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# DOES CLIMATE RISK EXACERBATE CORPORATE GREENWASHING? EVIDENCE FROM CHINESE LISTED FIRMS AND IMPLICATIONS FOR ENVIRONMENTAL DISCLOSURE REGULATION

## *O RISCO CLIMÁTICO AGRAVA O «GREENWASHING» CORPORATIVO? EVIDÊNCIAS DE EMPRESAS CHINESAS COTADAS EM BOLSA E IMPLICAÇÕES PARA A REGULAMENTAÇÃO DA DIVULGAÇÃO DE INFORMAÇÃO AMBIENTAL*

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**Abstract**
Climate risk has become an increasingly important factor influencing corporate environmental behavior. However, it remains unclear whether climate risk inhibits greenwashing or prompts companies to adopt more symbolic environmental strategies. This paper examines the impact of climate risk on corporate greenwashing behavior using a sample of A-share listed companies in China from 2009 to 2023. A conditionally fixed-effects logit model is employed, and a binary index is used to measure corporate greenwashing behavior. The results show that climate risk significantly increases the likelihood of companies engaging in greenwashing. This conclusion remains robust even after excluding years affected by the COVID-19 pandemic, using lagged climate risk variables, and replacing the dependent variable with a continuous greenwashing index. Heterogeneity analysis further indicates that the impact of climate risk on non-heavily polluting industries is numerically stronger than that on heavily polluting industries. These results

***Resumo***
*O risco climático tornou-se um fator cada vez mais importante na influência do comportamento ambiental das empresas. No entanto, ainda não está claro se o risco climático inibe o greenwashing ou se leva as empresas a adotarem estratégias ambientais mais simbólicas. Este artigo examina o impacto do risco climático no comportamento de greenwashing das empresas, utilizando uma amostra de empresas cotadas no mercado de ações A na China, entre 2009 e 2023. É utilizado um modelo logit de efeitos fixos condicionais, e um índice binário é utilizado para medir o comportamento de greenwashing das empresas. Os resultados mostram que o risco climático aumenta significativamente a probabilidade de as empresas se envolverem em greenwashing. Esta conclusão mantém-se robusta mesmo após excluir os anos afetados pela pandemia da COVID-19, utilizando variáveis de risco climático defasadas e substituindo a variável dependente por um índice contínuo de greenwashing. A análise de heterogeneidade*

suggest that rising climate risk may prompt companies to greenwash rather than make substantial environmental improvements to maintain their environmental legitimacy. This study contributes to the literature on climate risk and greenwashing and provides regulatory insights for environmental information disclosure, verification and accountability mechanisms, anti-greenwashing governance, and climate governance.

**Keywords:** China. Climate Risk. Environmental Regulation. Greenwashing. Symbolic Disclosure.

*indica ainda que o impacto do risco climático nas indústrias não altamente poluentes é numericamente mais forte do que nas indústrias altamente poluentes. Estes resultados sugerem que o aumento do risco climático pode levar as empresas a recorrer ao greenwashing, em vez de realizar melhorias ambientais substanciais para manter a sua legitimidade ambiental. Este estudo contribui para a literatura sobre risco climático e greenwashing e fornece insights regulatórios para a divulgação de informação ambiental, mecanismos de verificação e responsabilização, governação anti-greenwashing e governação climática.*

***Palavras-chave:*** *China. Risco Climático. Regulamentação Ambiental. Greenwashing. Divulgação Simbólica.*

## 1 INTRODUCTION

Against the backdrop of escalating global climate change, frequent extreme weather events, and rising natural disaster risks, Climate risk has become an increasingly important factor shaping corporate environmental behavior. In this paper, climate risk is measured by the frequency of climate-related keywords disclosed in firms' annual reports, which captures firm-level climate risk reflected in annual reports rather than direct meteorological shocks (Chen et al., 2024. Li et al., 2024. Yin et al., 2024). Simultaneously, with the deepening implementation of "dual carbon" targets, the pressure on enterprises to achieve green transformation is increasing daily. However, some enterprises have not translated external pressure into substantial environmental improvements. Instead, they have created a false green image through selective disclosure of environmental information and exaggeration of green achievements, which is a practice known as greenwashing (Lyon & Montgomery, 2015). Greenwashing not only misleads investors and consumers but also distorts the allocation efficiency of green capital, and fundamentally weakens the institutional effectiveness of the green finance system (Zhou et al., 2024).

Existing studies mainly examine the impact of climate risk on ESG performance, green innovation, or corporate environmental behavior, while direct evidence on the relationship between climate risk and corporate greenwashing remains limited. Moreover,

unlike prior studies that often rely on continuous greenwashing measures, this paper uses a binary greenwashing indicator and focuses on whether climate risk increases the likelihood that firms engage in greenwashing behavior.

Unlike studies focusing on ESG performance, this paper examines whether climate risk affects the probability that firms engage in greenwashing behavior. Moreover, different from studies using continuous greenwashing measures, this paper adopts a binary greenwashing indicator to identify whether firms cross the threshold of engaging in greenwashing. Importantly, increased climate risk does not necessarily translate into substantive environmental improvement. When green transformation is costly and time-consuming, firms may instead respond strategically through symbolic environmental disclosure.

Therefore, this paper attempts to answer the following question: Does climate risk inhibit corporate greenwashing, or does it instead increase the likelihood that firms engage in greenwashing as a strategic response? This question not only helps to deepen climate risk research but also helps to understand how different forms of external environmental pressure shape corporate environmental behavior.

This paper uses a sample of Chinese A-share listed companies from 2009 to 2023 and employs a conditionally fixed-effects logit model (clogit) to empirically test the impact of climate risk on the probability of corporate greenwashing behavior and its heterogeneity. Unlike existing studies that often use continuous greenwashing indicators to examine changes in the degree of greenwashing, this paper uses a binary greenwashing indicator to focus on identifying whether climate risk increases the likelihood of companies adopting greenwashing strategies. Therefore, this paper focuses not on the marginal change in the degree of greenwashing, but rather on whether companies will cross the threshold of "engaging in greenwashing behavior" in the context of rising climate risk. The marginal contributions of this paper are mainly reflected in the following three aspects: First, it incorporates climate risk into the analytical framework of corporate greenwashing behavior, expanding the research perspective on greenwashing drivers. second, it reveals the industry differences in how climate risk affects greenwashing behavior, starting from the heterogeneity between heavily polluting and non-heavily polluting industries. and third, it enhances the reliability of the research conclusions

through various robustness tests and provides empirical evidence for environmental disclosure regulation and climate governance policies.

Beyond its managerial implications, corporate greenwashing raises a regulatory and legal concern. Greenwashing weakens the effectiveness of environmental law by allowing firms to create an appearance of compliance without undertaking substantive environmental improvement. In this sense, symbolic environmental disclosure may undermine the objectives of environmental regulation, distort market signals, and reduce the credibility of climate governance. Therefore, climate-related disclosure should not be evaluated only by its volume or frequency, but also by its verifiability, consistency, and accountability.

## 2 LITERATURE REVIEW AND RESEARCH HYPOTHESES

### 2.1 The concept and causes of corporate greenwashing

Corporate greenwashing refers to the practice whereby firms construct a green image without achieving substantive environmental improvements through selective information disclosure, exaggerated environmental claims, or false green statements (Walker & Wan, 2012. de Freitas Netto et al., 2020). Existing studies have examined the drivers of greenwashing from several perspectives. From the perspective of external regulation, stronger environmental regulation may constrain the space for greenwashing, although formal regulation alone may not always identify all forms of symbolic compliance promptly (Zhang, 2023). From the perspective of information asymmetry, when environmental disclosure quality is low and external verification mechanisms are weak, firms have greater room to engage in greenwashing (Xu et al., 2023). Overall, greenwashing often emerges when firms face environmental expectations but lack either the incentive or the capability to undertake substantive environmental improvements.

### 2.2 Legitimacy pressure and symbolic response

Legitimacy pressure provides an important framework for understanding why firms engage in greenwashing. Institutional theory suggests that firms seek to maintain

legitimacy by aligning themselves with prevailing social expectations and institutional norms (Meyer & Rowan, 1977. DiMaggio & Powell, 1983). However, substantive environmental improvement usually requires substantial financial investment, organizational adjustment, and time. Under such conditions, firms may prefer low-cost and rapid symbolic disclosure strategies rather than real environmental transformation (Delmas & Burbano, 2011). Existing studies further show that external supervision, social norms, and disclosure pressure do not necessarily reduce greenwashing directly. Their effect depends on the nature of the pressure and the incentive structure associated with it. When pressure takes the form of strict monitoring and verifiable constraints, firms may reduce greenwashing. By contrast, when firms face stronger external pressure but substantive adjustment remains costly, they may increase symbolic environmental disclosure to preserve legitimacy, thereby intensifying greenwashing (Marquis, Toffel, & Zhou, 2016. Testa, Boiral, & Iraldo, 2018)

From a regulatory perspective, greenwashing is not merely a communication problem, but also a governance problem. When firms rely on symbolic disclosure to respond to environmental expectations, the effectiveness of environmental law may be weakened, because formal disclosure obligations can be satisfied in appearance while substantive environmental objectives remain unmet. This implies that climate-related disclosure requires verification and accountability mechanisms, rather than mere expansion in disclosure volume.

### 2.3 Climate risk and corporate greenwashing

Existing studies have begun to discuss the relationship between climate risk and corporate greenwashing. Liu et al. (2024) find that climate risk significantly restrains corporate greenwashing, mainly by enhancing innovation capacity and strengthening substantive environmental governance. Their results suggest that climate risk may function as a governance-enhancing external shock that encourages firms to adopt more substantive environmental actions. However, this conclusion does not necessarily imply that climate risk will always reduce greenwashing under different empirical settings.

In this paper, climate risk is also measured using a text-based firm-level indicator constructed from annual reports. Therefore, the difference between this study and prior

research does not lie in a simple distinction between "objective physical exposure" and "textual pressure," but more likely in differences in sample period, variable construction, model specification, and the measurement of greenwashing. More importantly, unlike studies focusing on changes in the intensity of greenwashing, this paper uses a binary greenwashing indicator and examines whether climate risk increases the likelihood that firms adopt greenwashing as a strategic response.

When climate risk rises, firms may face stronger external environmental pressure and greater legitimacy concerns. Yet substantive environmental transformation is often costly and time-consuming. Under such conditions, firms may choose symbolic disclosure as a low-cost response, thereby increasing the probability of engaging in greenwashing. Based on this reasoning, this paper proposes the following hypothesis:

Climate risk significantly exacerbates corporate greenwashing.

## 3 RESEARCH DESIGN

### 3.1 Data sources and sample selection

This paper uses Chinese A-share listed companies from 2009 to 2023 as the initial sample, and screens them according to the following procedures: (1) financial companies are excluded. (2) ST, *ST, and PT companies are excluded. (3) observations with missing core variables are excluded. (4) all continuous variables are shortened at the 1% and 99th percentiles. The final sample contains 44,638 company-year observations.

Regarding data sources: Corporate greening data (GW_dum) is constructed with reference to the speech-behavior decoupling method of Hu et al. (2023) and Wang et al. (2024). Green rhetoric is measured by the frequency of green words in the MD&A section of the annual report, and actual environmental performance is measured by environmental penalty records. When corporate green rhetoric is higher than the median, and there are environmental penalties, GW_dum=1, it is 0. the climate risk index comes from relevant databases and has been shortened. financial and corporate governance data come from the CSMAR database.

### 3.2 Variable definitions

The explained variable: Corporate greenwashing behavior (GW_dum), a binary dummy variable, where 1 indicates the existence of greenwashing behavior, and 0 indicates its non-existence.

The core explanatory variable is the Climate Risk Index (CR), constructed from the frequency of climate-related keywords in firms' annual reports. A higher value indicates more climate-risk-related disclosure and a higher level of firm-level climate risk reflected in annual reports.

Referring to existing literature Zhang, 2023, this paper controls the following variables: firm size (natural logarithm of total assets), firm age (natural logarithm of years since listing), debt-to-equity ratio (Lev), return on equity (ROE), Tobin's Q, revenue growth rate (Growth), total asset turnover (ATO), institutional investor shareholding ratio (INST), dual role of chairman and general manager, and audit opinion (Opinion).

**Table 1**

*Variable description*

| Variable | Form | Definition |
|---|---|---|
| Greenwashing | GW_dum | Dummy variable, equals 1 if the company engages in greenwashing behavior in year t, 0 otherwise |
| Climate Risk | CR | frequency of climate-related keywords disclosed in firms' annual reports |
| Firm Size | Size | Natural logarithm of total assets |
| Firm Age | FirmAge | Natural logarithm of years since listing |
| Leverage | Lev | Total liabilities divided by total assets |
| Return on Equity | ROE | Net profit divided by average net assets |
| Tobin's Q | TobinQ | Ratio of market value to replacement cost of assets |
| Revenue Growth | Growth | (Current year revenue − previous year revenue) / previous year revenue |

| Variable | Form | Definition |
|---|---|---|
| Total Asset Turnover | ATO | Revenue divided by average total assets |
| Institutional Ownership | INST | Proportion of shares held by institutional investors |
| CEO Duality | Dual | Dummy variable, equals 1 if the chairman and CEO are the same person |
| Audit Opinion | Opinion | Dummy variable, equals 1 if the firm receives a standard unqualified audit opinion |
| Firm Fixed Effects | α_i | Firm fixed effects |
| Year Fixed Effects | λ_t | Year fixed effects |

### 3.3 Model specification

To effectively control for unobservable individual heterogeneity at the firm level, this paper uses a conditionally fixed effects Logit model (clogit) for estimation. The baseline model is defined as follows:

$$Pr(GW\_dum_{it} = 1) = \Lambda(\alpha_{it} + \beta \ \text{Climate Risk Index}_{it} + \sum \gamma X \text{Controls}_{it} + \delta_t + \varepsilon_{it})$$

Where αi represents firm fixed effects, δt represents year fixed effects, and Λ(·) represents the logistic cumulative distribution function. The standard error is clustered at the firm level to correct for in-group correlations (Petersen, 2009).

## 4 EMPIRICAL RESULTS

### 4.1 Descriptive statistics and correlation analysis

Table 2 reports the descriptive statistics of the main variables. The mean of greenwashing behavior (GW_dum) among firms in the sample is 0.161, indicating that approximately 16.1% of firm-year observations show greenwashing behavior. The mean of the climate risk index is 0.177, with a standard deviation of 0.189 and a maximum

value of 1.049, indicating significant heterogeneity in the climate risk faced by firms during the sample period.

**Table 2**

*Descriptive statistics*

| Variable | N | Mean | SD | Min | P25 | P50 | P75 | Max |
|---|---|---|---|---|---|---|---|---|
| GW_dum | 44,638 | 0.161 | 0.367 | 0 | 0 | 0 | 0 | 1 |
| Climate Risk Index | 44,638 | 0.177 | 0.189 | 0.006 | 0.071 | 0.116 | 0.197 | 1.049 |
| Size | 44,638 | 22.171 | 1.289 | 19.676 | 21.242 | 21.967 | 22.893 | 26.086 |
| FirmAge | 44,638 | 2.908 | 0.358 | 1.386 | 2.708 | 2.944 | 3.178 | 3.526 |
| Lev | 44,638 | 0.415 | 0.208 | 0.052 | 0.246 | 0.406 | 0.569 | 0.894 |
| ROE | 44,589 | 0.063 | 0.131 | -0.636 | 0.028 | 0.073 | 0.123 | 0.354 |
| TobinQ | 44,075 | 2.009 | 1.233 | 0.855 | 1.249 | 1.608 | 2.287 | 7.780 |
| Growth | 44,613 | 0.154 | 0.373 | -0.573 | -0.034 | 0.099 | 0.258 | 2.213 |
| ATO | 44,633 | 0.642 | 0.436 | 0.075 | 0.361 | 0.547 | 0.793 | 2.657 |
| INST | 44,599 | 0.437 | 0.248 | 0.001 | 0.230 | 0.450 | 0.638 | 0.916 |
| Dual | 44,638 | 0.292 | 0.455 | 0 | 0 | 0 | 1 | 1 |
| Opinion | 44,638 | 0.973 | 0.162 | 0 | 1 | 1 | 1 | 1 |

Note: Values are taken from the latest descriptive-statistics output shown in the Stata log.

**Table 3**

*Key pairwise correlation*

| Variables | GW_dum | Climate risk index |
|---|---|---|
| GW_dum | 1.000 | 0.264*** |
| Climate risk index | 0.264*** | 1.000 |

Note: Full correlation matrix and VIF diagnostics were shown in the Stata output. Mean VIF reported in the text is 2.36 and the maximum VIF is 4.54

The correlation matrix in Table 2 shows a significant positive correlation between the climate risk index and corporate greenwashing behavior ($r = 0.264$, $p < 0.01$), preliminarily supporting the research hypothesis of this paper. The variance inflation factor (VIF) test results show that the mean VIF for each variable is 2.36, and the maximum is 4.54, far below the warning line of 10, indicating no serious multicollinearity problem.

### 4.2 Baseline regression results

Table 3 reports the benchmark regression results. The coefficient of the climate risk index is 4.169, which is significantly positive at the 1% significance level ($z = 9.83$),

supporting the hypothesis. Table 3 reports the benchmark regression results. The coefficient of the climate risk index is 4.169, which is significantly positive at the 1% significance level (z = 9.83), supporting the hypothesis. This result indicates that the higher the climate risk faced by a firm, the more likely the firm is to engage in greenwashing behavior.

**Table 4**

*Baseline and robustness results*

| Variables | Baseline (GW_dum) |
|---|---|
| Climate risk index | 4.169*** |
| | (9.83) |
| Controls | YES |
| Firm FE | YES |
| Year FE | YES |
| Model | clogit |
| N | 20,838 |

Note: z-statistics (clogit) and t-statistics (reghdfe) are reported in parentheses.
*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

These findings are highly consistent with institutional theory and the logic of symbolic responses. Against the backdrop of rising climate risks, companies face stronger external environmental pressures and legitimacy constraints. However, when the actual cost of green transformation is high, companies may prioritize selective environmental disclosure to cultivate a green image, thereby increasing the probability of greenwashing.

### 4.3 Robustness tests

To verify the robustness of the benchmark regression results, this paper conducts tests from three dimensions, and the results are reported in Table 5.

**Table 5**

*Baseline and robustness results*

| Variables | Exclude 2020 (GW_dum) | Lagged climate (GW_dum) | Continuous GW (gw) |
|---|---|---|---|
| Climate risk index | 4.126*** | | 0.341** |
| | (9.46) | | (2.10) |
| Lagged climate risk index | | 1.981*** | |
| | | (5.50) | |

| | | | |
|---|---|---|---|
| Controls | YES | YES | YES |
| Firm FE | YES | YES | YES |
| Year FE | YES | YES | YES |
| Model | clogit | clogit | reghdfe |
| N | 18,624 | 17,845 | 23,058 |

Note: z-statistics (clogit) and t-statistics (reghdfe) are reported in parentheses.
*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

1) Removal of the COVID-19 Pandemic Year (2020)

The COVID-19 pandemic in 2020 had a systemic impact on corporate operations and information disclosure, potentially disrupting the normal relationship between climate risk and greenwashing behavior. Column (2) of Table 4 reports the regression results after removing the 2020 sample, with a climate risk index coefficient of 4.126 ($z = 9.46$, $p < 0.01$), highly consistent with the baseline regression results.

2) One-Period Lagged Climate Risk

To further alleviate potential endogeneity concerns, this paper replaces the contemporaneous climate risk variable with its one-period lagged value. The coefficient remains significantly positive, indicating that the main findings are robust. The results show that the coefficient of the one-period lagged climate risk index is 1.981 ($z = 5.50$, $p < 0.01$), indicating that the previous period's climate risk has a sustained positive driving effect on current greenwashing behavior, further supporting the existence of a causal relationship. (3) Replacement of Dependent Variable

Table 5 replaces the binary greenwashing dummy variable with a continuous greenwashing index (gws) and re-estimates it using a two-way fixed-effects OLS model (reghdfe) (Correia, 2017). The results show that the coefficient of the climate risk index is 0.341 ($t = 2.10$, $p < 0.05$), indicating that climate risk not only affects whether enterprises engage in greenwashing behavior but also has a positive driving effect on the degree of greenwashing. the main conclusions remain robust.

### 4.4 Heterogeneity analysis

The impact of climate risk on enterprise greenwashing behavior may vary depending on industry characteristics. Table 6 groups the samples according to heavily polluting and non-heavily polluting industries.

**Table 6**

*Heterogeneity by industry pollution intensity*

| Variables | Heavy-polluting industries | Non-heavy-polluting industries |
|---|---|---|
| Climate risk index | 2.018***<br>(3.12) | 5.403***<br>(9.49) |
| Controls | YES | YES |
| Firm FE | YES | YES |
| Year FE | YES | YES |
| Model | clogit | clogit |
| N | 6,905 | 15,933 |

Note: z-statistics are reported in parentheses. This table uses heavy-polluting industry definition 1 as the main grouping criterion.

The results show that the coefficient of the climate risk index was 2.018 ($z = 3.12$, $p < 0.01$) in the heavily polluting industry subsample, and 5.403 ($z = 9.49$, $p < 0.01$) in the non-heavily polluting industry subsample. The results indicate that the impact of climate risk on greenwashing behavior in non-heavily polluting industries is numerically stronger than in heavily polluting industries, suggesting industry heterogeneity in this impact.

This heterogeneity has important theoretical and practical implications. Heavily polluting industries are under constant scrutiny from environmental regulators, and their environmental performance is subject to continuous monitoring by the government, media, and the public. The reputational damage and penalties they face when greenwashing is discovered are higher, thus constraining such behavior. In contrast, non-heavily polluting industries receive less environmental attention under normal circumstances. When climate risk rises, these companies face stronger "green image anxiety" and are more inclined to proactively build an environmental reputation through greenwashing to avoid potential reputational damage and regulatory risks.

## 5 CONCLUSIONS AND POLICY IMPLICATIONS

### 5.1 Main findings

This paper examines the impact of climate risk on corporate greenwashing behavior using Chinese A-share listed firms from 2009 to 2023. The estimates show that

climate risk is positively associated with the likelihood that firms engage in greenwashing behavior. This result remains robust after excluding the COVID-19 year, using lagged climate risk, and replacing the dependent variable with a continuous greenwashing measure. The heterogeneity analysis further suggests that the estimated effect is numerically stronger in non-heavily polluting industries than in heavily polluting industries. Overall, the findings indicate that climate-related pressure may induce some firms to rely on symbolic environmental disclosure rather than substantive environmental improvement.

### 5.2 Regulatory and governance implications

The findings carry several implications for environmental disclosure regulation and climate governance. First, environmental disclosure regulation should move beyond disclosure quantity and place greater emphasis on disclosure credibility. If climate-related disclosure is assessed mainly by the amount of information released, firms may have incentives to increase symbolic statements without improving actual environmental performance. Regulatory frameworks should therefore require closer consistency between climate-related claims and verifiable environmental outcomes.

Second, verification and accountability mechanisms should be strengthened. Climate-related disclosure should not rely solely on self-reporting by firms. Regulators, stock exchanges, auditors, and other external monitors should play a greater role in verifying whether climate-related statements are supported by substantive environmental practices. Stronger accountability rules are necessary to reduce the space for symbolic compliance and selective disclosure.

Third, anti-greenwashing governance should become an integral part of climate governance. The rise of climate-related discourse does not automatically imply better environmental behavior. On the contrary, without effective oversight, climate-related pressure may increase firms' incentives to manage legitimacy through symbolic disclosure. This means that anti-greenwashing rules should be treated as an important institutional component of climate governance, rather than as a secondary issue of corporate communication.

Fourth, differentiated supervision is needed across industries. Since the estimated effect is numerically stronger in non-heavily polluting industries, regulators should avoid focusing exclusively on traditionally high-polluting sectors. Firms in sectors that are not usually classified as heavily polluting may also engage in symbolic environmental claims when facing climate-related pressure. A differentiated supervisory framework can therefore improve the effectiveness of environmental governance.

Taken together, these findings suggest that an effective climate governance framework requires not only broader disclosure obligations but also stronger verification, clearer accountability, and more targeted anti-greenwashing supervision.

### 5.3 Limitations and future research

This study has several limitations. First, the climate risk variable is constructed from climate-related keywords disclosed in annual reports and therefore captures firm-level climate risk reflected in annual reports rather than direct meteorological shocks. Future research may distinguish more clearly between physical climate risk and transition climate risk. Second, while this paper identifies a significant positive relationship between climate risk and greenwashing, the channels through which firms strategically respond to climate-related pressure deserve further exploration. Third, this study focuses on Chinese listed firms, and the findings may not be directly generalizable to other institutional settings. Future research may examine whether the relationship between climate risk and greenwashing varies across legal and regulatory environments.

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## Authors' Contribution

All authors contributed equally to the development of this article.

## Data availability

All datasets relevant to this study's findings are fully available within the article.

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