RESEARCH ARTICLE

Corporate Social Responsibility and Environmental Management WILEY

How uncertainty can determine corporate ESG performance?

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Abstract

Using Sino-Securities Environmental, social, and governance (ESG) ratings data, we examine how environmental uncertainty affects the ESG performance of Chinese A-share non-financial listed firms from 2008 to 2020. Our findings show that environmental uncertainty harms corporate ESG performance. In particular, when environmental uncertainty increases, a firm's ESG score and ESG ratings decline due to factors such as financial constraints and industry competition. We argue that as the environmental risk premium rises, it increases the real options value of postponing sustainable investment for a firm. Consequently, the firms tend to cut down their ESG investment by weighing the long-term benefits and short-term direct costs. The value of real options changes with the investment opportunities available to the firms and the financing constraints and competitive pressure changes the size of investment opportunities. We argue that higher financing constraints and industry competition restrict available investment opportunities and dilute the negative impact of environmental uncertainty on corporate ESG performance. These results add to the existing literature investigating the impact of uncertainty on corporate ESG performance and offer insights to regulators and enterprise managers. These results are robust to alternate proxies of ESG performance and alternate regression techniques.

KEYWORDS
corporate ESG performance, environmental uncertainty, industry competition, investment opportunities, real options

JEL CLASSIFICATION
C23, G30, G34, M14

1 | INTRODUCTION

Environmental, social, and governance (ESG) performance is a measure of how well a company manages its impacts and responsibilities on the environment, society, and its stakeholders. ESG performance has become increasingly important for companies and investors in the global economy, as it reflects the sustainability, resilience, and competitiveness of a company in the long term (Clément et al., 2023; Feng

et al., 2022). It is widely recognized that ESG performance can have a significant impact on a company's financial performance and long-term sustainability (Azeem et al., 2020). Literature has shown that ESG performance can enhance the reputation and legitimacy of companies among their stakeholders, such as shareholders, regulators, customers, employees, and society at large (Yonghui et al., 2023). Companies that demonstrate high ESG performance can attract more investors, customers, and talent, as well as avoid regulatory

sanctions[1] and social backlash.[2] As mentioned by Feng et al. (2022), ESG performance can improve the operational efficiency and innovation capacity of companies by reducing costs, risks, and waste, as well as fostering creativity, learning, and collaboration. Companies that adopt ESG practices can benefit from lower energy consumption, higher resource productivity, better quality management, and more opportunities for new products and markets.[3] Xueying et al. (2022) illustrated that ESG performance can contribute to the long-term financial performance and resilience of companies by creating value and mitigating uncertainty. Companies that integrate ESG factors into their strategies and decisions can generate higher returns, lower volatility, and better risk-adjusted performance than their peers.[4]

Previous studies have examined the relationship between EPU and corporate social responsibility (CSR), which is a broader concept that encompasses ESG performance. CSR refers to the voluntary actions that a firm takes to address its social and environmental impacts beyond its legal obligations. Previous studies have found mixed results regarding the impact of EPU on CSR. Some studies have found that EPU has a negative impact on CSR, suggesting that firms are less likely to engage in CSR activities when faced with an uncertain environment (Chung-Jen et al., 2018; Yi-Chun et al., 2018). Other studies have found that EPU has a positive impact on CSR, implying that firms use CSR as a strategic tool to cope with uncertainty and enhance their reputation (Jiun-Lin et al., 2016; Ling et al., 2020). However, these studies have some limitations, such as using qualitative and self-reported measures of CSR, ignoring the heterogeneity of ESG dimensions, and neglecting the potential moderating and mediating factors that may affect the relationship between EPU and CSR.

ESG performance is also important for investors, regulators, customers, employees, and society at large, who demand more transparency and accountability from companies on their ESG practices (Grazia et al., 2022). However, achieving better ESG performance is not easy for companies, especially in emerging markets such as China, where they face various challenges and uncertainties. One of the major sources of uncertainty is economic policy uncertainty (EPU), which refers to the unpredictability of future economic policies and their effects on the economy (Milliken, 1987). EPU can arise from various sources, such as political instability, policy changes, trade disputes, and global events. EPU can affect the decisions and behaviors of economic agents, such as consumers, investors, firms, and governments (Sudip et al., 2013). China is a major economy that faces significant levels of EPU due to its rapid development, political system, and international relations (Yafei & Zhu, 2022). China is also a key player in the global ESG landscape, as it has made ambitious commitments to achieve carbon neutrality by 2060 and to improve its social and governance standards (Feng et al., 2020; Jingwen et al., 2022; Xin-Yu

et al., 2023). However, China also faces many challenges and gaps in its ESG performance, such as environmental pollution, social inequality, human rights issues, and corporate governance problems (Çiğdem, 2021; Lin & Li, 2023; Ya-Ru et al., 2022).

The motivation of companies to tackle EPU to perform better their ESG performance in China can be explained by two main theories: the *real options theory* and the *stakeholders' theory*. The *real options theory* suggests that firms may delay or defer their irreversible investment decisions under uncertainty until they receive more information or clarity about future outcomes (Muhammad et al., 2022). This implies that firms may postpone or reduce their ESG activities under high levels of EPU due to their irreversibility and sunk costs. However, this may also create an opportunity for firms to invest in more flexible and adaptable ESG activities that can cope with changing scenarios. The *stakeholders' theory* suggests that firms may respond to their stakeholders' expectations and demands under uncertainty by adopting proactive or reactive strategies (Ahmad et al., 2023). This implies that firms may increase or decrease their ESG activities under high levels of EPU depending on their stakeholder orientation and pressure. However, this may also create a challenge for firms to balance the conflicting interests of different stakeholder groups.

China is a developing country that faces significant environmental challenges due to its large population, rapid economic growth, and severe pollution (Yafei & Zhu, 2022). Therefore, ESG performance, which measures the sustainability and ethical impact of a company's activities, is crucial for China's long-term development. China has implemented various policies and regulations to encourage ESG performance and reduce environmental uncertainty, which refers to the unpredictability of future environmental conditions and policies. ESG-related research is also advancing and providing a more theoretical basis for the sustainable development of companies and society in China. However, there is a gap in the existing literature on how environmental uncertainty affects ESG performance at the micro level, that is, from the perspective of individual firms. Most studies have focused on the macro-level factors, such as EPU, or the firm-level factors, such as capital structure, earnings, and governance structure, that influence ESG performance. However, few studies have explored how environmental uncertainty, which varies for each firm depending on its industry, location, and strategy, affects ESG performance. Therefore, this study uses a sample of China's A-share companies listed from 2008 to 2020 to analyze the impact of environmental uncertainty on ESG performance at the micro level, while controlling for corporate financial factors and corporate governance characteristics.

The main finding of this article is that firms reduce their ESG investments when facing higher environmental uncertainty. During higher environmental uncertainty firms preferred to invest in real options as compared to ESG activities. Firms with less financing constraints have more real option investments; therefore, environmental uncertainty significantly reduces the ESG investments of these firms as compared to the firms with higher financing constraints. However, the firms operating in low-competitive industries also have more real option investments but these firms keep investing in ESG activities

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even during high environmental uncertainty to enhance their reputation. Furthermore, the article finds that the negative impact of firm-level environmental uncertainty on ESG performance dilutes during periods of high macro-level (economic policy) uncertainty.

The article is organized as follows: Section 2 reviews the literature on ESG performance and environmental uncertainty; Section 3 introduces the data and methodology; Section 4 presents the empirical results; Section 5 discusses the implications and limitations; Section 6 concludes the article. References are provided at the end.

2 | REVIEW OF LITERATURE

2.1 | Environmental uncertainty and its consequences

Environmental uncertainty measures the degree and rate of change in a firm's external environment and its unpredictability (Keats Barbara & Hitt, 1988). It includes many uncertainties such as macroeconomic, industrial structure, and market demand. More comprehensively, it reflects the degree of unpredictable changes faced by enterprises in various aspects (Feng et al., 2020). The existing literature has explored the economic consequences of environmental uncertainty from several perspectives. First, environmental uncertainty affects various types of investment activities such as innovation: the sense of potential crisis brought about by environmental volatility also motivates policy makers to engage in risk-taking activities, encouraging firms to increase their technological innovation efforts (Danny & Friesen, 1984; Jian et al., 2021; Tushman Michael & Romanelli, 1983). However, some scholars have also argued that environmental uncertainty increases the possibility of innovation failure and therefore reduces the incentive for firms to innovate (Xin-Yu et al., 2023). Second, environmental uncertainty affects the cost of equity capital: higher environmental uncertainty increases firms' business risks (Sikandar & Ahsan, 2020) while increasing the degree of information asymmetry between firms and investors and creditors, which adversely affects firms' business performance and leads to higher cost of equity capital (Bergh Donald & Lawless, 1998; Ma & Han, 2021).

Moreover, environmental uncertainty affects corporate governance efficiency such as surplus management and audit opinions: when environmental uncertainty is high, management may increase the degree of surplus management to cope with the impact of increased volatility (Ozili, 2021); the risks associated with environmental uncertainty may also prompt auditors to issue more nonstandard audit opinions to reduce possible loss compensation (Viet, 2022). However, environmental uncertainty may stimulate firms' dynamic adjustment ability and organizational learning: *organizational learning theory* suggests that an unknown environment can bring new knowledge and technology, new opportunities, and firms can exchange and learn from other firms to gain new competitive advantages (Maurizio & Winter, 2002; Ya-Ru et al., 2022). Finally, environmental uncertainty affects firm performance and growth: when the level of environmental uncertainty is high, firms reduce their

investments, which affects their business performance (Tanveer & Qureshi, 2021; Umer et al., 2019). In addition, environmental uncertainty affects firms' financial decisions such as financing and dividends: continuous volatility in the external environment increases the degree of information asymmetry and may restrict investors from making long-term investments due unavailability of timely and effective information (Baum Christopher et al., 2006; Jian et al., 2021). The more complex and volatile the business environment is, the more inclined are the firms to distribute cash dividends (Yafei & Zhu, 2022).

The above studies on the economic consequences of environmental uncertainty focus on the financial aspects of firms' decisions and performance, while studies on how environmental uncertainty affects firms' non-financial decisions, such as ESG performance, are scarce. ESG is a comprehensive framework for sustainable and coordinated development that involves how companies and investors incorporate environmental, social, and corporate governance issues into their business models and demonstrate their integrated performance in the marketplace. Rather than focusing on profit creation for shareholders only, companies aim to generate value for their stakeholders (including employees, customers, suppliers, communities, and governments) and try to achieve a win–win situation for all parties (Alex, 2023; Azeem et al., 2020; Stefan, 2020).

The existing literature examines the influencing factors of ESG from several aspects. At the micro level, factors such as corporate green innovation (Jian et al., 2021), equity structure (Sadok et al., 2016), family involvement (Sadok et al., 2016), and CEO personal characteristics (Hegde Shantaram & Mishra, 2019) can influence the ESG performance of firms. Several studies have also found that corporate digitalization can decrease agency costs, enhance corporate goodwill, and boost ESG performance (Helene et al., 2023; Mingyue et al., 2023). In terms of macro policies, the greening of the tax system can support corporate sustainability (Qihang et al., 2023), and central government administrative instruments such as environmental courts and environmental taxes can also play an important role in corporate environmental governance (Qihang et al., 2023; Xianhua et al., 2021). In addition, it has been noted that EPU increases the degree of CSR fulfillment (Çiğdem, 2021; Yi-Chun et al., 2018). However, there is no in-depth research on how environmental uncertainty at the firm level affects corporate ESG performance.

2.2 | Environmental uncertainty and corporate ESG performance

Environmental uncertainty may affect ESG performance in two ways. On one hand, from an investment decision perspective, firms need to weigh the costs and benefits of ESG investment before deciding whether to increase their investment in ESG activities. While facing uncertainty, the firms may reduce ESG investment as uncertainty increases the risk premium of long-term investment returns. Based on *real options theory* (Myers, 1977), firms may reduce or postpone their investments in order to benefit from potential future opportunities in the face of uncertainty. In other words, when environmental

uncertainty increases, the firms' operating environment becomes more complex due to increased risk as a result of higher uncertainty about investment returns. The increased risk due to environmental uncertainty can put direct pressure on firms' short-term cash flows (Asil, 2023). Considering that the ESG investments are long-term in nature and their benefits are mostly indirect and long-term (Jingwen et al., 2022; Wenbin & Price, 2016), which cannot bring benefits to firms in the short term, therefore, the firms may choose to reduce or postpone ESG activities after weighing the associated costs and discounted benefits.

Further, in terms of firms' precautionary motives; when facing higher uncertainty firms have stronger precautionary motives to invest less and hold cash (Phan Hieu et al., 2019). Indeed, firms' precautionary cash savings are equivalent to exercising real options (Michael, 2013). Jiun-Lin et al. (2016) also point out that the real option component of firms' cash holdings increases during economic downturns, which is explained by the increased value of precautionary savings. Higher levels of cash holdings are effective in enhancing firms' financial flexibility against the adverse effects of uncertainty shocks, such as financial crises (Denis David & Sibilkov, 2010; Ran et al., 2010). Therefore, firms may increase cash holdings under environmental uncertainty and reduce ESG investments that do not provide short-term benefits.

On the other hand, increasing cash holdings is not the only anti-risk strategy for the firms as ESG activities themselves may work as anti-risk strategies for the firms. Corporate ESG performance, as an important measure of reputation (Hatem et al., 2020), can act as a shield for the firms against operational risks associated with high uncertainty (Muhammad et al., 2022), by increasing stakeholder attention and engagement (Çiğdem, 2021). Therefore, firms may increase ESG investments to enhance risk resilience under environmental uncertainty. However, in the context of the Chinese financial market, such anti-risk measures may not be effective as the investors may not appreciate the ESG activities carried out by the firms (Tanveer et al., 2022). According to Shang Dao Rong Green's China Responsible Investment Report 2021,[5] there are only seven real ESG investment funds in the Chinese market by the end of 2020, and ESG ratings were only released in 2014 (MSCI released ESG ratings in the US in 2008[6]), which shows that the history of ESG investment in the Chinese market is not long and large enough. As a result, Chinese investors may not understand the concept of ESG investment well and may not pay enough attention to ESG activities (Tanveer et al., 2022). Martins (2022) points out that in developing countries, stakeholders may not be able to assess the benefits of ESG well and the competitive gains from ESG investment may be very limited. Further, the quality of ESG investments is not high enough as per the data of ESG ratings of China Securities. The percentage of ESG ratings reaching A or above is very small and gradually appeared after 2016. Therefore, low-quality ESG investment activities may not lead to higher risk

resilience. Based on these arguments, we develop our first hypothesis as under:

> **H1.** Environmental uncertainty is negatively associated with corporate ESG performance in China.

2.3 | Environmental uncertainty, corporate ESG performance, and investment opportunities

The investment opportunities are a set of feasible investment projects that a firm can undertake given its resources and constraints. It may also be referred to as a set of profitable projects that a firm can undertake with its available resources (Debarati & Dutta, 2021). These investment opportunities are influenced by a firm's financial constraints, which are the limitations on the firm's ability to raise external funds due to information asymmetry, agency costs, or market imperfections (Yacine & Khan, 2013). Financial constraints can affect a firm's optimal investments and financing decisions, and thus its value (Sai et al., 2013).

According to the *pecking order theory*, firms prefer to use internal funds over external funds when financing their investments, because internal funds are less costly and less riskier than external funds (Myers, 1984). Therefore, firms with more financial constraints or less access to external finance tend to hold more cash than firms with lesser financial constraints or more access to external finance (Yacine & Khan, 2013). Studies have shown that a firm with tight financing constraints has a smaller set of investment opportunities because it cannot access enough external funds to invest in profitable projects (Phan Hieu et al., 2019). However, a firm with fewer financing constraints has a larger set of investment opportunities due to its easier access to different financing options (Yacine & Khan, 2013).

Real options are the value that a firm creates when it has the option to make future investment decisions based on its set of investment opportunities, i.e., the range of possible investments at different times and under different circumstances (Myers, 1977). Real options theory implies that management has the flexibility to decide when to wait, delay, abandon, curtail, or expand the corresponding investment depending on the situation. Previous studies have shown that a larger set of investment opportunities provides managers with more options to choose from under uncertain conditions (Feixue, 2009; Jiun-Lin et al., 2016) and enhances the effectiveness of decisions (Dong & Yuanyang, 2017). Copeland Thomas and Antikarov (2005) demonstrate that the value of real options is greater when uncertainty is higher and managers have more room to adjust their investments. Feixue, 2009 also confirms that the negative relationship between uncertainty and firm investment becomes stronger with a larger set of investment opportunities.

Accordingly, we argue that if the firms under environmental uncertainty postpone or reduce their ESG investments to pursue other investment opportunities, then the firms with larger investment opportunities may have a higher tendency to reduce ESG investments and increase regular business investments in response to higher environmental uncertainty (Jingwen et al., 2022). Specifically, firms with

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[5]ESG Disclosure, Shang Dao Rong green, WIND information.

[6]https://www.msci.com/zh/esg-ratings#:~:text=MSCI%20ESG%20Ratings%20aim%20to,to%20power%20your%20investment%20decisions.

lesser financing constraints may curtail their ESG investments more due to their higher ability to finance real investments under higher environmental uncertainty. Based on these arguments, we formulate the following hypothesis.

H2. Financing constraints moderate the association between environmental uncertainty and corporate ESG performance in China.

2.4 | Environmental uncertainty, corporate ESG performance, and competition

Competitive pressure is generally manifested by intense industry competition or lower market position, which affects firms' risk aversion and investment decisions (Luigi et al., 2018). Under higher environmental uncertainty, firms may reduce their ESG investments, which are long-term, irreversible, and costly, and their benefits are indirect and uncertain. However, the degree of ESG reduction may vary depending on the competitive pressure faced by firms.

The degree of industry competition measures the level of rivalry among firms in an industry and is a key factor in regulating the relationship between uncertainty and firm investment behavior (Huseyin & Ion, 2016). In highly monopolistic industries, where there are few competitors, firms can afford to invest in ESG activities to gain a higher reputation and stakeholder support (Hatem et al., 2020), which can further consolidate their monopolistic position. In highly competitive industries, where there are many competitors, firms face serious business risks (Ni et al., 2023). On the one hand, to cope with the pressure of maintaining market position and ensuring stability, management may prefer to invest in projects that can bring short-term benefits due to their own interests and career development (Ling et al., 2020). On the other hand, firms may also disregard the long-term benefits of ESG activities due to survival pressure and choose to cut ESG costs. Given the various risks associated with technology and markets, and the lack of direct correlation between ESG inputs and outputs, management may reduce ESG investments to stay ahead of fierce competition.

Firms' risk also depends on their market position, which measures their relative share or rank in the market. Firms with lower market positions are more vulnerable to potential competitors, while firms with better market positions can reduce their losses by delaying investments and waiting for more information about market conditions (Hussein & Varela, 2017). In the context of ESG investments, firms with better market position can reduce the adverse effects of environmental uncertainty by increasing stakeholder association and reputational insurance through ESG investments. However, the firms with lower market positions may forgo the long-term gains from ESG enhancement due to small investment opportunities and insufficient payment capacity and may focus only on reducing ESG costs and enhancing short-term performance under environmental uncertainty. Therefore, a better market position or a lower industry may reduce the negative impact of environmental uncertainty on ESG investments. Accordingly, we develop our third hypothesis as under:

H3. Industry competition moderates the association between environmental uncertainty and corporate ESG performance in China.

3 | DATA, VARIABLES, AND METHODOLOGY

3.1 | Data sources

This article uses financial data from the China stock market and accounting research database and corporate ESG performance data from the China Securities ESG rating system. We finalize a dataset of 3045 Chinese firms listed during the period from 2008 to 2020. This sample dataset excludes financial firms, firms with missing data, and those with ST, ST*, or PT[7] status. To reduce the impact of outliers, we winsorize all the continuous variables at the 1% level.

3.2 | Variables

3.2.1 | Dependent variable (ESG performance)

Corporate ESG performance is our dependent variable and we measure it using the data from the Sino-Securities Index (SNSI) ESG Rating system.[8] This data source is preferred over other ESG rating systems, such as MSCI, Hexun, Bloomberg, Wind, and SynTao Green Finance, because it has better evaluation criteria, localization, reference indicators, coverage, update frequency, and retrospective period (Feng et al., 2022; Tianjiao et al., 2021). The SNSI ESG Rating system refers to the latest ESG reporting guideline published by the Hong Kong Exchange and follows international standards. It combines China's national conditions into the SNSI ESG rating methodology, covering 3 primary indicators, 14 secondary indicators, and 26 tertiary indicators, with over 130 underlying data indicators (See Table A1 for SNSI ESG Rating system). It also includes indicators relevant to the current development stage in China. The bottom-level indicators are weighted by industry to obtain the ESG score and the final AAA-C rating of nine grades for each company. The final ESG score has two variables: the original ESG score; and the ESG rating (the nine ratings are assigned from 9 to 1 in ascending order). A higher ESG score indicates a better ESG performance of the company.

3.2.2 | Explanatory variable

This article follows Dipankar and Olsen (2009) to measure the environmental uncertainty faced by firms using the industry-adjusted coefficient of variation of firm sales revenue. Environmental uncertainty originates from the external environment and affects the core

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[7]Special Treatment, Particular Treatment.

[8]https://chindices.com/files/Sino-Securities%20Index%20ESG%20Ratings%20Methodology.pdf.

business activities of enterprises, which are reflected in the fluctuations of their sales revenue. The calculation is as follows:

$$\text{Sale}_{it} = \beta_0 + \beta_1 \text{Year}_t + \epsilon_{it} \qquad (1)$$

The first step is to perform an ordinary least squares regression on Equation (1) and obtain the residual ϵ_{it} as the abnormal sales revenue. The second step is to calculate the standard deviation of abnormal sales revenue for 5 years and divide it by the average of sales revenue over the same period to get the unadjusted industry

uncertainty. The final step is to calculate the median environmental uncertainty of the firm's industry and divide the unadjusted industry uncertainty by it to get the industry-adjusted environmental uncertainty, following Dipankar and Olsen (2009).

3.2.3 | Moderating variables

This article measures the financing constraint (KZ) faced by firms using the KZ index adapted to the Chinese market context, following the

TABLE 1 Variable definitions.

Variable type	Variable names	Variable symbol	Variable definition
Dependent variables	ESG performance	ESG	ESG ratings provided by Sino-Securities Index (SNSI).
		ESG_S	ESG raw score divided by 100.
Explanatory variable	Environmental uncertainty	EU	Measured by the coefficient of variation of industry-adjusted firms' sales revenue over the past 5 years.
Moderating variables	Financing constraints	FC	Measured using Kaplan and Zingales (KZ) index.
	Industry competition	HHI	Measured using the Herfindahl Index HHI.
Control variables	Enterprise size	SIZE	Natural logarithm of total assets.
	Operating cash flow	OCF	Net cash flow from operating activities / Total assets.
	Financial leverage	LEV	Ratio of total liabilities to total assets.
	Corporate growth	GR	Annual sales growth.
	Profitability	ROA	Ratio of net profit to total assets.
	Board size	BSZ	Total number of board of directors.
	Board independence	BIN	Ratio of independent directors on board.
	Duality	DUAL	1 if the chairman and general manager are in one position, otherwise 0.
	Shareholding ratio of the largest shareholder	TOP1	Number of shares held by the largest shareholder at the end of the period/total share capital.

TABLE 2 Summary statistics.

	Obs.	Mean	Std. dev.	Median	Min.	Max.
ESG	23,287	4.030	1.165	4.000	1.000	8.000
ESG S	23,287	0.726	0.058	0.729	0.400	0.924
EU	23,287	1.300	1.159	0.963	0.124	6.847
FC	23,287	1.545	2.275	1.699	−5.071	6.914
HHI	23,287	0.087	0.104	0.052	0.015	1.000
SIZE	23,287	22.374	1.305	22.215	19.774	27.464
OCF	23,287	0.053	0.087	0.050	−0.234	0.341
LEV	23,287	0.467	0.202	0.468	0.069	0.936
GR	23,287	0.155	0.450	0.087	−0.639	2.923
ROA	23,287	0.028	0.069	0.030	−0.329	0.191
BSZ	23,287	8.744	1.794	9.000	0.000	18.000
BIN	23,287	0.392	0.091	0.375	0.000	1.000
DUAL	23,287	0.176	0.381	0.000	0.000	1.000
TOP1	23,287	33.908	15.072	31.570	0.286	89.986

Abbreviations: BIN, board independence; BSZ, board size; DUAL, CEO-chairman duality; ESG, environmental, social, and governance; EU, environmental uncertainty; FC, financial constraints; GR, corporate growth; HHI, Herfindahl index; OCF, operating cash flow; LEV, leverage; ROA, return on assets; TOP1, top shareholder's ownership.

study of Kaplan and Zingales (1997) and the method of Huanyu and Hao (2022). A higher value of the KZ index indicates a higher degree of financing constraints for a firm. The KZ index, compared with other indices, can capture and measure the financing constraint from multiple perspectives, such as net operating cash flow, dividend payment level, and Tobin's Q index, which are the main factors in the KZ index. The construction KZ index involves the following steps: first, it classifies enterprises based on their annual cash dividends/total assets (D/A), cash and cash equivalents/total assets (CASH/A), cash flows from operating activities/total assets (CF/A), and asset liability ratio (LEV). If D/A is below the median, then $KZ_1 = 1$; Cash/A is below the median, $KZ_2 = 1$; CF/A below the median, $KZ_3 = 1$; Lev is above the median, $KZ_4 = 1$. Subsequently, with KZ as the dependent variable and D/A, CASH/A, CF/A, and LEV as independent variables, Ordered Logit regression was performed on Equation (2) to estimate the regression coefficients of each variable:

$$KZ_{it} = \alpha_0 + \alpha_1 D_{it}/A_{it-1} + \alpha_2 CASH_{it}/A_{it-1} + \alpha_3 CF_{it}/A_{it-1} + \alpha_4 LEV_{it} \quad (2)$$

The larger the KZ index is, the higher the degree of financing constraint the listed company faces.

Industry competition (HHI) is our second moderator and we follow Ma and Han (2021) to measure industry competition using the Herfindahl–Hirschman Index. We calculate HHI by squaring the market share of each firm in the industry based on its sales revenue and summing them up. The market share of a firm is the ratio of its sales revenue to the total sales revenue of the industry. A higher value of the index indicates a higher concentration of firms and a lower degree of competition in the industry.

3.2.4 | Control variables

Based on prior significant studies (Chung-Jen et al., 2018; Sudip et al., 2013; Tanveer et al., 2022), this article controls for firm-level factors that may affect the ESG performance of firms. These factors include firm size (SIZE), operating cash flow (OCF), financial leverage (LEV), corporate growth (GR), return on assets (ROA), board size (BSZ), board independence (BIN), CEO-chairman duality (DUAL), and top shareholder's ownership (TOP1). Table 1 provides the definitions and measurements of all the variables.

3.3 | Methodology

To investigate the impact of environmental uncertainty (EU) on corporate ESG performance (H1), we develop the following baseline econometric model:

$$ESG\_P_{it} = \beta_0 + \beta_1 EU_{it} + \beta_m Controls_{it} + Industry_i + Year_t + \varepsilon_{it} \quad (3)$$

where ESG_P_{it} represents one of the two measures of ESG performance, i.e., ESG ratings (ESG) and ESG raw score divided

TABLE 3 Pairwise correlations.

Variables	ESG	ESG_S	EU	FC	HHI	SIZE	OCF	LEV	GR	ROA	BSZ	BIN	DUAL	TOP1	VIF
ESG	1.000														
ESG_S	0.965***	1.000													
EU	−0.170***	−0.177***	1.000												1.06
FC	−0.204***	−0.214***	0.090***	1.000											2.18
HHI	−0.049***	−0.051***	0.012	0.013***	1.000										1.02
SIZE	0.303***	0.309***	−0.056***	−0.025***	0.068***	1.000									1.65
OCF	0.117***	0.125***	−0.065***	−0.587***	0.060***	0.057***	1.000								1.23
LEV	−0.034***	−0.039***	0.041***	0.595***	0.021***	0.419***	−0.162***	1.000							2.28
GR	0.086***	0.092***	0.387***	−0.075***	0.003	0.058***	0.110***	0.024***	1.000						1.03
ROA	0.320***	0.339***	−0.132***	−0.480***	0.001	0.087***	0.363***	−0.314***	0.214***	1.000					1.24
BSZ	0.079***	0.082***	−0.065***	0.019***	0.087***	0.248***	0.057***	0.145***	−0.003	0.055***	1.000				1.18
BIN	0.067***	0.071***	−0.018***	−0.016***	−0.002	−0.040***	−0.009	−0.008	−0.007	0.042***	−0.257***	1.000			1.08
DUAL	−0.082***	−0.084***	0.023***	−0.057***	−0.057***	−0.132***	−0.009	−0.113***	0.015**	−0.013*	−0.168***	0.007	1.000		1.05
TOP1	0.124***	0.128***	−0.007	−0.057***	0.101***	0.261***	0.092***	0.099***	0.027***	0.140***	0.070***	0.030***	−0.069***	1.000	1.10

Note: The table presents pairwise correlations. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

TABLE 4 The impact of EU on ESG Performance.

	(1) ESG	(2) ESG_S	(3) ESG	(4) ESG_S	(5) ESG	(6) ESG_S
EU	−0.167***	−0.009***	−0.138***	−0.007***	−0.137***	−0.007***
	(0.006)	(0.000)	(0.006)	(0.000)	(0.006)	(0.000)
SIZE			0.325***	0.017***	0.315***	0.016***
			(0.007)	(0.000)	(0.007)	(0.000)
OCF			0.151*	0.008*	0.142*	0.008*
			(0.085)	(0.004)	(0.085)	(0.004)
LEV			−0.898***	−0.047***	−0.899***	−0.047***
			(0.043)	(0.002)	(0.043)	(0.002)
GR			0.184***	0.010***	0.187***	0.010***
			(0.017)	(0.001)	(0.017)	(0.001)
ROA			3.464***	0.185***	3.403***	0.182***
			(0.118)	(0.006)	(0.118)	(0.006)
BSZ					0.005	0.000
					(0.004)	(0.000)
BIN					0.814***	0.042***
					(0.082)	(0.004)
DUAL					−0.106***	−0.005***
					(0.018)	(0.001)
TOP1					0.002***	0.000***
					(0.000)	(0.000)
Constant	3.620***	0.705***	−2.936***	0.369***	−3.143***	0.358***
	(0.096)	(0.005)	(0.157)	(0.008)	(0.161)	(0.008)
Observations	23,287	23,287	23,287	23,287	23,287	23,287
Adjusted R^2	0.093	0.098	0.269	0.289	0.273	0.293
F-stat	28.121***	29.816***	92.919***	102.681***	91.160***	100.702***
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

by 100 (ESG_S), of firm i at time t. EU_{it} represents environmental uncertainty of firm i at time t measures as an industry-adjusted coefficient of variation of firm sales revenue. $Controls_{it}$ are nine firm-level control variables as explained in Table 1. $Industry_i$ and $Year_t$ are industry and time-fixed effects. ε_{it} represents standard errors.

Next, to investigate the moderating impact of financial constraints (FC) on the relationship between EU and ESG performance (H2), we extend our baseline model as under:

$$ESG\_P_{it} = \beta_0 + \beta_1 EU_{it} + \beta_2 FC_{it} + \beta_3 EU_{it} * FC_{it} + \beta_m Controls_{it} + Industry_i + Year_t + \varepsilon_{it} \quad (4)$$

where FC_{it} represents financial constraints for firm i at time t measured as Kalpan and Zingles index explained in section 3.2.

$EU_{it} * FC_{it}$ is the interaction term of environmental uncertainty and financing constraints of firm i at time t. Other variables are the same as explained in the baseline model.

Finally, to investigate the moderating impact of industry competition (HHI) on the relationship between EU and ESG performance (H3), we extend our baseline model as under:

$$ESG\_P_{it} = \beta_0 + \beta_1 EU_{it} + \beta_2 HHI_{it} + \beta_3 EU_{it} * HHI_{it} + \beta_m Controls_{it} + Industry_i + Year_t + \varepsilon_{it} \quad (5)$$

where HHI_{it} represents competition of firm i at time t measured as the Herfindahl–Hirschman Index explained in section 3.2. $EU_{it} * HHI_{it}$ is the interaction term of environmental uncertainty and the Herfindahl–Hirschman Index of firm i at time t. Other variables are the same as explained in the baseline model.

TABLE 5 The moderating impact of Financial Constraints (FC) on EU and ESG Performance.

	(1) ESG	(2) ESG_S	(3) ESG	(4) ESG_S
EU	−0.134***	−0.007***	−0.152***	−0.008***
	(0.006)	(0.000)	(0.008)	(0.000)
FC	−0.057***	−0.003***	−0.070***	−0.003***
	(0.006)	(0.000)	(0.006)	(0.000)
EU × FC			0.009***	0.001***
			(0.002)	(0.000)
SIZE	0.296***	0.015***	0.298***	0.015***
	(0.007)	(0.000)	(0.007)	(0.000)
OCF	−0.530***	−0.026***	−0.507***	−0.025***
	(0.108)	(0.005)	(0.108)	(0.005)
LEV	−0.552***	−0.029***	−0.556***	−0.030***
	(0.055)	(0.003)	(0.055)	(0.003)
GR	0.185***	0.010***	0.195***	0.010***
	(0.017)	(0.001)	(0.017)	(0.001)
ROA	3.154***	0.170***	3.155***	0.170***
	(0.121)	(0.006)	(0.121)	(0.006)
BSZ	0.004	0.000	0.004	0.000
	(0.004)	(0.000)	(0.004)	(0.000)
BIN	0.813***	0.042***	0.805***	0.041***
	(0.082)	(0.004)	(0.082)	(0.004)
DUAL	−0.108***	−0.005***	−0.107***	−0.005***
	(0.018)	(0.001)	(0.018)	(0.001)
TOP1	0.001***	0.000***	0.001***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	−2.635***	0.384***	−2.650***	0.383***
	(0.169)	(0.008)	(0.169)	(0.008)
Observations	23,287	23,287	23,287	23,287
Adjusted R^2	0.276	0.297	0.277	0.297
F-stat	91.652***	101.151***	90.980***	100.310***
Industry effect	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

4 | EMPIRICAL RESULTS

4.1 | Descriptive statistics and correlation analysis

We present descriptive statistics of the sample dataset in Table 2. The mean value of the ESG rating is 4.030, with a minimum of 1.000 and a maximum of 8.000. This indicates variations in ESG performance across different firms and on average a poor ESG performance by the Chinese sample firms. The mean value of 0.726 for ESG_S with a median value of 0.729 indicates that almost half of the sample firms have average ESG scores. The mean value of 1.300 for EU with a standard deviation of 1.159 indicates significant variations in environmental uncertainty faced by the sample Chinese firms.

Table 3 presents the results of pairwise correlations. We observe significant negative correlations of EU with ESG (−0.170***) as well as ESG_S (−0.177***), indicating that environmental uncertainty reduces the ESG performance of the Chinese firms (H1).

4.2 | The impact of environmental uncertainty on corporate ESG performance

Table 4 reports the regression results investigating the impact of environmental uncertainty on corporate ESG performance. Columns

TABLE 6 The impact of Industry Competition (HHI) on EU and ESG Performance.

	(1) ESG	(2) ESG_S	(3) ESG	(4) ESG_S
EU	−0.137***	−0.007***	−0.147***	−0.008***
	(0.006)	(0.000)	(0.008)	(0.000)
HHI	0.031	0.003	−0.137	−0.004
	(0.140)	(0.007)	(0.159)	(0.008)
EU × HHI			0.123**	0.005**
			(0.055)	(0.003)
SIZE	0.316***	0.016***	0.316***	0.016***
	(0.007)	(0.000)	(0.007)	(0.000)
OCF	0.141*	0.008*	0.141*	0.008*
	(0.085)	(0.004)	(0.085)	(0.004)
LEV	−0.899***	−0.047***	−0.901***	−0.047***
	(0.043)	(0.002)	(0.043)	(0.002)
GR	0.187***	0.010***	0.186***	0.010***
	(0.017)	(0.001)	(0.017)	(0.001)
ROA	3.402***	0.182***	3.399***	0.182***
	(0.118)	(0.006)	(0.118)	(0.006)
BSZ	0.005	0.000	0.005	0.000
	(0.004)	(0.000)	(0.004)	(0.000)
BIN	0.814***	0.042***	0.815***	0.042***
	(0.082)	(0.004)	(0.082)	(0.004)
DUAL	−0.106***	−0.005***	−0.106***	−0.005***
	(0.018)	(0.001)	(0.018)	(0.001)
TOP1	0.002***	0.000***	0.002***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	−3.149***	0.358***	−3.136***	0.358***
	(0.164)	(0.008)	(0.164)	(0.008)
Observations	23,287	23,287	23,287	23,287
Adjusted R^2	0.273	0.293	0.273	0.294
F-stat	90.226***	99.673***	89.380***	98.719***
Industry effect	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

(1 and 2) of Table 4 show the regression results with the core explanatory variable (EU) only. We observe highly significant associations of EU with ESG (−0.167***) and ESG_S (−0.009***). Columns (3 and 4) show the results of regression analysis including five firm-level control variables and Columns (5 and 6) show the result of regression analysis after controlling for firm-level characteristics as well as corporate governance variables. We observe a consistently significant negative association of EU with ESG as well as ESG_S in all the regression models. These results favor hypothesis 1 of the study and indicate that an increase in environmental uncertainty decreases the ESG performance of Chinese firms.

Among the firm-level control variables, we observe significant positive associations of SIZE, GR, and ROA with corporate ESG performance, indicating that bigger, growing, and more profitable Chinese firms have better ESG performance. Then, we observe a highly significant negative association between LEV and ESG performance, indicating a lower ESG performance for high-leveraged firms. Talking about corporate governance variables, we observe a highly significant negative association of BIN with ESG performance, indicating a negative impact of board independence on corporate ESG performance. However, we observe positive associations of DUAL and TOP1 with ESG performance, indicating positive impacts of

TABLE 7 The impact of EU on ESG performance; robustness– using alternate proxies.

	(1) ESG_HeXun	(2) ESG_Bloomberg
EU	−0.005***	−0.359***
	(0.001)	(0.067)
SIZE	0.039***	2.398***
	(0.001)	(0.065)
OCF	0.068***	3.283***
	(0.012)	(0.881)
LEV	−0.075***	−2.750***
	(0.006)	(0.467)
GR	0.004	0.103
	(0.002)	(0.183)
ROA	0.808***	−0.059
	(0.016)	(1.357)
BSZ	0.001**	0.055
	(0.001)	(0.037)
BIN	0.009	2.794***
	(0.011)	(0.755)
DUAL	−0.008***	−0.361*
	(0.002)	(0.185)
TOP1	0.000***	0.003
	(0.000)	(0.004)
Constant	−0.603***	−36.198***
	(0.023)	(1.571)
Observations	19,953	8634
Adjusted R^2	0.402	0.521
F-stat	145.177***	104.118***
Industry effect	Yes	Yes
Time effect	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

ownership concentration and power concentration with CEO on corporate ESG performance.

4.3 | Moderating impact of financing constraints and industry competition

Table 5 presents the regression results investigating the direct (Columns 1 and 2) and moderating (Columns 3 and 4) impact of financing constraints (FC) on corporate ESG performance. In Columns 1 and 2, we observe highly significant negative associations of FC with ESG (−0.057***) and ESG_S (−0.003***), indicating that financing constraints reduce corporate ESG performance. In Columns 3 and 4, we include the interaction term of EU with FC and observe highly significant positive associations of the interaction (EU × FC) with ESG (0.009***) and ESG_S (0.001***), favoring hypothesis 2 of

TABLE 8 The impact of EU on ESG performance; robustness– controlling for country-level variables.

	(1) ESG	(2) ESG_S
EU	−0.137***	−0.007***
	(0.006)	(0.000)
SIZE	0.315***	0.016***
	(0.007)	(0.000)
OCF	0.142*	0.008*
	(0.085)	(0.004)
LEV	−0.899***	−0.047***
	(0.043)	(0.002)
GR	0.187***	0.010***
	(0.017)	(0.001)
ROA	3.403***	0.182***
	(0.118)	(0.006)
BSZ	0.005	0.000
	(0.004)	(0.000)
BIN	0.814***	0.042***
	(0.082)	(0.004)
DUAL	−0.106***	−0.005***
	(0.018)	(0.001)
TOP1	0.002***	0.000***
	(0.000)	(0.000)
GDP	0.010	0.000
	(0.006)	(0.000)
BMG	0.031***	0.002***
	(0.005)	(0.000)
Constant	−3.788***	0.325***
	(0.177)	(0.009)
Observations	23,287	23,287
Adj R^2	0.273	0.293
F-stat	91.160***	100.702***
Industry effect	Yes	Yes
Time effect	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

the study. These positive associations of the interaction term (EU × FC) indicate that environmental uncertainty decreases corporate ESG performance, however, higher financing constraints dilute the negative impact of environmental uncertainty on corporate ESG performance. Firms with higher financing constraints have fewer investment opportunities as compared to firms with lower financing constraints. Therefore, when facing higher environmental uncertainty firms with better investment opportunities (lower financing constraints) have a higher probability of shifting their investment from ESG activities to real asset investments.

Table 6 presents the regression results investigating the direct (Columns 1 and 2) and moderating (Columns 3 and 4) impact of industry competition (HHI) on corporate ESG performance. In Columns 1 and 2, we observe insignificant associations of HHI with ESG (0.031) and ESG_S (0.003), indicating no direct impact of industry competition on corporate ESG performance. In Columns 3 and 4, we include the interaction term of EU with HHI and observe significant positive associations of the interaction (EU × HHI) with ESG (0.123**) and ESG_S (0.005**), favoring hypothesis H3 of the study. These positive associations of the interaction term (EU × HHI) indicate that environmental uncertainty decreases the corporate ESG performance, however, lower industry competition (higher values of HHI means lower industry competition) dilutes the negative impact of environmental uncertainty on corporate ESG performance. The plausible explanation is that industry competition increases the pressure and incentives for companies to differentiate themselves from rivals and gain a loyal customer base by enhancing their ESG performance. For example, in the highly competitive e-commerce industry in China, leading platforms such as Alibaba, JD.com, and Pinduoduo have launched various ESG initiatives such as green packaging, carbon neutrality, rural development, and consumer protection to attract and retain customers who care about sustainability and social impact. These initiatives may help them mitigate the negative effects of environmental uncertainty by creating a positive brand image and reputation. Moreover, industry competition reduces the bargaining power and influence of dominant players who may have lower ESG standards and practices. For example, in the less competitive coal industry in China, state-owned enterprises such as China Shenhua Energy and China Coal Energy have a large market share and political clout. These enterprises may have less motivation and pressure to improve their ESG performance due to their monopoly position and close ties with the government. They may also resist or delay the implementation of stricter environmental regulations and standards that may affect their profitability.

TABLE 9 The impact of EU on ESG performance; robustness–restricting time-period to 2008–2018.

	(1) ESG	(2) ESG_S
EU	−0.137***	−0.007***
	(0.006)	(0.000)
SIZE	0.315***	0.016***
	(0.007)	(0.000)
OCF	0.142*	0.008*
	(0.085)	(0.004)
LEV	−0.899***	−0.047***
	(0.043)	(0.002)
GR	0.187***	0.010***
	(0.017)	(0.001)
ROA	3.403***	0.182***
	(0.118)	(0.006)
BSZ	0.005	0.000
	(0.004)	(0.000)
BIN	0.814***	0.042***
	(0.082)	(0.004)
DUAL	−0.106***	−0.005***
	(0.018)	(0.001)
TOP1	0.002***	0.000***
	(0.000)	(0.000)
Constant	−3.143***	0.358***
	(0.161)	(0.008)
Observations	23,287	23,287
Adj R^2	0.273	0.293
F-stat	91.160***	100.702***
Industry effect	Yes	Yes
Time effect	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
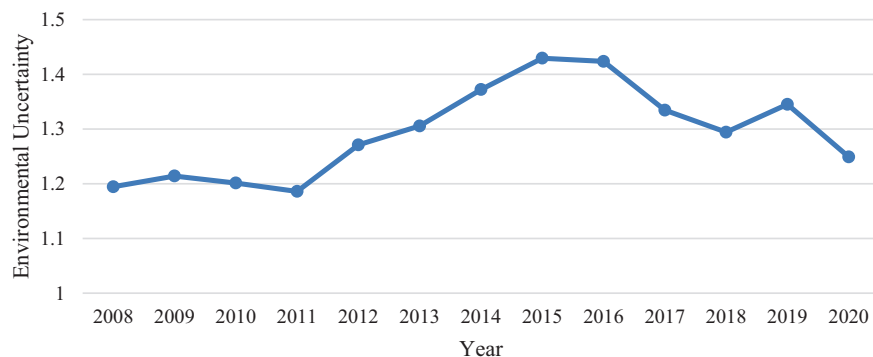*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

4.4 | Robustness

4.4.1 | Using alternate proxies of ESG performance

Since there is no consensus on ESG performance evaluation standards domestically and internationally, the ESG ratings of several major domestic and foreign rating agencies vary widely. Therefore, this article uses alternate proxies of ESG performance provided by different

FIGURE 1 Annual mean values of environmental uncertainty.

TABLE 10 The impact of EU on ESG performance; robustness–before and after the abrupt change in EU.

	Before 2015		After 2015	
	(1) ESG	(2) ESG_S	(3) ESG	(4) ESG_S
EU	−0.075***	−0.004***	−0.187***	−0.010***
	(0.008)	(0.000)	(0.010)	(0.000)
SIZE	0.308***	0.016***	0.328***	0.017***
	(0.009)	(0.000)	(0.010)	(0.001)
OCF	0.020	0.003	0.405***	0.020***
	(0.102)	(0.005)	(0.138)	(0.007)
LEV	−0.779***	−0.039***	−1.042***	−0.056***
	(0.055)	(0.003)	(0.065)	(0.003)
GR	0.100***	0.005***	0.261***	0.015***
	(0.021)	(0.001)	(0.026)	(0.001)
ROA	2.951***	0.152***	3.321***	0.181***
	(0.180)	(0.009)	(0.161)	(0.008)
BSZ	0.014***	0.001***	−0.004	−0.000
	(0.005)	(0.000)	(0.007)	(0.000)
BIN	1.033***	0.053***	0.675***	0.034***
	(0.112)	(0.005)	(0.119)	(0.006)
DUAL	−0.112***	−0.006***	−0.100***	−0.005***
	(0.025)	(0.001)	(0.025)	(0.001)
TOP1	−0.000	−0.000	0.003***	0.000***
	(0.001)	(0.000)	(0.001)	(0.000)
Constant	−3.158***	0.359***	−3.650***	0.331***
	(0.201)	(0.010)	(0.254)	(0.013)
Observations	11,379	11,379	11,908	11,908
Adjusted R^2	0.255	0.274	0.302	0.325
F-stat	44.241***	48.653***	60.170***	66.766***
Industry Effect	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

rating agencies for robustness purposes. We use HeXun[9] and Bloomberg[10] ESG scores as alternate proxies and re-run baseline regression analysis. The results are presented in Table 7. Using these alternate proxies reduces our sample size, however, the results indicate significant negative associations of EU with ESG_HeXun (−0.005***) and

ESG_Bloomberg (−0.359***), consistent with the main results of the study.

4.4.2 | Controlling for country-level variables

The macroeconomic conditions in a country can affect the firm performance and consequently corporate ESG performance (Azeem et al., 2020). Therefore, to control for the impact of economic conditions, we include GDP (GDP per capita growth rate) and BMG (broad money growth rate) in the baseline regression equation and re-run the analysis. The regression results are presented in Table 8. We observe significant negative associations of EU with ESG (−0.137***) and ESG_S (−0.007***) even after controlling for macro-economic factors.

TABLE 11 The impact of EU on ESG performance; robustness–addressing endogeneity due to reverse causality–lagged regressions.

	(1) ESG	(2) ESG_S	(3) ESG	(4) ESG_S	(5) ESG	(6) ESG_S
L1.EU	−0.109***	−0.006***				
	(0.006)	(0.000)				
L2.EU			−0.107***	−0.005***		
			(0.007)	(0.000)		
L3.EU					−0.101***	−0.005***
					(0.008)	(0.000)
SIZE	0.332***	0.017***	0.341***	0.017***	0.345***	0.018***
	(0.007)	(0.000)	(0.008)	(0.000)	(0.009)	(0.000)
OCF	0.168*	0.009*	0.201*	0.011**	0.253**	0.013**
	(0.094)	(0.005)	(0.104)	(0.005)	(0.116)	(0.006)
LEV	−0.910***	−0.047***	−0.940***	−0.049***	−0.980***	−0.051***
	(0.048)	(0.002)	(0.052)	(0.003)	(0.057)	(0.003)
GR	0.043**	0.002***	0.032*	0.002**	0.042**	0.002**
	(0.017)	(0.001)	(0.019)	(0.001)	(0.021)	(0.001)
ROA	3.759***	0.202***	3.753***	0.203***	3.617***	0.196***
	(0.128)	(0.006)	(0.140)	(0.007)	(0.150)	(0.007)
BSZ	0.005	0.000	0.005	0.000	0.006	0.000
	(0.005)	(0.000)	(0.005)	(0.000)	(0.005)	(0.000)
BIN	0.853***	0.044***	0.845***	0.043***	0.816***	0.042***
	(0.090)	(0.004)	(0.097)	(0.005)	(0.104)	(0.005)
DUAL	−0.132***	−0.006***	−0.149***	−0.007***	−0.165***	−0.008***
	(0.020)	(0.001)	(0.022)	(0.001)	(0.024)	(0.001)
TOP1	0.002***	0.000***	0.002***	0.000***	0.002***	0.000***
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Constant	−3.760***	0.328***	−3.924***	0.318***	−3.966***	0.315***
	(0.175)	(0.009)	(0.193)	(0.010)	(0.210)	(0.010)
Observations	23,287	23,287	23,287	23,287	23,287	23,287
Adjusted R^2	0.276	0.296	0.277	0.297	0.279	0.299
F-stat	80.815***	88.871***	70.688***	77.647***	62.329***	68.520***
Industry effect	Yes	Yes	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

4.4.3 | Restricting time-period to 2008–2018

On April 4, 2019, the China Securities Regulatory Commission officially issued the revised Code of Governance for Listed Companies.[11] This revised code helped firms enhance social responsibility and information disclosure requirements and to foster communication between companies and stakeholders. It also encouraged the proactive social responsibility of companies with market mechanisms and consequently influenced the ESG performance of companies. Therefore, to exclude the impact of this special event on the research findings, this study excludes data from 2019

and 2020 and estimates the baseline model for the period from 2008 to 2018. The results reported in Table 9 show a consistent negative impact of environmental uncertainty on corporate ESG performance.

4.5 | Before and after the abrupt change in environmental uncertainty

Figure 1 shows the annual mean values of environmental uncertainty during the sample period, and it can be observed from the figure that the average environmental uncertainty of China's listed companies experienced a structural break in 2015. The mean values of EU had an increasing trend before 2015, in 2015 it reached its

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[11]http://www.csrc.gov.cn/csrc_en/c102034/c1372459/1372459/files/P020190415336431477120.pdf.

maximum point and then it showed a decreasing trend. Therefore, this article examines the impact of environmental uncertainty on corporate ESG performance around 2015, and the regression results are presented in Table 10. The results indicate a significant negative association of environmental uncertainty with corporate ESG performance before and after 2015, which is consistent with the previous results.

4.6 | Endogeneity issues

Although environmental uncertainty is relatively exogenous for firms, ESG performance may affect firms' decisions and their sales performance (Lins Karl et al., 2017; Ni et al., 2023), i.e., ESG changes may cause fluctuations in firms' sales performance, which in turn may lead to increased environmental uncertainty for firms, thus creating reverse causality. To address the reverse causality issue, this study follows Susanne and Dumay (2022) and considers the lagged values of environmental uncertainty as a remedy. We introduce one to three-year lagged values of the explanatory variables into our baseline regression model. The results are reported in Table 11. We observe a significant negative association of environmental uncertainty with corporate ESG performance consistent for 1–3 years lagged models, indicating that the results of the study do not suffer from endogeneity issues due to reverse causality.

Besides the endogeneity problem due to reverse causality in the empirical testing process of this article, there may also be endogeneity problems due to omitted variables, such as CEO characteristics, legal environment, local digitalization level, and other firm-specific factors that may affect ESG performance (Badi, 2008). For this reason, we apply firm-fixed effects regression and the results are presented in

TABLE 12 The impact of EU on ESG performance; robustness–addressing endogeneity due to unobserved heterogeneity and selection bias.

	Fixed-effects		PSM	
	(1) ESG	(2) ESG_S	(3) ESG	(4) ESG_S
EU	−0.054***	−0.003***	−0.133***	−0.007***
	(0.006)	(0.000)	(0.008)	(0.000)
SIZE	0.211***	0.011***	0.304***	0.016***
	(0.014)	(0.001)	(0.009)	(0.000)
OCF	−0.033	−0.001	−0.134	−0.005
	(0.076)	(0.004)	(0.112)	(0.006)
LEV	−0.726***	−0.041***	−0.938***	−0.049***
	(0.058)	(0.003)	(0.057)	(0.003)
GR	0.156***	0.008***	0.268***	0.015***
	(0.014)	(0.001)	(0.030)	(0.001)
ROA	2.588***	0.140***	3.496***	0.186***
	(0.110)	(0.005)	(0.154)	(0.008)
BSZ	−0.020***	−0.001***	0.009*	0.000*
	(0.006)	(0.000)	(0.005)	(0.000)
BIN	0.319***	0.016***	0.759***	0.038***
	(0.078)	(0.004)	(0.111)	(0.006)
DUAL	−0.021	−0.000	−0.107***	−0.006***
	(0.021)	(0.001)	(0.024)	(0.001)
TOP1	0.000	0.000	0.001**	0.000**
	(0.001)	(0.000)	(0.001)	(0.000)
Constant	−0.214	0.495***	−2.831***	0.374***
	(0.287)	(0.014)	(0.216)	(0.011)
Observations	23,287	23,287	13,324	13,324
Adjusted R^2	0.047	0.023	0.287	0.305
F-stat	92.018***	115.323***	54.695***	59.423***
Firm effect	Yes	Yes	No	No
Industry effect	No	No	Yes	Yes
Time effect	Yes	Yes	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

Table 12 (Columns 1 and 2). We observe significant negative associations of EU with ESG (-0.054***) and ESG_S (-0.003***) even after controlling for firm-fixed effects.

Finally, to control for the endogeneity issues due to selection bias, this study uses the propensity score matching (PSM) method. We classify environmental uncertainty into two groups using the median value of EU. We assign EU = 1 if a firm's EU is higher than its median 0.963, and 0 otherwise. Using the previous controls as matching variables, a 1:1 nearest neighbor matching method was applied to the sample to categorize firms into the control group and the treatment group. The results of the post-match sample regression are reported in Table 12 (Columns 3 and 4). The results of the matched regression estimation also indicate that there is a significant negative impact of environmental uncertainty on corporate ESG performance, i.e., the core findings of this study.

4.7 | Additional analysis

Considering that environmental uncertainty may have different effects on corporate ESG performance across different industries (Tanveer et al., 2022). Therefore, we split our sample into highly polluting and environmentally sensitive industries based on the 2012 revised Guidelines on Industry Classification of Listed Companies by the China Securities Regulatory Commission. We run our baseline regression model on this split sample and report the results in Table 13. The results show that the impact of EU on corporate ESG performance is significantly negative for both groups.

Finally, we examine the impact of micro-level environmental uncertainty on firms' ESG performance under different macro-level environmental uncertainty. Referring to the findings of Hatem et al. (2020); Helene et al. (2023) and Tianjiao et al. (2021) the higher the

TABLE 13 The impact of EU on ESG performance–heavy-polluting and environmentally sensitive industries.

	Heavy-polluting industries		Environmentally sensitive industries	
	(1) ESG	(2) ESG_S	(3) ESG	(4) ESG_S
EU	−0.164***	−0.009***	−0.139***	−0.008***
	(0.016)	(0.001)	(0.022)	(0.001)
SIZE	0.285***	0.015***	0.274***	0.014***
	(0.017)	(0.001)	(0.023)	(0.001)
OCF	0.287	0.014	0.590**	0.032**
	(0.198)	(0.010)	(0.285)	(0.014)
LEV	−0.934***	−0.048***	−0.913***	−0.043***
	(0.101)	(0.005)	(0.149)	(0.007)
GR	0.265***	0.015***	0.190***	0.011***
	(0.040)	(0.002)	(0.057)	(0.003)
ROA	3.336***	0.177***	3.140***	0.171***
	(0.260)	(0.013)	(0.362)	(0.018)
BSZ	0.010	0.000	0.032**	0.001*
	(0.011)	(0.001)	(0.015)	(0.001)
BIN	0.811***	0.039***	0.887***	0.043***
	(0.183)	(0.009)	(0.259)	(0.013)
DUAL	−0.136***	−0.007***	0.065	0.004
	(0.038)	(0.002)	(0.055)	(0.003)
TOP1	0.004***	0.000***	0.002	0.000
	(0.001)	(0.000)	(0.002)	(0.000)
Constant	−2.416***	0.400***	−2.100***	0.422***
	(0.386)	(0.019)	(0.537)	(0.027)
Observations	4778	4778	2177	2177
Adjusted R^2	0.274	0.291	0.316	0.330
F-stat	21.220***	23.004***	12.673***	13.439***
Industry effect	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

TABLE 14 The moderating impact of EPU on EU and ESG performance.

	(1) ESG	(2) ESG_S	(3) ESG	(4) ESG_S
EU	−0.137***	−0.007***	−0.584***	−0.031***
	(0.006)	(0.000)	(0.163)	(0.008)
EPU	4.492***	0.233***	4.386***	0.227***
	(0.537)	(0.027)	(0.539)	(0.027)
EU × EPU			0.091***	0.005***
			(0.033)	(0.002)
SIZE	0.315***	0.016***	0.315***	0.016***
	(0.007)	(0.000)	(0.007)	(0.000)
OCF	0.142*	0.008*	0.143*	0.008*
	(0.085)	(0.004)	(0.085)	(0.004)
LEV	−0.899***	−0.047***	−0.898***	−0.047***
	(0.043)	(0.002)	(0.043)	(0.002)
GR	0.187***	0.010***	0.187***	0.010***
	(0.017)	(0.001)	(0.017)	(0.001)
ROA	3.403***	0.182***	3.396***	0.182***
	(0.118)	(0.006)	(0.118)	(0.006)
BSZ	0.005	0.000	0.005	0.000
	(0.004)	(0.000)	(0.004)	(0.000)
BIN	0.814***	0.042***	0.815***	0.042***
	(0.082)	(0.004)	(0.082)	(0.004)
DUAL	−0.106***	−0.005***	−0.106***	−0.005***
	(0.018)	(0.001)	(0.018)	(0.001)
TOP1	0.002***	0.000***	0.001***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	−25.890***	−0.821***	−25.362***	−0.793***
	(2.728)	(0.135)	(2.734)	(0.135)
Observations	23,287	23,287	23,287	23,287
Adjusted R^2	0.273	0.293	0.273	0.294
F-stat	91.160***	100.702***	90.332***	99.803***
Industry effect	Yes	Yes	Yes	Yes
Time effect	Yes	Yes	Yes	Yes

Note: Standard errors are in parentheses. All the variables are defined in Table 1.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

EPU increases the CSR. Therefore, we introduce EPU in our baseline regression model and interact it with environmental uncertainty to examine the impact of environmental uncertainty on corporate ESG performance under an uncertain macroeconomic environment. We use a news-based EPU index developed by (Davis Steven et al., 2019). The related regression results are reported in Table 14. We observe significant positive direct impact of EPU on corporate ESG performance (Columns 1 and 2), indicating that EPU increases ESG performance of the Chinese firms. Then, we observe significant positive moderating impact of EPU on the relationship between EU and corporate ESG performance (Columns 3 and 4). These results indicate that the negative impact of environmental uncertainty on corporate ESG performance is mitigated under high EPU. The possible reason is that overall macro

uncertainty reduces the set of investment opportunities for all firms (Huseyin & Ion, 2016), and thus the value of real options for firms to delay ESG investments is smaller under high EPU compared to low EPU, and thus high EPU weakens the negative relationship between environmental uncertainty and ESG performance.

5 | DISCUSSION

Environmental uncertainty is a key factor that affects firms' ESG performance, which reflects their sustainability and social impact. However, the literature on how environmental uncertainty influences ESG performance is scarce and inconclusive. Some studies have

focused on the macro-level factor of EPU and its impact on ESG or CSR (Çiğdem, 2021; Lin & Li, 2023; Ya-Ru et al., 2022), but they have not considered the micro-level factor of environmental uncertainty that varies for each firm depending on its industry, location, and strategy. Moreover, some studies have examined the determinants of ESG performance from different perspectives, such as country-level factors, firm-level factors (Sadok et al., 2016), management-level factors (Hegde Shantaram & Mishra, 2019), and others, but they have not explored how environmental uncertainty affects ESG performance and what mechanisms are involved.

This study suggests that environmental uncertainty hurts ESG performance and that this effect is moderated by the size of the investment opportunity set and the competitive pressure faced by firms. The study explains this finding based on the *real options theory* which suggests that firms may delay or defer their investments under uncertainty until they receive more information or clarity about future outcomes. When environmental uncertainty increases, firms face a more complex business environment and greater investment risks, and the value of real options for firms to delay sustainable investments increases. Therefore, firms tend to reduce ESG investments after weighing the long-term benefits and short-term direct investment costs under high-risk premiums. Moreover, the value of real options and the scope of investment adjustment depend on the size of the investment opportunities and the competitive pressure faced by firms. Firms with higher investment opportunities have more real options and can reduce their ESG investments more under higher environmental uncertainty.

Stakeholder theory suggests that firms should consider the interests and needs of all their stakeholders in their strategic decisions, not just their shareholders. By doing so, firms can enhance their reputation and legitimacy, improve their operational efficiency and innovation, and contribute to their long-term financial performance and resilience. Firms facing lower competition understand this and invest in ESG even during high environmental uncertainty to consolidate their monopolistic position in the market.

The article's findings are relevant and important for understanding the ESG performance of firms in China, which is a key country to watch in all aspects of ESG performance — not just because of its economic importance, but also as a case example of how a heavily centralized government decides to implement ESG policies going forward.[12] The article's findings can also provide some implications and recommendations for managers, investors, regulators, and policymakers who are interested in improving the ESG performance of firms in China. For example, managers could use scenario analysis or sensitivity analysis to assess the impact of different types of uncertainty on their ESG performance and make more informed and proactive decisions. Investors could use ESG ratings or indicators to evaluate the ESG performance of firms in China and incorporate them into their portfolio selection or asset allocation strategies. Regulators could use incentives or penalties to encourage or discourage certain types of

ESG activities or disclosures by firms in China. Policymakers could use communication or coordination mechanisms to reduce uncertainty and increase clarity for firms in China regarding their ESG expectations and requirements.

6 | CONCLUSION AND RECOMMENDATIONS

This article empirically investigates how environmental uncertainty affects firms' ESG performance, which reflects their sustainability performance. The article uses data from China's A-share listed companies from 2008 to 2020, based on the ESG ratings of China Securities. The article finds that: (1) Environmental uncertainty has a negative impact on ESG performance, and firms lower their ESG activities when they face higher environmental uncertainty. (2) The negative impact of environmental uncertainty on ESG performance is weaker for firms with higher financing constraints, as they have less flexible investment opportunities and probably cannot shift their ESG investments under higher environmental uncertainty. (3) The negative impact of environmental uncertainty on ESG performance is also weaker for firms in less competitive industries or with better market positions, as these firms do not face high competitive pressure and keep investing in ESG activities to build their reputation under higher environmental uncertainty. (4) Environmental uncertainty negatively affects the ESG performance of the firms operating in heavily polluting and environmentally sensitive industries. (5) High EPU weakens the negative relationship between environmental uncertainty and ESG performance, as it reduces the value of real options and the scope of investment adjustment for firms.

The article explains the findings based on the *real options theory* and *stakeholders' theory*. *Real options theory* suggests that firms may delay or defer their investments under uncertainty until they receive more information or clarity about future outcomes. When environmental uncertainty increases, firms face a more complex business environment and greater investment risks, and the value of real options for firms to delay sustainable investments increases. Therefore, firms tend to reduce ESG investments after weighing the long-term benefits and short-term direct investment costs under high-risk premiums. Moreover, the value of real options and the scope of investment adjustment depend on the size of the investment opportunity set and the competitive pressure faced by firms. Firms with lower competitive pressure may keep investing in ESG activities under higher environmental uncertainty to satisfy their stakeholders.

The study has some practical implications for firms, regulators, and investors. For firms, it is important to improve their ability to quickly identify and respond to environmental uncertainties and to flexibly adjust their business decisions. They should also choose appropriate ESG investment strategies at different stages, taking into account their actual situation. For regulators, they should formulate differentiated policies to encourage ESG under different environmental uncertainties. They should implement different incentive policies according to the micro characteristics of firms, such as increasing

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[12] https://www.weforum.org/agenda/2020/12/green-wave-of-esg-investment-is-breaking-in-china/.

subsidies for firms with high environmental uncertainty to promote sustainable development. They should also avoid frequent fluctuations in macroeconomic policies to create a prudent policy environment. Policy fluctuations may intensify environmental uncertainties, change firms' expectations and decision-making behavior, and ultimately affect the green and coordinated development of the economy. Therefore, economic policy adjustments should remain prudent and steady. For investors, this article's research can help them judge the value of ESG performance, and the rationality of ESG decisions, and select an appropriate investment portfolio based on environmental uncertainty and ESG performance.

ACKNOWLEDGMENT

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APPENDIX A

TABLE A1 Sino-securities index ESG rating system (SNSI).

Three pillars	14 thematic indicators	26 key indicators
Environmental	Environmental management system	Environmental management system
	Green management objectives	Plans or targets for low carbon
		Green procurement policy or plan
	Green products	Carbon footprint
		Sustainable products or services
	External environmental certification	Environmental certification of product or company
	Environmental violations	Environmental violations and infractions
Social	Institution system	Quality of social responsibility reporting
	Health and safety	Goals or plans to reduce safety incidents
		Negative operating incidents
		Trend of operating accidents
	Social contribution	Social responsibility-related donations
		Employee growth rate
		Rural revitalization
	Quality management	Quality certification of products or companies
Corporate governance	Institution building	Corporate self ESG monitoring
	Governance structure	Connected transactions
		Director/supervisor ratio
	Operating activities	Tax transparency
	Operational risks	Asset quality
		Overall financial credibility
		Short-term debt service risk
		Pledge ratio of major shareholders
		Quality of information disclosure
	External discipline	Exchange sanctions, etc.
		Violations by executives of listed companies