

Article

Climate Policy Uncertainty and Corporate Sustainable Performance: An Empirical Study Based on Chinese Listed Companies

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Abstract

With the global climate governance development, climate policy uncertainty has shifted as one of the most important institutional factors influencing corporate sustainability. However, existing studies have shown mixed evidence regarding the effects of governance and have paid little attention to the boundary conditions that climate policy uncertainty shapes corporate sustainability. The relationship between climate policy uncertainty and corporate sustainability performance will be investigated in this study using a sample of Chinese A-share listed firms from 2016 to 2025, which is proxy measured through ESG (environmental, social, and governance) performance scores. We utilized a two-way fixed-effects model, including various robustness, endogeneity, and heterogeneity tests. The empirical findings suggest that the uncertainty of climate policies boosts corporate sustainability. Moreover, this positive impact is particularly significant for enterprises situated in southern China, firms engaged in sectors benefitting from industrial policy support and large enterprises. According to this finding, climate policy uncertainty's governance impact is predicated on the interaction of external institutional settings and firms' organizational features. By offering a more comprehensive clarification of how climate policy uncertainty affects governance, this study contributes to the literature on corporate sustainability and climate policy uncertainty and advances our knowledge of firms' sustainability responses in the context of policy uncertainty.

Keywords: climate policy uncertainty; corporate sustainability performance; ESG; industrial policy; sustainability



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1. Introduction

Climate change has fundamentally reshaped the global policy agenda, making climate governance an increasingly important institutional context for corporate decision-making [1]. In response, governments have accelerated the transition toward low-carbon development through increasingly comprehensive climate-policy frameworks. Since the adoption of the Paris Agreement in 2015, climate policy has evolved beyond traditional environmental regulatory instruments into a broader institutional mechanism that reshapes industrial competition [2], reallocates market resources [3], and influences firms' long-term

strategic decisions [4]. Moreover, the continuous evolution of policy objectives and regulatory instruments has substantially increased climate policy uncertainty (CCPU), which requires firms to make strategic decisions in an increasingly dynamic institutional environment. Consequently, understanding how firms respond to CCPU has become increasingly important in climate governance and strategic management.

Accordingly, a growing body of research has examined corporate sustainability from multiple perspectives. Existing research has evolved primarily in three complementary streams. The first investigates the determinants of corporate sustainability performance, highlighting the roles of environmental regulation, green innovation, and firm-specific characteristics in promoting firms' long-term sustainability [5–10]. The second focuses on the governance effects of climate-related policies, showing that climate and environmental policies influence firms' investment decisions, innovation activities, and strategic transformation under low-carbon development objectives [11–13]. Recently, increasing attention has shifted from climate policies to CCPU, recognizing it as an emerging institutional factor that shapes firms' strategic responses to dynamic climate governance [14]. Together, these studies provide an important foundation for understanding corporate sustainability in climate governance.

Two important gaps remain in the literature despite these advances. Existing studies on CCPU have begun but primarily focus on macro and financial effects of CCPU while the governance effect on corporate sustainability performance (CSP) remains largely unexplored. In addition, past studies have focused mostly on average effects of climate policies and provided limited evidence on contextual conditions under which the governance effect of CCPU may differ. Heterogeneity resulting from regional institutional environment, industrial policy support, and firms' resource endowment has been given less attention. Elucidating these gaps demands a more comprehensive insight into how CCPU conditions corporate sustainability performance within varied institutional and organizational contexts.

To address these issues in client capitalism, the authors develop a framework that explains how client capitalism influences corporate sustainability performance across different institutional and organizational contexts. Using a panel dataset of Chinese A-share listed firms, we use ESG to assess corporate sustainability performance as a comprehensive proxy. This study attempts to investigate the overall governance effect of the CCPU as well as its heterogeneous effects on regional institutional environments, industrial policy support and firm size, guided by disciplines' multiple complementary theoretical perspectives. Three main contributions are made to the literature. To begin with, it adds to the CCPU literature by changing the analytical focus from its macroeconomic and financial impact to the governance one, providing new firm-level evidence on the sustainability implications of policy uncertainty. Furthermore, we argue that the effects of climate policy uncertainty at the firm level can vary based on an actor's institutional environment. Therefore, this study introduces a multilevel analytical perspective to account for these variances in effects at macro, meso and micro levels. This perspective assists in delineating the boundary conditions where climate policy uncertainty affects corporate sustainability performance. Third, it proposes an integrated research framework incorporating two or more complementary theoretical perspectives to provide a more holistic explanation of how firms react to CCPU under dynamic climate governance.

2. Research Hypotheses

2.1. Climate Policy Uncertainty and Corporate Sustainability Performance

Institutional theory provides the overarching theoretical foundation for this study by explaining how external institutional environments shape firms' strategic behavior.

Under evolving climate governance, the CCPU represents a dynamic institutional pressure that continuously alters firms' regulatory expectations, strategic planning, and resource allocation decisions. Rather than serving solely as an external source of uncertainty, the CCPU reshapes the institutional environment in which firms operate, encouraging them to adjust their strategic responses to maintain organizational legitimacy and long-term competitiveness. Building on this overarching perspective, Porter's hypothesis, dynamic capability theory, and the resource-based view provide complementary explanations for how firms translate institutional pressure into sustainability-oriented strategic actions.

From the perspective of firms' strategic responses, moderate institutional pressure generated by the CCPU is more likely to stimulate proactive rather than passive adaptation. Porter's hypothesis suggests that appropriately designed environmental policy pressure can encourage firms to strengthen green innovation, improve resource allocation, and enhance sustainability governance rather than merely increasing compliance costs [15]. Dynamic capability theory further explains that firms continuously integrate, reconfigure, and deploy internal and external resources to respond to changing policy environments, thereby improving their adaptability and long-term sustainability performance [16,17]. Together, these complementary theoretical perspectives indicate that the CCPU can encourage firms to strengthen their sustainability-oriented strategic responses, ultimately improving corporate sustainability performance.

An alternative perspective suggests that excessive policy uncertainty may discourage firms from undertaking long-term sustainability investments because frequent policy adjustments increase compliance costs, investment risks, and managerial uncertainty [18,19]. Under such circumstances, firms may postpone green innovation, reduce long-term strategic investments, and prioritize short-term risk management over sustainable development. However, recent empirical evidence increasingly suggests that within China's evolving climate governance framework, moderate CCPU is more likely to stimulate strategic adaptation than hinder sustainable transformation [20,21]. As firms strengthen sustainability governance, optimize strategic resource allocation, and improve organizational adaptability in response to changing policy expectations, the positive governance effects of CCPU are expected to outweigh its potential adverse effects.

Hypothesis 1 (H1). *Climate policy uncertainty positively affects corporate sustainability performance.*

2.2. Regional Heterogeneity in the Relationship Between Climate Policy Uncertainty and Corporate Sustainability Performance

Regional institutional environments represent important boundary conditions that shape the governance effect of climate policy uncertainty (CCPU) on corporate sustainability performance. Institutional theory suggests that firms' responses to external policy pressure depend not only on policy characteristics but also on the institutional environments in which they operate [22,23]. Regional differences in market development, innovation ecosystems, industrial structures, and policy implementation capacity influence firms' ability to interpret and utilize policy information, thereby affecting how external policy pressure is translated into sustainability-oriented strategic responses. Consequently, even when firms face similar levels of CCPU, the governance effect of climate policy uncertainty may vary across regional institutional settings.

Compared with firms located in northern China, those in southern China generally operate in institutional environments characterized by stronger innovation capability, more market-oriented resource allocation, and more efficient policy implementation [24,25]. These institutional advantages enhance firms' policy signal absorption capabilities, enabling them to identify climate policy changes more promptly and incorporate evolving policy expectations into long-term strategic decision-making. Consistent with Porter's hypothesis,

firms with stronger responsiveness to policy signals are more likely to convert external policy pressure into improvements in environmental governance, organizational upgrading, and stakeholder management rather than merely bearing compliance costs [26]. Dynamic capability theory further suggests that firms with stronger adaptive capabilities can more effectively reconfigure their organizational resources and strengthen their sustainability-oriented strategic responses under changing policy conditions [27].

In contrast, many firms in northern China remain concentrated in resource-intensive and heavy industrial sectors, where higher asset specificity and greater green transition costs constrain strategic flexibility and increase the costs of responding to policy change. Under uncertain climate policy conditions, these firms are more likely to postpone long-term sustainability investments, weakening the positive governance effect of the CCPU on corporate sustainability performance. Therefore, firms operating in southern China are expected to translate climate policy uncertainty into proactive ESG governance more effectively because they possess stronger capabilities to absorb policy signals and convert institutional pressure into sustainability-oriented strategic responses. Accordingly, the positive relationship between CCPU and corporate sustainability performance is expected to be stronger among firms located in southern China.

Hypothesis 2 (H2). *The positive relationship between climate policy uncertainty and corporate sustainability performance exhibits significant regional heterogeneity, with the positive effect being stronger among firms located in southern China than among those located in northern China.*

2.3. Industrial Policy Support for the Relationship Between Climate Policy Uncertainty and Corporate Sustainability Performance

Industrial policy support constitutes an important institutional context that may influence the relationship between climate policy uncertainty (CCPU) and corporate sustainability performance. Institutional theory suggests that firms' responses to external institutional pressure are shaped not only by regulatory expectations but also by complementary institutional arrangements that facilitate strategic adaptation [28]. By providing a clearer policy orientation and supportive institutional resources, industrial policies improve firms' ability to interpret and utilize climate policy information, thereby strengthening their policy-signal absorption ability. Consequently, although climate policy uncertainty is expected to encourage firms to improve their corporate sustainability performance, the magnitude of this governance effect may differ according to the degree of industrial policy support.

Industrial policy support strengthens firms' ability to transform climate policy signals into sustainability-oriented strategic responses. Firms receiving policy support generally benefit from greater resource availability, more stable policy expectations, and stronger government guidance, enabling them to undertake long-term investments in environmental governance and organizational upgrading [29,30]. Consistent with Porter's hypothesis, supportive institutional arrangements reduce firms' adjustment costs and increase their willingness to respond proactively to evolving climate policies rather than merely complying with regulatory requirements [31]. Dynamic capability theory further suggests that complementary policy resources enhance firms' ability to integrate policy information, reconfigure organizational resources, and continuously adjust sustainability strategies under changing institutional conditions [32].

Nevertheless, industrial policy support should not be regarded as a prerequisite for firms' responses to climate policy uncertainty. Regardless of whether firms receive industrial policy support, they remain subject to environmental regulation, investor scrutiny, stakeholder expectations, and market competition, all of which encourage improvements in corporate sustainability. However, firms that benefit from industrial policy support are ex-

pected to exhibit stronger governance effects because supportive institutional arrangements reinforce their ability to absorb policy signals, reduce the costs of strategic adjustments, and facilitate the implementation of sustainability-oriented strategies. Therefore, industrial policy support is expected to reinforce, rather than determine, the positive relationship between climate policy uncertainty and corporate sustainability.

Hypothesis 3 (H3). *The positive relationship between climate policy uncertainty and corporate sustainability performance is stronger for firms receiving industrial policy support than for those without industrial policy support.*

2.4. Firm Size Heterogeneity in the Relationship Between Climate Policy Uncertainty and Corporate Sustainability Performance

Firm size represents an important organizational boundary condition that influences the relationship between climate policy uncertainty (CCPU) and corporate sustainability performance. While institutional theory explains how external policy pressure motivates firms to strengthen their sustainability-oriented strategic responses, the resource-based view argues that firms differ substantially in their ability to respond because of heterogeneous resource endowments [33]. Financial resources, managerial capabilities, organizational systems, and information-processing capabilities determine firms' policy signal absorption capabilities, thereby influencing their ability to translate climate policy uncertainty into corporate sustainability performance. Consequently, although climate policy uncertainty may encourage firms to improve their sustainability performance, its governance effect is expected to vary according to firms' resource endowments.

Large firms generally possess more abundant financial resources, stronger organizational capabilities, and more mature governance systems, which enable them to respond more effectively to changing climate policy expectations. According to the resource-based view, these resource advantages provide firms with a greater capacity to mobilize internal resources and undertake long-term sustainability investments. Dynamic capability theory further suggests that firms with stronger resource orchestration capabilities can more effectively integrate policy information, reconfigure organizational resources, and implement sustainability-oriented strategic responses under changing institutional conditions [34,35]. In addition, large firms usually receive greater regulatory attention, investor scrutiny, and reputational pressure, providing stronger incentives to transform climate policy uncertainty into proactive ESG governance [36].

Nevertheless, climate policy uncertainty is expected to encourage all firms to strengthen their sustainability-oriented strategic responses to varying degrees. However, the effectiveness of these responses depends on firms' capacity to mobilize and coordinate the resources required for long-term sustainable investment. Compared with small and medium-sized firms, large firms are better positioned to absorb policy signals, reduce strategic adjustment costs, and implement sustainability-oriented strategies because they possess stronger resource endowments and organizational capabilities. Therefore, firm size is expected to function as a resource threshold, reinforcing the positive relationship between climate policy uncertainty and corporate sustainability performance, rather than determining whether such a relationship exists.

Hypothesis 4 (H4). *The positive relationship between climate policy uncertainty and corporate sustainability performance is stronger for large firms than for small and medium-sized firms.*

Based on the above theoretical arguments and hypotheses, the conceptual framework of this study is shown in Figure 1.

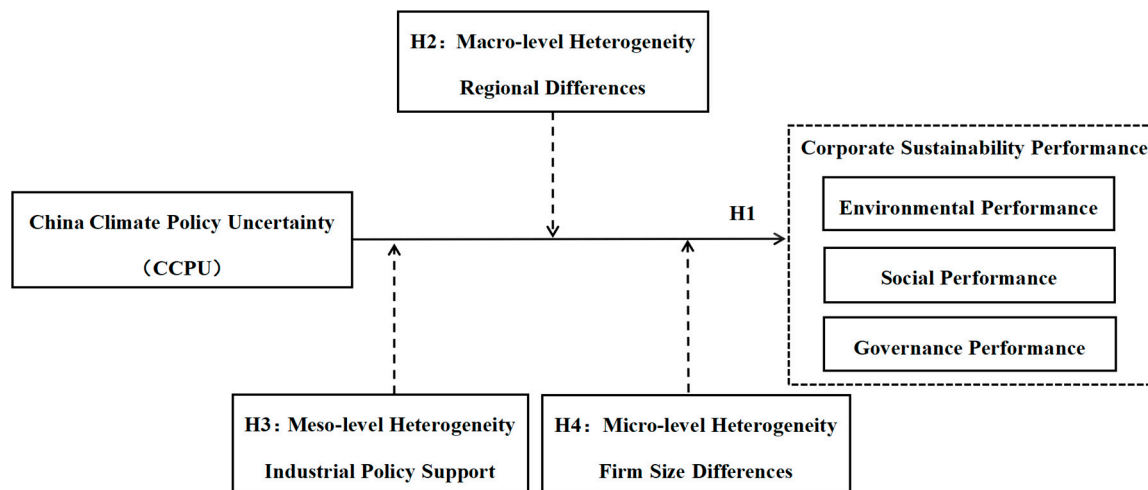


Figure 1. Research Framework.

3. Methodology and Data

3.1. Data and Sample

This study employs an unbalanced panel of Chinese A-share listed companies on the Shanghai and Shenzhen Stock Exchanges for 2016 to 2025 to examine the impact of climate policy uncertainty on corporate sustainability performance. The sample period begins in 2016 because the Paris Agreement officially entered into force, and China's Thirteenth Five-Year Plan (2016–2020) simultaneously incorporated green development into the national development strategy, jointly marking a new stage of institutionalized climate governance. Since then, climate-related policies concerning carbon emission reduction, energy transition, and green development have been implemented more systematically, resulting in more frequent policy adjustments and making climate policy uncertainty an increasingly important institutional factor influencing firms' strategic decision-making.

The climate policy uncertainty (CCPU) index was obtained from the publicly available Figshare dataset developed by Ma et al. (2023) [33], with supplementary calculations conducted by the authors where necessary. Corporate sustainability performance was measured using the Huazheng ESG rating. Firm-level financial information, corporate governance characteristics, and other firm-specific variables were collected from the China Stock Market and Accounting Research (CSMAR) database, and information on industrial policy support was obtained from the China Research Data Service Platform (CNRDS). Following the literature, financial and insurance firms, firms under special treatment (ST and *ST), delisted firms, and observations with substantial missing values were excluded. In addition, all the continuous variables were winsorized at the 1st and 99th percentiles to mitigate the influence of extreme values. After these screening procedures were applied, the final sample comprised 34,722 firm-year observations from 4544 companies. All the empirical analyses were conducted using Stata/MP version 19.0.

3.2. Variables

3.2.1. Dependent Variables: Corporate Sustainable Performance

The dependent variable in this study is corporate sustainability performance (CSP), measured using environmental, social, and governance (ESG) ratings. As a multidimensional latent construct, corporate sustainability performance cannot be directly observed; therefore, authoritative ESG ratings have been widely adopted as reliable proxy measures in the literature [35,37]. Among the available ESG databases for Chinese listed companies, the Huazheng ESG rating is widely recognized for its comprehensive evaluation framework, extensive market coverage, and high reliability. Previous studies have confirmed that

the Huazheng ESG rating effectively captures the sustainability performance of Chinese A-share listed firms [38]. Accordingly, this study employs the Huazheng ESG score as a proxy measure of corporate sustainability performance, with higher scores indicating better overall performance in terms of environmental responsibility, social responsibility, and corporate governance.

3.2.2. Independent Variable: China Climate Policy Uncertainty (CCPU)

The core independent variable in this study is the China Climate Policy Uncertainty (CCPU) index developed by Ma et al. [33]. Following the prevailing approach in the policy uncertainty literature, the index is constructed using news-based text mining to capture dynamic changes in the climate-policy environment. The provincial-level CCPU index is matched to each firm according to its registered province and observation year. The original dataset covers all 31 provincial-level administrative regions in mainland China and provides monthly and annual CCPU indices for 2000–2022. Because firms' financial statements and ESG ratings are reported annually, this study employs the annual provincial-level CCPU index for the empirical analysis.

Ma et al. (2023) [33] constructed the CCPU index using 1,755,826 news articles published between 2000 and 2022 by six authoritative Chinese news media outlets: *People's Daily*, *Guangming Daily*, *Economic Daily*, *Global Times*, *Science and Technology Daily*, and *China News Service*. The construction procedure combined manual annotation with the MacBERT deep-learning language model [33]. Climate policy-related news is first identified through a predefined keyword system and subsequently classified by MacBERT, which captures contextual semantic information beyond simple keyword frequency. Unlike conventional dictionary-based approaches, the model automatically learns the relative importance of textual features during supervised training rather than assigning predetermined keyword weights, thereby providing a more transparent and reliable measure of climate policy uncertainty.

To extend the dataset to 2025, this study strictly follows the estimation framework and publicly available source code provided by Ma et al. (2023) without modifying the original keyword system, text classification model, or index construction procedure [33]. Following the original estimation procedure, the monthly proportion of climate policy uncertainty news was first calculated for each newspaper to account for differences in publication volume. The resulting series was then standardized using the time series standard deviation of each newspaper and averaged across the six newspapers to obtain the monthly CCPU index, which was subsequently aggregated into annual provincial-level indices. Higher CCPU values indicate greater uncertainty regarding climate policy adjustment, policy orientation, and implementation expectations in the province in which a firm is located.

The original CCPU index underwent extensive technical validation. Ma et al. (2023) evaluated the index using multiple approaches, including alternative news sources, manual annotation consistency, alternative deep learning models, and model classification performance, and the results demonstrated high classification accuracy, annotation consistency, and model robustness [33]. Consistent with this validation framework, this study further employs an alternative annual aggregation approach for the CCPU index in robustness tests to verify that the empirical findings are not driven by the temporal aggregation of indicators.

3.2.3. Control Variables

To mitigate potential omitted-variable bias, this study controls for a series of firm-level characteristics that may systematically influence corporate sustainability performance,

following prior studies [39]. The control variables are grouped into three categories: firm financial characteristics, corporate governance, and firm-specific attributes. Firm financial characteristics include firm size (Size), measured as the natural logarithm of total assets; financial leverage (LEV), measured as the ratio of total liabilities to average total assets; profitability (ROA), measured as the ratio of net profit to total assets; cash flow (Cashflow), measured as the ratio of net operating cash flow to total assets; and firm growth (Growth), measured as the annual growth rate of operating revenue.

To account for differences in corporate governance, this study further controls for board size (Board), measured as the natural logarithm of the number of directors; board independence (Indep), measured as the proportion of independent directors; ownership concentration (Top1), measured as the shareholding ratio of the largest shareholder; and ownership balance (Balance), measured as the ratio of the shareholding of the second-largest shareholder to that of the largest shareholder. Firm age (FirmAge) is included as a firm-specific characteristic and is measured as the natural logarithm of the number of years since a firm's establishment, calculated as $\ln(\text{current year-establishment year} + 1)$, to account for differences in firms' life-cycle stage, accumulated operating experience, and organizational inertia. The detailed definitions and measurements of all the variables are presented in Table 1.

Table 1. Variable Definitions and Measurements.

Variable Type	Variable Symbol	Variable Definition	Measurement
Dependent Variable	ESG	Corporate Sustainability Performance	Huazheng ESG Performance Rating Score
Independent Variable	CCPU	China Climate Policy Uncertainty Index	Provincial China Climate Policy Uncertainty (CCPU) Index developed by Ma et al. (2023) [33], matched according to firms' registered province and year
Control Variables	Size	Firm Size	Natural logarithm of total assets
	LEV	Financial Leverage	Total liabilities/Average total assets
	ROA	Profitability	Net profit/Total assets
	Cashflow	Cash Flow	Net operating cash flow / Total assets
	Growth	Firm Growth	Annual growth rate of operating revenue
	Board	Board Size	Natural logarithm of the number of directors
	Indep	Board Independence	Proportion of independent directors
	Top1	Ownership Concentration	Shareholding ratio of the largest shareholder
	Balance	Ownership Balance	Shareholding of the second-largest shareholder/Shareholding of the largest shareholder
	FirmAge	Firm Age	$\ln(\text{Current year-Establishment year} + 1)$

3.3. Modelling

To test the proposed hypotheses, this study employs a two-way fixed-effects model that effectively controls for unobserved firm heterogeneity and common time-specific

shocks in firm-level panel data. By accounting for both firm and year fixed effects, the model controls for time-invariant firm characteristics as well as common macroeconomic conditions, policy changes, and other time-specific factors, thereby mitigating potential omitted variable bias and improving the consistency of the estimation results. The baseline regression model is specified as follows:

$$ESG_{it} = \beta_0 + \beta_1 CCPU_{it} + Controls_{it} + \alpha_i + \delta_t + \varepsilon_{it} \quad (1)$$

where i denotes the firm and t denotes the year of observation. ESG_{it} represents the corporate sustainability performance of firm i in year t . $CCPU_{it}$ is the core explanatory variable that measures the level of China climate policy uncertainty in the corresponding province and year. The coefficient β_1 captures the marginal effect of climate policy uncertainty on corporate sustainability performance and is the primary parameter of interest in this study's analysis. $Controls_{it}$ represents the set of control variables included in the model. α_i denotes firm fixed effects that control for unobservable firm-specific characteristics that remain constant over time, whereas δ_t denotes year fixed effects that capture common macroeconomic conditions, policy changes, and other time-specific shocks. Finally, ε_{it} is a random error term. On the basis of the baseline model, robustness tests and heterogeneity analyses were subsequently conducted to examine the stability and reliability of the empirical findings.

4. Results

4.1. Descriptive Statistics

Table 2 reports the descriptive statistics and Pearson correlation matrix of the main variables. The final sample consists of 34,722 firm-year observations. Overall, the means, standard deviations, and value ranges of all the variables fall within reasonable intervals, indicating sufficient cross-sectional and time series variation to support the subsequent empirical analysis.

The mean value of corporate sustainability performance (ESG) is 73.410, with a standard deviation of 6.119, indicating substantial variation in sustainability performance across firms. The mean value of China's climate policy uncertainty (CCPU) is 2.961, with a standard deviation of 0.873, suggesting considerable regional variation in climate policy uncertainty during the sample period.

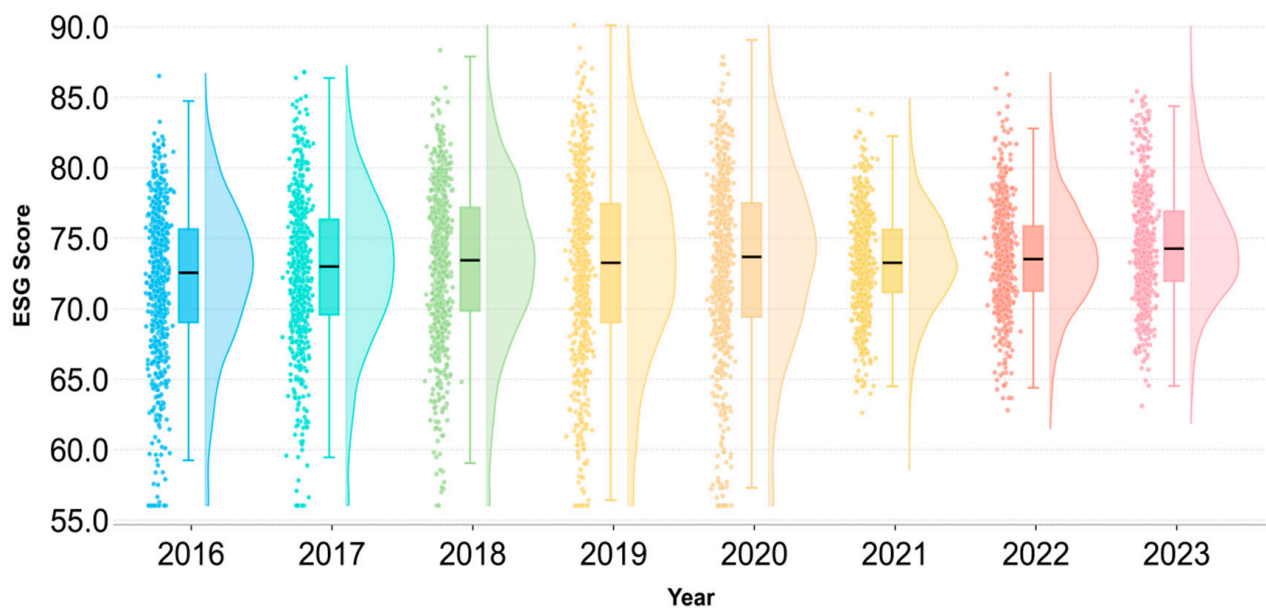
The Pearson correlation results show that CCPU is positively correlated with ESG at the 1% significance level, indicating a positive association between climate policy uncertainty and corporate sustainability. In addition, the variance inflation factor (VIF) tests indicated that multicollinearity was not a concern, suggesting that the explanatory variables could be included simultaneously in the regression analysis.

The annual distribution of corporate sustainability performance (ESG) over the sample period of 2016–2023 is shown in Figure 2. Overall, the ESG scores exhibit a gradual upward trend, with both the median and central distribution shifting upwards over time, indicating a continuous improvement in corporate sustainability performance. After 2020, the density distributions became relatively more concentrated around the median, suggesting a moderate reduction in the dispersion of ESG performance across firms. Although substantial heterogeneity remains, the interquartile ranges and overall distributions become relatively more stable in the later years of the sample period.

Table 2. Descriptive Analysis.

	ESG	CCPU	Size	Lev	ROA	Cashflow	Growth	Board	Indep	Dual	Top1	Balance1	FirmAge
ESG	1												
CCPU	0.044 ***	1											
Size	0.271 ***	0.001	1										
Lev	−0.102 ***	−0.004	0.469 ***	1									
ROA	0.225 ***	−0.076 ***	0.052 ***	−0.344 ***	1								
Cashflow	0.122 ***	0.001	0.110 ***	−0.145 ***	0.472 ***	1							
Growth	−0.002	−0.088 ***	0.032 ***	0.026 ***	0.292 ***	0.056 ***	1						
Board	0.057 ***	−0.060 ***	0.275 ***	0.133 ***	0.032 ***	0.050 ***	0.010 *	1					
Indep	0.038 ***	0.029 ***	−0.022 ***	−0.018 ***	−0.019 ***	−0.001	−0.014 ***	−0.580 ***	1				
Dual	−0.010 *	0.037 ***	−0.198 ***	−0.134 ***	0.018 ***	−0.018 ***	0.025 ***	−0.187 ***	0.110 ***	1			
Top1	0.112 ***	−0.026 ***	0.185 ***	0.010 *	0.179 ***	0.127 ***	0.008	0.016 ***	0.031 ***	−0.062 ***	1		
Balance1	−0.016 ***	0.010 *	−0.072 ***	−0.057 ***	−0.018 ***	−0.007	0.018 ***	0.018 ***	−0.015 ***	0.030 ***	−0.601 ***	1	
FirmAge	−0.023 ***	0.151 ***	0.197 ***	0.182 ***	−0.111 ***	0.012 **	−0.123 ***	0.108 ***	−0.020 ***	−0.157 ***	−0.042 ***	−0.056 ***	1
N	34,722	34,722	34,722	34,722	34,722	34,722	34,722	34,722	34,722	34,722	34,722	34,722	34,722
Min	56.040	1.513	20.050	0.056	−0.233	−0.147	−0.564	1.609	0.333	0.000	0.079	0.014	2.197
Max	90.120	4.747	26.390	0.902	0.215	0.239	1.766	2.565	0.571	1.000	0.733	0.996	3.664
Mean	73.410	2.961	22.360	0.409	0.034	0.049	0.121	2.094	0.380	0.327	0.327	0.386	3.059
SD	6.119	0.873	1.310	0.202	0.068	0.066	0.332	0.196	0.054	0.469	0.147	0.283	0.300

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

**Figure 2.** Distribution of Corporate Sustainability Performance.

4.2. Benchmark Regression Results

The Hausman test rejects the null hypothesis of the random-effects model ($p < 0.01$), indicating that the two-way fixed-effects model is more appropriate for empirical analysis. Accordingly, firm- and year-fixed effects are included to control for unobserved firm-specific heterogeneity and common time-specific shocks. To examine the impact of climate policy uncertainty on corporate sustainability performance, Column (1) reports the benchmark model, including only the core independent variable, whereas Column (2) incorporates the full set of control variables. The benchmark regression results are shown in Table 3.

Table 3. Benchmark Regression Results for Corporate Sustainability Performance.

Variables	(1)	(2)
	ESG	ESG
CCPU	0.264 *** (0.073)	0.176 ** (0.070)
Size		2.766 *** (0.098)
Lev		−8.130 *** (0.358)
ROA		1.327 ** (0.652)
Cashflow		−1.392 *** (0.518)
Growth		−0.786 *** (0.089)
Board		1.643 *** (0.356)
Indep		5.452 *** (1.099)
Dual		0.116 (0.097)
Top1		2.121 *** (0.801)
Balance1		−0.069 (0.289)
FirmAge		−0.978 (0.846)
_cons	72.623 *** (0.219)	11.245 *** (3.317)
N	34,722	34,722
adj. R ²	0.429	0.459
Firm FE	YES	YES
Year FE	YES	YES

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

The data in Table 3 imply the coefficient of China’s climate policy uncertainty (CCPU) is positive and significant in both specifications. The coefficient of CCPU is estimated at 0.264, $p < 0.01$. In Column (2), after controlling for financial characteristics and corporate governance, the coefficient remains positive and significant ($\beta = 0.176$, $p < 0.05$). This finding suggests that the association between climate policy uncertainty and corporate sustainability performance holds even after accounting for these additional variables. Hypothesis 1 is thus true.

Beyond its statistical significance, the estimated effect is also economically meaningful. Specifically, a one-unit increase in CCPU is associated with an average increase of 0.176 points in firms’ ESG scores. When evaluated at one standard deviation of CCPU, corporate sustainability performance increases by approximately 0.154 points, which is equivalent to 2.52% of the standard deviation of the ESG scores. This magnitude suggests that climate policy uncertainty exerts a measurable influence on firms’ sustainability performance rather than merely having a statistically detectable effect.

These findings suggest that climate policy uncertainty functions not only as a source of external risk but also as an institutional signal that encourages firms to strengthen their sustainability practices. Consequently, firms are more likely to strengthen their environmental, social, and governance practices in response to a more uncertain climate policy environment.

The estimated coefficients of the control variables are generally consistent with the theoretical expectations. Firm size, profitability, board size, board independence, and ownership concentration are positively associated with corporate sustainability performance, whereas financial leverage, cash flow, and firm growth have significantly negative effects. Ownership balance and firm age are not statistically significant. Overall, these findings are broadly consistent with the literature, providing additional support for the validity of the model's specification.

4.3. Robustness Tests

4.3.1. Excluding the Crisis Period and Alternative Treatment of Outliers

Two robustness tests were conducted to examine whether the benchmark results were sensitive to major external shocks and extreme observations. First, observations from the COVID-19 pandemic period (2020) are excluded to mitigate the pandemic's potential influence on firms' operating environment and ESG-related decisions. Second, a more stringent 5% two-sided winsorization was applied to all the continuous variables to further reduce the influence of extreme observations. The two-way fixed-effects model was then re-estimated, and the results are reported in Table 4.

Table 4. Robustness Test Results: Excluding the Crisis Period and Alternative Treatment of Outliers.

	Excluding the COVID-19 Period	5% Two- Sided Winsorization
Variables	ESG	ESG
CCPU	0.142 ** (0.068)	0.153 ** (0.062)
_cons	8.960 *** (3.025)	22.253 *** (2.852)
N	31,469	34,722
adj. R ²	0.456	0.468
Firm FE	YES	YES
Year FE	YES	YES
Control Variables	YES	YES

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

Column (1) of Table 4 reports the estimation results after excluding observations from the COVID-19 pandemic. The coefficient of CCPU remains positive and statistically significant ($\beta = 0.142, p < 0.05$). Column (2) presents the results after applying the 5% two-sided winsorization, where the coefficient of CCPU also remains positive and statistically significant ($\beta = 0.153, p < 0.05$). In both cases, the sign and statistical significance of the estimated coefficients remain consistent with those reported in the benchmark regression.

These findings indicate that the positive relationship between climate policy uncertainty and corporate sustainability performance is not driven by the COVID-19 pandemic or extreme observations in the sample. Overall, the benchmark results remain robust under alternative sample selection and outlier treatment, further supporting the reliability of these findings.

4.3.2. Alternative Variable Measures

To further examine whether the benchmark results are sensitive to alternative variable measurements, the dependent, independent, and control variables are replaced in turn, and the two-way fixed-effects model is re-estimated. The results of the robustness test are reported in Table 5.

Table 5. Robustness Test Results: Alternative Variable Measures.

Variables	Alternative Dependent Variable	Alternative Independent Variable	Alternative Control Variables
CCPU	DESG 0.033 ** (0.015)	ESG	ESG 0.174 ** (0.070)
CCPU_Year		0.203 *** (0.040)	
_cons	−8.800 *** (0.692)	9.858 *** (2.153)	10.517 *** (3.337)
N	34,722	34,722	34,722
adj. R ²	0.436	0.450	0.459
Firm FE	YES	YES	YES
Year FE	YES	NO	YES
Control Variables	YES	YES	YES

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

Column (1) replaces the original ESG score with the ESG rating (coded 1–9, corresponding to ratings C–AAA) as the dependent variable. The estimated coefficient of CCPU remains positive and statistically significant ($\beta = 0.033$, $p < 0.05$), indicating that the benchmark findings are not sensitive to alternative measurements of corporate sustainability. Column (2) replaces the provincial-level climate policy uncertainty index with the annual national-level climate policy uncertainty index (CCPU_Year). The estimated coefficient of CCPU_Year remains positive and statistically significant ($\beta = 0.203$, $p < 0.01$), suggesting that the positive relationship between climate policy and corporate sustainability performance is robust across different spatial levels of climate policy uncertainty. Column (3) replaces ROA with ROE, Top1 with Top10, and redefines the ownership balance variable as the ratio of the combined shareholding of the second- to fifth-largest shareholders to that of the largest shareholder. The estimated coefficient of CCPU remains positive and statistically significant ($\beta = 0.174$, $p < 0.05$), indicating that the benchmark findings are robust to alternative measurements of control variables.

Across all alternative variable specifications, the estimated CPU coefficient of climate policy uncertainty remains positive and statistically significant. These results demonstrate that the benchmark findings are robust to alternative measurements of the dependent, independent, and control variables, providing further support for the robustness of the baseline regression results.

4.3.3. Alternative Estimation Methods

To further examine whether the benchmark findings depend on the choice of estimation method, several alternative estimation approaches are employed, including cluster-robust standard errors, a high-dimensional fixed-effects model, a correlated random-effects (CRE) model, a maximum likelihood estimation (MLE) model, and a population-averaged (PA) model. The corresponding estimation results are presented in Table 6.

Column (1) reports the estimation results when cluster-robust standard errors are used, where the coefficient of CCPU remains positive and statistically significant ($\beta = 0.172$, $p < 0.05$). Column (2) further estimates a high-dimensional fixed-effects model that additionally controls for industry-by-year fixed effects, and the estimated coefficient of CCPU remains positive and statistically significant ($\beta = 0.222$, $p < 0.01$). Columns (3)–(5) present the estimation results obtained from the correlated random-effects (CRE), maximum likelihood estimation (MLE), and population-averaged (PA) models, respectively. Across all three specifications, the estimated coefficients of CCPU remain positive and statisti-

cally significant, with estimated coefficients of 0.176 ($p < 0.01$), 0.135 ($p < 0.05$), and 0.134 ($p < 0.05$), respectively.

Table 6. Robustness Test Results: Alternative Estimation Methods.

Variables	Cluster-Robust Standard Errors	High- Dimensional Fixed Effects	Correlated Random Effects (CRE)	Maximum Likelihood Estimation (MLE)	Population- Averaged (PA)
CCPU	ESG 0.172 ** (0.070)	ESG 0.222 *** (0.070)	ESG 0.176 *** (0.064)	ESG 0.135 ** (0.061)	ESG 0.134 ** (0.061)
_cons	12.187 *** (3.334)	18.734 *** (3.360)	27.405 *** (2.308)	30.961 *** (1.174)	31.024 *** (1.166)
N	34,722	34,722	34,722	34,722	34,722
adj. R ²	0.461	0.493	-	-	-
Firm FE	YES	YES	YES	NO	NO
Year FE	YES	YES	YES	YES	YES
Industry × Year FE	NO	YES	NO	NO	NO
Control Variables	YES	YES	YES	YES	YES

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

Together, these results confirm that the positive effect of climate policy uncertainty on corporate sustainability performance is not driven by the choice of estimation method, further reinforcing the robustness of the benchmark findings.

4.4. Endogeneity Analysis

Potential endogeneity may arise from reverse causality and omitted variable bias. To alleviate these concerns, all explanatory and control variables are first lagged by one period so that current climate policy uncertainty explains firms' corporate sustainability performance in the subsequent period. Furthermore, the Lewbel (2012) heteroskedasticity-based identification approach is employed to construct internal instrumental variables and estimate the model within a two-stage panel fixed-effects framework [40]. Previous studies have typically employed Bartik-type instrumental variables constructed from the interactions between extreme climate risks and industry-level climate exposure [41,42]. However, in the research setting of this study, extreme climate risks may directly affect firms' production activities, environmental performance, and ESG practices, potentially violating the exclusion restriction. Therefore, this study adopts the Lewbel approach, which uses model heteroscedasticity to generate internal instrumental variables and is more appropriate for the present research setting. Table 7 presents the estimation results obtained using the Lewbel instrumental variable approach.

Table 7 shows that the Anderson canonical correlation LM statistic for the under-identification test is 29.875 ($p < 0.01$), rejecting the null hypothesis of under-identification and confirming that the constructed instrumental variables are sufficiently correlated with the endogenous explanatory variable. Moreover, the Cragg–Donald Wald F statistic is 29.896, exceeding the Stock–Yogo critical value of 16.38, indicating that the model does not suffer from a weak-instrument problem. The second-stage estimation further reveals that the coefficient of CCPU remains positive and statistically significant ($\beta = 0.719$, $p < 0.01$), indicating that climate policy uncertainty continues to have a significant positive effect on corporate sustainability performance after potential reverse causality and omitted-variable bias are accounted for.

Table 7. Endogeneity Analysis: Lewbel Instrumental Variable Estimation.

Variables	ESG _{i,t+1}
CCPU _{i,t}	0.719 *** (0.132)
N	29,687
R ²	−125.447
Firm FE	YES
Year FE	YES
Control Variables	YES
Underidentification Test (Anderson LM)	29.875 ***
Weak-Instrument Test (Cragg–Donald F)	29.896 > 16.38

Note: *** indicates significance at the 1% level; standard errors are in parentheses.

Together, these results provide further evidence that the positive effect of climate policy uncertainty on corporate sustainability performance is robust after potential endogeneity concerns are addressed, thereby reinforcing the validity of our benchmark findings.

4.5. Heterogeneity Analysis

4.5.1. Regional Heterogeneity

Systematic differences exist between southern and northern China in terms of industrial structure, dependence on energy resources, innovation environments and the efficiency of policy transmission. These regional differences influence firms' abilities to perceive, absorb, and respond to changes in climate policy. Previous studies have shown that compared with northern China, southern China generally has stronger innovation capacity, more efficient resource allocation, and more effective policy implementation, enabling external policy signals to be translated more readily into technological innovation and corporate governance. In contrast, many northern regions remain more dependent on heavy industries and resource-based sectors, where industrial transformation is constrained by higher sunk costs and structural rigidity. Accordingly, the sample is divided into southern and northern subsamples according to firms' registered locations, and separate regressions are estimated for each group. A Chow test was conducted to examine whether the estimated coefficients differed significantly between the two subsamples. The results are presented in Table 8.

Table 8. Heterogeneity Analysis: Regional Heterogeneity.

Variables	Northern China	Southern China
	ESG	ESG
CCPU	0.065 (0.110)	0.323 *** (0.109)
_cons	8.955 (6.178)	11.435 *** (3.946)
N	10,353	24,369
adj. R ²	0.469	0.455
Firm FE	YES	YES
Year FE	YES	YES
Control Variables	YES	YES
Chow Test	12.420 ***	

Note: *** indicates significance at the 1% level; standard errors are in parentheses.

Table 8 shows that climate policy uncertainty significantly improves corporate sustainability performance among firms located in southern China ($\beta = 0.323$, $p < 0.01$). In contrast, although the estimated coefficient remains positive for firms in northern China, it

is not statistically significant ($\beta = 0.065$, $p > 0.10$). The Chow test is significant at the 1% level, indicating that the effect of climate policy uncertainty differs significantly between the two regions. From an economic perspective, the estimated effect in southern China (0.323) is nearly five times greater than that in northern China (0.065), suggesting that the positive impact of climate policy uncertainty on corporate sustainability performance is concentrated primarily among firms located in southern China. Therefore, these findings provide empirical support for Hypothesis 2.

These regional differences mainly reflect firms' heterogeneous capabilities in translating climate policy signals into ESG governance practices. Firms in southern China generally operate in more dynamic innovation environments, exhibit greater industrial flexibility, and benefit from more efficient policy transmission mechanisms, enabling them to respond more proactively to policy uncertainty by strengthening environmental governance, stakeholder management, and internal governance systems. In contrast, firms in many northern regions are more deeply embedded in heavy industrial and resource-based sectors, where higher asset specificity and green transition costs make long-term sustainability investments more difficult under uncertain policy conditions. Consequently, climate policy uncertainty is less likely to translate into immediate improvements in corporate sustainability performance in northern China.

4.5.2. Heterogeneity by Industrial Policy Support

Industrial policy support may shape firms' responses to climate policy uncertainty by improving resource availability and providing clearer guidance. Government subsidies, preferential credit, and factor support can reduce firms' financial constraints, whereas signals regarding priority industries and future regulatory orientations facilitate strategic adjustments. Accordingly, the sample is divided into firms operating in industries that are either supported or not supported by industrial policies, and separate regressions are estimated for the two groups. A Chow test was conducted to examine whether the estimated coefficients differed significantly between the two subsamples. The results are presented in Table 9.

Table 9. Heterogeneity Analysis: Industrial Policy Support.

Variables	Supported Industries	Non-Supported Industries
	ESG	ESG
CCPU	0.250 *** (0.091)	0.232 ** (0.111)
_cons	3.435 (4.749)	14.907 *** (5.515)
N	19,632	15,090
adj. R ²	0.507	0.483
Firm FE	YES	YES
Year FE	YES	YES
Control Variables	YES	YES
Chow Test		10.030 ***

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

The data in Table 9 show that climate policy uncertainty has a positive and statistically significant effect on corporate sustainability performance in both groups. For firms operating in industries supported by industrial policies, the coefficient of CCPU was 0.250 ($p < 0.01$). For firms in non-supported industries, the coefficient remains positive and statistically significant ($\beta = 0.232$, $p < 0.05$). The Chow test is significant at the 1% level, confirming that the effect of climate policy uncertainty differs significantly between the two groups. From an economic perspective, a one-unit increase in CCPU is associated with

increases of 0.250 and 0.232 points in ESG scores for firms in supported and non-supported industries, respectively. Therefore, the estimated effect was 0.018 points, or approximately 7.8%, greater in the supported group. These results indicate that the positive effect of climate policy uncertainty is not confined to industries receiving policy support but is moderately strengthened by industrial policy support. These findings provide empirical support for Hypothesis 3.

The results suggest that industrial policy support functions as a reinforcing rather than a necessary condition. Firms in both groups remain exposed to environmental regulations, investor scrutiny, supply chain requirements, and reputational pressure, which encourage sustainability-oriented responses to climate policy uncertainty. However, firms receiving industrial policy support benefit from additional resources and clearer policy expectations, enabling them to absorb climate policy signals and implement ESG-related adjustments more effectively.

4.5.3. Heterogeneity by Firm Size

Resource endowments differ substantially across firms, influencing their ability to identify external environmental changes and to implement strategic responses. Compared with small and medium-sized firms, large firms generally possess stronger financial resources, organizational capabilities, and information-processing capabilities, enabling them to respond more effectively to climate policy uncertainty. Accordingly, firms' resource endowments may constitute important boundary conditions affecting the relationship between climate policy and corporate sustainability performance. To minimize grouping bias caused by differences in industry capital intensity and annual fluctuations in asset prices, the median value of total assets is calculated at the industry-year level as follows: The sample is then divided into small and medium-sized firms and large firms, and separate regressions are estimated for each group. A Chow test was conducted to examine whether the estimated coefficients differed significantly between the two subsamples. The results are presented in Table 10.

Table 10. Heterogeneity Analysis: Firm Size.

Variables	Small and Medium-Sized Firms	Large Firms
	ESG	ESG
CCPU	0.163 (0.101)	0.306 *** (0.100)
_cons	25.834 *** (5.204)	−16.799 *** (5.525)
N	17,251	17,471
adj. R ²	0.450	0.487
Firm FE	YES	YES
Year FE	YES	YES
Control Variables	YES	YES
Chow Test		36.870 ***

Note: *** indicates significance at the 1% level; standard errors are in parentheses.

The data in Table 10 show that the coefficient of CCPU is positive but statistically insignificant for small and medium-sized enterprises ($\beta = 0.163$, $p > 0.10$). In contrast, climate policy uncertainty has a significantly positive effect on corporate sustainability performance among large firms ($\beta = 0.306$, $p < 0.01$). The Chow test is significant at the 1% level, confirming that the estimated coefficients differ significantly between the two groups. From an economic perspective, a one-standard-deviation increase in CCPU is associated with an average increase of approximately 0.267 points in ESG scores for large

firms, which is equivalent to approximately 4.36% of the standard deviation of ESG scores. These findings indicate that climate policy uncertainty generates economically meaningful improvements in corporate sustainability performance primarily among large firms. These findings provide empirical support for Hypothesis 4.

The results suggest that firm size is an important resource boundary condition. Compared with small and medium-sized firms, large firms possess stronger resource reserves and organizational capabilities and greater external governance pressure, enabling them to translate climate policy uncertainty into more proactive ESG practices. In contrast, smaller firms are more constrained by limited resources and adjustment capacity, making it more difficult for climate policy uncertainty to generate immediate improvements in corporate sustainability performance.

5. Discussion

5.1. Interpretation of the Main Findings

The principal finding of this study is that climate policy uncertainty positively influences corporate sustainability performance. This suggests that climate policy uncertainty should not be viewed solely as an external source of regulatory risk that discourages long-term investment. Instead, it serves as an institutional signal that conveys changing regulatory priorities, stakeholder expectations, and future policy orientations, encouraging firms to strengthen ESG governance in anticipation of future climate-related requirements. Rather than passively responding to policy uncertainty, firms tend to improve environmental management, stakeholder engagement, and internal governance arrangements to enhance organizational legitimacy while reducing future regulatory, financing, and reputational risks.

These findings are broadly consistent with the Porter hypothesis, which argues that appropriately designed environmental regulations can stimulate organizational innovation and strategic adjustment rather than merely increasing compliance costs [43]. This finding is consistent with recent studies suggesting that climate policy uncertainty may encourage firms to undertake strategic adaptation and sustainability-oriented transformation under supportive institutional conditions. However, these studies differ from those reporting that climate policy uncertainty crowds out corporate investment or green innovation by increasing precautionary behavior and delaying irreversible investment decisions [44,45]. This apparent inconsistency primarily reflects the differences in the outcomes examined. Whereas previous studies have focused mainly on investment behavior or green innovation, this study examines corporate sustainability performance, which captures firms' environmental, social, and governance performance more comprehensively. Consequently, firms may postpone certain capital-intensive investments while simultaneously strengthening ESG governance and sustainability disclosures to better cope with future policy uncertainty.

These findings can be further explained from complementary theoretical perspectives. Institutional theory suggests that changes in external governance environments reshape firms' strategic priorities as organizations seek to maintain their legitimacy [46]. From this perspective, signalling theory argues that greater policy uncertainty increases firms' incentives to communicate long-term resilience and sustainability commitments through ESG practices and information disclosure [47]. Dynamic capability theory further explains how firms absorb policy information, reconfigure organizational resources, and continuously adjust their strategic decisions in response to changing policy environments [48]. Taken together, these theoretical perspectives suggest that climate policy uncertainty can function not only as an external regulatory pressure but also as a catalyst that stimulates firms' adaptive governance and long-term sustainable development.

5.2. Interpretation of Heterogeneity Findings

While the benchmark results indicate that climate policy uncertainty generally promotes corporate sustainability performance, the heterogeneity analyses further suggest that this governance effect is contingent on specific institutional and organizational conditions. Rather than representing isolated empirical findings, the heterogeneous effects reveal that firms' responses to climate policy uncertainty depend on both external institutional environments and internal organizational capabilities. The following discussion focuses on three important boundary conditions: the regional institutional environment, industrial policy support, and firm resource endowment.

Regional heterogeneity. The stronger governance effect observed in southern China should not be interpreted as a consequence of higher levels of economic development. Instead, it reflects differences in institutional quality, innovation capacity, industrial structure, environmental governance, and policy transmission efficiency. Compared with northern China, southern China generally has more market-oriented institutional environments, stronger innovation ecosystems, and greater industrial flexibility, enabling firms to absorb climate policy signals and translate them into sustainability-oriented organizational responses more efficiently [48,49]. In contrast, the greater concentration of heavy industries and resource-dependent sectors in northern China increases asset specificity and green transition costs, reducing firms' willingness to undertake irreversible sustainability investment under uncertain policy conditions. This explanation is consistent with studies suggesting that institutional quality and regional innovation systems shape firms' environmental strategies and sustainability performance [50,51].

Industrial policy support. Climate policy uncertainty improves corporate sustainability performance in both supported and non-supported industries, indicating that industrial policy is not a prerequisite for firms' sustainability responses. Rather, industrial policy primarily serves as a reinforcing condition that strengthens firms' adaptive capacity [52]. Although firms outside supported industries remain subject to environmental regulation, investor monitoring, supply chain requirements, and reputational pressure, policy-supported firms generally enjoy better access to financial resources, technological support, and clearer policy guidance, enabling them to undertake ESG-related investments more proactively when climate policy uncertainty increases. These findings suggest that industrial policy complements climate governance by reducing adjustment costs and strengthening firms' ability to translate policy uncertainty into sustainability-oriented actions [53].

Firm size heterogeneity. The firm-size results further highlight the importance of firms' internal adaptive capacities. According to the resource-based view, firms differ substantially in terms of their financial resources, organizational capabilities, and information processing capacity [3]. Dynamic capability theory emphasizes firms' ability to integrate and reconfigure these resources in response to environmental change [27]. Compared with small and medium-sized firms, large firms possess stronger resource reserves and greater organizational flexibility, allowing them to sustain long-term ESG investments under uncertain policy conditions [54]. In addition, greater market visibility exposes large firms to stronger stakeholder pressure from regulators, institutional investors, analysts, supply chain partners, and the public, increasing their incentives to maintain organizational legitimacy through ESG governance [55]. In contrast, resource constraints and limited organizational capacity make it more difficult for small and medium-sized firms to transform climate policy uncertainty into substantive sustainability improvements. These findings further support the view that firms' sustainability responses to policy uncertainty depend not only on external institutional pressure but also on their ability to mobilize and deploy strategic resources [56].

5.3. Theoretical Contributions

This study contributes to the literature in three important ways. First, it extends the existing research on climate policy uncertainty by demonstrating that its influence extends beyond corporate investment, financing decisions, and green innovation to encompass corporate sustainability performance. By adopting ESG performance as a multidimensional governance outcome, this study broadens the current understanding of how firms strategically respond to climate-related policy uncertainty.

Second, this study advances the literature by identifying the boundary conditions under which climate policy uncertainty promotes corporate sustainability performance. Rather than separately examining regional characteristics, industrial policy support, or firm-level resources, it integrates these contextual factors into a unified analytical perspective. These findings suggest that firms' sustainability responses are jointly shaped by external institutional environments, policy support, and internal organizational capabilities, thereby providing a more comprehensive explanation of heterogeneous governance outcomes under climate policy uncertainty.

Finally, this study contributes to theory by integrating institutional theory, signalling theory, dynamic capability theory, and the resource-based view into a coherent explanatory framework. Institutional theory explains why climate policy uncertainty creates governance pressure, while the remaining perspectives clarify how firms perceive policy signals, mobilize strategic resources, and strengthen ESG governance in response to changing policy environments. By linking external institutional uncertainty to firms' adaptive governance processes, this study provides a more integrated theoretical explanation of the relationship between climate policy uncertainty and corporate sustainability performance.

5.4. Policy and Managerial Implications

The findings of this study have several implications for policymakers. First, improving the stability, transparency, and predictability of climate policies is essential for encouraging firms to undertake long-term sustainability investments. Although climate policy uncertainty can stimulate firms' sustainability responses, excessive policy volatility may increase adjustment costs and discourage long-term strategic investments. Therefore, policymakers should strengthen policy coordination and provide clearer long-term policy guidance. Additionally, differentiated policy instruments should be implemented according to regional institutional conditions. For regions facing greater transition challenges, complementary measures such as green finance, technological support, and transition assistance can help reduce adjustment costs and facilitate firms' sustainability transformations. Industrial policy should complement climate governance by improving resource allocation rather than substituting market mechanisms.

These findings have important implications for corporate managers. Rather than viewing climate policy uncertainty solely as a compliance challenge, firms should recognize it as a strategic signal of evolving regulatory expectations and stakeholder demand. Strengthening policy monitoring capabilities, integrating climate-related risks into strategic decision-making, and continuously improving ESG governance can enhance firms' adaptive capacity in uncertain policy environments. In particular, firms with relatively limited resources should actively leverage external support through collaboration with governments, financial institutions, and supply chain partners to overcome resource constraints and strengthen sustainability-oriented capabilities. Such adaptive governance will not only improve firms' responses to climate policy uncertainty but also enhance their long-term resilience and sustainability.

6. Conclusions

This study investigates the relationship between climate policy uncertainty and corporate sustainability performance using a panel of Chinese A-share listed companies. Employing a two-way fixed-effects model, together with a series of robustness, endogeneity, and heterogeneity analyses, the findings indicate that climate policy uncertainty significantly improves corporate sustainability performance. Moreover, this governance effect is not uniform across firms but varies according to regional institutional environments, industrial policy support, and firm resource endowments. These findings suggest that climate policy uncertainty should be viewed not only as an external regulatory challenge but also as a governance mechanism that can promote firms' long-term sustainability transitions.

Overall, this study contributes to a better understanding of the governance implications of climate policy uncertainty. By extending the research focus from investment and green innovation to corporate sustainability performance, this study broadens the current knowledge of firms' strategic responses to climate-related policy change. Furthermore, by demonstrating that the governance effect of climate policy uncertainty depends on the interaction between institutional environments and firms' adaptive capabilities, this study provides a more comprehensive explanation for heterogeneous sustainability responses. These findings also offer useful insights for policymakers seeking to improve climate governance and managers striving to strengthen ESG governance and organizational resilience in increasingly uncertain policy environments.

Despite these contributions, several limitations of this study should be acknowledged. First, this study focuses on Chinese A-share-listed companies, which may limit the generalizability of the findings to unlisted firms or firms operating in different institutional environments. Second, although several important contextual factors are incorporated into the analytical framework, other potentially relevant determinants, such as digital transformation, managerial characteristics, ownership structure, and industry-specific features, are not explicitly considered. Third, although rigorous econometric approaches are employed to mitigate endogeneity concerns, this study does not explicitly examine the dynamic adjustment process or potential spatial spillover effects of climate policy uncertainty across regions. Future research could therefore expand the sample to different institutional contexts, employ dynamic or longitudinal research designs, and further investigate spatial spillover effects by incorporating spatial econometric approaches and additional organizational and institutional factors. Such efforts would deepen our understanding of how climate policy uncertainty shapes corporate sustainability performance and further advance research on corporate sustainability and climate governance in increasingly uncertain policy environments.

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