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The Impact of Carbon Disclosure on Business Valuation

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Abstract

Against the backdrop of accelerating global carbon neutrality and deepening Paris Agreement rules, this study explores the economic impacts of carbon disclosure (CD), a key link between corporate environmental governance and capital market valuation. Using panel data of Chinese A-share listed firms (2015–2022), we employ fixed-effects models, mediation tests, and regression analyses to examine CD's effects on firm valuation. Key findings include: (1) one unit increase in CD level raises valuation by 8.6%; (2) CD's valuation boost is stronger for non-state-owned and manufacturing firms; (3) Introducing the SA index to measure financing constraints reveals a mediating mechanism: CD alleviates information friction, reduces financing constraints, and improves investment efficiency. The study empirically supports refining CD systems and environmental governance strategies, while innovatively integrating stakeholder theory with dynamic valuation models to expand the frontiers of firm valuation research.

JEL classification numbers: G34,G38, G39.
Keywords: Carbon disclosure, Corporate valuation, Financing constraints, Sustainable development.

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1. Introduction

Against the backdrop of intensifying global climate change and the advancement of the "dual carbon goal", carbon disclosure has become an important practice in corporate environmental governance. According to the United Nations Environment Programme (UNEP) 2024 report, 87 countries around the world have implemented mandatory carbon disclosure systems. Corporate carbon information disclosure should be improved in quality and quantity (IIGF, 2024).

This institutional change makes carbon information gradually become a new dimension for assessing corporate value in the capital market. Under the perspective of finance, enterprise valuation, as a core indicator of resource allocation, has been expanded from traditional financial indicators to environmental, social, and governance (ESG) dimensions. By the end of 2022, the global ESG investment scale reached 30.32 trillion dollars, and it is expected that the global ESG scale will reach 50 trillion dollars in 2025. Among them, the quality of carbon disclosure has become an important basis for institutional investors to screen targets. This incomplete disclosure may lead to misjudgment of corporate value in the capital market (GSIA, 2023). Meanwhile, the relationship between carbon disclosure and financing constraints has been studied by many scholars in recent years. Therefore, the mechanism of carbon disclosure's impact on firm valuation under China's special institutional background still remains theoretically controversial, especially the mediating effect of financing constraints, industry heterogeneity, and other key issues need to be explored in depth.

This study aims to construct a theoretical framework for the impact of carbon disclosure on corporate valuation, and to achieve three core objectives through empirical analysis: first, to reveal the path of carbon disclosure on corporate valuation, especially the mediating effect of financing constraints; second, to explore the moderating effect of different industry attributes and corporate nature on the impact effect; and third, to provide an opportunity for the regulator to improve the disclosure system, enterprises to optimize the information disclosure strategy, and investors to improve the valuation model, based on the findings of the study. Third, based on the findings of the study, it provides decision-making basis for regulators to improve the disclosure system, enterprises to optimize the disclosure strategy, and investors to improve the valuation model.

The rest of the paper is structured as follows: Section 2 includes a comprehensive literature review and the relevant conceptual and theoretical foundations. Section 3 provides a complex description of the research methodology employed and outlines the dataset used. Section 4 provides an in-depth empirical analysis with a comprehensive discussion. Section 5 summarizes the main findings of the study and provides relevant recommendations for future action.

2. Literature Review and Theoretical Assumptions

The literature review presents the main concepts related to the research topic under consideration, the theories that support its hypotheses, and the results of similar empirical studies.

2.1 Methods and Influencing Factors of Business Valuation

2.1.1 Methods of Enterprise Valuation

Enterprise valuation is the process of assessing the value of the whole or part of the assets of an enterprise through quantitative methods, the core of which is to determine the present value of discounted future cash flows. At the methodological level, enterprise valuation is mainly divided into two systems: absolute valuation method and relative valuation method.

The absolute valuation method is represented by the discounted free cash flow (DCF) model, whose theory emphasizes that the value of the enterprise is determined by future free cash flow. Relative valuation method is based on the market effectiveness hypothesis, through the price-to-earnings ratio (P/E), price-to-book ratio (P/B) and other multipliers for horizontal comparison, but the method is facing challenges in the transition to a green economy - Wind data show that the standard deviation of the price-to-earnings ratio of the A-share new energy industry in 2023 amounted to 58.7%, which is significantly higher than that of traditional manufacturing industries The standard deviation of P/E ratio of A-share new energy industry in 2023 is 58.7%, which is significantly higher than that of traditional manufacturing industry (29.3%), reflecting the complexity of comparable company selection.

Tobin's Q is a measure of the relationship between the market value of a firm and the replacement cost of its assets (Tobin, 1969; Tobin & Brainard, 1977). It has important applications in business valuation, investment decisions and macroeconomic analysis.

2.1.2 Influencing factors of enterprise valuation

As a core topic of finance research, enterprise valuation presents diversified characteristics of its influencing factors. With the evolution of the global economic environment and the concept of sustainable development, the macroeconomic environment, the characteristics of micro subjects, the quality of accounting information, ESG practices, etc. will affect enterprise valuation.

Macroeconomic fluctuations affect valuation by changing the cost of capital and risk premium. Lin (2021) constructs a valuation model for technology firms and finds that every 1% increase in money supply can reduce the discount rate of the semiconductor industry by 0.3 percentage points, but the effect on biopharmaceutical firms is not significant. Wei (2023) points out that investor attention is regionally heterogeneous: the ESG valuation premium in the eastern region is 14.2% lower than that in the west, which stems from the diminishing marginal effect caused by the difference in market maturity.

Firm-specific factors have a differentiated impact on valuation: Cusumano et al. (2024) find that firms adopting the platform model have a 42% higher valuation than the traditional model, and the elasticity coefficient of user growth due to the network effect reaches 1.3. Yu (2024), taking the New Third Board firms as a sample, reveals that R&D intensity has an inverted U-shape relationship with valuation, with peaks occurring in the R&D ratio of 8%-10%. interval. Su (2022) emphasizes the importance of management quality, with each additional 5 years of CEO industry experience increasing the P/E ratio by 1.2 times standard deviation.

Information transparency enhances valuation efficiency by reducing information asymmetry. Jiang and Huang (2024) for bio-breeding firms show that each one standard deviation increase in accounting disclosure quality increases the P/E ratio by 0.18. This effect is more significant in firms with more than 15% institutional investor ownership, verifying the sensitivity of professional investors to information quality. Lu (2024) confirms through the case of the GEM registration reform that the mandatory disclosure requirement. The strengthening of mandatory disclosure requirements reduces firm valuation dispersion by 23%, suggesting that regulatory policies can enhance pricing effectiveness by improving the information environment.

Environmental, social and governance (ESG) performance has become an important dimension in corporate valuation. Rahat and Nguyen (2024) for 16 emerging markets show that ESG scores are significantly positively correlated with valuation metrics such as price-to-book ratios and price-to-sales ratios, and ESG controversial events can negatively impact valuation through the RepRisk index. Cai et al. (2024) further found that executive academic background and gender differences moderated the value creation effect of ESG practices, and the ESG premium was more significant for firms with a master's degree or higher or a high percentage of female executives. Wang et al. (2023) confirm through a quasi-natural experiment that an increase in MSCI-ESG ratings can increase firms' Tobin's Q by 12.7% on average, highlighting the market signaling effect of ESG certification.

2.2 Quantitative Approaches and Causes of Carbon Disclosure

2.2.1 Quantification method of carbon information disclosure

In terms of the method of obtaining carbon disclosure index, Chen and Li (2023) summed up carbon emissions, carbon emission reduction targets, and the number of patents of green technologies into a carbon disclosure index, empirically found its positive impact on financial performance, and verified the robustness of the method through the mediation effect test. Liu et al. (2021) used the summation method to construct the carbon disclosure level variable and found that it had a significant negative effect on the cost of equity financing, indicating that the summation method is also applicable in capital market research. Huang et al. (2025) analyzed the impact of carbon disclosure on green innovation efficiency by extracting the keywords of carbon information (e.g. “carbon neutrality”, “emission reduction technology”) from the annual reports of enterprises through text analysis,

counting the frequency of their occurrence and summing them up as the carbon disclosure Score. Therefore, this method simplifies the process of quantifying complex information and obtains significant empirical results.

2.2.2 Causes of Carbon Disclosure

In the current context of global climate change and increasing attention to environmental protection, carbon disclosure has become an important way for companies to respond to social responsibility and regulatory requirements. Carbon disclosure can provide transparency on corporate GHG emissions and help investors and other stakeholders to assess the environmental performance and risks of a company, so as to influence the cost of financing and the attractiveness of investment. For example, Rehman et al. (2023) show that the need for external financing motivates firms to make carbon disclosures, and that such disclosures can have a positive effect on lowering the cost of financing in countries with lower-quality financial markets.

A synthesis of different papers suggests that carbon disclosure is driven by external financing pressures, investor pressure, policy and regulatory requirements, and self-regulatory incentives. Studies have shown that these factors work together to influence firms' carbon disclosure decisions, and further influence firms' financing costs, investor relations, and market value. For example, Zhu et al. (2024) emphasize the relationship between carbon disclosure and market value of firms, and suggest that investor interest in carbon information can increase firm value. Instead, in the study of Yan and Liu (2024), the high quality of carbon disclosure is regarded as an important factor in enhancing corporate value and affecting corporate value through the mediation of the cost of debt capital.

2.3 Mechanism of carbon disclosure on corporate valuation

With the deepening of global concern for sustainable development, carbon disclosure has gradually become the core content of corporate social responsibility and significantly affects corporate valuation. Existing studies show that carbon disclosure has direct and indirect impacts on corporate value through channels such as reducing information asymmetry, enhancing social reputation, and optimizing financing costs.

Carbon disclosure has a direct effect on the market's assessment of corporate value by making transparent corporate environmental responsibility practices. Du and Wu (2016) found that carbon disclosure enhances corporate value, a finding that was deepened in subsequent studies. For example, Zou (2023) empirical analysis of Chinese listed companies shows that carbon disclosure level is positively related to corporate performance, and the higher the quality of disclosure, the more significant the enhancement. Tian and Li (2024) further indicate that for every 1% increase in carbon disclosure level in the biomanufacturing industry, enterprise value increases by 0.24% on average, and that the increase in investor attention strengthens this effect. Gong et al. (2024) point out that the mechanism of its action is mainly

reflected in two aspects: first, through the disclosure of carbon emissions data to reduce the information asymmetry between enterprises and investors, and enhance market trust; second, through the demonstration of environmental responsibility commitment to enhance the brand image, to attract ESG-focused investors and consumers, and to form a differentiated competitive advantage.

Financing constraint is a key intermediary variable of carbon disclosure affecting corporate valuation, which refers to the phenomenon of limited access to capital caused by financial market friction in the process of external financing, specifically manifested in the difficulty of enterprises to satisfy the scale of capital required for optimal investment at marketized costs through channels such as the credit market, bond market or equity financing. Research has shown that high-quality carbon information disclosure can significantly reduce the cost of corporate finance, especially in the period of economic volatility (Zhang et al., 2022). The mechanism is that the transparency of carbon information reduces investors' concern about "environmental risk premium", thus lowering the cost of debt financing (Zhang et al., 2021); at the same time, enterprises that disclose their emission reduction results are more likely to be favored by green credits and ESG funds, thus optimizing the structure of equity financing (Song 2024). Cross-country data from Du and Zhang (2025) verified that the cost of debt of firms with a high level of carbon disclosure is reduced by 0.8% on average, and the cost of equity capital decreases by 1.2%. In addition, Chi et al. (2023) find that non-state-owned enterprises and non-heavily polluting industries have more significant effects on alleviating financing constraints through carbon disclosure, indicating that the marginal benefits of disclosure are affected by industry attributes

Existing research on the measurement of financing constraints mainly adopts four types of methods:

1) Single-indicator method: using financial indicators such as interest expense ratio and cash holdings as proxies.
2) KZ index: a multivariate linear combination constructed by Kaplan and Zingales (1997).
3) WW index: Whited and Wu (2006) investment decision model based on Euler equation.
4) SA index: a non-financial indicator measure proposed by Hadlock and Pierce (2010), which calculates the SA index.

2.4 Theoretical hypotheses

Based on the existing literature in the international arena, this study analyzes in depth the intrinsic links between carbon disclosure, financing constraints and corporate valuation of Chinese manufacturing enterprises. It is found that financing constraints, as an important intermediary factor, effectively connect the relationship between carbon disclosure and corporate valuation, providing a feasible path for manufacturing enterprises to enhance their own value while satisfying their social responsibilities. This finding is important for guiding enterprises to better manage carbon and optimize resource allocation.

Based on the relationship between carbon disclosure level and enterprise valuation, this paper makes the following hypotheses.

Hypothesis 1. The level of carbon disclosure is positively related to corporate valuation.

Hypothesis 2. Financing constraints play a partial mediating role in the relationship between carbon disclosure and valuation.

3. Research Tools and Methods

3.1 Sources of Data and Sample Selection

3.1.1 Source of data

All the data in the sample selected in this paper come from the financial reports of all A-share listed companies from 2014 to 2023 published in the Cathay Pacific database, Juchao Information Network, etc., and are combined with various information released by the companies in their official websites, and the authors have organized the required data according to the above information.
In order to the accuracy of the empirical research in this paper, the sample data need to be selected, and this paper adopts the following criteria to screen the sample data.

1) The listing time of the sample companies in 2014 and before is excluded;
2) For the enterprises that do not have complete data materials during this research period are excluded from the sample, because this research requires a number of indicators, which requires enterprises to have complete data during this period, otherwise it may affect the validity of the results.

In accordance with the above criteria, after excluding enterprises that do not meet the requirements of the study in this paper, followed by the author's manual processing, processing mainly using Excel and STATA to process and analyze the data.

3.1.2 Source of data

This paper selects A-share listed companies to exclude the companies marked as ST as the research sample, and finds the data related to this study from the annual financial reports disclosed by listed companies and the information on the official website of the enterprises published in the database of GuotaiAnn, Juchao Information Network, etc., in order to analyze the impact of the disclosure of carbon disclosure information of enterprises on the valuation of the enterprises.

3.2 Selection and Description of Indicator System

3.2.1 Design of Carbon Disclosure Level Indicators

As shown in Table 1, this paper analyzes the content of carbon information disclosure of enterprises, for the carbon information of low carbon strategy, goals,

plans; low carbon construction participation; low carbon management; low carbon technology; carbon emissions; carbon emission reduction; negative environmental information; ISO9001 certification; ISO14001 certification of the several aspects of the data, and marking, disclosure of information for 1, undisclosed for 0, and finally these dimensions of the score summing, and then the carbon information disclosure level indicators. Finally, the scores of these dimensions are summed up, and the summed score is taken as the final carbon information disclosure level.

Table 1: Indicator system design table

Indicators	**Meaning of the indicator**	**Scoring Criteria**
Low Carbon Strategy, Objectives, Plans	Whether to disclose information on low carbon strategy, low carbon target, low carbon plan	0=Not disclosed; 1=disclosed
Low Carbon Construction Participation	Whether to disclose information on low carbon risks and opportunities, carbon tax, carbon assets, carbon liabilities, carbon emission rights and their trading.	0=Not disclosed; 1=Disclosed
Low Carbon Management	Whether to disclose management-related information such as low carbon system and low carbon department.	0=Not disclosed; 1=Disclosed
Low carbon technology	Whether to disclose information on low-carbon technologies	0=Not disclosed; 1=Disclosed
Carbon Emission	Whether to disclose greenhouse gas emissions such as carbon dioxide	0=Not disclosed; 1=Disclosed
Carbon Emission Reduction	Whether to disclose emission reduction of carbon dioxide and other greenhouse gases	0=Not disclosed; 1=Disclosed
Negative Environmental Information	Whether to disclose negative information such as environmental violations, environmental incidents, and environmental fines.	0=Not disclosed; 1=Disclosed
ISO9001 Certification	Whether or not to disclose information on ISO9001 certification	0=Not disclosed; 1=Disclosed
ISO14001 Certification	Whether to disclose information on ISO14001 certification	0=Not disclosed; 1=Disclosed

3.2.2 Selection of enterprise valuation indicators

There are many kinds of firm value measures, but most scholars choose Tobin's Q in their research, and this paper also chooses this index because it can explain different corporate phenomena, so it is also the most commonly used. Montgomery and Wernerfelt (1988) use Tobin's Q to explore the relationship between industrial structure and economic rents, Lang and Stulz (1994) also adopt Tobin's Q in their assessment of the economic consequences of corporate diversification. In addition to this, Tobin's value has also been used to study the impact of corporate governance on firm value and so on. In this paper, the Tobin's Q value is chosen to represent the valuation quantity of the firm, because it is more difficult to choose the replacement cost in the formula in the specific application, so the replacement cost is replaced by the book value of the total assets at the end of the year. The formula becomes:

Q = the market value of the total capital of the enterprise / the replacement cost of the total capital of the enterprise = (the value of the enterprise's common stock + the liquidation value of the enterprise's preferred stock + the value of the enterprise's debt) / the book value of the total assets. (1)

This paper examines an important mediating variable as corporate financing constraints, which is calculated using the formula proposed by Hadlock and Pierce (2010):

$$SA=-0.737\times Size+0.043\times Size^{2}-0.040\times Age \quad (2)$$

where Size is the total assets of the firm (taking the natural logarithm) and Age is the number of years of existence. The formula is constructed using two variables, enterprise size and enterprise age, which do not change much over time and are highly exogenous. SA takes a negative value in general, and a larger absolute value means a higher degree of financing constraints. The advantage of the SA index lies in the fact that it can effectively overcome the bias problem of the traditional measurement methodology by eliminating the endogenous financial variables, which ensures the validity of the measurements, and also enhances the comparability of the results across the studies.

3.3 Model Construction

As shown in Table 2, based on the research methodology described above, and in combination with the research purpose of this paper, it is selected to construct the carbon disclosure level and enterprise valuation measurement variables as well as the basis of control variables. And on this basis, according to the method of multiple linear regression, the use of the model is used to test the hypothesis that the level of corporate carbon disclosure has a promotional impact on company valuation. Through the empirical analysis of the model, we can test whether it is consistent with the hypothesis, so as to clarify the relationship between the level of corporate

carbon disclosure and corporate valuation. The model is expressed as follows

$$TobinQ_{i,t} = \alpha + \beta_1 CDL_{i,t} + \beta_2 size_{i,t} + \beta_3 lev_{i,t} + \beta_4 Shrcr1_{i,t} + \beta_5 flowcash_{i,t} + \beta_6 ROE_{i,t} + \beta_7 growth_{i,t} + \varepsilon \quad (3)$$

In the above model:
α: intercept term
β_1, β_2, β_3, β_4, β_5, β_6, β_7: regression coefficient
ε: randomized disturbance term

Table 2: List of variable definitions

Nature of the variable	Variable Name	Variable Meaning	Calculation method
Explained Variables	TobinQ	Firm valuation (Tobin's Q)	(Market value of equity + Book value of liabilities)/Book value of total assets
Explanatory variables	CDL	Carbon Disclosure Level	Whether the enterprise discloses (low carbon strategic target plan, low carbon construction participation, low carbon management, low carbon technology, carbon emission situation, carbon emission reduction situation, negative environmental information) each summary score
Mediating variable	SA	Financing constraints	-0.737*size+0.043*size^2-0.04*age
Control variable	size	Firm size	Natural logarithm of year-end total assets
	lev	Debt capacity	Total liabilities at the end of the period / Total assets at the end of the period
	Shrcr1	Equity Concentration	Percentage of shares held by the company's largest shareholder
	flowcash	Cash Flow Level	Corporate free cash flow per share
	ROE	Profitability	Return on net assets
	growth	Growth	(Current operating income - previous period's operating income)/previous period's operating income

4. Empirical results and analysis

4.1 Basic descriptive statistics of indicators

As shown in Table 3, in this sample, the market value of enterprises relative to their replacement cost (TobinQ value) averages 2.007, showing that enterprises are generally given higher valuations by the market, but its standard deviation is 1.343, indicating that there is a large valuation difference among enterprises. Carbon Disclosure Level (CDL) has a mean value of 1.370, indicating that there is still room for improvement in carbon disclosure for most enterprises, although a score of up to 6.000 suggests that some enterprises have excelled in this area. Firm size (size) in natural logarithmic form has a mean of 22.383 for total assets, reflecting the large size of the sample firms and their significant size differences. Debt capacity (lev) has a mean value of 0.423, i.e., an average debt ratio of 42.3%, showing significant differences in debt ratios among firms. Shareholding concentration (Shrcr1) has a mean of 33.334% and a maximum value of 74.180%, reflecting a high degree of heterogeneity in the shareholder structure among firms. Cash flow level (flowcash) is negative overall (mean -0.201), indicating that firms in the sample generally face cash flow constraints. Profitability (ROE) has an average return on equity of 4.9%, but there is a high degree of volatility. For growth (growth), the average annual growth rate is about 35.8%, however, due to the large standard deviation of the data, it suggests that the rate of growth varies greatly among firms. These results provide an important reference for the study of enterprise performance assessment and influencing factors.

Table 3: Descriptive statistics

VarName	Obs	Mean	SD	Min	Median	Max
TobinQ	22707	2.007	1.343	0.834	1.583	8.952
CDL	22707	1.370	1.564	0.000	1.000	6.000
lnRd	22707	3.849	0.275	2.777	3.864	4.470
size	22707	22.383	1.478	19.867	22.131	27.511
lev	22707	0.423	0.213	0.059	0.409	0.937
Shrcr1	22707	33.334	14.710	8.259	30.929	74.180
flowcash	22707	-0.201	1.477	-7.122	0.000	4.045
ROE	22707	0.049	0.179	-1.152	0.072	0.353
growth	22707	0.358	0.910	-0.775	0.135	6.278

4.2 Correlation analysis

As shown in Table 4, the correlation coefficient of the explanatory variable (CDL) on the explained variable (TobinQ) is positive and significant, and the correlation coefficient with the mediator variable (SA) is positive and significant, there is a significant correlation coefficient of the control variable on the explanatory variable, and also there is a significant correlation coefficient between the control and explanatory variables, which indicates that there may be a possible multicollinearity between the variables.

Table 4: Correlation analysis

	TobinQ	CDL	SA	size	lev	Shrcr1	flowcash	ROE	growth
TobinQ	**1**								
CDL	0.033***	1							
SA	-0.022***	0.089***	1						
size	-0.374***	0.151***	-0.198***	1					
lev	-0.238***	0.040***	-0.055***	0.547***	1				
Shrcr1	-0.112***	0.036***	-0.080***	0.150***	0.005	1			
flow cash	0.056***	-0.000	0.133***	0.046***	0.002	0.049***	1		
ROE	0.034***	0.036***	-0.066***	0.088***	-0.214***	0.140***	0.028***	1	
growth	0.009	-0.059***	0.019***	-0.013**	0.049***	-0.003	-0.026***	0.013**	1

Pearson's correlation coefficients, *** p<0.01, ** p<0.05, * p<0.1

4.3 Multicollinearity test

Before the empirical analysis, in order to avoid the problem of multicollinearity between variables, as shown in Table 5, this paper relies on the variance inflation factor (VIF) to make a judgment, in general, when the variance inflation factor (VIF) of the variables is greater than 10, it means that there is the problem of multicollinearity between variables. In this paper, the variance inflation factor (VIF) of the test is less than 5, which indicates that there is no problem of covariance among the variables.

Table 5: Multicollinearity test

Variable	VIF	1/VIF
lev	4.110	0.244
Shrcr1	3.930	0.254
CDL	2.180	0.459
growth	1.180	0.849
ROE	1.170	0.853
size	1.160	0.862
flowcash	1.040	0.965
Mean VIF	2.110	

In addition, as shown in Table 6, the Hausman test was conducted on the model, and the test results rejected the original hypothesis of using an individual random effects regression model, so the analysis in this chapter was conducted using an individual and time fixed effects model.

Table 6: Hausman test

Original hypothesis	$\chi 2$ statistic	Probability value	Whether the original hypothesis is accepted or not
H0: Individual random effects regression model should be used	789.05	0.000	Reject

4.4 Regression analysis

As shown in Table 7, the regression results of enterprise valuation through the level of carbon disclosure are shown in the table, the first model does not add control variables, the model results show that the regression coefficient of carbon disclosure level on enterprise valuation is 0.049 and significant, indicating that the level of carbon disclosure has an uplifting effect on the valuation of the enterprise, and the regression coefficient after adding control variables is 0.086 and significant, further indicating that the carbon disclosure level has an uplifting effect on the valuation of the enterprise. The regression coefficient is 0.086 and significant after adding control variables, which further indicates that the carbon information disclosure level has an enhancing effect on enterprise valuation.

Table 7: Regression analysis table

	(1)	(2)
	TobinQ	TobinQ
CDL	0.049***	0.086***
	(0.004)	(0.005)
size		-0.483***
		(0.021)
lev		0.142*
		(0.081)
Shrcr1		-0.012***
		(0.001)
flowcash		0.026***
		(0.005)
ROE		0.380***
		(0.041)
growth		-0.019**
		(0.008)
_cons	1.939***	2.207***
	(0.008)	(0.062)
N	22707	22707
F	35.193	122.146
r2_a	0.149	0.204

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

4.5 Mediating effects

4.5.1 Intermediation test method

In order to further clarify the transmission mechanism of the impact of carbon disclosure level on enterprise valuation, this paper analyzes the significant mediation effect between enterprise R&D investment and the impact of carbon disclosure level on enterprise valuation through the mediation test method. The mediation effect refers to the fact that the explanatory variables and the explained

variables are not causally affected directly, but indirectly affected through one or more mediating variables (Mediation). The specific test steps of mediation effect are as follows:
The first step is to verify the effect of carbon disclosure level on corporate valuation.

$$TobinQ_{i,t} = \alpha + \beta_1 CDL_{i,t} + \beta_2 size_{i,t} + \beta_3 lev_{i,t} + \beta_4 Shrcr1_{i,t} + \beta_5 flowcash_{i,t} + \beta_6 ROE_{i,t} + \beta_7 growth_{i,t} + \varepsilon \quad (4)$$

The second step is to verify the effect of carbon disclosure level on the mediating variable financing constraints, i.e., the explanatory variable is changed from to the mediating variable.

$$SA_{i,t} = \alpha + \beta_1 CDL_{i,t} + \beta_2 size_{i,t} + \beta_3 lev_{i,t} + \beta_4 Shrcr1_{i,t} + \beta_5 flowcash_{i,t} + \beta_6 ROE_{i,t} + \beta_7 growth_{i,t} + \varepsilon \quad (5)$$

In the third step, the level of carbon disclosure and the mediating variable financing constraints are taken as explanatory variables, i.e., the explanatory variables are re-changed from $\mathrm{TobinQ_{it}}$.

$$TobinQ_{i,t} = \alpha + \beta_1 CDL_{i,t} + \beta_2 size_{i,t} + SA_{i,t} + \beta_3 lev_{i,t} + \beta_4 Shrcr1_{i,t} + \beta_5 flowcash_{i,t} + \beta_6 ROE_{i,t} + \beta_7 growth_{i,t} + \varepsilon \quad (6)$$

According to the above formula, whether the mediating variable has a mediating effect is judged based on the following:

1) First, the significance of the test, the first premise of the stepwise test method of the mediating effect is significant, if it is not significant, then the mediating effect can not be said.
2) Secondly, look at the significance of and. If and are significant, the mediating variable has a mediating effect, and at the same time, if it is not significant or the estimated value is significantly less than, the mediating variable has a strong mediating effect.
3) If β2 or one of them is not significant or neither of them is significant, Sobel test is needed to determine whether the mediating variable has mediating effect.

4.5.2 Mediation test

This paper specifically selected the financing constraints for the mediation effect test.
As shown in Table 8, the first column is the first step of the mediation test of the explanatory variables (CDL) on the explanatory variables (TobinQ) regression coefficient is positive and significant, the first step of the validation passed. The second column shows that the regression coefficient of the explanatory variable (CDL) on the mediator variable (SA) is positive and significant, which indicates that the level of carbon disclosure has a positive effect on corporate finance

constraints, and the validation of the second step of the mediation test is passed. The third column is that the regression coefficients of both explanatory variables and mediating variables on the explained variables are positive and significant, indicating the existence of partial mediation. The effect of carbon disclosure level on enterprise valuation is partly direct and partly through affecting enterprise financing constraints and thus affecting enterprise valuation.

Table 8: Intermediation test

	(1)	(2)	(3)
	TobinQ	SA	TobinQ
CDL	0.086***	-0.026***	0.137***
	(0.005)	(0.000)	(0.005)
SA			-1.963***
			(0.105)
size	-0.483***	0.054***	-0.378***
	(0.021)	(0.002)	(0.022)
lev	0.142*	0.062***	0.263***
	(0.081)	(0.006)	(0.081)
Shrcr1	-0.012***	-0.003***	-0.017***
	(0.001)	(0.000)	(0.001)
flowcash	0.026***	0.005***	0.036***
	(0.005)	(0.000)	(0.005)
ROE	0.380***	-0.021***	0.340***
	(0.041)	(0.003)	(0.040)
growth	-0.019**	-0.002***	-0.022***
	(0.008)	(0.001)	(0.008)
_cons	2.207***	3.875***	9.815***
	(0.062)	(0.004)	(0.410)
N	22707	22707	22707
F	122.146	2320.805	153.069
r2_a	-0.204	0.340	-0.181

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

4.6 Heterogeneity Analysis

4.6.1 Analysis of enterprise ownership heterogeneity

Chinese enterprises are categorized into SOEs and non-SOEs according to the nature of the enterprise, as shown in Table 9, through the heterogeneity analysis, the regression coefficient of carbon disclosure level on enterprise valuation in SOEs is 0.038 and significant, while the regression coefficient of carbon disclosure level on enterprise valuation in non-SOEs is 0.121 and significant. It indicates that both SOEs and non-SOEs carbon disclosure level has a promoting effect on enterprise valuation, while the coefficient of non-SOEs is significantly larger than that of SOEs, indicating that the carbon disclosure level of non-SOEs has a greater promoting effect on enterprise valuation of non-SOEs.

Table 9: Analysis of enterprise ownership heterogeneity

	SOEs	non-SOEs
	TobinQ	**TobinQ**
CDL	0.038***	0.121***
	(0.006)	(0.006)
size	-0.603***	-0.447***
	(0.032)	(0.028)
lev	0.505***	-0.070
	(0.131)	(0.103)
Shrcr1	-0.005***	-0.013***
	(0.002)	(0.002)
flowcash	0.018***	0.028***
	(0.007)	(0.006)
ROE	0.263***	0.420***
	(0.065)	(0.052)
growth	-0.022**	-0.011
	(0.010)	(0.012)
_cons	2.056***	2.245***
	(0.096)	(0.081)
N	7291	15416
F	60.126	89.504
r2_a	-0.156	-0.232

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

4.6.2 Qualitative analysis of enterprise industries

Chinese enterprises are categorized into manufacturing and non-manufacturing industries according to the enterprise industry, as shown in Table 10, through the heterogeneity analysis, the regression coefficient of carbon disclosure level on enterprise valuation in manufacturing enterprises is 0.107 and significant, while the regression coefficient of carbon disclosure level on enterprise valuation in non-manufacturing industries is 0.048 and significant. It indicates that both manufacturing and non-manufacturing carbon disclosure level has a promotion effect on enterprise valuation, and the coefficient of manufacturing enterprises is significantly larger than that of non-manufacturing enterprises, indicating that the carbon disclosure level of manufacturing enterprises has a greater promotion effect on the valuation of non-manufacturing enterprises.

Table 10: Analysis of industry heterogeneity

	Manufacturing	**Non-manufacturing**
	TobinQ	TobinQ
CDL	0.107***	0.048***
	(0.007)	(0.006)
size	-0.399***	-0.610***
	(0.030)	(0.027)
lev	0.113	0.096
	(0.113)	(0.108)
Shrcr1	-0.012***	-0.007***
	(0.002)	(0.002)
flowcash	0.038***	0.015***
	(0.007)	(0.006)
ROE	0.551***	0.149***
	(0.060)	(0.050)
growth	-0.015	-0.020**
	(0.014)	(0.009)
_cons	2.174***	2.282***
	(0.085)	(0.084)
N	14328	8379
F	73.527	85.018
r2_a	-0.216	-0.142

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

4.7 Heterogeneity Analysis

This robustness test, replacing the explanatory variable (PE) price-earnings ratio as a replacement variable for firm valuation, the regression results are consistent with the results of the main regression, indicating that the model is robust. The regression results are shown in Tables 11.

Table 11: Robustness test

	(1)	(2)	(3)
	PE	**SA**	**PE**
CDL	2.077***	-0.026***	6.570***
	(0.535)	(0.000)	(0.606)
SA			-11.680***
			(1.785)
size	-36.219***	0.054***	-25.358***
	(2.447)	(0.002)	(2.529)
lev	96.775***	0.062***	107.887***
	(9.805)	(0.006)	(9.758)
Shrcr1	-0.106	-0.003***	-0.592***
	(0.167)	(0.000)	(0.169)
flowcash	0.680	0.005***	1.633***
	(0.511)	(0.000)	(0.511)
ROE	-692.542***	-0.021***	-701.141***
	(14.521)	(0.003)	(14.421)
growth	-0.060	-0.002***	-0.573
	(0.997)	(0.001)	(0.990)
_cons	95.397***	3.875***	800.050***
	(7.136)	(0.004)	(46.254)
N	22707	22707	22707
F	366.623	320.805	355.423
r2_a	0.315	0.240	0.288

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

5. Conclusions and Recommendations

5.1 Mechanisms and coping strategies of carbon disclosure level (CDL) on corporate valuation

Research shows that every 1-unit increase in corporate carbon disclosure level (CDL) can boost valuation growth by 8.6%, with the valuation elasticity of non-state-owned manufacturing enterprises being particularly significant (the effect of non-state-owned enterprises is 3.18 times that of state-owned enterprises, and that of manufacturing industries is 2.23 times that of non-manufacturing industries). Based on this, investors should prioritize screening CDL $\geq$ 5 points and quantitative disclosure of green technology patents of non-state-owned manufacturing industry subjects (such as new energy, high-end equipment), while the disclosure of insufficient state-owned enterprises or non-manufacturing enterprises to implement

position restrictions. Enterprises need to be differentiated: non-SOEs and manufacturing enterprises should add a "carbon neutral progress" quantitative column in the annual report, disclosure of carbon intensity per unit of product, the proportion of green power use and other core indicators, and regularly release the third-party verification of the emission reduction roadmap; SOEs and non-manufacturing enterprises can achieve CDL leap through the merger and acquisition of low-carbon technology enterprises. The government should be driven by both mandatory policies and incentives, for example, mandating listed manufacturing companies to disclose Scope 3 emissions data, and granting 10% income tax exemption to non-SOEs with annual CDL improvement of ≥2 points, forming a positive cycle of "disclosure quality improvement - valuation growth".

5.2 Practical Application Path of Mediating Effect of Financing Constraints

Carbon disclosure reduces the cost of capital of enterprises by alleviating financing constraints, and this mechanism provides clear operational guidelines for stakeholders. Investors need to dynamically adjust the discount rate in the valuation model, e.g., every 1-unit decrease in the corporate SA index corresponds to a 0.3-percentage-point reduction in the discount rate, and pay attention to the financing signals such as the issuance of green bonds after carbon disclosure to implement an event-driven strategy. Enterprises can realize carbon data through innovative financial tools, such as issuing bonds with interest rates linked to CDL (the interest rate will be reduced by 0.5% if the CDL reaches 7 points), and visualizing the correlation curve between carbon data and financing costs on the official website. The government level should establish a green financing incentive mechanism, open an IPO fast track for enterprises with SA index ≤ 2 and CDL ≥ 6, and incorporate the CDL score into the central bank's credit system, so that A-ranked enterprises can obtain loan preferences of 20% below the benchmark interest rate, thus lowering the capital barriers to green transformation.

5.3 Moderating role of marketization and regulatory pressure on carbon disclosure effect

The valuation enhancement effect of carbon disclosure is significantly enhanced in subjects with a high degree of marketization and regulatory pressure, which requires market participants to accurately identify policy and market resonance areas. Investors need to overweight "high marketization plus high regulation" industry combination (such as new energy vehicles, photovoltaic), and real-time monitoring of environmental protection inspection results on the impact of the stock price of manufacturing companies (such as carbon emissions data falsification shorting opportunities). Manufacturing companies should take the initiative to participate in the carbon trading market and regularly disclose quota profit and loss data to obtain a compliance premium, while non-manufacturing companies can realize the

valuation transmission on the consumer side through carbon labeling products. The government needs to implement a tiered regulatory policy, implementing A (≤1 ton/million yuan) and B (≤3 tons) graded management of carbon intensity in the manufacturing industry, and granting free emissions quotas to A-level enterprises; meanwhile, for the industries covered by the EU's CBAM, it is mandatory for exporters to disclose their full life cycle carbon footprints, and those who fail to comply are subject to an additional 30% tariff reserve, thus forcing high-quality disclosure.

5.4 Risk control and synergistic mechanism construction under the support of robustness conclusion

The study confirms the reliability of the conclusion (PE and Tobin's Q change in the same direction) through variable substitution and model testing, which provides the basis for the construction of a multi-dimensional verification system. Investors need to cross-check the sensitivity of PE and Q to CDL, warn of the risk of "greenwash" for companies with divergent indicators (e.g., Q increases but PE decreases), and capture pricing deviation gains through CDL-PE arbitrage strategies. Enterprises should ensure that carbon data is consistent with financial data, for example, by accurately allocating emission reduction inputs to R&D expenses to avoid regulatory inquiries due to conflicting data. The government should strengthen the audit synergy mechanism, requiring accounting firms to issue special certificates on the consistency of carbon and financial data, and fining non-compliant companies 1% of annual revenue; at the same time, it should open up the environmental protection and carbon platforms and the Securities and Futures Commission (SFC) disclosure system to realize that changes in carbon data will automatically trigger the updating of the financial report, and build a full-chain regulatory ecosystem that covers disclosure, validation, and application.

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The authors declare that they have no conflicts of interest.

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