innovation and total green innovation (EnvrPat), that is, taking the logarithm of the number of green patents applied for by listed companies in that year.

(3) Executive green cognition

Select a series of keywords, including the frequency of 19 keywords appearing in the annual reports of listed companies, such as energy conservation, emission reduction, and environmental protection strategies, to measure executive green cognition (EPG), that is, a series of key words about the green cognition of executives of listed companies. Add 1 to the word to perform logarithmic processing.

(4) ESG performance

Consumers and investors are increasingly paying attention to corporate social responsibility and environmental contributions. This article uses the ESG rating data released by the China Securities Index as a proxy variable for corporate ESG performance, specifically including (environmental; social; corporate governance). The higher the score, the better the corporate ESG performance.

(5) Variables related to enterprise characteristics

Factors related to corporate characteristics at the organizational level have an important impact on carbon emission reduction behavior under the dual carbon goals. This article starts from the perspective of listing age (ListAge), asset-liability ratio (Lev), return on total assets (ROA), enterprise size (Size), whether it is losing money (Loss), Tobin Q value (TobinQ), nature of property rights (SOE), financing Constraints (FC) and other aspects to measure corporate characteristics. Among them, the listing age (ListAge) is limited by the company's listing years; the asset-liability ratio (Lev) is equal to the ratio of corporate liabilities to assets; the return on total assets (ROA) is measured by the ratio of corporate net profit to total assets; Enterprise size (Size) is expressed by the natural logarithm of total assets plus 1; whether it is losing money (Loss), a dummy variable is introduced. If the enterprise is losing money, the variable takes the value 1, otherwise it is 0; Tobin Q value (TobinQ), reflects the market's estimate of the company's future profitability, and can better reflect the company's growth; the nature of property rights (SOE), introduces a dummy variable, if it is a state-owned enterprise, the value of this variable is 1, otherwise it is 0; Financing constraints (FC), the larger the FC index, the greater the degree of financing constraints.

(6) Variables related to governance structure

Regarding factors related to the governance structure at the organizational level, this article measures corporate governance structure from two aspects: the shareholding ratio of the largest shareholder (TOP 1) and the dual position (Dual). Among them, the shareholding ratio of the largest shareholder (TOP 1) is measured by the number of shares held by the shareholder with the largest shareholding ratio in the current year to the total share capital. The higher the shareholding ratio of the largest shareholder, it means the more concentrated the company's equity; Dual refers to the fact that the CEO and the chairman of the board of directors are held by the same person. A dummy variable is introduced. If the same person holds the position, the value of this variable is 1, otherwise it is 0.

(7) Media attention

Drawing on the research of Liu Yiwen et al. [3], the sum of the number of media report titles from the quantitative statistics of newspaper financial news and the quantitative statistics of online news in the China Research Data Service Platform is used to measure the intensity of media attention received by heavily polluting enterprises. Based on the online media attention data, this article adds 1 to the total number of news in which the company's title appears to take a logarithm, and uses it as a proxy variable (Media) for the company's media attention. The larger the indicator, the higher the media attention.

(8) Degree of competition in the industry

This article uses the "Herfindahl- Hirschman Index" to measure the degree of competition in the industry, which is the sum of the squares of the proportion of the main business income of each company in the industry to the total main business income of the industry. This index is a reverse index, and the index exceeds. The larger the value, the lower the degree of competition in the industry.

(9) Government environmental management subsidies

Table 1. Definition of main variables

Variable type	variable name	variable symbol	Variable definitions
Explained variable	carbon performance	nnJC	(Enterprise operating cost/total carbon emissions of industrial enterprises) Take the logarithm
	Green technology innovation	EnvrPat	(The number of green patents applied for by the company in the current year + 1) Take the logarithm
Explanatory variables	Executive green awareness	EPG	(Keywords in the green cognition series of listed company executives + 1) Take the logarithm
	ESG performance	ESG	Data from Huazheng ESG Ratings
Explanatory variables	Years on the market	ListAge	(year of current year - year of listing + 1) Take the logarithm
	Assets and liabilities	Lev	Total liabilities/total assets
	return on total assets	ROA	Net profit/average total assets
	Enterprise size	Size	Take the logarithm of total assets + 1
	Tobin Q	TobinQ	Market value/total assets of the company
	Whether there is a loss	Loss	The company's loss for the current year is assigned a value of 1, otherwise it is 0
	Nature of property rights	SOE	The value of state-owned enterprises is 1, otherwise it is 0
	financing constraints	FC	From Guotai'an database FC index
	Shareholding ratio of the largest shareholder	TOP1	Shareholding ratio of the largest shareholder
	Two jobs in one	Dual	If the CEO and the chairman of the board are the same person, the value is 1, otherwise it is 0.
	media attention	Media	(The total number of news articles in which the company appears in the title + 1) Take the logarithm
	Industry competition level	HHI	Sum of squares of main business income/proportion of total main business income in the industry
	Government environmental management subsidies	Pubsub	(Subsidy amount for government environmental management projects + 1) Take the logarithm
	annual effect	Year	year dummy variable
	industry effect	Industry	Industry dummy variable

Generally speaking, government subsidies include financial patent subsidies, corporate talent training subsidies, high-tech subsidies, export foreign exchange and other types. Combined with this article's research on the impact mechanism of carbon emission reduction, this article refers to the research of Chen Xiaoshan et al. [8] and uses the amount of government subsidies disclosed by the CNRDS China Research Data Service Platform to support enterprises in developing and conducting environmental governance projects as the measurement index of government environmental governance subsidy (pub sub). The larger the indicator, the higher the government's environmental governance subsidy.

3. Empirical Analysis

3.1. Descriptive Statistics

The descriptive statistical results of the variables in this article are shown in Table 4-1. The mean value of the carbon performance index (lnCE) is 10.050, the maximum value is 11.147, the minimum value is 8.679, and the standard deviation is 0.338. From the standard deviation and the maximum and minimum values, it can be seen that there are significant differences in carbon performance levels between samples, which is worthy of in-depth discussion. Green technology innovation (EnvrPat), executive green cognition (EPG), ESG performance, asset-liability ratio (Lev), return on total assets (ROA), enterprise size (Size), whether there is a loss (Loss), Tobin's Q value (TobinQ), etc. are similar to the descriptive statistics of existing studies. In summary, the overall level of carbon performance indicators and related indicators at the technical, organizational and environmental levels is in line with expectations, which also ensures the robustness of this study to a certain extent.

Table 2. Descriptive statistics of main variables

	Observations	mean	standard deviation	minimum value	maximum value
	(1)	(2)	(3)	(4)	(5)
nnJC	19021	10.050	0.338	8.679	11.147
EnvrPat	19021	0.380	0.763	0	3,367
EPG	19021	0.871	0.837	0	3,135
ESG	19021	4,139	1,057	1	6
ListAge	19021	1,931	0.948	0	3,332
Lev	19021	3,677	3,065	1,113	19,535
ROA	19021	0.044	0.059	-0.231	0.223
Size	19021	22.138	1.270	17.954	28.636
TobinQ	19021	2.038	1.222	0.862	8.177
Loss	19021	0.092	0.289	0	1
SOE	19021	0.294	0.455	0	1
FC	19021	0.508	0.267	0.006	0.939
TOP1	19021	34.405	14.475	8.700	74.295
Dual	19021	0.314	0.464	0	1
Media	19021	4.375	0.971	0	8.655
HHI	19021	0.175	0.128	0.040	1
Pubsub	19021	2.102	4.696	0	15.996

3.2. Benchmark Regression Results and Analysis

Table 4-2 reports the basic test results of the factors affecting the carbon performance level of industrial enterprises at the technical level, organizational level and environmental level. The results in column(1) show the test results of factors affecting the carbon performance level of

industrial enterprises at the technical level, organizational level and environmental level without controlling for industry fixed effects and year fixed effects. This article will discuss in detail based on the results in column (2).

Technical level: The estimated coefficient of green technology innovation (EnvrPat) is 0.012, which is significantly positive at the 1% level, indicating that the higher the level of green technology innovation of an enterprise, it will help to promote the reduction of corporate carbon emissions, confirming the level of green technology innovation. The view that improvement can promote the improvement of carbon emission reduction performance shows that the level of green technology innovation is an important influencing mechanism of carbon emission intensity. That is, enterprises pay attention to improving the level of green technology innovation, which can better restrain carbon emission intensity and promote enterprise carbon reduction. Platoon strategy.

Organizational level: The estimated coefficient of executive green cognition (EPG) is 0.012, which is significantly negative at the 1% level, indicating that the higher the executive's green cognition, the more conducive it is to improving carbon performance and suppressing corporate carbon emission intensity, that is, executives' green cognition does have a positive impact on curbing corporate carbon emissions. The estimated coefficient of ESG performance is 0.018, which is significantly positive at the 1% level, which means that corporate ESG performance (environment, social and corporate governance) can significantly affect carbon performance.

corporate characteristics at the organizational level: the estimated coefficient of listing age (ListAge) is 0.056, which is positive at the 1% confidence level, indicating that there is a positive correlation between listing age and carbon performance. The estimated coefficient of the asset-liability ratio (Lev) is 0.005, which is significantly positive at the 1% level, indicating that the asset-liability ratio can inhibit corporate carbon emissions. The estimated coefficient of return on total assets (ROA) is -0.124, which is positive at the 5% confidence level. The results indicate that there is a negative relationship between return on total assets and carbon performance levels. The reason for this result may be that enterprises with high pollution and high emissions require higher capital investment and generate higher carbon emission intensity. The estimated coefficient of enterprise size (Size) is 0.049 and is positive at the 1% confidence level, which means that the larger the enterprise size, the higher the carbon performance level. The estimated coefficient of loss (Loss) is 0.056, which is significantly positive at the 1% level, indicating that the carbon emission intensity of enterprises is reduced and the carbon performance is better when the enterprise is losing money. As companies may face financial pressure, this affects their investment in production and energy consumption. The estimated coefficient of Tobin's Q value (TobinQ) is 0.008, which is significantly positive at the 1% level. This result shows that companies with higher Tobin's Q value tend to have higher carbon performance levels and lower carbon emission intensity. The estimated coefficient of property rights (SOE) is negative at the 1% confidence level. This result shows that state-owned enterprises have higher carbon emission intensity and worse carbon performance levels. The estimated coefficient of financing constraints (FC) is 0.206, which is positive at the 1% confidence level, indicating that companies with greater financial constraints have higher carbon performance levels. It may be that companies with greater financial constraints may need to obtain funds, so they pay more attention to investment and maintenance in environmental protection and reputation, and also pay more attention to improving the company's own carbon emission reduction performance.

In terms of governance structure at the organizational level: the coefficient of the shareholding ratio of the largest shareholder (TOP1) is 0.001, which is significantly positive at the 1% level, indicating that companies with a higher shareholding ratio of the largest shareholder have higher carbon performance levels. The estimated coefficient of Dual is -0.013, which is

significantly negative at the 5% level, indicating that companies with Dual have lower carbon performance levels.

Table 3. Baseline regression results

	(1)	(2)
	nnJC	nnJC
EnvrPat	0.005	0.012 ***
	(0.003)	(0.003)
EPG	0.013***	0.012 ***
	(0.003)	(0.003)
ESG	0.021***	0.018***
	(0.002)	(0.002)
ListAge	0.063***	0.056***
	(0.004)	(0.004)
Lev	0.006***	0.005***
	(0.001)	(0.001)
ROA	0.008	-0.124**
	(0.055)	(0.057)
Size	0.037***	0.049***
	(0.004)	(0.005)
TobinQ	0.001	0.008***
	(0.002)	(0.002)
Loss	0.073***	0.056***
	(0.011)	(0.011)
SOE	-0.031***	-0.035***
	(0.006)	(0.007)
FC	0.182***	0.206***
	(0.019)	(0.019)
TOP1	0.001***	0.001***
	(0.000)	(0.000)
Dual	-0.011**	-0.013**
	(0.005)	(0.005)
Media	0.018***	0.011***
	(0.003)	(0.003)
HHI	0.071***	0.075**
	(0.018)	(0.033)
Pubsub	0.003***	0.002***
	(0.001)	(0.001)
cons	8.775***	8.602***
	(0.106)	(0.109)
Year	No	Yes
Industry	No	Yes
N	19021	19021
R ²	0.0520	0.0810

Note : The numbers in parentheses are robust standard errors . *** , ** , and * indicate significance at the 1% , 5% , and 10% levels respectively.

Environmental level: The estimated coefficient of media attention (Media) is positive and significant at the 1% level, indicating that companies with higher media attention have higher carbon performance levels and lower carbon emission intensity. The reason for this result may be that companies with higher media attention may receive more public attention, supervision and recognition, and thus have more motivation and pressure to reduce their carbon emission intensity and improve carbon emission reduction performance. The estimated coefficient of

industry competition level (HHI) is 0.075 and is significant at the 5% level, indicating that the lower the industry competition level, the higher the corporate carbon performance level. A reasonable explanation is that companies with low levels of industry competition usually face relatively less market competition pressure and innovation incentives, while providing companies with more space and resources to focus on carbon performance. The estimated coefficient of government environmental subsidies (Psubsub) is positive and significant at the 1% level, indicating that companies with higher government environmental subsidies have higher carbon performance levels and lower carbon emission intensity. The reason is that government environmental subsidies are usually an economic incentive provided to encourage enterprises to reduce environmental pollution, adopt environmental protection measures and reduce carbon emission intensity, and have a positive impact on the carbon emission intensity and carbon emission reduction performance of enterprises.

3.3. Robustness Check

In order to test the robustness of the research conclusions of this article , further verify the impact mechanism of carbon emission reduction, and enhance the reliability of the benchmark regression results, this article replaces the measurement method of the explained variables, replaces high-latitude fixed effects (adds province fixed effects) and Re-run the regression by replacing the regression sample (eliminating the municipality sample).

1) Replace the explained variable with LnCP

First of all, this paper chooses to replace the core variable, that is, the measurement method of the explained variable (replaced with LnCP, that is, the natural logarithm of corporate operating income/total corporate carbon emissions is taken to re-regress . The regression results of column (1) in Table 4-3 show that, The improvement and development of factors such as green technology innovation factors at the technical level, green cognition of executives at the organizational level, ESG performance and other factors at the environmental level, as well as factors such as media attention, industry competition and government environmental subsidies at the environmental level can significantly promote carbon emission performance and curb carbon emissions. It is basically consistent with the previous test results, which can further prove that the research conclusions of this article are robust and reliable.

2) High -dimensional fixed effects

When studying the impact mechanism of carbon emission reductions in industrial enterprises, this article tries to incorporate more comprehensive factors from the technical, organizational and environmental levels. However, there may be estimation bias issues caused by different situations during the research process. Therefore, this article uses province fixed effects to reduce the problem of estimation bias. It can be seen from column (2) of Table 4-3 that the technical level green technology innovation (EnvrPat) is also significantly positive at the 1% level; the organizational level executive green cognition (EPG), ESG performance, company listing age Natural logarithm (Listage), asset-liability ratio (Lev), return on total assets (ROA), enterprise size (Size), whether it is losing money (Loss), Tobin Q value (Tobin Q), nature of property rights (SOE) and In terms of financing constraints (FC) and governance structure, the shareholding ratio of the largest shareholder (Top 1) and the combination of two positions (Dual) are significant and consistent with the benchmark regression results ; at the environmental level, media attention, industry competition, and government environment Factors such as governance subsidies are also significant, which is consistent with the previous regression results, further supporting the reliability of the empirical research results of this article, indicating that the above influencing factors can significantly affect carbon emission intensity.

3) Replace the regression sample

Since the carbon emissions of industrial enterprises are closely related to the local resource endowment, energy structure, industry structure, etc., in order to avoid the estimation bias caused by differences in sample locations and better study the impact mechanism of carbon emission reductions of industrial enterprises, The samples of industrial enterprise samples registered in four municipalities including Beijing and Shanghai were eliminated and re-regressed. From column (3) in Table 4-3, we can see that corporate characteristics such as technical level green technology innovation (EnvrPat), organizational level executive green cognition (EPG), ESG performance, listing years (ListAge), asset-liability ratio (Lev), etc. The estimated coefficients of factors such as the shareholding ratio of the largest shareholder (Top1) and dual positions (Dual), environmental media attention, and government environmental governance subsidies are still significant in terms of aspects and governance structure, which can illustrate the empirical conclusion of this article. It still holds true when excluding the municipality sample.

Table 4. Robustness check

	Replace the explained variable	High latitude fixed effects	Remove some samples
	(1)	(2)	(3)
	nnJC	nnJC	nnJC
EnvrPat	0.012*** (0.003)	0.010*** (0.003)	0.009** (0.004)
EPG	0.012*** (0.003)	0.012*** (0.004)	0.010*** (0.004)
ESG	0.018*** (0.002)	0.017*** (0.002)	0.021*** (0.003)
ListAge	0.056*** (0.004)	0.056*** (0.003)	0.060*** (0.004)
Lev	0.005*** (0.001)	0.005*** (0.001)	0.004*** (0.001)
ROA	-0.124** (0.057)	-0.155*** (0.057)	-0.0880 (0.062)
Size	0.049*** (0.005)	0.052*** (0.004)	0.037*** (0.005)
TobinQ	0.008*** (0.002)	0.009*** (0.002)	0.005* (0.003)
Loss	0.056*** (0.011)	0.056*** (0.011)	0.057*** (0.012)
SOE	-0.035*** (0.007)	-0.026*** (0.007)	-0.034*** (0.007)
FC	0.206*** (0.019)	0.210*** (0.016)	0.182*** (0.018)
TOP1	0.001*** (0.000)	0.001*** (0.000)	0.000 (0.000)
Dual	-0.013** (0.005)	-0.014*** (0.005)	-0.013** (0.006)
Media	0.011*** (0.003)	0.011*** (0.003)	0.007** (0.003)
HHI	0.075** (0.033)	0.080** (0.034)	0.0450 (0.038)
Pubsub	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)
cons	8.602*** (0.109)	8.477*** (0.094)	8.870*** (0.107)
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Province	No	Yes	No
N	19021	19021	16124
R ²	0.0810	0.0870	0.0760

Note : The numbers in parentheses are robust standard errors . *** , ** , and * indicate significance at the 1% , 5% , and 10% levels respectively.

3.4. Heterogeneity Analysis

This article has confirmed that there are multiple factors that affect corporate carbon emission reduction. At the same time, further consideration is needed, is there heterogeneity in the impact of various factors at the technical level, organizational level and environmental level under different situations and conditions? In view of this, it is very important to further explore the heterogeneity of carbon performance levels among factors at the technical, organizational and environmental levels.

1) Regional heterogeneity analysis

It is necessary to explore the regional heterogeneity of the impact of technical, organizational and environmental factors on corporate carbon performance, and explore the differences and characteristics of the technical, organizational and environmental factors affecting carbon emissions between different regions. It is of great significance to formulate carbon emission reduction policies and measures. First, this article conducts heterogeneous analysis from the perspective of different regions and divides the total sample into three regions: eastern region, western region and central region. As can be seen from Table 4-8, for the technical level, the estimated coefficient of green technology innovation (*EnvrPat*) in the eastern region is significantly positive at the 1% level, but not significant in the central and western regions, indicating that enterprises in the eastern region are green. The improvement of technological innovation is more obvious for improving carbon performance levels and curbing corporate carbon emission intensity. Regarding the green cognition of executives at the organizational level, it is significant at the 5% level in the eastern and central regions, but not significant in the west; ESG performance is more significant in the eastern and central regions, but not significant in the west; corporate characteristics and governance. Taking a comprehensive view of structural factors, the eastern region is more significant. The possible reason is that the eastern region has better resource endowments and has more significant advantages than the central and western regions in terms of economic development level, human capital level, and foreign investment. Regarding the environmental aspect, the factors of media attention and industry competition are more significant in the eastern region. The possible reason is that the enterprise development platform and infrastructure construction in the eastern region are better, and the factors of media attention and industry competition are amplified here. Regarding the factor of government environmental governance subsidies, government environmental governance subsidies in the western region have a prominent effect in suppressing the carbon emission intensity of enterprises. This may be because enterprises in the western region are more sensitive to government incentives and policy guidance, and at the same time pay more attention to the government's economic excitation.

2) Analysis of heterogeneity of enterprise life cycle

The enterprise life cycle refers to the different stages of an enterprise from growth, maturity to decline. Each stage has specific operating characteristics, strategic goals and resource allocation methods. Factors affecting a company's carbon emissions may vary significantly at different stages of the company's life cycle. Based on the currently widely used cash flow method, this article uses the combination of three types of cash flows: operating, investment and financing to divide the enterprise life cycle into a growth period, a maturity period and a decline period. The results based on the analysis of enterprise life cycle heterogeneity are shown in Table 4-4. The results show that green technology innovation of enterprises in the recession period has a more significant impact on carbon performance, while the corporate characteristics, governance structure and media attention factors of enterprises in the mature period have a more significant impact on carbon performance levels. A reasonable explanation is that companies in the mature stage are more capable and willing to take carbon emission reduction measures, and can better play the positive role of media attention. It may be because

as the scale of enterprises expands, the market competition they face becomes more intense, and enterprises begin to pay more attention to their green environmental image and actively assume social responsibilities. In addition, for companies in recession, government environmental governance subsidies have a more significant impact on carbon performance levels. The possible reason is that companies in recession face problems such as reduced profitability, and companies actively pursue sustainable development strategies by catering to government policies, in order to find a way out to maintain the competitiveness and brand image of the enterprise. Therefore, enterprises should adopt appropriate behaviors and strategies based on their own development stages and strategic goals to achieve a win-win situation of economic and social benefits.

Table 5. Heterogeneity test

	east	central	west	growth period	mature stage	Recession
	(1)	(2)	(3)	(1)	(2)	(3)
	nnJC	nnJC	nnJC	nnJC	nnJC	nnJC
EnvrPat	0.013*** (0.004)	-0.001 (0.008)	0.009 (0.012)	0.008 (0.007)	0.006 (0.005)	0.013*** (0.005)
EPG	0.009** (0.004)	0.021** (0.008)	0.0140 (0.011)	0.025*** (0.008)	0.016*** (0.005)	0.002 (0.005)
ESG	0.021*** (0.003)	0.019*** (0.006)	0.001 (0.008)	0.024*** (0.006)	0.005 (0.004)	0.011*** (0.003)
ListAge	0.059*** (0.004)	0.047*** (0.008)	0.052*** (0.010)	-0.012 (0.010)	0.003 (0.006)	0.000 (0.006)
Lev	0.005*** (0.001)	0.00300 (0.002)	0.00100 (0.003)	0.006*** (0.002)	0.005*** (0.001)	0.005*** (0.001)
ROA	-0.152** (0.069)	-0.146 (0.133)	0.0360 (0.189)	-0.0390 (0.127)	-0.0480 (0.085)	-0.0470 (0.090)
Size	0.058*** (0.005)	0.041*** (0.010)	0.00600 (0.013)	0.026** (0.010)	0.044*** (0.006)	0.039*** (0.006)
TOP1	0.001*** (0.000)	0.00100 (0.000)	0 (0.001)	0.000 (0.000)	0.001** (0.000)	0.000* (0.000)
Dual	-0.0100 (0.006)	-0.029** (0.013)	-0.053** (0.021)	-0.0120 (0.012)	-0.009 (0.008)	-0.005 (0.008)
TobinQ	0.012*** (0.003)	0.013** (0.006)	-0.0120 (0.007)	0.004 (0.005)	0.003 (0.004)	0.007** (0.004)
Loss	0.071*** (0.013)	0.040* (0.023)	-0.00200 (0.031)	0.049* (0.026)	0.056*** (0.016)	0.085*** (0.015)
SOE	-0.038*** (0.009)	-0.039*** (0.014)	-0.00200 (0.019)	0.036** (0.018)	-0.018* (0.010)	-0.027*** (0.009)
FC	0.241*** (0.020)	0.164*** (0.039)	0.0370 (0.053)	0.098** (0.041)	0.122*** (0.027)	0.068*** (0.026)
Media	0.012*** (0.004)	0.017** (0.007)	0.00500 (0.009)	0.00500 (0.008)	0.010** (0.005)	0.004 (0.004)
HHI	0.128*** (0.041)	-0.0280 (0.098)	-0.0680 (0.091)	0.113 (0.080)	0.084 (0.052)	0.050 (0.047)
Pubsub	0.001* (0.001)	0.001 (0.001)	0.005*** (0.002)	0.003** (0.001)	0.001 (0.001)	0.003*** (0.001)
cons	8.361*** (0.110)	8.855*** (0.232)	9.783*** (0.292)	9.240*** (0.230)	8.915*** (0.146)	9.100*** (0.143)
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
N	13332	3468	1977	2896	6694	7951
R ²	0.0890	0.0990	0.103	0.0560	0.0550	0.0890

Note : 1. The numbers in brackets are robust standard errors. ***, **, and * indicate significance at the 1% , 5% , and 10% levels respectively; 2. The eastern part includes: Beijing , Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Hainan, Shandong and Guangdong, the central part includes: Shanxi, Jilin, Heilongjiang, Inner Mongolia Autonomous Region, Guangxi, Anhui, Jiangxi, Henan, Hubei and Hunan, the western part includes: Guangxi Zhuang Autonomous Region, Xinjiang Uygur Autonomous Region, Ningxia Hui Autonomous Region, Tibet Autonomous Region, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi and Gansu.

4. Conclusion

Under the TOE theoretical framework, different influencing factors have a significant impact on the carbon emission reduction performance of micro-enterprises. At the technical level, green technology innovation capabilities can significantly improve the company's carbon emission reduction effect ; at the organizational level: the green cognitive level of executives has a positive impact on the improvement of carbon performance. At the same time, the company's environmental, social and corporate governance (ESG) performance can also significantly improve carbon performance. In addition, the corporate asset-liability ratio will inhibit carbon emissions , and the larger the corporate scale, the corporate is in a state of loss, the higher the Tobin's Q value, and the higher the shareholding ratio of the largest shareholder in the governance structure, the higher the carbon performance level. ; At the environmental level , companies with high media attention, low industry competition, and companies that receive government environmental subsidies are more likely to achieve better carbon emission reduction performance. However, there are significant differences between the influencing factors at the technical level, organizational level and environmental level under different scenarios, which means that when formulating corporate carbon emission reduction strategies, the particularities of different scenarios need to be considered. When formulating and optimizing corporate carbon reduction strategies, When formulating strategies, we should focus on the effective improvement and continuous improvement of various influencing factors at the technical, organizational and environmental levels.

Acknowledgments

Thank you to all the supporters who provided the data.

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