



Climate Policy Uncertainty and the Quality of Carbon Information Disclosure: Evidence from Chinese A-Share Listed Corporations

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Abstract. In response to the escalating challenges of climate change, the Chinese government has been actively developing climate policies, which face uncertainties related to climate change itself and varying levels of implementation. Carbon disclosure, a crucial mechanism for enterprises to showcase their environmental responsibility to stakeholders, is integral to their green and low-carbon development strategies. This study establishes a carbon disclosure quality evaluation index and employs a fixed-effects model to examine the relationship between climate policy uncertainty (CCPU) and corporate carbon disclosure quality (CDI). The analysis uses data from A-share listed companies on the Shanghai and Shenzhen stock exchanges from 2010 to 2022. The results indicate that (1) CCPU has a positive impact on CDI; (2) CCPU enhances CDI by promoting corporate research and development (R&D) investments; (3) Government subsidies positively influence the relationship between CCPU and CDI.

Keywords: Climate policy uncertainty, Carbon disclosure quality, Government Subsidies, R&D investment

1 Introduction

Climate change presents significant challenges to human survival by causing extreme weather events, altering rainfall patterns, and exacerbating both droughts and floods^[1]. According to the International Energy Agency (IEA), global carbon dioxide (CO₂) emissions were approximately 3.43 billion tons in 2020, significantly lower than the 9.147 billion tons recorded in 1960. However, global temperatures continue to rise, with the average temperature increasing by approximately 1°C over the past century^[2]. The Sixth Assessment Report of the IPCC highlights the urgent need to limit global warming to no more than 1.5°C above pre-industrial levels. As one of the world's largest carbon emitters, China has committed to reaching peak carbon emissions by 2030 and achieving carbon neutrality by 2060. Additionally, the State Council introduced the '14th Five-Year Plan' in 2021 to promote energy conservation, emission reductions, and a green transformation. As significant carbon emitters, companies are urged by stakeholders to balance economic and environmental objectives and manage risks through

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the disclosure of carbon emissions and other greenhouse gases. The increasing uncertainty surrounding climate policies not only affects corporate financial costs and risk behavior but also compels the market to focus on corporate environmental strategies. This paper aims to explore the impact of climate policy uncertainty on the quality of corporate carbon disclosure and its associated factors, while also constructing carbon disclosure evaluation indices through textual analysis to examine the relationship between these variables.

2 Research Hypothesis

2.1 The Relationship Between Climate Policy Uncertainty and the Quality of Carbon Disclosure

China has developed a series of climate mitigation and adaptation policies to address the adverse effects of climate change^[3]; however, climate policy uncertainty persists due to the complexities of climate change and the necessity for the government to balance economic growth with carbon reduction efforts^[4]. Transparent and comprehensive carbon disclosure can signal to investors, regulators, and other stakeholders the company's commitment to environmental responsibility, its capacity to mitigate climate change, and its progress in low-carbon transformation. In the context of climate policy uncertainty, enterprises that invest in enhancing their carbon reduction performance and improving the quality of carbon disclosure can gain a distinct competitive advantage. Furthermore, corporate executives with varying levels of environmental awareness and concern for sustainability will proactively adapt their business and strategic models, opting to disclose environmental information amid uncertainty^[5]. Consequently, Hypothesis 1 is proposed: Climate policy uncertainty is positively related to the quality of carbon disclosure.

2.2 Mechanism of Action of CCPU on CDI

R&D Investment. According to Schumpeter's innovation theory, continuous innovation is essential for firms to establish a competitive advantage and generate revenue^[6]. Policy uncertainty creates both risks and opportunities, so seizing development opportunities amidst uncertainty guides firms to invest more in R&D, realize excess profits through technological innovation^[7], and enhance their competitiveness. As transparency and reporting requirements for carbon emissions increase, companies are subject to greater regulatory pressure. By increasing investment in research and development (R&D), companies can better comply with regulatory requirements and align with market demands for carbon disclosure. Therefore, in the context of climate policy uncertainty, firms may increase their investment in R&D to develop new technologies or improve existing ones. In the long term, increased investment in R&D can yield sustained environmental benefits and enhance social responsibility, aligning not only with increasingly stringent global environmental regulations but also assisting companies in

adapting to the evolving demands of a future low-carbon economy. We propose Hypothesis 2: Climate policy uncertainty promotes the quality of corporate carbon disclosure through increased R&D investment by firms.

2.3 Moderating Effects between CCPU and CDI

Government Subsidies. Government subsidies are a crucial mechanism for addressing market failures^[8]. As climate policy uncertainty increases, government environmental protection subsidies can help mitigate the risks and uncertainties that companies face in carbon disclosure. These subsidies serve two primary functions: providing resource compensation and signaling. Specifically, they alleviate the high costs associated with carbon disclosure and enable subsidized companies to convey stronger signals to external stakeholders regarding their value^[9]. Additionally, subsidies help reduce information asymmetry between companies, their external responsibilities, and investors, thereby further lowering risks and policy uncertainty^[10]. Thus, we propose the following hypothesis 3: Government subsidies can positively regulate the relationship between the two.

3 Empirical Model and Methodology

3.1 Fixed Effects Model

We construct the following a fixed-effects model to test the impact of CCPU on firms' CDI:

$$CDI_{i,t} = \alpha_0 + \alpha_1 \ln CCPU_{i,t} + \sum control_{i,t} + Industry_i + Year_t + \varepsilon_{i,t} \quad (1)$$

3.2 Mediating Effect Model

We examine whether CCPU influences firms' CDI through their R&D investment (H2). We construct the following mediation effect model:

$$Med_{i,t} = \beta_0 + \beta_1 \ln CCPU_{i,t} + \sum control_{i,t} + Industry_i + Year_t + \varepsilon_{i,t}$$

$$CDI_{i,t} = \gamma_0 + \gamma_1 \ln CCPU_{i,t} + \gamma_2 Med_{i,t} + \sum control_{i,t} + Industry_i + Year_t + \varepsilon_{i,t} \quad (2)$$

3.3 Moderating Effect Model

We use the interaction term of $CCPU \times Mod_{i,t}$ to judge the moderating effects of the moderating variables.

$$CDI_{i,t} = \omega_0 + \omega_1 \ln CCPU_{i,t} + \omega_2 \ln CCPU * Mod_{i,t} + \omega_3 Mod_{i,t} + \sum control_{i,t} + Industry_i + Year_t + \varepsilon_{i,t} \quad (3)$$

4 Variable Definitions and Data Sources

This study focuses on A-share listed companies in Shanghai and Shenzhen from 2010 to 2022. Financial data on the listed companies were obtained from the Cathay Pacific (CSMAR) database. The final sample comprises 9,192 company-year observations after excluding companies that were designated with special treatment (e.g., ST, *ST), as well as delisted companies, financial and insurance firms, companies with unstable operations, and those with missing data during the observation period.

4.1 Independent Variable

China Climate Policy Uncertainty Index: Following^[11]Lee and Cho (2023), who extracted China's climate policy-related data from Twitter using text mining techniques, we utilize the monthly CCPU index as a benchmark. We calculate the annual CCPU by taking the arithmetic mean of the monthly indices. Finally, we compute the logarithm of the CCPU index, denoted as lnCCPU.

4.2 Dependent Variable

Carbon Disclosure Quality: This study adopts the methodology of^[12]Li Li et al.(2019) . Building on previous studies, we initially evaluated the reports based on the carbon disclosure content in CSR reports and company annual reports (see Table 1), focusing on five dimensions and subdividing them into 15 secondary indicators. An innovative carbon disclosure quality evaluation index system was developed based on the scoring results. This enables the exploration of the relationship between climate policy uncertainty and corporate carbon disclosure quality.

Table 1. Carbon Disclosure Quality Assessment System

First-level variables	Second-level variables	Description of indicators
Low-carbon strategy	Emission reduction strategies	1 mark for strategy description involving carbon reduction elements, otherwise 0 marks.
	Emission reduction targets	1 mark for setting a target to reduce carbon emissions, otherwise 0.
	Emission reduction risks	1 mark for describing the risks that could result, otherwise 0 marks.
	Emission reduction concepts	1 mark for low carbon promotion to (staff, customers), 1 mark for training (staff, customers) in low carbon knowledge, 2 marks for both.

Low-carbon management	Emission Reduction Agency	1 point for the establishment of a specialised administration, otherwise 0 points;
	Emission reduction system	1 point for establishing a management system related to emission reduction, 1 point for describing emission reduction measures, and 0 point for neither;
	Emission reduction incentives	Whether the designated emission reduction target is assessed and incentivised when the target is reached; 1 point for qualitative description, 2 points for quantitative description, otherwise 0 points.
Low-carbon inputs and performance	Emission reduction inputs	1 mark for qualitative description, 2 marks for combination of qualitative and quantitative, otherwise 0 marks.
	Emission reduction performance	Savings achieved to date as a result of the abatement programme; 1 mark for qualitative description, 2 marks for quantitative description, otherwise 0.
	Emission reduction recognition	1 mark for carbon reduction recognised by government, otherwise 0 mark;
Carbon emissions accounting	Carbon emission accounting methodologies	1 mark for a simple qualitative description, 2 marks for a detailed qualitative description, 3 marks for a combination of quantitative and qualitative, otherwise 0 marks;
	Carbon emission trading	Participation in carbon emissions trading (trading volume, income, etc.), 1 point for involvement in carbon emissions trading, otherwise 0 points;
Text quality of disclosures	Timeliness	Need to check whether the carbon information disclosure (social responsibility report) is issued at a reasonable time. If the time of disclosure is after or in line with the annual report disclosure, assign a value of 1 point; if it is before the annual report disclosure, it is necessary to check the description in the carbon information collection process system, and there is no system, assign a value of 0 points.
	Reliability	If there is no carbon information collection process system, 0 points will be assigned; if there is a description of the relevant GHG device or an introduction of the calculation method, 1 point will be assigned; if there is a detailed and complete introduction of the process system, 2 points will be assigned.
	Comprehensibility	Availability of carbon disclosure images, text and terminology, with a value of 0 points if none, 1 point if one of the three, 2 points if text and data, and 3 points if all three.

4.3 Controlled Variables

We select the following firm-level control variables, which are presented in Table 2.

Table 2. Variable definitions

Variables Type	Variables	Full Name	Variable Explanation
Dependent Variable	CDI	Carbon disclosure quality	Score of firms making carbon disclosures
Independent Variable	lnCCPU	Climate policy uncertainty index	Logarithm of the annual climate policy uncertainty index
Controlled variables	Size	Enterprise size	Natural logarithm of firms' total assets
	Lev	Enterprise leverage	Total liabilities/total assets
	ROA	Enterprise profitability	Net profit/total assets
	ATO	Total asset turnover rate	Operating income/average total assets
	Growth	The growth rate of net assets	(Current year's operating income/previous year's operating income)-1
	TobinQ	Enterprise investment opportunity	(Market value of stock + total liabilities)/total assets
	INV	Inventory as a percentage	Net Inventory/Total Assets
	REC	Accounts receivable as a percentage	Net accounts receivable/total assets
	Board	Number of Board members	The number of board of directors takes the natural logarithm

4.4 Statistical Characteristics of the Data

Table 3 presents the descriptive statistics for each variable. The mean carbon disclosure quality (CDI) is 3.076, with a maximum of 12 and a minimum of 0. The substantial difference between the maximum and minimum values, combined with the low mean, suggests significant variation in the quality of carbon disclosure among listed companies in China, with the overall disclosure level skewed toward a lower range. The mean and standard deviation of CCPU are 4.418 and 1.164, respectively, with significant variation between the maximum and minimum values, indicating considerable fluctuation in CCPU over the sample period.

Table 3. Descriptive statistics

Variables Type	Variables	Obs.	Mean	Std.Dev.	Min	Max
Dependent Variable	CDI	9,192	3.076	2.537	0	12
Independent Variable	lnCCPU	9,192	4.418	1.164	2.123	5.906
Controlled variables	Size	9,192	23.15	1.407	20.45	26.93
	Lev	9,192	0.474	0.197	0.0643	0.887

ROA	9,192	0.0466	0.0597	-0.162	0.250
ATO	9,192	0.662	0.457	0.0828	2.632
Growth	9,192	0.152	0.318	-0.493	1.698
TobinQ	9,192	1.839	1.222	0.805	7.974
INV	9,192	0.154	0.149	0.000224	0.708
REC	9,192	0.0973	0.0931	0.000186	0.434
Board	9,192	2.171	0.203	1.609	2.708

5 Empirical Results

5.1 Correlation Analysis

A VIF value greater than 5 indicates a potential issue with multicollinearity. As shown in Table 4, the VIF values for all variables range from 1.06 to 2.12, and most correlation coefficients are below 0.6, suggesting that multicollinearity among the variables is not a significant concern.

Table 4. VIF

Variable	VIF	1/VIF
lnCCPU	1.060	0.944
Size	1.750	0.571
Lev	2.120	0.471
ROA	1.610	0.620
TobinQ	1.360	0.735
INV	1.160	0.860
ATO	1.140	0.880
Growth	1.130	0.883
REC	1.130	0.888
Board	1.080	0.930

5.2 Baseline Regression

This paper first analyzes the relationship between lnCCPU and CDI, and Table 5 reports the regression results of climate policy uncertainty on the quality of carbon disclosure. Column (1) includes only the key independent variable lnCCPU without control variables, and the results indicate that the coefficient for lnCCPU is significantly positive. Column (2) includes all control variables, and the model's explanatory power remains significant. Additionally, columns (3) and (4) control for year and industry, with the coefficients for lnCCPU remaining significantly positive at the 1% level. The empirical results support the validity of Hypothesis 1.

Table 5. Effect of CCPU on CDI

	(1)	(2)	(3)	(4)
	OLS	OLS	FE	FE
lnCCPU	0.530*** (24.050)	0.468*** (21.679)	2.164*** (16.807)	1.766*** (12.646)
Controls	NO	YES	NO	YES
Constant	0.735*** (7.295)	11.048*** (-20.213)	8.070*** (-10.194)	-19.271*** (-18.340)
Year/Industry FE	NO	NO	YES	YES
N	9192	9192	9192	9192
R ²	0.059	0.150	0.195	0.271

Note: Robustness standard errors are in parentheses; * * *, * *, * indicate that the test passes at the 1 per cent, 5 per cent and 10 per cent significance levels, respectively.

5.3 Robustness Tests

Changing the independent variable measures. We replaced the independent variable of the original model with the US Climate Uncertainty Index (CPU) created by Gavriilidis (2021)^[13]. The regression coefficients in column (1) of Table 6 are significantly positive, indicating the robustness of the benchmark regression results.

Changing the dependent variable measures. We ran a Logit regression model where the dependent variable was redefined as a dummy variable equal to one if a firm's CDI is above the industry median and zero otherwise^[14]. As shown in Column (2) in Table 6, our previous main results remain unchanged, confirming that our main findings are robust to alternative measures of carbon disclosure.

Change sample time. To mitigate the impact of COVID-19, we re-estimated the empirical analysis excluding data from 2020. Column (3) in Table 6 demonstrates that the relationship between CCPU and CDI remains significantly positive at the 1 percent level, and the results are highly consistent with the benchmark regression results.

Reverse Causality. To address possible endogeneity between the independent and dependent variables, we applied the two-stage least squares (2SLS) method using two linear regressions. As an exogenous factor in corporate carbon disclosure, we used the average temperature of each prefecture-level city in the current year as an instrumental variable for climate policy uncertainty to address endogeneity concerns^[15]. The regression coefficients of the instrumental variables in Column (4) of Table 6 are significant at the 1% level, and the Wald test F-statistic exceeds 10, indicating no weak instrumental variable and confirming its validity. Finally, the regression results show that the directionality and significance of lnCCPU are consistent with the benchmark regression, further indicating minimal endogenous bias.

Table 6. Robustness test

	(1)	(2)	(3)	(4)
Incpu	2.226*** (12.646)			
lnCCPU		0.822*** (5.235)	1.754*** (12.487)	4.483* (2.536)
Controls	YES	YES	YES	YES
Constant	-21.511*** (-18.640)	-12.403*** (-12.424)	-19.590*** (-18.285)	33.337*** (12.894)
F—Test				73.01
IV				First-step results 0.002*** (0.000)
Year/Industry FE	YES	YES	YES	YES
N	9192	9192	8390	8,498
R ²	0.271		0.274	0.253
Pseudo R2		0.112		

5.4 Mediating Effects

Firms' R&D Investment. We measure this variable by taking the natural logarithm of the firm's annual R&D investment amount. In column (1), the regression coefficient of lnCCPU on R&D is 1.373 and is significant at the 1% level, suggesting that when firms experience a rise in CCPU, their R&D investment increases. Column (2) reports the regression results with CDI as the dependent variable. The regression coefficients for lnCCPU and lnRD are both significantly positive, and the confidence intervals obtained from the Bootstrap test do not include zero and are positive, indicating that the Bootstrap test confirms the mediating effect. Indicates that hypothesis 4 was tested.

Table 7. Mediating effects of firms' R&D investment

	(1) R&D	(2) CDI
lnCCPU	1.373*** (18.810)	1.575*** (7.999)
lnRD		0.109***
Table 7 Mediating effects of firms' R&D investment(continued)		
	(1) R&D	(2) CDI
Control	YES	YES
Constant	-9.386*** (-17.613)	-19.301*** (-14.329)
Bootstrap test confidence interval	—	(0.0983, 0.2185)
Year/Industry FE	YES	YES
N	7634	7634
R ²	0.630	0.288

5.5 Moderating Effects

Government subsidies. Columns (1) and (2) of Table 8 report significantly positive regression coefficients for the interaction term between LnCCPU and Subsidies. In Column (2), with the inclusion of year and industry fixed effects, the interaction term between CCPU and government subsidies remains significantly positive for the CDI, thereby further confirming the positive moderating effect of government subsidies.

Table 8. Moderating effect of government subsidies

	(1) CDI	(2) CDI
lnCCPU	0.470*** (21.818)	1.735*** (12.425)
LnCCPU*Subsidies	0.000*** (2.818)	0.000*** (3.412)
Subsidies	-0.000 (-1.532)	-0.000* (-1.887)
Controls	YES	YES
Constant	-9.992*** (-17.014)	-18.229*** (-16.928)
Year/Industry FE	NO	YES
N	9192	9192
R ²	0.153	0.274

5.6 Heterogeneity Analysis

Risk Taking We use the volatility of ROA from year t-1 to t+1 to examine differences in this relationship across varying levels of risk-taking (Huang et al., 2022). The results of the heterogeneity analysis for firms with different risk-taking levels are presented in Table 9 models (1) (2) indicate that the coefficient of CCPU's impact is significantly positive at the 1 percent level for high-risk firms, whereas for low-risk firms, the coefficient is significantly negative at the same level. High-risk firms, facing greater uncertainty, usually emphasize risk management and transparency to address potential volatility. Consequently, these firms are more likely to provide detailed and comprehensive carbon information to aid investors and stakeholders in assessing risks.

Industry type We categorize the firms in the sample into carbon-intensive and non-carbon-intensive categories^[16]. Column (4) of Table 9 demonstrates that the effect of CCPU on CDI for non-carbon-intensive firms is not statistically significant, whereas in column (3), the effect of CCPU on CDI for carbon-intensive firms is significantly positive. This result is explicable, as carbon-intensive firms are typically subject to more stringent regulatory and statutory constraints. In light of the risks posed by climate policy uncertainty, these firms may prioritize compliance and reduce legal and reputational risks by disclosing more detailed and accurate carbon emissions data. Moreover, this may also help mitigate the impact of increased demands for transparent and open carbon emissions disclosures from consumers, investors, and regulatory agencies.

The Degree of Industry Competition To measure industry competition, this paper calculates the Herfindahl index based on sales and classifies industries with Herfindahl indices below the median as highly competitive and those above the median as less competitive^[17]. The regression results, following the sample classification, are presented in columns (5) and (6) of Table 9. The coefficient for highly competitive industries is 2.092, indicating a stronger level of significance compared to less competitive industries. This can primarily be attributed to the fact that in highly competitive industries, firms must continuously enhance their competitiveness and adapt to market demand. As climate policy uncertainty increases, firms may be more inclined to disclose carbon emissions to demonstrate their responsibility and transparency in environmental protection and sustainable development, as well as to leverage such disclosures for competitive advantage.

Table 9. Industry type heterogeneity results

	(1)Firms with higher risk taking	(2)Firms with lower risk taking	(3)Carbon- intensive firms	(4)Car- bon-non- intensive firms	(5)High level of competi- tion	(6)Low level of competi- tion
lnCCPU	1.855*** (10.315)	-1.766*** (-5.765)	2.268*** (13.469)	-0.119 (-0.531)	2.092*** (10.261)	1.436*** (7.313)
Controls	YES	YES	YES	YES	YES	YES
Constant	-21.940*** (-16.978)	0.000 (.)	0.000 (.)	-8.644*** (-5.413)	0.000 (.)	- 17.566*** (-12.638)
Year/Indus- try FE	YES	YES	YES	YES	YES	YES
N	6002	2907	6947	2245	4622	4570
R ²	0.299	0.192	0.280	0.214	0.313	0.244

6 Conclusions

This study focuses on A-share listed companies in China from 2010 to 2022 as the subject of the research. We construct a system of indicators to measure the quality of carbon information disclosure and employ a fixed-effect model to explore the impact of CCPU on CDI. R&D investment serves as the mediating factor, while government subsidy functions as the moderating factor. The results indicate that (1) there is a positive relationship between CCPU and CDI; (2) an increase in CCPU leads to a rise in R&D investment, which subsequently promotes CDI; and (3) as government subsidies increase, the effect between CCPU and CDI is strengthened. The heterogeneity analysis reveals that CCPU has a stronger impact on firms with higher risk-taking behavior and carbon intensity. The findings suggest that policymakers should develop a more robust policy framework that takes into account the impact of CCPU on firms and design differentiated policies tailored to various firm types to promote the endogenous motivation for carbon disclosure^[18].

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Answer the Question in the Return

1. Combining Quantitative and Qualitative Data: In addition to traditional quantitative data (e.g., financial metrics, environmental impact assessments), integrating qualitative data will provide a more comprehensive understanding of the phenomenon. This could involve analyzing industry reports, regulatory filings, sustainability reports, and other publicly available datasets to complement numerical data.

Longitudinal and Cross-sectional Data: By using both longitudinal (time-series) and cross-sectional data, researchers can capture trends over time and compare companies across different regions or sectors, enriching the analysis.

2. Incorporating an analysis of the impact of international climate policy uncertainty on Chinese companies with significant global operations would offer deep insights into how such companies are navigating a rapidly changing regulatory environment. This would be important for understanding their risk management strategies, innovation processes, investment decisions, and overall long-term sustainability. It would also help policymakers, businesses, and investors understand the broader economic, strategic, and environmental implications of climate policy uncertainty in a globally interconnected economy.

References

1. Huang, J., Wang, Z., Jiang, Z., & Zhong, Q. (2023). Environmental policy uncertainty and Corporate Green Innovation: Evidence from China. *European Journal of Innovation Management*, 26(6), 1675–1696.
2. Saeed, F., Schleussner, C., & Ashfaq, M. (2021). Deadly heat stress to become commonplace across South Asia already at 1.5°C of global warming. *Geophysical Research Letters*, 48(7).
3. Guo, J., & Yong, Z. T. (2023). Climate Policy Uncertainty and Corporate Green Innovation-Measurement Based on the Text Analysis Method of News Media. *Finance and Economy*.
4. Ren, X., Shi, Y., & Jin, C. (2022). Climate policy uncertainty and corporate investment: Evidence from the Chinese Energy Industry. *Carbon Neutrality*, 1(1).
5. Arbex, M., & Batu, M. (2020). What if people value nature? climate change and welfare costs. *Resource and Energy Economics*, 61, 101176.
6. Shahzad, F., Lu, J., & Fareed, Z. (2019). Does firm Life Cycle Impact Corporate Risk taking and performance? *Journal of Multinational Financial Management*, 51, 23–44.
7. Du, L., Wei, M., Zhang, S., & Pan, J. (2023). Unveiling the policy intervention effects of natural resource regulation on firm-level pollution emissions: Evidence from China's restrained Land Supply. *Resources Policy*, 86, 104081.
8. Choi, J., & Lee, J. (2017). Repairing the R&D market failure: Public R&D subsidy and the composition of private R&D. *Research Policy*, 46(8), 1465–1478.

9. Huang, Z., Liao, G., & Li, Z. (2019). Loaning scale and government subsidy for promoting Green Innovation. *Technological Forecasting and Social Change*, 144, 148–156.
10. Wu, A. (2017). The signal effect of government R&D subsidies in China: Does ownership matter? *Technological Forecasting and Social Change*, 117, 339–345.
11. Lee, K., & Cho, J. (2023). Measuring Chinese climate uncertainty. *International Review of Economics & Finance*, 88, 891–901.
12. Li, L., Liu, Q. Q., & Tang, D. L. (2019). Carbon Performance, Carbon Information Disclosure Quality and Cost of Equity Financing. *Business Review*, 221–235.
13. Bai, D., Du, L., Xu, Y., & Abbas, S. (2023). Climate policy uncertainty and Corporate Green Innovation: Evidence from Chinese A-share listed industrial corporations. *Energy Economics*, 127, 107020.
14. Luo, X., Zhang, R., & Wang, J. (2022). Product market competition and carbon disclosure: Evidence from China. *Carbon Management*, 13(1), 379–400.
15. He, X., Yu, Y., & Jiang, S. (2023). City centrality, population density and energy efficiency. *Energy Economics*, 117, 106436.
16. Huang, T., & Sun, Z. (2023). Climate policy uncertainty and firm investment. *International Journal of Finance & Economics*.
17. Herfindahl, & Orris Clemens, O. C. (1950). Concentration in the steel industry (Doctoral Dissertation). *Columbia University, New York*.
18. Lee, C.-C., & Chang, C.-P. (2007). Energy consumption and GDP revisited: A panel analysis of developed and developing countries. *Energy Economics*, 29(6), 1206–1223.

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