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RESEARCH ARTICLE OPEN ACCESS

CEO Characteristics, Carbon Disclosure and Earnings Management in China: The Role of Risk Tolerance and Environmental Uncertainty

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ABSTRACT

This study examines how earnings management shapes the relationship between CEO characteristics, i.e., gender, education, age, tenure and financial expertise, and corporate carbon disclosure. While prior research links managerial attributes to environmental transparency, limited attention has been paid to the role of financial reporting incentives and contextual contingencies in explaining heterogeneous outcomes. Drawing on a sample of Chinese listed firms, we find that earnings management significantly moderates the association between CEO characteristics and carbon disclosure, although the direction and magnitude of this effect vary across firms. We further show that firm-level risk tolerance and environmental uncertainty act as important boundary conditions. In high-risk-tolerance firms, CEO age is negatively associated with carbon disclosure, whereas female and more-educated CEOs are associated with higher disclosure levels; these relationships are not observed in low-risk-tolerance firms. Under high environmental uncertainty, female CEOs disclose more carbon information, while longer-tenured CEOs disclose less. In contrast, in low-uncertainty contexts, older CEOs disclose more, whereas CEOs with higher education and financial expertise disclose less. Our results are robust to alternative measures and sensitivity tests. Focusing on China, this study highlights the conditional role of managerial traits in environmental reporting and offers implications for governance design and disclosure oversight. Our findings should be interpreted cautiously as they are based on Chinese listed firms and CEO demographic proxies, which may limit generalisability and may not fully capture underlying managerial mechanisms.

1 | Introduction

Greenhouse gas (GHG) emissions have increasingly been recognised as a critical global challenge requiring urgent and coordinated action from policymakers, corporations and society at large (Beck and Ferasso 2023; Yamineva and Liu 2019). In response to international agreements, such as the Paris Agreement in 2015, governments have intensified regulatory and institutional efforts to enhance environmental accountability and transparency. In

this context, China has emerged as a particularly important setting, not only due to its status as one of the world's largest carbon emitters but also because of its proactive policy agenda, including green finance initiatives introduced in 2016 and ambitious targets to achieve carbon peaking and carbon neutrality by 2030 and 2050, respectively (Yamineva and Liu 2019). These developments have heightened the strategic importance of corporate carbon disclosure as a mechanism for aligning firm behaviour with broader sustainability objectives.

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In this context, a growing body of literature has examined the role of CEO characteristics, such as gender, age, tenure, education and financial expertise, in shaping corporate environmental disclosure practices (e.g., Amore et al. 2019; Chithambo et al. 2020; Cho et al. 2019; Huang 2013; Saraswati 2021; Velte 2026). However, existing evidence remains inconclusive and fragmented (Saraswati 2021; Velte 2026). For example, while some studies find that female leadership enhances environmental transparency (Caby et al. 2024; Chithambo et al. 2020), others suggest that such effects are contingent on contextual factors and may not be universally observed. Similarly, research on CEO age reports mixed findings, with some studies indicating that older CEOs adopt more conservative or sustainability-oriented strategies, while others find no systematic relationship (Cho et al. 2019; Huang 2013). The role of CEO tenure is equally debated, as longer tenure may either facilitate strategic continuity and environmental commitment or lead to managerial entrenchment that constrains disclosure incentives (Chen et al. 2019; Khan et al. 2020). Moreover, although CEO education and financial expertise are generally associated with enhanced decision-making capabilities and strategic awareness of environmental risks (Amore et al. 2019), empirical support for their direct influence on carbon disclosure remains inconsistent.

These inconsistencies point to a critical gap in the literature. Crucially, there is a lack of attention to the underlying mechanisms and contextual conditions that shape the CEO characteristics–carbon disclosure nexus. Addressing this gap requires moving beyond direct-effect models toward a more contingent framework that incorporates managerial incentives and organisational contexts. In this regard, earnings management represents a particularly salient yet underexplored mechanism. As a manifestation of managerial discretion in financial reporting, earnings management reflects underlying agency conflicts and raises concerns about the credibility of corporate disclosures (Healy and Wahlen 1999; Kim et al. 2012). Prior research offers two competing perspectives. From an opportunistic standpoint, managers may strategically use environmental disclosures to obscure opportunistic reporting behaviour or engage in ‘greenwashing’ (Abbas et al. 2023; Luo and Wu 2019). In contrast, the ethical perspective suggests that managers committed to social responsibility are less likely to manipulate earnings and more likely to provide transparent environmental disclosures (Laksmmana and Yang 2009; Salewski and Zülch 2014). These competing views imply that earnings management may fundamentally condition how CEO characteristics translate into carbon disclosure outcomes.

Building on this premise, this study adopts a contingency-based extension of upper echelons theory, which posits that organisational outcomes reflect the values, experiences and cognitive bases of top executives, but that these effects are shaped by contextual factors (Cho et al. 2019; Huang 2013). Specifically, we argue that the influence of CEO characteristics on carbon disclosure is contingent not only on internal reporting incentives (i.e., earnings management) but also on external and organisational conditions. To capture this heterogeneity, we introduce risk tolerance and environmental uncertainty as boundary conditions. Risk tolerance reflects a firm’s strategic orientation

and willingness to undertake long-term investments, which may strengthen or constrain managerial discretion in disclosure practices. Environmental uncertainty, in turn, captures the volatility and unpredictability of the firm’s operating environment, which can alter managerial incentives, increase scrutiny and shape disclosure strategies (Gerged 2021; Lemma et al. 2020). These contingencies provide a more nuanced theoretical lens through which to understand the complex interplay between CEO attributes, financial reporting behaviour and environmental transparency.

Empirically, this study utilises panel data from Chinese listed firms over the period 2010–2021, focusing on carbon-intensive industries where disclosure pressures are particularly salient. The findings reveal that earnings management significantly moderates the relationship between CEO characteristics and carbon disclosure, although the nature of this moderation varies across contexts. Specifically, older CEOs are generally associated with lower levels of carbon disclosure, whereas more educated and female CEOs tend to enhance disclosure. However, these relationships are not uniform. In high-risk-tolerance firms, the negative effect of CEO age is more pronounced, while the positive effects of female leadership and education are strengthened. Under conditions of high environmental uncertainty, female CEOs exhibit greater disclosure, whereas longer tenured CEOs reduce disclosure; in contrast, in low-uncertainty environments, older CEOs disclose more, while CEOs with higher education and financial expertise disclose less. These findings highlight the importance of considering both internal and external contingencies in explaining managerial influence on environmental reporting.

This study makes several important contributions. First, it advances the carbon disclosure literature by introducing earnings management as a critical moderating mechanism in the relationship between CEO characteristics and environmental transparency, thereby bridging the gap between financial reporting quality and sustainability disclosure (Bilal et al. 2022; Kim et al. 2012). Second, it extends the application of upper echelons theory by incorporating firm-level and environmental contingencies, i.e., risk tolerance and environmental uncertainty, to explain heterogeneity in managerial effects. Third, by focusing on China, the study provides context-specific insights into environmental governance in a major emerging economy undergoing rapid regulatory and institutional transformation. From a practical perspective, the findings offer actionable implications for regulators, standard setters and corporate stakeholders. They highlight the need for more targeted governance and disclosure oversight mechanisms that account for managerial traits, reporting incentives and contextual risks, particularly in high-emission settings. More broadly, the study contributes to ongoing efforts to enhance corporate accountability and supports global sustainability agendas, including the United Nations Sustainable Development Goals related to responsible consumption and climate action (Beck and Ferasso 2023).

2 | Review of the Literature

Previous research has extensively investigated the relationship between sustainability-related disclosures and earnings

management, with a predominant focus on developed economies (Kim et al. 2012; Liu et al. 2017). However, there remains a noticeable gap in the literature pertaining to developing economies. While some studies have explored this nexus in countries like Kuwait (Gerged et al. 2020) and Jordan (Gerged et al. 2023), they devoted less attention to the specific link between carbon disclosures and earnings management (Bilal et al. 2022). Moreover, the conclusions drawn from prior studies on the carbon disclosure-earnings management relationship remain inconclusive, suggesting the presence of other influential factors. For instance, Velte (2026) highlighted the crucial role of moderators in the relationship between CEO characteristics and carbon disclosure. Our study aims to contribute to this contemporary literature by examining the moderating role of earnings management on the relationship between CEO characteristics and carbon disclosure.

Prior work has extensively explored the motivations behind corporate disclosures of carbon-related information, particularly in relation to stakeholder engagement (Lemma et al. 2020). Lemma et al. (2020) argue that firms often disclose carbon emissions data and adopt ethical practices to foster long-term relationships with their stakeholders. Consistent with this perspective, previous research indicates that companies committed to ethical conduct, including transparent carbon disclosures, are generally averse to engaging in deceptive practices such as earnings management (Muttakin et al. 2015; Yip et al. 2011). However, the relationship between carbon disclosure and earnings management remains complex. While some studies have found a negative correlation between carbon disclosure and earnings management (Gerged et al. 2020; Kumala and Siregar 2020), others have observed a direct influence of sustainability-related disclosures on earnings manipulation (Gargouri et al. 2010; Habbash and Haddad 2019).

Our research is anchored in the frameworks of stakeholder, legitimacy and agency theories, providing a multifaceted lens to explore this relationship. We argue that firms that engage in such disclosures may also feel pressured to maintain higher reporting standards, thereby reducing the propensity for earnings management. From an agency theory perspective, enhanced carbon disclosure can reduce information asymmetry, prompting more responsible financial reporting (Jensen and Meckling 1976). Legitimacy theory suggests that these disclosures help firms align their actions with societal expectations, thereby discouraging manipulative practices (Suchman 1995). Stakeholder theory indicates that robust carbon disclosure is critical for maintaining stakeholder trust, which in turn may deter earnings manipulation (Freeman 1984).

In our study, we propose that earnings management could play a significant moderating role in the relationship between CEO characteristics and carbon disclosure, an aspect that is largely unexplored in the existing literature. By examining the potential influence of CEO characteristics such as age, gender, educational background and tenure on this relationship, our study aims to fill this empirical void. Specifically, we focus on the Chinese context, which offers a unique setting to explore these dynamics, given its status as a major emerging economy with distinct corporate and environmental challenges.

In addition, our research introduces a novel perspective on two boundary conditions, high- vs. low-risk tolerance and environmental uncertainty, by extending the earnings management detailed moderating analysis in the Chinese economic landscape.

2.1 | Hypotheses Development

2.1.1 | CEO Characteristics, Carbon Disclosure and Earnings Management

Upper echelons theory, as proposed by Hambrick and Mason (1984), suggests that managers' perceptions and strategic decisions are influenced by their intrinsic demographic characteristics, such as gender, age, tenure, educational background and financial expertise. First, prior research has reported mixed results on the relationship between female CEOs and sustainability disclosures (Kassinis et al. 2016; Velte 2026). For example, Caby et al. (2024) documented the positive impact of female CEOs on carbon disclosure, while Caby et al. (2020) failed to find any impact. Second, research suggests that CEO age is associated with less carbon disclosure. Older CEOs are more concerned with risk aversion and traditional business models instead of sustainability or carbon-related information (Kollmuss and Agyeman 2002). Other studies show mixed results regarding the influence of CEO age on environmental disclosures (Chen et al. 2019; Chithambo et al. 2020; Huang 2013).

Third, studies on CEO tenure also present mixed findings, with some research indicating that long serving executives may have more expertise and resilience (Chen et al. 2019; Huang 2013; Owusu et al. 2022; Wei et al. 2018), while other studies suggest conflicting views on tenure's impact on environmental performance (Cho et al. 2019; Khan et al. 2020). Finally, education and financial expertise of CEOs are crucial for informed decision-making and effective addressing of environmental concerns (Amore et al. 2019; Chen et al. 2019). Nevertheless, some studies indicate a negative relationship between CEO characteristics and environmental disclosure (Li et al. 2022; Muttakin et al. 2018). Given the mixed evidence in the literature, Velte (2026) proposed that the moderation analysis is the appropriate way to extend this literature. Hence, our study contributes to this emerging literature by examining the moderating impact of earnings management on the relationship between CEO characteristics and carbon disclosure.

We expect that earnings management is a hypothetically powerful moderator as it captures managerial discretion and incentives in financial reporting, which shape the credibility and strategic intent of nonfinancial disclosures such as carbon disclosure. Earnings management under agency theory reflects information asymmetry and opportunistic incentives that can affect whether stakeholders view carbon disclosure as credible transparency or as strategic communication (Bilal et al. 2022; Chi and Cheng 2026).

Prior literature offers two contrasting perspectives. First, from an opportunistic standpoint, managers may strategically use

environmental disclosures to engage in 'greenwashing' to mislead the stakeholders (Abbas et al. 2023; Luo and Wu 2019). Second, the ethical perspective suggests that managers committed to social responsibility are less likely to manipulate earnings and more likely to provide transparent environmental disclosures (Laksmana and Yang 2009; Salewski and Zülch 2014). These competing views imply that earnings management may fundamentally condition how CEO characteristics translate into carbon disclosure outcomes. Conceptual discussions explicitly link earnings management and greenwashing/impression management as intertwined reporting behaviours, reinforcing the plausibility that earnings management changes the way CEO characteristics map into carbon disclosure choices. Therefore, we infer that the influence of CEO characteristics on carbon disclosure should vary with earnings management and hypothesise that:

Hypothesis 1. *Earnings management moderates the relationship between CEO characteristics and carbon disclosure.*

2.1.2 | Boundary Conditions: Risk Tolerance

Building on the premise that earnings management conditions how CEO characteristics influence the carbon disclosure (Hypothesis 1), we argue that the strength of this moderation is contingent on firms' risk tolerance, since risk appetite posture shapes both the incentives for discretionary reporting and the scrutiny applied to it (García Osma and Grande-Herrera 2021). Risk tolerance is measured by the long-term capital debt ratio, which reflects the firm's willingness to rely on long-horizon debt financing and thereby to accept greater exposure to downside risk and contracting pressure (Bagh et al. 2025). Prior studies claim that leverage is empirically linked to managers' earnings management behaviour and to the choice of earnings management instruments (Anagnostopoulou and Tsekrekos 2017; Chen et al. 2025), implying that the informational meaning and salience of earnings management differ between higher and lower debt reliance firms. Although carbon disclosure has become mandatory in different countries recently, however, it still gives discretion to the managers to choose what to disclose. Earnings management, which is also has the same discretion, is more likely to function as a consequential conditioning mechanism for CEO characteristics driven carbon disclosure when financing commitments heighten the costs of credibility loss and the benefits of strategic transparency (Farag and Mallin 2018; Zhao et al. 2024).

From an agency and disclosure incentives perspective, higher long-term debt reliance amplifies the importance of credible communication because lenders and other capital providers are more sensitive to information risk and downside outcomes (He et al. 2023; Suttipun 2023; Tang et al. 2024), thereby increasing the likelihood that the CEO characteristics-carbon disclosure relationship is contingent on the earnings management level. Related evidence in the literature further supports that leverage and environmental disclosure are jointly embedded in firms' strategic financing and communication choices, reinforcing that financing posture can shape disclosure incentives and constraints (Liu and Song 2025; Todaro et al. 2021; Tran and Pham 2024). Accordingly, we expect the CEO characteristics

and earnings management interaction to differ between high- and low-risk-tolerance firms. Thus, we formulate the following hypothesis:

Hypothesis 2. *The moderating role of earnings management in the relationship between CEO characteristics and carbon disclosure differs between high- and low-risk-tolerance firms.*

2.1.3 | Boundary Conditions: Environmental Uncertainty

Firm's environmental uncertainty reshapes the information environment in which discretionary climate disclosures are produced and evaluated (Bin-Feng et al. 2024; Habib et al. 2011; Magerakis and Habib 2022; Zhao and Wang 2025). From an information asymmetry perspective, higher uncertainty increases stakeholders' difficulty in assessing firm prospects and risk exposure, thereby altering the marginal benefits of voluntary disclosure and the demand for decision useful information (Bueno-García et al. 2026; Gregory and Keeney 2017; Romito and Vurro 2021). Consistent with this mechanism, evidence shows that firms respond to heightened investor uncertainty by increasing the likelihood and timeliness of carbon disclosure, implying that uncertainty systematically changes disclosure behaviour (Bueno-García et al. 2026; Habib et al. 2011). In CEO characteristics and carbon disclosure relationship perspective, uncertainty can heighten the relevance of the reporting, incentive reporting environment captured by earnings manipulation, making CEO characteristics more likely to translate into different carbon disclosure outcomes at different levels of earnings when the operating environment is less predictable (Zhao and Wang 2025).

At the same time, environmental uncertainty can raise disclosure frictions, verification difficulty, proprietary costs and perceived exposure to enforcement or reputational penalties, thereby changing how earnings management influences the CEO characteristics and carbon disclosure relationship (Bueno-García et al. 2026). Evidence from environmental disclosure settings shows that heightened scrutiny can restrict carbon disclosures and reduce quantitative specificity, illustrating that environmental information flows are constrained by oversight related frictions (Zhao and Wang 2025). Moreover, uncertainty can directly influence reporting incentives: Empirical evidence indicates that environmental uncertainty may be associated with greater earnings management, implying that the credibility environment proxied by earnings management is itself shaped by uncertainty regimes (Bermpei et al. 2022; Ghosh and Olsen 2009; Habib et al. 2011). Taken together, these arguments imply that the CEO characteristics and earnings management interaction should not be stable across uncertainty levels: Under high uncertainty, earnings management may condition CEO characteristics and the carbon disclosure relationship differently than under low uncertainty because both the benefits of disclosure (information demand) and the costs of disclosure (scrutiny and verifiability) change. Accordingly, we posit the following boundary condition hypothesis.

Hypothesis 3. *The moderating role of earnings management in the relationship between CEO characteristics and carbon disclosure differs between high and low environmental uncertainty firms.*

3 | Methodology

3.1 | Data and Sample

The sample consisted of 9197 firm-year observations of Chinese companies from 2010 to 2021 based on the data availability from the recently constructed WinGo textual analytics database. Data for earnings management, CEO characteristics and other control variables were collected from the CSMAR database. We extracted carbon disclosure data from the WinGo textual analytics database.

3.2 | Measurements of Research Variables

3.2.1 | Carbon Disclosure Index (CDI)

The dependent variable, the CDI, has been measured by using content analysis for 30 uniquely identified keywords of carbon disclosure. These keywords include air pollution, air quality, carbon dioxide, carbon footprint, carbon monoxide, climate change, direct emissions, waste disposal, emission of pollutants, emission reduction, emissions, emission source, energy consumption, energy efficiency, generation, energy saving, energy, GHG, low carbon, renewable energy, R & D personnel, patent, power saving, wastewater discharge, government subsidy, fossil fuel, consumables, water consumption, wastewater treatment and biodiversity.

3.2.2 | CEO Characteristics as Independent Variables

Following previous studies (García-Sánchez and Martínez-Ferrero 2019; Ting et al. 2015), we used CEO characteristics as a Independent variables in our study. These CEO characteristics are CEO gender, CEO education, CEO age, CEO tenure, and CEO financial expertise.

3.2.3 | Earnings Management Measures as Moderating Variables

In this study, we used three proxies to measure earnings management, acknowledging that these measures may capture different aspects of earnings manipulation, including income smoothing. The first proxy is discretionary accruals (EM1), measured using the modified Jones model (Dechow et al. 1995). The second is working capital accruals (EM2), assessed through the Dechow and Dichev (2002) model. Finally, real earnings management (REM) is evaluated using the approach outlined by Roychowdhury (2006). While these proxies are widely accepted in the literature, we recognise that they may not fully capture the complexities of managerial earnings behaviour and aim to present our findings with an awareness of potential biases in measurement.

Main Model

Following the modified Jones model (Dechow et al. 1995):

$$\frac{TA_{it}}{A_{it-1}} = \beta_0 \frac{1}{A_{it-1}} + \beta_1 \frac{\Delta SAL_{it}}{A_{it-1}} + \beta_2 \left(\frac{PPE_{it}}{A_{it-1}} \right) + \varepsilon_{it} \quad (1)$$

$$NDA_{it} = \beta_0 \frac{1}{A_{it-1}} + \beta_1 \frac{\Delta SAL_{it} - \Delta REC_{it}}{A_{it-1}} + \beta_2 \left(\frac{PPE_{it}}{A_{it-1}} \right) \quad (2)$$

$$DA_{it} = \frac{TA_{it}}{A_{it-1}} - NDA_{it} \quad (3)$$

TA_{it} : TA here stands for total accruals derived from deducting *the net cash flows from operations* from operating profit;

A_{it-1} : Lag value of total assets for removing the scale effect.

ΔSAL_{it} : Changes in sales volume (SAL).

PPE_{it} : PPE depicts the net value of proprietary, plant and equipment (e.g., fixed assets).

ΔREC_{it} : REC means for changes in accounts receivable.

NDA_{it} : NDA stands for nondiscretionary accruals.

DA_{it} : DA represents the discretionary accruals.

The coefficients of regression derived from Equation (1) are substituted into Equation (2) in order to get the nondiscretionary accruals (NDA_{it}). Further, we calculate the values of modified discretionary accruals (DA_{it}) after substituting the NDA_{it} value in Equation (3).

The current study has also used the working capital accruals (EM2) measured through Dechow and Dichev (2002) model. We use REM as an alternative proxy and measured EM through the Roychowdhury (2006).

3.2.4 | Boundary Conditions: Risk Tolerance and Environmental Uncertainty

We have included the two boundary conditions. First, risk tolerance is measured through the long-run debt capital ratio that a firm is going to use for its long-run projects. We have taken the above median value of this ratio for the high-risk-tolerance subsample and the below median value as low-risk tolerance. Second, following Liu and Song (2025), environmental uncertainty was predicted as abnormal revenues based on the residual values of the last 5 years' revenues, then we have taken the ratio of the standard deviation of the company's abnormal sales revenue over the past 5 years to the average sales revenue over the past 5 years. Similar to this condition, we have taken the above median value of this ratio for the high environmental uncertainty subsample and the below median value as low environmental uncertainty.

3.2.5 | Control Variables

These variables, including firm-specific characteristics, i.e., SOE, change in cash flow, change in revenues, size of the firm, leverage, profitability, CSR assurance and CSR_score, have been introduced for the robustness of the study analysis

as followed by previous researchers (Choi et al. 2013; Rezaee et al. 2020; Tan et al. 2020). We also control for corporate governance factors such as CEO duality, board size, and industry effects by using a dummy variable for high-polluting vs. low-polluting firms. The above variables have been defined and explained in Appendix 1.

3.3 | Research Models

In the current study, we used the fixed-effects model to test the hypotheses of our study as shown in Equation (4).

$$\begin{aligned} \text{CDI}_{it} = & \beta_{0i} + \beta_1 \text{CC}_{it} + \beta_2 \text{EM}_{it} + \beta_3 \text{CC}_{it} * \text{EM}_{it} + \beta_4 \text{CD}_{it} \\ & + \beta_5 \text{BS}_{it} + \beta_6 \text{HP}_{it} + \beta_7 \text{SOE}_{it} + \beta_8 \text{ROA}_{it} \\ & + \beta_9 \text{CF_vol}_{it} + \beta_{10} \text{Rev_vol}_{it} + \beta_{11} \text{SIZE}_{it} \\ & + \beta_{12} \text{LEV}_{it} + \beta_{13} \text{CSR_ass}_{it} + \beta_{14} \text{CSR_score}_{it} + u_{it} \end{aligned} \quad (4)$$

3.4 | Additional Analyses

For additional analysis, the disclosure measures have been divided (using median values) into two categories based on high and low carbon disclosure. Similarly, an additional investigation has been carried out for high and low-CSR-rated firms. These are also calculated on the basis of median values of CSR ratings. We have also used alternative proxies for our moderating variable (earnings management) to enhance robustness.

3.5 | Robustness

For robustness, we conduct the system GMM for the dynamic panel recommended by Arellano and Bond (1991) as shown in Equation (5).

$$\begin{aligned} \text{CDI}_{it} = & \beta_{0i} + \beta_1 \text{CDI}_{it-1} + \beta_2 \text{CC}_{it} + \beta_3 \text{EM}_{it} + \beta_4 \text{CC}_{it} * \text{EM}_{it} \\ & + \beta_5 \text{CD}_{it} + \beta_6 \text{BS}_{it} + \beta_7 \text{HP}_{it} + \beta_8 \text{SOE}_{it} \\ & + \beta_9 \text{ROA}_{it} + \beta_{10} \text{CF_vol}_{it} + \beta_{11} \text{Rev_vol}_{it} \\ & + \beta_{12} \text{SIZE}_{it} + \beta_{13} \text{LEV}_{it} + \beta_{14} \text{CSR_ass}_{it} + \beta_{15} \text{CSR_score}_{it} + u_{it} \end{aligned} \quad (5)$$

Drawing on prior research, we employed a two-step system GMM to address dynamic endogeneity arising from unobserved firm heterogeneity, simultaneity and persistence in carbon disclosure; compared with difference GMM, system GMM improves efficiency and mitigates weak-instrument concerns when variables are highly persistent by combining moment conditions in first differences and levels (Eugster 2020).

We have also used Heckman (1979) two-stage model to ensure the robustness of our findings. This technique is helpful in the face of the sample selection bias since a few companies failed to disclose their carbon emission. When applying this technique, we follow a similar approach to Zalata et al. (2019), which involves computing the inverse mills ratio (IMR) from the probit model in the first stage. We used a dummy variable as the dependent variable of the probit model. We assign the value of 1 if a firm's data are extracted from the WinGo textual analytics database and 0 if there is no data available. To estimate the probit model, following Bilal et al. (2022), we added the industry

CDI average as the instrumental variable as it captures industry norms or peer pressure, along with our main models' independent and control variables. To address endogeneity issues and sample selection bias, we additionally controlled for IMR in the second stage of the Heckman model.

4 | Empirical Results

Table 1, Panel A, describes the summary statistics for the variables. There is a total number of 9197 firm-year observations. The average value of carbon disclosure (dependent variable) is 0.19, which suggests that the disclosures regarding carbon emission are around 19% out of 100%, whereas 0.72 is the maximum score. This result is greater than the 11% reported by Tan et al. (2020). The average values of EM1, EM2 and REM are 0.04, 0.03 and 0.08, respectively. This finding is similar to that of Rezaee et al. (2020) in the Chinese context. The average value of CEO age is 54.24, with a standard deviation of 6.77, which implies that most Chinese CEOs are between 31 and 76 years old. The average value for CEO education is 4.64, with a standard deviation of 2.11, indicating that most of the Chinese CEOs have a master's or equivalent level of education. The CEO gender has a mean value of 0.10, suggesting that our sample has only 10% female CEOs. We find that 24% of CEOs in our dataset have financial expertise, while their average tenure is 6.28. Similarly, Table 1 describes the mean and standard deviation of the risk tolerance, environmental uncertainty and the control variables.

Table 1 also presents a univariate examination of SOEs vs. non-SOEs using *t*-tests (Panel B). The study indicates a substantial difference between SOEs and non-SOEs. We find that SOEs disclosed more carbon information than non-SOEs.

Table 2 describes the Pearson correlation coefficients with a significance level of 5%. The highest value of correlation is between return on assets and cash flow volatility (0.66), which is below the 0.70 cut-off point. Therefore, multicollinearity is not present in our model.

Table 3 in the study presents empirical evidence to evaluate Hypothesis 1 using fixed-effects model, exploring the moderating role of earnings management between CEO characteristics and carbon disclosure. The study uncovers several findings related to CEO characteristics. Firstly, CEO age is negatively associated with carbon disclosure. Secondly, the education level of CEOs exhibits a positive and significant relationship with carbon disclosure. Thirdly, the impact of CEO gender on carbon disclosure is positive. Fourthly, CEOs with financial expertise demonstrate a positive and significant influence on carbon disclosure. Lastly, CEO tenure also positively influences carbon disclosure. The results also reveal a significant negative association between earnings management and carbon disclosure. Finally, regarding the moderation effect of earnings management, the interaction term (e.g., CEO age * EM1) is negative and significant, indicating that earnings management weakens the relationship between CEO age and carbon disclosure. While earnings management interacts with other components of CEO characteristics such as education, gender, financial expertise, and tenure, which

TABLE 1 | Descriptive statistics.

Panel A: Overall sample						
Variable	Obs	Mean	Std. dev.	Min	Max	
CDI	9197	0.19	0.20	0.00	0.72	
EM1	9197	0.04	0.09	−0.01	0.08	
EM2	9197	0.03	0.09	−0.01	0.08	
REM	9197	0.08	0.12	−0.02	0.10	
CEO age	9197	54.24	6.77	31.00	76.00	
CEO edu	9197	4.64	2.11	1.00	7.00	
CEO gender	9197	0.10	0.27	0.00	1.00	
CEO expertise	9197	0.24	0.43	0.00	1.00	
CEO tenure	9197	6.28	4.42	4.00	9.00	
RT	9197	0.53	0.50	0.00	1.00	
EU	9197	0.48	0.50	0.00	1.00	
CEO duality	9197	0.27	0.46	0.00	1.00	
Board size	9197	6.20	1.05	4.00	11.00	
HP	9197	4.42	2.06	1.00	6.00	
SOE	9197	0.49	0.47	0.00	1.00	
ROA	9197	0.09	0.08	−0.17	0.23	
CF_vol	9197	0.06	0.11	−0.46	0.50	
REV_vol	9197	0.81	0.60	0.03	6.62	
SIZE	9197	26.30	2.62	18.10	28.46	
LEV	9197	0.51	0.26	0.06	0.88	
CSR_ass	9197	0.32	0.52	0.00	1.00	
CSR_score	9197	3.04	0.92	−2.74	5.06	
Panel B: SOEs vs. non-SOEs sample						
Variables	SOEs mean	Non-SOEs mean	Dif	St. err.	t value	p
CDI	0.18	0.15	−0.03	0.00	−9.52	0.00
EM1	0.02	0.02	0.00	0.00	3.82	0.01
CEO age	52.14	48.98	−3.16	0.21	−13.04	0.00
CEO edu	4.88	4.23	−0.65	0.04	−16.64	0.00
CEO gender	0.05	0.11	0.06	0.01	8.60	0.00
CEO expertise	0.22	0.22	0.00	0.01	−0.28	0.82
CEO tenure	44.28	53.15	8.87	2.04	7.94	0.00
CEO duality	0.21	0.25	0.04	0.01	0.32	0.00
Board size	4.02	3.92	−0.10	0.02	−5.14	0.00
HP	4.86	3.96	−0.09	0.04	−15.65	0.00
ROA	0.05	0.08	0.03	0.00	18.14	0.00
CF_vol	0.03	0.06	0.03	0.00	19.74	0.00
REV_vol	0.82	0.78	−0.04	0.01	−3.06	0.01
SIZE	25.27	22.16	−3.11	0.04	−38.12	0.00
LEV	0.49	0.42	−0.07	0.02	−30.24	0.00
CSR_ass	0.46	0.22	−0.24	0.01	−24.52	0.00
CSR_score	3.24	3.04	−0.20	0.02	−5.04	0.00

Note: Appendix 1 explains the proxies of all the variables.

TABLE 2 | Correlations between independent and control variables.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) CDI	1.00																
(2) CEO age	−0.14*	1.00															
(3) CEO edu	0.09*	−0.13*	1.00														
(4) CEO gender	0.06*	−0.03	−0.09*	1.00													
(5) CEO expertise	0.08*	0.07*	−0.06*	0.19*	1.00												
(6) CEO tenure	0.02	0.21*	0.06*	0.00	0.00	1.00											
(7) CEO duality	0.07*	0.11*	0.14*	0.08*	0.00	0.07*	1.00										
(8) Board size	0.18*	0.02	0.06*	−0.13*	0.09*	0.02	0.08*	1.00									
(9) HP	0.24*	0.13*	0.12*	−0.06*	−0.01	−0.08*	0.24*	−0.09*	−1.00								
(10) SOE	−0.13*	0.17*	0.21*	−0.09*	0.01	−0.08*	−0.14*	0.00	−0.14*	1.00							
(11) ROA	−0.02	−0.08*	−0.07*	0.06*	0.06*	0.01	−0.14*	0.09*	0.02	−0.26*	1.00						
(12) CF_vol	−0.06*	−0.12*	−0.07*	0.02	−0.02	0.01	−0.19*	0.45*	0.02	−0.29*	0.66*	1.00					
(13) REV_vol	−0.05*	−0.03	0.02	0.05*	−0.07*	0.03	0.05*	0.06*	−0.01	0.06*	0.07*	−0.02	1.00				
(14) SIZE	0.28*	0.24*	0.21*	−0.08*	0.09*	−0.02	0.51*	−0.15*	−0.21*	−0.06*	−0.22*	−0.27*	−0.07*	1.00			
(15) LEV	0.19*	0.18*	0.16*	−0.10*	0.02	0.05*	0.41*	−0.44*	−0.25*	−0.05*	0.42*	−0.40*	−0.05*	0.62*	1.00		
(16) CSR_ass	0.19*	0.12*	0.13*	−0.05*	−0.02	−0.08*	0.29*	−0.10*	−0.17*	0.01	0.24*	0.12*	0.00	0.39*	0.19*	1.00	
(17) CSR_score	0.17*	0.02	0.06*	−0.08*	0.05*	0.02	0.07*	0.47*	0.30*	0.02	0.09*	−0.10*	0.27*	0.16*	−0.16*	0.38*	1.00

Note: Appendix 1 explains the proxies of all the variables, and * indicates 5% significance level.

TABLE 3 | Main results.

Variables	(1) CDI	(2) CDI	(3) CDI	(4) CDI	(5) CDI	(6) CDI
CEO age	−0.046*** (0.006)	−0.046*** (0.007)	−0.045*** (0.006)	−0.048*** (0.006)	−0.049*** (0.007)	−0.047*** (0.006)
EM1		−0.447*** (0.155)	−0.421*** (0.152)	−0.431*** (0.156)	−0.418** (0.182)	−0.442*** (0.156)
CEO age*EM1		−0.051*** (0.020)				
CEO edu	0.016** (0.007)	0.018** (0.008)	0.018** (0.009)	0.016** (0.008)	0.019** (0.008)	0.018** (0.008)
CEO edu*EM1			0.038** (0.018)			
CEO gender	0.066*** (0.009)	0.069*** (0.009)	0.068*** (0.008)	0.072*** (0.008)	0.070*** (0.010)	0.069*** (0.009)
CEO gender*EM1				0.162** (0.073)		
CEO expertise	0.052*** (0.005)	0.051*** (0.006)	0.052*** (0.005)	0.050*** (0.005)	0.052*** (0.007)	0.048*** (0.006)
CEO expertise*EM1					0.064*** (0.012)	
CEO tenure	0.039*** (0.008)	0.040*** (0.009)	0.038*** (0.008)	0.042*** (0.008)	0.032*** (0.008)	0.040*** (0.008)
CEO tenure*EM1						0.054** (0.025)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.294*** (0.060)	−0.273*** (0.062)	−0.269*** (0.062)	−0.273*** (0.062)	−0.269*** (0.062)	−0.265*** (0.062)
Obs.	9197	9197	9197	9197	9197	9197
R ²	0.179	0.187	0.176	0.186	0.186	0.188
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes

Note: Appendix 1 explains the proxies of all the variables.

***, ** and * indicate 1%, 5% and 10% significance level, respectively.

are positive and significant, suggesting that earnings management strengthens the relationship between those characteristics and carbon disclosure. Therefore, these findings support our Hypothesis 1, and we find evidence that earnings management moderates the relationship between CEO characteristics and carbon disclosure. Hence, earnings management changes the way CEO characteristics map into carbon disclosure choices.

Table 4 reports the results of the first firm-level risk tolerance boundary condition. In high-risk-tolerance firms (Panel A), in case of higher earnings management, CEO age is negatively associated with carbon disclosure, whereas female and more-educated CEOs are associated with higher disclosure levels; these relationships are not observed in low-risk-tolerance firms (Panel B). Therefore, these findings support our Hypothesis 2 and conclude that earnings management moderates the relationship

TABLE 4 | Boundary condition: high- vs. low-risk tolerance.

Panel (A): High-risk tolerance (long-term capital debt ratio)						
Variables	(1) CDI	(2) CDI	(3) CDI	(4) CDI	(5) CDI	(6) CDI
CEO age	0.002 (0.001)	0.002 (0.002)	0.002 (0.002)	0.002 (0.002)	0.002 (0.002)	0.002 (0.002)
EM1		0.982*** (0.312)	−0.383*** (0.118)	−0.061 (0.060)	−0.046 (0.054)	−0.121 (0.075)
CEO age*EM1		−0.021*** (0.007)				
CEO edu	0.007* (0.003)	0.006 (0.004)	0.005 (0.004)	0.005 (0.004)	0.005 (0.004)	0.005 (0.004)
CEO edu*EM1			0.094** (0.031)			
CEO gender	0.008 (0.018)	0.016 (0.016)	0.014 (0.017)	0.015 (0.017)	0.015 (0.017)	0.015 (0.017)
CEO gender*EM1				0.288* (0.150)		
CEO expertise	−0.043 (0.025)	−0.043* (0.023)	−0.043* (0.022)	−0.043* (0.023)	−0.044* (0.023)	−0.044* (0.023)
CEO expertise*EM1					0.028 (0.091)	
CEO tenure	−0.008*** (0.002)	−0.008** (0.002)	−0.007** (0.002)	−0.007** (0.002)	−0.007** (0.002)	−0.007** (0.003)
CEO tenure*EM1						0.018 (0.010)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−5.764*** (0.236)	−6.234*** (0.165)	−6.235*** (0.164)	−6.240*** (0.165)	−6.239*** (0.162)	−6.237*** (0.165)
Obs.	4874	4874	4874	4874	4874	4874
R ²	0.181	0.187	0.187	0.187	0.187	0.187
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Panel (B): Low-risk tolerance (long-term capital debt ratio)						
CEO age	0.001 (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)
EM1		−0.017 (0.175)	0.046 (0.048)	0.012 (0.026)	0.021 (0.027)	−0.002 (0.033)
CEO age*EM1		0.001 (0.004)				

(Continues)

TABLE 4 | (Continued)

Panel (B): Low-risk tolerance (long-term capital debt ratio)						
CEO edu	0.006*	0.007***	0.007***	0.007***	0.007***	0.007***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
CEO edu*EM1			−0.009			
			(0.012)			
CEO gender	−0.051***	−0.057***	−0.057***	−0.057***	−0.057***	−0.057***
	(0.015)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
CEO gender*EM1				0.009		
				(0.040)		
CEO expertise	0.015	0.026***	0.026***	0.026***	0.026***	0.026***
	(0.009)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)
CEO expertise*EM1					−0.048	
					(0.046)	
CEO tenure	−0.001	−0.002	−0.002	−0.002	−0.002	−0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
CEO tenure*EM1						0.003
						(0.009)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−2.331***	−2.598***	−2.592***	−2.594***	−2.597***	−2.597***
	(0.207)	(0.226)	(0.225)	(0.229)	(0.233)	(0.227)
Obs.	4323	4323	4323	4323	4323	4323
R ²	0.101	0.106	0.106	0.105	0.106	0.105
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes

Note: Appendix 1 explains the proxies of all the variables.

***, ** and * indicate 1%, 5% and 10% significance level, respectively.

between CEO characteristics and carbon disclosures differently in high- and low-risk-tolerance firms. Specifically, in high-risk-tolerance firms, the negative effect of CEO age is more pronounced, while the positive effects of female leadership and education are strengthened.

Table 5 reports on the other boundary condition, environmental uncertainty findings. Under high environmental uncertainty (Panel A), in case of higher earnings management, female CEOs disclose more carbon information, while longer-tenured CEOs disclose less. In contrast, in low-uncertainty contexts, older CEOs disclose more, whereas CEOs with higher education and financial expertise disclose less. Therefore, these findings support our Hypothesis 3 and conclude that earnings management moderates the relationship between CEO characteristics and carbon disclosures differently in high- and low-risk environmental uncertainty firms. Specifically, under conditions of high environmental uncertainty, female CEOs exhibit greater disclosure, whereas longer-tenured CEOs reduce disclosure; in contrast, in low-uncertainty environments,

older CEOs disclose more, while CEOs with higher education and financial expertise disclose less.

An additional analysis divides the sample into high and low-polluting firms (unablated). Results for high-polluting firms indicate relatively more pronounced findings than the low-polluting firms' subsample. For example, the high-polluting firms' subsample has a higher coefficient value between carbon disclosure and earnings management relationships, also with earnings management playing a significant moderating role with higher coefficient values. Conversely, results for low-polluting companies' subsample are also significant with lower coefficient values. These findings suggest that high-polluting firms in China with higher carbon disclosure are more likely to adopt ethical practices and have higher quality accounting information, consistent with recent studies on Chinese high-polluting firms (Abbas et al. 2023; Bilal et al. 2022).

Further, the sample is divided into state-owned (SOEs) and privately-owned (Non-SOEs) companies (unablated). The

TABLE 5 | Boundary condition: high vs. low environmental uncertainty.

Panel (A): High environmental uncertainty						
Variables	(1) CDI	(2) CDI	(3) CDI	(4) CDI	(5) CDI	(6) CDI
CEO age	0.002** (0.001)	0.002 (0.001)	0.002 (0.001)	0.002 (0.001)	0.002 (0.001)	0.002 (0.001)
EM1		−0.132 (0.144)	−0.038 (0.063)	−0.040 (0.052)	−0.008 (0.033)	0.036 (0.056)
CEO age*EM1		0.002 (0.003)				
CEO edu	0.015** (0.006)	0.018** (0.007)	0.018** (0.007)	0.018** (0.007)	0.018** (0.007)	0.018** (0.007)
CEO edu*EM1			0.002 (0.017)			
CEO gender	0.010 (0.023)	0.014 (0.031)	0.014 (0.031)	0.017 (0.030)	0.014 (0.031)	0.015 (0.031)
CEO gender*EM1				0.137* (0.072)		
CEO expertise	0.017 (0.016)	0.030* (0.016)	0.030* (0.016)	0.030* (0.016)	0.032 (0.018)	0.030* (0.016)
CEO expertise*EM1					−0.103 (0.128)	
CEO tenure	0.001 (0.002)	0.002 (0.003)	0.002 (0.003)	0.002 (0.003)	0.002 (0.003)	0.003 (0.003)
CEO tenure*EM1						−0.014* (0.007)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−4.564*** (0.090)	−5.099*** (0.105)	−5.100*** (0.104)	−5.100*** (0.104)	−5.102*** (0.102)	−5.101*** (0.107)
Obs.	4415	4415	4415	4415	4415	4415
R ²	0.168	0.172	0.172	0.172	0.172	0.172
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Panel (B): Low environmental uncertainty						
CEO age	0.003*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.004*** (0.001)
EM1		−0.364** (0.159)	0.029 (0.056)	−0.080 (0.046)	−0.053 (0.041)	−0.087 (0.054)
CEO age*EM1		0.006* (0.003)				

(Continues)

TABLE 5 | (Continued)

Panel (B): Low environmental uncertainty						
CEO edu	0.021*** (0.006)	0.023*** (0.007)	0.021*** (0.006)	0.023*** (0.007)	0.023*** (0.007)	0.023*** (0.007)
CEO edu * EM1			−0.026** (0.012)			
CEO gender	0.005 (0.012)	−0.011 (0.010)	−0.011 (0.010)	−0.004 (0.011)	−0.010 (0.010)	−0.011 (0.010)
CEO gender * EM1				0.132 (0.103)		
CEO expertise	0.013 (0.018)	0.024 (0.020)	0.024 (0.020)	0.024 (0.020)	0.021 (0.021)	0.024 (0.020)
CEO expertise * EM1					−0.098* (0.054)	
CEO tenure	−0.007** (0.003)	−0.008** (0.003)	−0.008** (0.003)	−0.008** (0.003)	−0.008** (0.003)	−0.007** (0.003)
CEO tenure * EM1						0.003 (0.007)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−4.621*** (0.258)	−5.038*** (0.225)	−5.032*** (0.225)	−5.031*** (0.225)	−5.035*** (0.224)	−5.034*** (0.225)
Obs.	4782	4782	4782	4782	4782	4782
R ²	0.177	0.186	0.186	0.186	0.186	0.186
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes

Note: Appendix 1 explains the proxies of all the variables.

***, ** and * indicate 1%, 5% and 10% significance level, respectively.

findings for SOEs indicate an inverse relationship between carbon disclosure and earnings management, with earnings management playing a significant moderating role (Panel A). Conversely, results for non-SOEs companies (Panel B) are not significant, suggesting that Chinese SOEs report higher carbon disclosure and have higher quality accounting information. These findings indicate that Chinese SOEs are portraying the efforts of the Chinese government toward dual sustainability goals (e.g., carbon peaking by 2030 and neutrality by 2060) and global largest firms (e.g., Fortune top 500 list) playing the role of best citizens.

An additional analysis divides the sample into higher and lower carbon disclosure index (CDI) companies, presented in Table 6 (Panels A and B). Results for high CDI companies indicate an inverse relationship between carbon disclosure and earnings management, with earnings management playing a

significant moderating role (Panel A). Conversely, results for low CDI companies (Panel B) are not significant, as suggested earlier, Chinese firms with higher carbon disclosure are more likely to adopt ethical practices and report more transparent disclosures. In line with Chinese high-polluting firms' literature (Abbas et al. 2023; Bilal et al. 2022; Tan et al. 2020), we have also found that Chinese firms disclosing higher carbon disclosure are more responsive to the stakeholders' demand for higher carbon disclosure.

Table 7 divides the sample based on CSR ratings, reaffirming the study's primary findings. The results only hold for higher CSR ratings companies (Panel A), as the subsample with lower CSR ratings (Panel B) is not significant. It suggests that financial managers in Chinese firms engage in responsible practices, marked by transparent carbon disclosure and reduced earnings management.

TABLE 6 | Additional results: higher and lower carbon disclosure.

Panel A: Higher carbon disclosure						
Variables	(1) CDI	(2) CDI	(3) CDI	(4) CDI	(5) CDI	(6) CDI
CEO age	−0.060*** (0.009)	−0.058*** (0.008)	−0.060*** (0.008)	−0.058*** (0.009)	−0.058*** (0.009)	−0.059*** (0.009)
EM1		−0.413*** (0.113)	−0.374*** (0.128)	−0.089** (0.044)	−0.078* (0.043)	−0.067** (0.033)
CEO age * EM1		−0.057*** (0.021)				
CEO edu	0.018*** (0.004)	0.019*** (0.005)	0.020*** (0.004)	0.019*** (0.005)	0.021*** (0.006)	0.020*** (0.005)
CEO edu * EM1			0.152*** (0.042)			
CEO gender	0.037** (0.016)	0.038** (0.016)	0.038** (0.017)	0.035* (0.019)	0.041** (0.017)	0.039** (0.016)
CEO gender * EM1				0.120** (0.052)		
CEO expertise	0.053*** (0.007)	0.055*** (0.008)	0.054*** (0.009)	0.055*** (0.008)	0.057*** (0.007)	0.055*** (0.008)
CEO expertise * EM1					0.093*** (0.024)	
CEO tenure	0.068*** (0.011)	0.067*** (0.011)	0.066*** (0.010)	0.069*** (0.012)	0.068*** (0.011)	0.067*** (0.011)
CEO tenure * EM1						0.061*** (0.020)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.228*** (0.080)	−0.166** (0.082)	−0.172** (0.084)	−0.166** (0.082)	−0.163** (0.082)	−0.142* (0.082)
Obs.	5072	5058	5058	5058	5058	5058
R ²	0.251	0.255	0.258	0.255	0.255	0.257
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: Lower carbon disclosure						
CEO age	−0.025 (0.017)	−0.019 (0.015)	−0.019 (0.014)	−0.019 (0.015)	−0.018 (0.014)	−0.021 (0.015)
EM1		−0.364 (0.314)	−0.234 (0.301)	−0.023 (0.049)	−0.018 (0.055)	−0.103 (0.074)

(Continues)

TABLE 6 | (Continued)

Panel B: Lower carbon disclosure						
CEO age*EM1		−0.012 (0.009)				
CEO edu	0.010 (0.011)	0.011 (0.012)	0.016 (0.013)	0.011 (0.013)	0.011 (0.012)	0.012 (0.013)
CEO edu*EM1			0.077 (0.051)			
CEO gender	0.013 (0.012)	0.010 (0.010)	0.009 (0.012)	0.008 (0.011)	0.009 (0.012)	0.009 (0.012)
CEO gender*EM1				0.072 (0.091)		
CEO expertise	0.017 (0.014)	0.018 (0.013)	0.019 (0.014)	0.018 (0.013)	0.018 (0.014)	0.017 (0.014)
CEO expertise*EM1					0.009 (0.023)	
CEO tenure	0.007 (0.011)	0.008 (0.011)	0.009 (0.010)	0.008 (0.011)	0.008 (0.012)	0.008 (0.012)
CEO tenure*EM1						0.005 (0.006)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.114 (0.080)	−0.114 (0.082)	−0.115 (0.082)	−0.119 (0.083)	−0.119 (0.082)	−0.121 (0.082)
Obs.	4125	4139	4139	4139	4139	4139
R ²	0.121	0.127	0.128	0.127	0.127	0.128
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes

Note: Appendix 1 explains the proxies of all the variables.

***, ** and * indicate 1%, 5% and 10% significance level, respectively.

The study also examines the effect of earnings management on the relationship between CEO characteristics and carbon disclosure using alternative proxies (working capital accruals and REM) in Table 8, Panel A and B, respectively. The results are consistent with the main findings.

For robustness, we have rerun the main results with the system generalised method of moments (GMM) estimator for a dynamic panel. The results in Table 9 hold as they are in line with the main analysis. Therefore, we have consistent findings as the main results. Finally, we present the results of Heckman's two-stage model in Table 10, addressing potential sample selection bias and endogeneity issues. The first stage computes the IMR from a probit model using the industry CDI average as an

instrumental variable. The second stage includes the IMR as a control variable. The results corroborate the main findings, indicating that CEO age, gender, education, financial expertise and tenure significantly impact carbon disclosures and have a moderating effect on the relationship between carbon disclosure and earnings management.

5 | Discussion and Implications

This research explores the link between earnings management, CEO characteristics and carbon disclosure in major polluting Chinese corporations, with a particular focus on the moderating role of earnings management in this dynamic.

TABLE 7 | Additional results: high and low CSR rating.

Panel A: High CSR rating firms						
Variables	(1) CDI	(2) CDI	(3) CDI	(4) CDI	(5) CDI	(6) CDI
CEO age	−0.058*** (0.009)	−0.056*** (0.010)	−0.058*** (0.009)	−0.056*** (0.011)	−0.056*** (0.009)	−0.057*** (0.009)
EM1		−0.512* (0.270)	−0.384*** (0.130)	−0.089** (0.040)	−0.074* (0.042)	−0.078** (0.038)
CEO age*EM1		−0.055** (0.026)				
CEO edu	0.018*** (0.004)	0.018*** (0.005)	0.019*** (0.004)	0.017*** (0.005)	0.019*** (0.005)	0.018*** (0.005)
CEO edu*EM1			0.154*** (0.042)			
CEO gender	0.036** (0.015)	0.036** (0.015)	0.037** (0.017)	0.034** (0.016)	0.040** (0.018)	0.038** (0.018)
CEO gender*EM1				0.157** (0.073)		
CEO expertise	0.051*** (0.007)	0.054*** (0.009)	0.053*** (0.007)	0.054*** (0.007)	0.057*** (0.008)	0.055*** (0.007)
CEO expertise*EM1					0.135** (0.056)	
CEO tenure	0.072*** (0.010)	0.071*** (0.010)	0.059*** (0.009)	0.071*** (0.010)	0.073*** (0.009)	0.072*** (0.010)
CEO tenure*EM1						0.052*** (0.019)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.256*** (0.080)	−0.214*** (0.084)	−0.209*** (0.083)	−0.193** (0.082)	−0.187** (0.082)	−0.171** (0.082)
Obs.	5150	5118	5118	5118	5118	5118
R ²	0.250	0.253	0.256	0.252	0.252	0.254
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: Low CSR rating firms						
CEO age	−0.032 (0.024)	−0.026 (0.016)	−0.025 (0.016)	−0.026 (0.017)	−0.026 (0.016)	−0.024 (0.016)
EM1		−0.366 (0.310)	−0.253 (0.178)	−0.021 (0.050)	−0.013 (0.055)	−0.107 (0.078)
CEO age*EM1		−0.014 (0.010)				

(Continues)

TABLE 7 | (Continued)

Panel B: Low CSR rating firms						
CEO edu	0.009 (0.010)	0.010 (0.011)	0.015 (0.017)	0.010 (0.012)	0.010 (0.013)	0.010 (0.012)
CEO edu*EM1			0.064 (0.041)			
CEO gender	0.007 (0.011)	0.003 (0.011)	0.005 (0.009)	0.002 (0.011)	0.005 (0.010)	0.003 (0.011)
CEO gender*EM1				0.122 (0.089)		
CEO expertise	0.015 (0.013)	0.016 (0.012)	0.016 (0.014)	0.015 (0.014)	0.016 (0.013)	0.015 (0.013)
CEO expertise*EM1					0.007 (0.024)	
CEO tenure	0.009 (0.011)	0.009 (0.011)	0.010 (0.012)	0.010 (0.011)	0.011 (0.012)	0.010 (0.011)
CEO tenure*EM1						0.004 (0.005)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.129 (0.084)	−0.125 (0.086)	−0.126 (0.084)	−0.131 (0.086)	−0.130 (0.086)	−0.132 (0.086)
Obs.	4047	4079	4079	4079	4079	4079
R ²	0.125	0.132	0.133	0.131	0.131	0.133
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes

Note: Appendix 1 explains the proxies of all the variables.

***, ** and * indicate 1%, 5% and 10% significance level, respectively.

Our findings reveal that earnings management moderates the relationship between CEO characteristics and carbon disclosure. In line with upper echelons theory and two competing perspectives: First, under the opportunistic view, Chinese executives engage in earnings management; their CEOs might also engage in impression management or greenwashing to disclose more carbon disclosures (Bilal et al. 2022). On the other hand, from an ethical perspective, it indicates that firms with higher financial reporting quality (e.g., without earnings manipulations) are more likely to provide more and accurate carbon emission information to their stakeholders (Gerged et al. 2023; Kim et al. 2012).

In addition, we claim that earnings management moderation is not the same for all firms; their risk tolerance and environmental uncertainty act as important boundary conditions. In high-risk-tolerance firms, in the case of higher earnings management,

older CEOs are associated with less carbon disclosures, whereas female and more-educated CEOs are associated with higher disclosure levels. These relationships are not observed in low-risk-tolerance firms. On the other hand, under high environmental uncertainty, in the case of higher earnings management, female CEOs disclose more carbon information, while longer-tenured CEOs disclose less. In contrast, in low-uncertainty contexts, older CEOs disclose more, whereas CEOs with higher education and financial expertise disclose less. These findings are also in line with the upper echelons theory and prior literature (Velte 2026).

The study's outcomes also highlight the significant impact of CEO characteristics including gender, age, education, financial expertise and tenure on earnings management practices, corroborating previous research findings in this domain (Chen et al. 2019; Huang 2013). Our findings are in line with the

TABLE 8 | Additional results: alternative proxies of earnings management.

Panel A: Working capital accruals						
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	CDI	CDI	CDI	CDI	CDI	CDI
CEO age	−0.046*** (0.006)	−0.046*** (0.007)	−0.045*** (0.006)	−0.047*** (0.006)	−0.049*** (0.007)	−0.047*** (0.006)
EM2		−0.567*** (0.217)	−0.460*** (0.130)	−0.156*** (0.046)	−0.142** (0.071)	−0.221*** (0.076)
CEO age * EM2		−0.062*** (0.023)				
CEO edu	0.016** (0.008)	0.018** (0.008)	0.018** (0.009)	0.017** (0.008)	0.019** (0.008)	0.019** (0.009)
CEO edu * EM2			0.040*** (0.013)			
CEO gender	0.066*** (0.009)	0.069*** (0.009)	0.067*** (0.008)	0.071*** (0.008)	0.070*** (0.010)	0.069*** (0.009)
CEO gender * EM2				0.133** (0.057)		
CEO expertise	0.052*** (0.005)	0.051*** (0.005)	0.052*** (0.006)	0.052*** (0.005)	0.050*** (0.006)	0.051*** (0.006)
CEO expertise * EM2					0.066*** (0.010)	
CEO tenure	0.039*** (0.008)	0.040*** (0.007)	0.040*** (0.007)	0.039*** (0.008)	0.38*** (0.006)	0.039*** (0.007)
CEO tenure * EM2						0.055** (0.026)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.294*** (0.060)	−0.273*** (0.062)	−0.269*** (0.062)	−0.272*** (0.062)	−0.270*** (0.062)	−0.266*** (0.062)
Obs.	9197	9197	9197	9197	9197	9197
R ²	0.179	0.187	0.176	0.186	0.186	0.187
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: Real earnings management						
CEO age	−0.046*** (0.006)	−0.043*** (0.007)	−0.041*** (0.006)	−0.045*** (0.006)	−0.045*** (0.007)	−0.043*** (0.006)
REM		−0.148*** (0.046)	−0.164*** (0.041)	−0.168*** (0.040)	−0.124** (0.055)	−0.152*** (0.036)

(Continues)

TABLE 8 | (Continued)

Panel B: Real earnings management						
CEO age*REM		−0.049**				
		(0.021)				
CEO edu	0.016**	0.017**	0.016**	0.015**	0.018**	0.017**
	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
CEO edu*REM			0.032**			
			(0.014)			
CEO gender	0.066***	0.070***	0.068***	0.070***	0.068***	0.069***
	(0.009)	(0.008)	(0.007)	(0.008)	(0.009)	(0.009)
CEO gender*REM				0.138***		
				(0.036)		
CEO expertise	0.052***	0.054***	0.057***	0.054***	0.055***	0.054***
	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)
CEO expertise*REM					0.056**	
					(0.024)	
CEO tenure	0.039***	0.037***	0.034***	0.039***	0.032***	0.036***
	(0.008)	(0.009)	(0.007)	(0.008)	(0.009)	(0.008)
CEO tenure*REM						0.052**
						(0.023)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.294***	−0.282***	−0.278***	−0.286***	−0.280***	−0.286***
	(0.060)	(0.064)	(0.062)	(0.064)	(0.062)	(0.064)
Obs.	9012	9197	9197	9197	9197	9197
R ²	0.180	0.182	0.171	0.184	0.184	0.186
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes

Note: Appendix 1 explains the proxies of all the variables.

***, ** and * indicate 1%, 5% and 10% significance level, respectively.

studies from other contexts. For example, Lewis et al. (2014) found that CEO education and tenure are positively associated with environmental disclosures in the United States. Likewise, Caby et al. (2024) found the female executives' positive impact on carbon disclosures in an international context. Velte (2026) recommended in a systematic review to focus on the climate-related education and expertise, which our study has highlighted as having a significant association of CEO characteristics with carbon disclosure in the Chinese context. Although our study has shown the significant role of the CEOs characteristics in promoting carbon disclosure for their stakeholders. However, some institutional constraints in China, such as the guanxi culture, state influence, CEO power, and political connections may be the critical factors that might not

lead to the useful outcomes as have been highlighted in our analysis.

From a practical perspective, our research provides valuable insights for policymakers and corporate leaders, particularly in the context of evolving climate change-related legislation and dual sustainability goals (e.g., carbon peaking 2030 and carbon neutrality 2060) in China and other emerging economies. The findings underscore the importance of rigorous executive selection processes that account for diverse aspects such as gender, age, financial expertise, educational background and in-depth knowledge of carbon-related issues. Such a comprehensive approach in selecting top executives aligns with the firm's strategic goals, enhances operational efficiency

TABLE 9 | Robust results: system GMM.

Variables	(1) CDI	(2) CDI	(3) CDI	(4) CDI	(5) CDI	(6) CDI
L.CDI	0.822*** (0.072)	0.819*** (0.073)	0.812*** (0.074)	0.834*** (0.073)	0.819*** (0.086)	0.818*** (0.070)
CEO age	−0.049*** (0.008)	−0.048*** (0.009)	−0.049*** (0.008)	−0.050*** (0.007)	−0.042*** (0.008)	−0.050*** (0.008)
EM1		−0.460*** (0.170)	−0.437*** (0.168)	−0.444*** (0.171)	−0.432*** (0.180)	−0.456*** (0.170)
CEO age * EM1		−0.062*** (0.022)				
CEO edu	0.023** (0.010)	0.024** (0.011)	0.026** (0.011)	0.024** (0.010)	0.027** (0.012)	0.026** (0.011)
CEO edu * EM1			0.051** (0.023)			
CEO gender	0.075*** (0.012)	0.078*** (0.012)	0.076*** (0.011)	0.079*** (0.011)	0.082*** (0.012)	0.078*** (0.011)
CEO gender * EM1				0.174** (0.075)		
CEO expertise	0.062*** (0.007)	0.061*** (0.008)	0.062*** (0.007)	0.060*** (0.007)	0.061*** (0.009)	0.058*** (0.007)
CEO expertise * EM1					0.081*** (0.016)	
CEO tenure	0.046*** (0.009)	0.046*** (0.010)	0.045*** (0.009)	0.049*** (0.009)	0.036** (0.012)	0.048*** (0.009)
CEO tenure * EM1						0.068** (0.030)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−1.108*** (0.226)	−1.161*** (0.227)	−1.161*** (0.226)	−1.146*** (0.227)	−1.166*** (0.226)	−1.178*** (0.225)
Obs.	8277	8185	8185	8185	8185	8185
Sargan	0.278	0.326	0.243	0.320	0.402	0.233
AR1	0.123	0.136	0.121	0.109	0.114	0.101
AR2	0.187	0.163	0.207	0.189	0.211	0.195

Note: Appendix 1 explains the proxies of all the variables.

***, ** and * indicate 1%, 5% and 10% significance level, respectively.

and bolsters environmental disclosure, contributing to the achievement of sustainable development goals. Moreover, considering the varied levels of carbon emissions across different business operations, CEOs equipped with high-quality

attributes are essential for meeting the stringent requirements of carbon disclosure and reporting, thereby potentially increasing the company's market value and ensuring its long-term sustainability.

TABLE 10 | Robust results: Heckman two-stage model.

Variables	(1) CDI	(2) CDI	(3) CDI	(4) CDI	(5) CDI	(6) CDI
CEO age	−0.053*** (0.009)	−0.054*** (0.010)	−0.053*** (0.009)	−0.055*** (0.010)	−0.054*** (0.009)	−0.054*** (0.009)
EM1		−0.468*** (0.175)	−0.435*** (0.162)	−0.433*** (0.168)	−0.442** (0.188)	−0.446*** (0.172)
CEO age*EM1		−0.062*** (0.022)				
CEO edu	0.021** (0.009)	0.023** (0.010)	0.023** (0.010)	0.021** (0.009)	0.024** (0.011)	0.021** (0.009)
CEO edu*EM1			0.057** (0.024)			
CEO gender	0.076*** (0.012)	0.079*** (0.011)	0.079*** (0.012)	0.076*** (0.012)	0.075*** (0.014)	0.074*** (0.011)
CEO gender*EM1				0.178** (0.083)		
CEO expertise	0.060*** (0.007)	0.060*** (0.007)	0.061*** (0.008)	0.060*** (0.007)	0.059*** (0.007)	0.061*** (0.009)
CEO expertise*EM1					0.080*** (0.019)	
CEO tenure	0.048*** (0.011)	0.048*** (0.011)	0.042*** (0.010)	0.047*** (0.010)	0.049*** (0.010)	0.048*** (0.011)
CEO tenure*EM1						0.067** (0.029)
IMR	0.304*** (0.057)	0.295*** (0.058)	0.301*** (0.058)	0.294*** (0.059)	0.296*** (0.059)	0.302*** (0.058)
Constant	−0.846*** (0.129)	−0.805*** (0.130)	−0.814*** (0.130)	−0.804*** (0.130)	−0.804*** (0.131)	−0.811*** (0.130)
Control, firm, year	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	9197	9197	9197	9197	9197	9197
R ²	0.186	0.194	0.194	0.194	0.194	0.195

Note: Here, IMR means inverse mills ratio. Appendix 1 explains the proxies of all the variables.
 ***, ** and * indicate 1%, 5% and 10% significance level, respectively.

6 | Conclusions

This study significantly extends existing research by examining the moderating role of earnings management on the relationship between CEO characteristics and carbon disclosure in Chinese firms, although the nature of this moderation varies across contexts. Specifically, older CEOs are generally associated with lower levels of carbon disclosure, whereas more educated and

female CEOs tend to enhance disclosure. However, these relationships are not uniform. In high-risk-tolerance firms, the negative effect of CEO age is more pronounced, while the positive effects of female leadership and education are strengthened. Under conditions of high environmental uncertainty, female CEOs exhibit greater disclosure, whereas longer-tenured CEOs reduce disclosure; in contrast, in low-uncertainty environments, older CEOs disclose more, while CEOs with higher education

and financial expertise disclose less. These findings highlight the importance of considering both internal and external contingencies in explaining managerial influence on environmental reporting.

One of the notable contributions of this research is its critique of the DA method traditionally used in earnings management literature (Kothari et al. 2005). Addressing the limitations of this method, our study employs alternative proxies for earnings management, such as DA methods, working capital accruals and REM. This approach enhances the robustness of our analysis by mitigating potential measurement biases. Additionally, the study's findings are fortified against various statistical challenges, including firm-level heterogeneities, endogeneity and sample selection bias. This is achieved through the application of diverse statistical techniques, such as the system GMM model, fixed-effects model and the two-step Heckman model. These methodologies ensure that the results are not only reliable but also applicable across different contexts.

From a practical perspective, our research provides valuable insights for policymakers and corporate leaders, particularly in the context of evolving climate change-related legislation in China. The findings of this study are interesting to firms and investors, enabling them to increase their carbon disclosure by considering the demographic characteristics of CEOs such as age, level of education, financial expertise and tenure. Our results will also help regulators to encourage more culture of transparency among non-SOEs that will help improve their carbon disclosure practices. It also highlights the importance of considering the unique attributes of CEOs in the formulation of policies and strategies for environmental disclosure and in mitigating earnings management.

However, the study is not without limitations. It focuses exclusively on firms in China, leaving a gap in understanding similar dynamics in other geographical regions. Therefore, future research is encouraged to include firms from multiple regions, such as Asia, Europe, Africa, Australia and the Americas. Such an expansion would significantly enhance our comprehension of the interplay between CEO characteristics, earnings management and carbon disclosure across different cultural, regulatory and environmental landscapes. By exploring these nexuses in diverse settings, subsequent studies can provide a more holistic and global perspective on these critical corporate governance issues.

Author Contributions

Shihong Zeng: writing – review and editing, validation. **Ali Abbas:** conceptualization, methodology, writing – review and editing, writing – original draft. **Ali Meftah Gerged:** writing – original draft, writing – review and editing. **Ernest Ezeani:** writing – original draft, writing – review and editing. **Bilal Bilal:** conceptualization, methodology, software, writing – review and editing, writing – original draft, investigation.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Appendix 1: Variables Proxies

Variable type	Variable name	Proxy
Dependent variables	Carbon disclosure index (CDI _{it})	Carbon disclosure index was constructed by the presence or absence of 30 different carbon disclosure items, a score obtained based on the actual disclosure items out of a total of 30 items.
Independent variables	CEO characteristics (CC _{it})	CEO gender, a dummy variable, was measured as 1 for female CEOs and 0 otherwise.
		CEO education is a categorical variable (1 to 5), 1 for secondary school or below, 2 for the associate degree, 3 for bachelor's degree, 4 for master's degree and 5 for PhD degree.
		CEO age is measured as the natural log of the CEO current age in a particular year.
		CEO tenure is measured as the total number of years a CEO hold the office.
		CEO's financial expertise is measured as an indicator variable that takes the value of 1 if the CEO is a financial expert and 0 otherwise.
Moderating variable	Discretionary accruals (EM1 _{it})	The absolute values of the discretionary accruals from the modified Jones models (Dechow et al. 1995).
	Working capital accruals (EM2 _{it})	The absolute values of the discretionary accruals from the DD model Dechow and Dichev (2002).
	Real earnings management (REM _{it})	The total of the abnormal values of abnormal discretionary expenses, cash flow from operations and production costs (Roychowdhury 2006).
Boundary conditions	Risk tolerance (RT _{it})	It is measured through the long-run debt capital ratio that a firm is going to use for its long-run projects. Specially, a dummy variable that equals 1 if this ratio is above the median value for the high-risk-tolerance subsample, and 0 otherwise (low-risk tolerance subsample).
	Environmental Uncertainty (EU _{it})	Following Liu and Song (2025) environmental uncertainty was predicted as abnormal revenues based on the residual values of the last 5 years' revenues, then we have taken the ratio of the standard deviation of the company's abnormal sales revenue over the past 5 years to the average sales revenue over the past 5 years. Finally, we have constructed a dummy variable, 1 in case this ratio above the median value for the high environmental uncertainty subsample, and 0 otherwise (low environmental uncertainty subsample).
Control variables	CEO duality (CD _{it})	It has been coded as 1 for CEO's who hold a chairman position for board of director, and coded 0 otherwise.
	Board size (BS _{it})	Number of directors on the board.
	High polluting (HP _{it})	Dummy variable is taken as 1 if firm belongs to high-polluting group, and 0 otherwise.
	State ownership (SOE _{it})	A binary indicator that treated state-owned companies with 1 and privately-owned companies with 0.
	Profitability (ROA _{it})	Calculated via return on assets ratio.
	Volatility of cash flows (CF_vol _{it})	The variations in the cash flows scaled by total assets over the prior 5-year window.
	Revenue volatility (REV_vol _{it})	The standard deviation of revenues scaled by company's total assets in 5-year time window.
	Firm size (SIZE _{it})	The log value of company's total assets.
	Leverage (LEV _{it})	The ratio of company's total debt to total assets.
	CSR assurance (CSR_ass _{it})	Another binary indicator that treated as 1 if a company's ESG report verified by the third party, and 0 otherwise.
	CSR rating (CSR_score _{it})	CSR ratings were collected from the HEXUN site (Li and Foo 2015).