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An Empirical Analysis of the Impact of Carbon Disclosure on Firms' Market Value in a "Dual Carbon" Context

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Abstract

With the acceleration of global warming, climate change and environmental issues have become a hotspot of global concern. At present, it has become a global consensus to vigorously develop a green economy and achieve "carbon neutrality and carbon peak". In this context, as an important part of the national economy, listed companies should pay more attention to carbon emission and information disclosure to help achieve the goals of "carbon peak" and "carbon neutral". In this paper, we use a multiple linear regression model to explore the specific mechanism of the impact of carbon emission disclosure on enterprise market value. In constructing the model, we consider that factors such as asset size, operating profit margin, and cash flow ratio may affect the market value of enterprises, so we add control variables in the model and use t-test, F-test, and analysis of covariance to verify whether there is a significant difference between different groups. Descriptive statistics and Pearson's correlation coefficient were also carried out during data processing in order to observe whether there is a correlation between carbon emissions and company market value. By analysing the results of regression fitting, we find that under the background of "dual-carbon", the active disclosure of carbon emissions by enterprises can help enterprises to improve their transparency, thus enhancing the trust and recognition of consumers and investors, and thus positively affecting the market value of the enterprises, and the impact of the active disclosure of carbon emissions by enterprises with high carbon emissions is even more significant on their market value. market value is even more significant. This implies that companies should actively participate in emission reduction actions and demonstrate their action on environmental protection by proactively disclosing carbon emission information in their annual reports or CSR reports.

Keywords

'Dual carbon', carbon disclosure, firm value, multiple linear regression modelling.

1. Introduction

Since the implementation of reform and opening up in 1978, China has achieved great economic development, but it has also brought about increasingly serious environmental problems. Environmental pollution, ecological damage, aggravation of the greenhouse effect, and global warming have gradually become prominent issues of concern to countries around the world. in September 2020, at the 75th session of the United Nations General Assembly, General Secretary Xi Jinping proposed that China would adopt strong policies and measures to achieve the "double carbon" goal, that is, to achieve carbon peaking by 2030 and to achieve carbon neutrality by 2060. This is to achieve carbon peaking by 2030 and carbon neutrality by 2060. This goal has a certain direction for the future development of enterprises.

Excellent enterprises actively carry out carbon disclosure to enhance climate transparency. Enterprises, as an important micro-entity in the market, should take the initiative to assume

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the important responsibility of protecting the environment, saving energy and reducing emissions in the context of climate change and the "dual carbon".

In 2021, more than 13,000 companies have made their environmental governance information publicly available on the CDP platform, with the size of these companies reaching an all-time high of 64 per cent worldwide. In addition, as a result of increasing market demand for corporate environmental transparency, more than 590 investors and 200 purchasers with total assets of more than $110 trillion have already obtained corporate environmental information from CDP in 2021.

In view of this, this project aims to explore the mutual influence mechanism between corporate carbon disclosure and corporate value under the goal of "dual carbon" by manually collecting data related to corporate carbon disclosure and corporate value and applying empirical analyses with a sample of Chinese enterprises.

2. Literature and Theoretical Foundations

2.1. Literature review

Carbon information refers to a range of measures taken by companies to address climate change and achieve low-carbon development. Carbon disclosure refers to a proven method of communicating information about a company's carbon emissions, carbon assets, carbon management strategy, and potential opportunities and challenges related to carbon emissions to those who need carbon information, ensuring that investment decision makers, business managers, and external regulators have access to useful information for decision making. The carbon information is communicated to those who need it, ensuring that investment decision makers, business managers and external regulators have useful information for decision making.

Company value is an important indicator of a company's expected profitability and ability to grow sustainably. At the firm level, value refers to the sum of the value that a firm obtains in a transaction. In 1959, Modigliani and Miller of the United States introduced the concept of "enterprise value" from the viewpoint of financial management, which refers to the price at which a company trades in a free market, determined by the sum of the prices of stocks and bonds. It is determined by the sum of the prices of stocks and bonds. According to Myers' theory, the value of a company consists of two aspects: first, the value of the company's existing assets, and second, the future cash flow of the company. Along with the continuous development of market economy, some scholars expand the perspective to the internal and external stakeholders of the enterprise, and believe that the enterprise value refers to the sum of the value of all the assets claimed by the enterprise, which includes the enterprise's equity, liabilities, employee welfare subsidies, and other aspects. Then, the value of the company moves towards the direction of intrinsic value and social value.

Currently, there are few studies on corporate carbon emissions and firm value. Zhang Qiaoliang (2013) used the 2010 CDP questionnaire as the basis for constructing 85 samples of the top 500 U.S. companies and empirically analysing their corporate value, and the results showed that there is no obvious correlation between the quality of corporate carbon disclosure and corporate value. He Yu et al. (2014) also used data from the CDP to study 181 companies in the sample that met the criteria, and the results showed that there is a negative correlation between a firm's cost of capital and carbon disclosure, which implies that carbon disclosure will help to increase the value of the firm.

All existing studies have certain shortcomings, especially the lack of in-depth analyses of endogenous factors, leading to a lack of credibility in the relevant findings. Recently, Philipp (2015) took the European stock market as the object of his study and found that mandatory carbon disclosure has a significant positive relationship with firms' market capitalisation by

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using the European stock market (e.g., the London stock market in the UK) and applying the natural experiment method.

2.2. Relevant concepts

2.2.1. Carbon disclosure

Carbon information is receiving increasing attention in the context of "dual carbon". Carbon information is an extension and refinement of environmental information on carbon issues. At present, the Carbon Disclosure Project (CDP) has a more authoritative position in the framework of carbon information disclosure, through cooperation with enterprises, the use of questionnaire surveys to measure the objectives and problems of enterprises regarding the environment and climate. Enterprises can choose to participate and disclose their answers, or they can choose not to participate. Carbon disclosure mainly includes the following:

Table 1 :Carbon Disclosure Project

Carbon Disclosure Project	Low carbon strategy	Carbon risk management
		Low-carbon development opportunities
		Carbon management strategy
		Carbon reduction target
	Greenhouse gas emission strategies	Carbon accounting methods
		Direct accounting of carbon emissions
		Indirect accounting of carbon emissions
	Corporate Governance for Carbon Emission Reduction	liabilities
		Individual performance
		link up
	Global climate governance	Responsibility sharing for climate change
		Effectiveness of emission reductions at the aggregate and individual levels
		International climate governance mechanisms

2.2.2. Enterprise value

With the development of society and economy and the seriousness of environmental problems, enterprises gradually realise that measuring enterprise value purely from economic benefits in the past is no longer suitable for today's times, and that they should comprehensively consider economic benefits, social benefits, ecological benefits as well as the social responsibility of enterprises. According to the stakeholder theory, enterprises need to change their concepts, and gradually shift the idea of profit maximisation to the integrated consideration of economic, social and ecological benefits, in order to achieve the sustainable development of enterprises. From the perspective of stakeholders, this paper argues that in today's "dual-carbon" context, stakeholders need enterprises to provide relevant environmental information, such as carbon emission information, in order to make rational decisions.

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2.3. Rationale

2.3.1. Information asymmetry theory

Information asymmetry theory is a theory proposed by three American economists in the 1970s, and this theory provides a new thing for the study of market economy. Information asymmetry refers to the fact that the two parties to a transaction have different degrees of mastery of the same kind of information, and the two parties are in an unequal state in terms of information acquisition. The theory of information asymmetry suggests that in the process of market transactions, the party with more information will be in an advantageous position, and the party with less information will be in a disadvantageous position. For example, the seller in the market will have more information than the buyer. If the seller has more information than the buyer, the buyer will lower the price in order to reduce the risk caused by information asymmetry, but the seller will not be willing to sell at a low price because of the high quality of the product, and the behaviour of the two will result in the decrease of the quantity of high-quality products in the market, and the increase of the quantity of poor-quality products. In addition, in order to achieve their own interests, enterprises will disclose as much information as possible to the outside world that is favourable to the enterprise, and conceal or even whitewash unfavourable information, which will result in untrue and unreliable information disclosure. Carbon information disclosure, as an important element of information disclosure, will naturally occur in such a situation, and then the market signal display can compensate for such problems to a certain extent.

2.3.2. Signalling theory

Signalling theory refers to the fact that when there is a serious asymmetry of information in the market, the party with more information will take the initiative to pass information to the party with less information in order to improve the efficiency of the transaction. Under the current "dual-carbon" background, some companies will voluntarily disclose carbon information in order to get more investment and have an advantageous position in the market, so as to differentiate themselves from companies with poor carbon emission performance and thus highlight their own advantages. Companies that do not disclose carbon information will be regarded as intentionally concealing the company's interests and will not be favourably viewed by investors. Therefore, the signalling theory is an important guide for corporate carbon disclosure, which also implies that corporations are beginning to shift from pursuing economic interests to pursuing economic interests while paying attention to social interests and corporate responsibility. The theory of signalling has an important direction for carbon disclosure. Enterprises can convey their competitive advantages in energy saving and emission reduction to the outside world through carbon disclosure, thus attracting investors and enhancing corporate value.

2.3.3. Theory of disclosure

Information disclosure refers to the voluntary disclosure of company information by listed companies to the outside world for the purpose of enhancing the company's image, attracting investors as well as reducing risks, such as the company's long-term strategy, relevant data, and so on. Voluntary information disclosure is mainly based on three theories - Principal Generation Theory, Signalling Theory and Excess Return Theory. Delegation generation theory means that the cost of delegated agency will reduce the value of the company, then investors will give up their investment because they do not want to bear the cost, which is a major blow to the company. Therefore, in order to solve this problem, timely disclosure of information to the outside world can help investors to watch and judge, so as to reduce the risk of the enterprise. Signalling theory suggests that if firms do not have the same level of information, then those that actively disclose information to the public will be more likely to elicit a response from the market than those that do not. Excess Return Theory suggests that voluntary carbon disclosure

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is essential, and that companies need to continuously improve their transparency and transmit effective information quickly and accurately to the outside world, in order to elicit a market response and increase their own value. Therefore, from the above three theories, it can be seen that the full disclosure of carbon information is an important part of the enhancement of enterprise value.

3. Research hypotheses

The impact of carbon emission disclosure on the market value of enterprises in the context of "dual carbon" is a topic of great interest. Firstly, we need to clarify some concepts. Dual-carbon refers to the two goals of "carbon neutrality" and "carbon dioxide peaking", i.e., to gradually reduce China's greenhouse gas emissions after they have peaked by 2060, and ultimately to realise "zero emissions"; at the same time, it promotes the transformation of the whole society into a green and low-carbon one; and it also promotes the transformation of the whole society into a green and low-carbon one. "The market value of an enterprise refers to the price assigned to a company in the market for stocks, bonds and other financial instruments.

According to statistics, over the past decade, an increasing number of governments have introduced environmental regulations and encouraged industries to implement more stringent pollutant limitations or greenhouse gas mitigation strategies. This strong global support for sustainable development has also brought new challenges and opportunities for companies: increased consumer awareness, policy changes, and increased investor attention to corporate social responsibility and environmental awareness have all become important factors in influencing market value.

In practice, however, the incorporation of carbon disclosure into sustainable development strategies by enterprises has not significantly increased their market value. In this context, targeted analyses of the relationship between carbon disclosure and market value can reveal the linkages more clearly and help firms to develop more rational and effective environmental policies, coal-to-gas reductions and other low-carbon action plans.

Based on the above, the following two hypotheses are proposed:

(1) Scenario 1

In the dual-carbon context, the proactive disclosure of carbon emission information by enterprises is more helpful to their market value.

In a dual-carbon context, automatic carbon disclosure by enterprises helps to increase their transparency and makes it easier for investors and stakeholders to understand their carbon emissions. Increased transparency helps build trust, which in turn increases the reputation and market capitalisation of the firm. Meanwhile, with the growing global concern over climate change, many countries and regions have enacted stringent carbon emission regulations. Automated carbon disclosure by companies helps them to comply with these regulations and avoid fines and reputational damage due to non-compliance.

In addition, investors are increasingly concerned about the sustainable development and environmental responsibility of enterprises. Automatic carbon emission disclosure helps enterprises to demonstrate their efforts in environmental protection, thus attracting more investors and improving competitiveness. By knowing about carbon emissions, enterprises can take measures to reduce carbon emissions, thereby reducing costs. This helps to improve the profitability of enterprises. Governments in many countries and regions are taking steps to encourage companies to make carbon disclosures. These policies may include tax incentives, subsidies and other incentives. Automated carbon disclosure can help companies to access these policy supports and thus increase their market capitalisation.

(2)Scenario 2

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High-carbon emitters gain more from proactive carbon disclosure .

Proactive disclosure of carbon emissions by high-carbon-emitting enterprises can increase their transparency and credibility, enhance their recognition by consumers, investors and government agencies, help improve their image and reduce business risks. In addition, by disclosing their environmental information, companies can better respond to regulatory pressures.

In addition, against the backdrop of increasing global climate change, more and more consumers and investors are paying attention to the actions taken by companies to protect the environment. Therefore, proactive disclosure of carbon emissions is also a reflection of keeping up with the times and responding to the needs of society. Of course, before disclosing carbon emissions, it is necessary to ensure the accuracy and comparability of data, and to work with relevant organisations to formulate a sustainable development plan in order to achieve real reductions in carbon emissions. Only in this way can we achieve long-term, reliable returns and win the respect of society.

4. Data and study design

4.1. Data sources

In order to verify the above assumptions, we collected carbon disclosure data from various industries through RESSET financial research database, National Enterprise Information Publication System and China Environmental Network, etc. and combined with annual reports and interim reports compiled by enterprises, and a total of 1,932 samples from 644 listed A-shares in the period of 2020-2022 were collected. In order to reduce the differences in carbon disclosure behaviours of different enterprises in different industries, and to make the data more targeted, the industries in which the data were collected were high carbon emission industries such as mining, manufacturing, electricity, heat, gas and water production and supply, construction, and transport, storage and postal industries. Other sectors are classified as non-carbon emitting.

4.2. Explained and control variables

This paper will explore the relationship between corporate carbon disclosure and market value in a dual-carbon context through empirical analyses. Specifically, this paper uses a multiple regression model for empirical analysis: the model is tested based on the traditional hypothesis testing method. Considering that the strictness of pollutant limitation rules varies in different industries and the potential flooding effect due to the differences in various basic information may make the results inaccurate. Here, variables such as industry type, company size, net assets per share, whether it is a state-owned enterprise or not, and whether it is a high-carbon emitting enterprise or not are used as control variables to circumvent these problems.

Table 2: Description and definition of variables

variable name	Description of indicators	define
Lstknm	Latest Stock Name	Shares have just been issued and listed for normal operation
PPS	par value	Market price per share
CED	Carbon emissions disclosure	Dummy variable: 1 if disclosed, 0 otherwise
BPS	net asset per share	Shareholders' equity/total shares

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SOD	Whether or not it is a state-owned enterprise	Dummy variable: 1 if state-owned, 0 otherwise
IFH	Whether it is a high carbon emitting enterprise	Dummy variable: 1 if high carbon, 0 otherwise

With share price per share as the explanatory variable and carbon emission disclosure as the explanatory variable, meanwhile, in order to control the influence of other factors, based on the reference to the existing literature research, we choose five dimensions to control. First, industry type: different industries have different carbon emissions and market demand, which may affect the market value of enterprises; second, company size: the larger the size of the company, the corresponding increase in its economic strength and influence, which may have an impact on the market value of the enterprise; third, financial status: companies with good financial status tend to be more capable of investing in environmental protection facilities and technological transformation, which reduces carbon emissions and improves their competitive advantage; Fourth, market share: companies with a larger market share usually have more resources, brand awareness and other advantages, and receive more attention after the disclosure of information, which further enhances the market value of the company; and fifth, country-specific cultural background factors: there are differences in the understanding of climate change, environmental awareness and management concepts in different countries and regions.

Firstly, the event window setting is used to portray the difference in stock price performance before and after firms publish carbon emission information. Second, the existence of heterogeneity in the effect and possible explanatory mechanisms are further explored. Specifically, at the industry level, knowledge-intensive industries such as financial services and electronic equipment are more likely to capture a premium from information disclosure relative to other traditional heavy industry sectors, while at the corporate governance level, the impact of firms' financial performance and risk management capabilities on market value is captured through indicators such as ROA and capital structure. Other potentially influential factors such as equity structure and market liquidity are also considered.

5. Empirical results and analyses

5.1. Descriptive statistical analyses

Overall, the 644 companies in this collection have a share price per share PPS and net assets per share BPS are highly polarised, with the difference between their respective maximum and minimum values being extremely large, indicating that there are huge differences in the value of different enterprises in the stock market due to factors such as their industries, business models, financial conditions, and brand awareness. After relevant calculations, the share price per share of 644 A-share enterprises from 2020 to 2022 is PPS are centrally distributed in (13.95, 20.49) while the net asset per share BPS is then concentrated at (5.56, 6.16). As shown in the following chart, the carbon emission disclosure from 2016-2018 CED_{i-1} mean value is 0.63, the corporate carbon emission disclosure for 2020-2022 CED_i The average value of carbon emission disclosure for 2016-2018 is 0.63, and the average value of carbon emission disclosure for 2020-2022 is 0.67. Generally speaking, under the background of "dual carbon", enterprises pay more attention to carbon emission disclosure, and more and more enterprises understand the value and significance of active disclosure of carbon emission for themselves and the whole society, and take the initiative to undertake the social responsibility that they should have as an enterprise: active disclosure of carbon emission helps enterprises to better understand the situation of carbon emission and to promote the development of carbon

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emissions. Disclosure of carbon emissions helps enterprises better understand their carbon emissions and promote the development and innovation of environmental protection technologies and solutions, which in turn promotes the development of a green economy.SOD The average value of 0.88 indicates that the mining, manufacturing, electricity, heat, gas and water production and supply, construction, and transport, storage and postal industries are mainly dominated by state-owned enterprises (SOEs), and although SOEs accounted for 0.88% of the total number of SOEs actively disclosing their carbon emissions, they only accounted for 60-70% of the total number of SOEs that voluntarily disclose carbon emissions, and some SOEs and private enterprises still disclose their emissions for financial reasons. State-owned enterprises and private enterprises do not actively disclose carbon emissions in their annual reports or social responsibility reports due to financial interests and corporate strategy considerations. However, in order to promote the active disclosure of ESG reports by more listed companies held by central enterprises, the State-owned Assets Supervision and Administration Commission of the State Council (SASAC) issued the "Work Programme for Improving the Quality of Listed Companies Held by Central Enterprises" in May 2022, aiming at the full coverage of relevant ESG reports by 2023, which is the first time that SASAC has published a report on the quality of listed companies held by central enterprises. The special report disclosure "full coverage". From this, we can see that the country's positive attitude towards carbon emission reduction is not just superficial. DataIFH The average value of 0.77 indicates that most of the 644 A-share listed companies are high carbon emission enterprises.CEDT he average value of 0.77 shows that most of the 644 A-share listed companies are high carbon emission enterprises, and the average value of 0.77 shows that most of the 644 A-share listed companies are high carbon emission enterprises, and the average value of 0.77 shows that most of the 644 A-share listed companies are high carbon emission enterprises.

Table 3:Descriptive statistics of data variables for 644 enterprises, 2020-2022

Variable	N	mean	sd	min	p50	max
PPS	1932	17.04	77.53	1.17	7.42	1885.69
BPS	1932	5.86	6.69	0.16	4.63	164.55
CED_i	1932	0.67	0.47	0.00	1.00	1.00
CED_{i-1}	1932	0.63	0.48	0.00	1.00	1.00
SOD	1932	0.88	0.33	0.00	1.00	1.00
IFH	1932	0.77	0.42	0.00	1.00	1.00

5.2. Correlation analysis

Table 4:Pearson correlation coefficients for data

relevance						
		PPS	BPS	CED	SOD	IFH
PPS	Pearson Correlation	--				
	Number of cases	1932				
BPS	Pearson Correlation	.844**	--			
	Significance (two-tailed)	.000				
	Number of cases	1932	1932			

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CED	Pearson Correlation	.080**	.068**	--		
	Significance (two-tailed)	.000	.003			
	Number of cases	1932	1932	1932		
SOD	Pearson Correlation	.003	.019	-.027	--	
	Significance (two-tailed)	.909	.411	.229		
	Number of cases	1932	1932	1932	1932	
IFH	Pearson Correlation	.031	.043	-.048*	.010	--
	Significance (two-tailed)	.167	.060	.035	.667	
	Number of cases	1932	1932	1932	1932	1932
**. The correlation is significant at the 0.01 level (two-tailed).						
*. The correlation is significant at the 0.05 level (two-tailed).						

Based on the results of correlation analysis in the above table, it can be seen that both BPS and CED are correlated with PPS at 1% level, indicating that there is a significant correlation between BPS and CED respectively with PPS, but CED and PPS lack in significance.BPS is correlated with CED at 1% level, indicating that there is a significant correlation between BPS and CED, and CED is correlated with IFH at 5% level correlation, indicating a significant correlation between CED and IFH. However, BPS, IFH and CED lack in significance.

5.3. Regression modelling

In order to test the impact of proactive disclosure of carbon emission information on the market value of enterprises in the context of "dual-carbon", this paper designs the following econometric model, as shown in equation (1). Where i denotes the year, because the annual report and social responsibility report are published in January-April of the following year, in order to better reflect the relationship between the variables, reduce autocorrelation and seasonal effects, so as to improve the robustness of the empirical analyses, this paper lags one period of the dummy variable CED (whether the enterprise proactively discloses carbon emissions) in the regression model.

$$PPS_i = \beta_0 + \beta_1 CED_{i-1} + \beta_2 BPS_i + \beta_3 SOD + \beta_4 IFH \quad (1)$$

A total of 644 A-share companies' dynamic data were collected in this regression for a total of 3 years from 20-22 years, in order to make the results more robust, this paper has conducted the variance factor test on the regression equation before regressing the data, and it has confirmed that there is no multicollinearity between the variables, and it has been determined that the model has a certain degree of explanatory power, and the results of the multivariate linear regression are reported in the table below.

Table 5 : Regression results of the impact of proactive disclosure of carbon emissions on the market value of enterprises in the context of "dual-carbon".

	(1)	(2)
	PPS	ln PPS
CED	6.035***(10.88)	0.417***(13.30)

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BPS	1.962^{***}(25.52)	
SOD	-1.265^{***}(−1.58)	$-.125^{***}$(−2.76)
IFH	-0.280^{*}(−0.46)	$-.0241^{*}$(-0.70)
ln BPS		0.752^{***}(32.98)
cons	-1.513^{*}(-1.45)	0.852^{***}(13.56)
N	1932	1932
adj. R − sq	0.304	0.411

Note: ***, **, ** denote significance at the 1 per cent, 5 per cent and 10 per cent significance levels, respectively, and t-values adjusted for robustness standard errors are reported in parentheses.

From the regression results of model (1) in Chart 5, it can be seen that there is an obvious positive correlation between CED and PPS, and it is significant at the 1% level, but due to the lack of other effective control variables in this regression, coupled with the amount of data collected is too small, it is possible that there is a pseudo-regression in this model, so in order to weaken the heteroskedasticity of the data in the model, to better simulate the form of the model, and to better allow the data to indicate whether the enterprise discloses the In order to weaken the heteroskedasticity of the data in the model, better simulate the model form, better let the data indicate whether the enterprise discloses the correlation between carbon emissions and the enterprise market value, therefore, on the basis of model (1), the logarithmic treatment and tailing treatment were done on the dependent variable PPS and the independent variable BPS, such as the model (2) in chart 5 shows that the model is still positive in the correlation coefficient of the CED after the correlation processing of the data and it is significant at the level of 1 per cent. In summary hypothesis 1 is tested. The result shows that for investors, the active disclosure of carbon emissions by enterprises indicates that enterprises actively respond to the "dual-carbon" policy proposed by the government on 22 September 20, which is in line with the favourable policy and enhances investor confidence, resulting in a high level of capital inflows, which in turn contributes to the increase in the share price of enterprises.

5.4. Subgroup regression modelling

5: Subgroup regression results of the impact of carbon emission disclosure on market capitalisation of enterprises in the context of "dual carbon".

	(1)	(2)
	IFHTrue	IFHFalse
CED	15.386^{***}	−5.625
N	1431	401
adj. R − sq	0.187	0.231

Note: ***, **, ** denote significance at the 1 per cent, 5 per cent and 10 per cent significance levels, respectively, and t-values adjusted for robustness standard errors are reported in parentheses.

In order to test hypothesis 2, this paper carried out group regression on dummy variables CED and IFH, and it can be seen from Table 6 that the coefficient of CED in model (1) is 15.386, with a coefficient greater than 0, which is significant at the level of 1%, and the sample regression coefficient is larger than the full-sample regression result by 9.315, and the coefficient of CED in model (2) is -5.635, which is smaller than 0, but the result is not significant. The above results indicate that high carbon emitting companies benefit more from proactive disclosure of carbon emissions compared to low carbon emitting companies.

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6. Robustness tests

6.1. Altered sample period method

Although the above model test concludes that the active disclosure of carbon emissions by enterprises in the context of "dual-carbon" is more conducive to the enhancement of market value, in order to ensure the validity of the conclusions and avoid the independent selection of samples, this paper also collects the relevant data for the period of 2016-2018 and conducts a multiple regression analysis to determine the correlation coefficients of several variables in different sample periods. Multiple regression analysis to derive the correlation coefficients of several variables in different sample periods, and compare them with the correlation coefficients of the variables tested in the above model as a test group, so as to test whether the active disclosure of carbon emissions by enterprises in the context of the "dual-carbon" is conducive to the enhancement of corporate value. Figure 3 below shows in detail the fit of the data from 2016 to 2018.

Table 6: Relevant data fits for 2016-2018

	(1)
	PPS
CED	0.834 (0.81)
BPS	4.605^{***}(53.21)
SOD	$-1.09(-1.13)$
IFH	$-3.129^{***}(-3.97)$
cons	$-5.970^{***}(-4.03)$
N	2091
adj. $R-sq$	0.577

Note: ***, **, ** denote significance at the 1 per cent, 5 per cent and 10 per cent significance levels, respectively, and t-values adjusted for robustness standard errors are reported in parentheses.

From the regression results in Table 7, it can be seen that the correlation coefficient of CED is 0.833 in the three years from 2016 to 2018, which is a positive correlation, but it does not pass the significance test, and it can be deduced that whether the enterprises disclose their carbon emissions or not has no direct influence on the changes of the market value of the enterprises before the target of "dual carbon" is formally put forward. It can be inferred that whether enterprises disclose carbon emissions or not before the "dual carbon" target is formally proposed has no direct influence on the change of enterprise market value.

6.2. Robustness test based on double differencing

Although the validity of the conclusions can be improved to a certain extent by changing the source of sample data, since the behaviour of enterprises in disclosing carbon emissions has always been affected by many uncertain factors such as policy, market, competition, etc., simply relying on the selection of samples in different periods for the multiple regression analysis may still affect the representativeness and reliability of the results of this research, which leads to the low credibility of the results. Based on the above considerations, in order to improve the analysis precision of the data, ensure the reliability and stability of the data, improve the credibility of the research results, as well as to expand the scope of application of this research, this paper combines the data of 2016-2018 and 2020-2022 to carry out a double-difference treatment. This test takes PPS as the dependent variable and sets the dummy variable Time (because the "dual carbon" policy was first proposed in 2019, so 2016-2018 is before the implementation of the policy, and the dummy variable is taken as 0, while 2020-2022, after the

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implementation of the policy, the dummy variable is taken as 0). The dummy variable takes 1 for 2020-2022) and the dummy variable CEDIF (1 for active disclosure of carbon emissions during the implementation of the "dual-carbon" policy, and 0 otherwise). The two dummy variables Time and CEDIF are multiplied together to produce the interaction term did, and finally the three variables Time, CEDIF and did are regressed on the PPS as explanatory variables to draw conclusions.

Table 7:Results of DID analysis

	PPS
Time	−2.371***(-2.76)
CEDIF	1.94***(2.38)
did	11.182***(3.98)
cons	10.654***(17.71)

Note: ***, **, ** denote significance at the 1 per cent, 5 per cent and 10 per cent significance levels, respectively, and t-values adjusted for robustness standard errors are reported in parentheses.

As can be seen from Table 8, the coefficient of the dummy variable CEDIF is 1.94, and it is at the 1% significance level, which indicates that the active disclosure of carbon emissions during the implementation of the "dual-carbon" policy has a positive impact on the market value of enterprises. The coefficient of did of 644 A-share companies selected in this paper in the context of "dual carbon" is 11.182, which is significantly positive, and it is established at 1% significance level, indicating that the implementation of "dual carbon" policy has a significant positive effect on the PPS of enterprise's share price at 1% significance level. This indicates that the implementation of the "dual carbon" policy has a significant positive effect on the stock price PPS of enterprises at the 1% significance level, which further verifies the feasibility of the model.

7. Conclusions and recommendations

7.1. Conclusion

In this paper, a simple econometric model is constructed to investigate the impact of carbon disclosure on the market capitalisation of enterprises in the context of "dual carbon". The above study shows that in the context of "dual-carbon", the active disclosure of carbon emissions by enterprises can help enterprises to improve their transparency, which can enhance the trust and recognition of consumers and investors, and thus have a positive impact on the market value of enterprises, and the active disclosure of carbon emissions by high-carbon emission enterprises has a more significant impact on their market value. This means that companies should actively participate in emission reduction initiatives. This implies that companies should actively participate in emission reduction actions and demonstrate their power of action for environmental protection by proactively disclosing carbon emission information in their annual reports or CSR reports. In addition, the results of this paper also have implications for enterprises in terms of production management. On the one hand, enterprises should strengthen environmental management and reduce carbon emissions by increasing energy efficiency and optimising supply chain management. On the other hand, enterprises should actively disclose their carbon emissions to the public to enhance public trust and recognition of enterprises. It should be noted that the conclusions of this study are based on the relevant data of 644 A-share enterprises in China. In other countries or regions, the impact of enterprises' active disclosure of carbon emissions on their market capitalisation may be different. Therefore, future research should further explore the impact of enterprises' proactive disclosure of carbon emissions on their share prices in different countries and regions.

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7.2. Recommendations

7.2.1. Enterprise level

Enterprises, as one of the main bodies of carbon emissions in China, should take more initiative to assume more social responsibility under the background of "dual-carbon" nowadays. Carbon information disclosure can effectively encourage enterprises to carry out effective carbon emission management and promote energy saving and emission reduction. Enterprises can formulate reasonable low-carbon strategies according to their own situation and current policies, and at the same time increase research and development and investment in carbon reduction technologies, optimise production methods, improve resource efficiency, thereby reducing carbon emissions, reducing production costs and gaining competitive advantages. In addition, according to the content of stakeholder theory, enterprises to strengthen the management of carbon information emissions and take the initiative to disclose the relevant information to the outside world, will make investors more optimistic about the future prospects and development of the enterprise, and increase the attention to the enterprise as well as investment.

7.2.2. Government level

At present, China does not have a unified legal policy on carbon information disclosure by enterprises, and mainly implements voluntary carbon information disclosure. In the present low-carbon economy, the government should increase the guidance and encouragement policy, increase the initiative of enterprises on carbon information disclosure, and improve their awareness of low-carbon management. In addition, since the main purpose of enterprises is to maximise profits, if the consequences of implementing carbon information disclosure will result in higher costs than benefits, enterprises will not take the initiative to disclose, therefore, enterprises should improve the relevant disclosure system and policies, and give different subsidies and welfare support according to different industries, such as tax breaks and technological subsidies, etc., to compensate for costs incurred by enterprises actively assuming social responsibility, and to guide enterprises to actively take the initiative to disclose carbon information to the public. Costs to compensate for the enterprise to take the initiative to undertake the corresponding energy saving and emission reduction responsibility to guide enterprises to actively take the initiative.

7.2.3. Social dimension

The level of people's environmental awareness is an important indicator of the degree of development of environmental protection in a country or region.

Therefore, the relevant departments should take effective measures to increase public participation in low-carbon undertakings and give full play to the supervisory role of the public; in addition, they should also strengthen publicity and education work for enterprises and individuals, and enhance the environmental protection awareness of the whole nation; at the same time, they should also strengthen rewards and penalties for enterprises and individuals, so as to create a favourable social atmosphere for the development of low-carbon. The mass media should popularise low-carbon knowledge and environmental protection knowledge among the general public, publicise it to enterprises, and promote enterprises to set up a low-carbon image the most, so as to achieve a consensus on reducing carbon dioxide emissions and lowering the hazards brought by abnormal climate.

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