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The Impact of Sustainability Audit on Climate Change Performance: The Role of Governance Quality and Greenwashing

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ABSTRACT

This study investigates how sustainability audit quality influences corporate climate change performance and examines the moderating roles of governance quality and greenwashing. Using panel regressions on 6140 firm-year observations from 39 countries between 2008 and 2023, the findings reveal that higher sustainability audit quality is associated with lower carbon emission intensity, indicating improved climate change performance through enhanced transparency, monitoring and credibility of sustainability disclosures. The results further show that governance quality weakens the negative relationship between sustainability audit quality and emission intensity. Specifically, the emissions-reducing effect of sustainability assurance becomes less pronounced in firms operating within stronger governance environments, suggesting that internal governance structures and institutional monitoring mechanisms may partially substitute for the quality role of external sustainability assurance. Similarly, greenwashing weakens the effectiveness of sustainability audit quality, implying that symbolic environmental disclosure practices undermine the credibility and substantive impact of sustainability assurance on climate-related outcomes. The findings highlight the importance of high-quality sustainability assurance in improving corporate climate change performance while demonstrating that its effectiveness is conditioned by firms' governance environments and disclosure practices.

1 | Introduction

The importance of sustainability assurance has increased significantly in recent times with the introduction of the Eco-Management and Audit Scheme (EMAS) in 1993 and ISO 14001 in 1996 (Barbu et al. 2012; Tourais and Videira 2016). The introduction of EMAS and ISO 14001 marked the beginning of the formalisation of environmental responsibility. Before the introduction of the frameworks, firms' efforts on environmental issues were largely voluntary and lacked standardised evaluation procedures. EMAS was developed to provide a comprehensive system that requires firms to conduct green audits, set measurable performance targets and publicly report their progress. ISO 14001 soon came into effect to complement and extend these principles globally through a standardised Environmental Management System (EMS) that could be certified and verified independently (Iraldo et al. 2009; Matuszak-Flejszman and Paliwoda 2022). The bodies introduced a consistent auditing mechanism and a third-party verification system (Muktiono and Soediantono 2022; Riglar 2017). Prior evidence has investigated factors at the firm and country levels that may affect corporate climate change performance (Bolton and Kacperczyk 2023; Deswanto and Siregar 2018). According to the Intergovernmental Panel on Climate Change (IPCC), the observed climate changes today are unprecedented over the past thousand years. They are primarily driven by human activities related to emissions. These human-induced changes are already affecting every region globally and are expected to intensify

with each rise in global warming (Mandel and Lipovetsky 2021). Operating in carbon-intensive and environmentally sensitive industries, these companies play a significant role in global emissions (Tauringana and Moses 2023). Many of the largest multinational corporations (MNCs) are based in developed nations and are responsible for carbon emissions, both in total volume and per capita output (Banerjee 2021; Dong et al. 2022; Earthjustice 2022).

Recently, sustainability assurance practices have evolved further with the emergence of internationally recognised assurance standards designed to improve the credibility, consistency and reliability of sustainability-related reporting. In particular, the International Standard on Assurance Engagements (ISAE) 3410, Assurance Engagements on Greenhouse Gas Statements, provides guidance for assurance practitioners evaluating greenhouse gas emissions reporting, including requirements for evidence collection, risk assessment, materiality evaluation and disclosure procedures (Auditing and Board 2012a, 2012b). Similarly, the International Standard on Sustainability Assurance (ISSA) 5000 establishes broader requirements for sustainability assurance engagements by outlining principles relating to assurance scope, professional scepticism, governance processes, internal controls and the reliability of sustainability information (Hay et al. 2024; Richard et al. 2026). These standards contribute towards strengthening the institutionalisation of sustainability assurance by enhancing the transparency, comparability and credibility of corporate climate-related disclosures and assurance processes.

Climate change damages infrastructure, undermines business reputations and introduces new regulatory and compliance risks, challenging business resilience (Amran et al. 2016; Broccardo et al. 2025; Weekes-Marshall 2020). The UN Global Compact encourages organisations to adopt a precautionary approach to sustainability challenges, promoting environmental responsibility and supporting eco-friendly technologies through research, innovation, cooperation, education and self-regulation (Ozsozgun Caliskan 2018). The global consensus among companies is to limit the temperature rise to 1.5°C (Opoku 2016). Many countries have already enacted national carbon regulations, and a robust regulatory framework with standardised reporting can improve the quality of carbon reporting (Houqe and Khan 2023). The European Court of Auditors (ECA) has been focusing on corporate climate change through assurance services, assessing EU actions on issues such as floods, desertification, energy efficiency and greenhouse gas emissions, ensuring transparency and effectiveness in meeting climate goals (Brenninkmeijer et al. 2018; Uman et al. 2023). The severe consequences of climate change, driven by high greenhouse gas emissions, make it clear that a reactive approach to emissions management is no longer sufficient (Giannarakis et al. 2017). The United Nations' Sustainable Development Goals (SDGs) address environmental pollution, with SDG 13 specifically focusing on climate action and holding both public and private sectors accountable (Banerjee 2021; Oyewo et al. 2023). SDG target 13.2 urges governments to integrate climate change measures into national policies, whereas SDG target 13.3 calls on private organisations and other stakeholders to improve education, awareness and capacity-building related to climate change mitigation and adaptation (Telleria 2024). Despite these insights, the role of sustainability auditing in steering corporate climate change strategies remains underexplored. Therefore, this study investigates the impact of sustainability audit quality on corporate climate change performance and examines the moderating roles of firm-level governance quality and greenwashing.

We hypothesise that the quality of sustainability audits negatively affects corporate climate change performance, drawing on impression management and stakeholder–agency theories. Impression management theory focuses on deliberate disclosure actions intentionally developed to manipulate or influence how firms are perceived (Bolino et al. 2016), and stakeholder–agency theory offers a more nuanced framework that considers the complexities of today's market situations and the interests of key stakeholders (Kivits et al. 2021). The impact of sustainability audit quality and corporate climate change performance remains underexplored (Alaamri et al. 2023). Increased engagement of audit committees in non-financial disclosures, such as climate change, often correlates with a larger committee size and higher fees for conducting thorough audits related to corporate accountability towards environmental and social issues (Ghafran and O'Sullivan 2017). The quality of audits, therefore, plays a significant role in determining a company's transparency in areas like climate change disclosures, which affects overall corporate performance (Brammer and Pavelin 2008).

To explore the interplay between sustainability audit quality and corporate climate change performance, we hypothesise a positive moderating effect of governance quality, such that the negative effect of sustainability audit quality on corporate climate change performance is substituted in countries with higher governance quality. It is built on the fact that the effectiveness of sustainability assurance in mitigating climate change may be hindered or enhanced depending on the strength of a country's institutions. In this study, governance quality refers to firm-level governance mechanisms that shape managerial oversight, accountability, ethical conduct and strategic sustainability decision-making. Strong internal governance structures may substitute for external sustainability assurance by strengthening monitoring and reducing information asymmetry. Also, quality governance promotes the efficient use of state resources by controlling corruption, maintaining law and order and ensuring freedom of expression (Cao et al. 2022). Again, quality governance enables firms to promote sustainable development effectively and may result in carbon emissions mitigation (Hunjra et al. 2020). Conversely, weak institutions, characterised by corruption and lawlessness, often redirect resources from eco-friendly projects to harmful ones. These institutions may fail to implement policies that shift from biomass to renewable energy sources, such as solar, wind and ocean energy, to reduce carbon emissions (Ntow-Gyamfi et al. 2020). The interaction term between sustainability auditing and governance quality is positive and significant. This suggests that the effectiveness of sustainability auditing in enhancing corporate climate change practices in an environment with strong, robust institutions, transparency in governance, accountability and legal enforcement will weaken the impact of sustainability audit quality on corporate climate change performance.

To explore another interplay between sustainability audit quality and corporate climate change performance, we hypothesise

that greenwashing weakens this relationship, as deceptive or misleading sustainability disclosures reduce the credibility and effectiveness of sustainability audit quality in improving corporate climate performance. In this study, greenwashing is used as a firm-level behavioural variable that captures firms that engage in misleading or exaggerating their sustainability practices. The findings reveal a statistically significant positive interaction between sustainability audit and corporate climate change performance. Given that the main effect of sustainability audit quality is negative, this result indicates that greenwashing attenuates the beneficial impact of audit quality on total emission intensity. Specifically, the emissions-reducing effect of high-quality audits weakens in firms exhibiting higher levels of greenwashing. This suggests that although assurance quality generally improves sustainability performance, its effectiveness is constrained in settings where firms engage in symbolic sustainability disclosure. Also, the findings demonstrate that higher quality sustainability assurance is associated with lower total emission intensity, indicating improved corporate climate change performance. The relationship is weakened by greenwashing, suggesting that the effectiveness of assurance depends on the extent to which corporate sustainability disclosures reflect substantive sustainability practices. Again, misleading claims about their sustainability practices and the effectiveness of the sustainability assurance undermine the integrity and intention to promote real environmental performance. Prior studies suggest that sustainability greenwashing is becoming a strategy that corporations adopt to cope with political, economic and environmental pressures (Zhang and Zhang 2024). Greenwashing is the deceptive disclosure of all sustainability factors of the environment, social and governance (Yu et al. 2020).

To test our predictions, we employed a large-scale firm-level dataset comprising 6140 observations from firms listed by S&P Global in 39 countries spanning 2008 and 2023. The study's evidence suggests a negative relationship between sustainability audit quality and corporate climate change performance. Also, empirical evidence suggests a positive relationship between governance qualities and the impact of sustainability audit quality on corporate climate change performance. The effectiveness of sustainability assurance in enhancing sustainability practices in an environment with strong, robust governance, transparency, accountability and legal enforcement will further weaken the impact of sustainability audit quality on corporate climate change performance as they substitute each other. Additional interaction evidence of greenwashing and the impact of sustainability audit quality on corporate climate change performance reveals a positive and statistically significant relationship, implying that misleading claims about their sustainability practices and the effectiveness of sustainability assurance undermine the integrity and intention to promote real climate change performance. Our findings are robust to alternative variable definitions, channel analysis, model specifications, sub-sampling, endogeneity problems and estimation techniques.

Our study makes several contributions to the literature. First, we extend existing research on the role of informal institutions in shaping corporate climate performance and strategic decision-making. Although prior studies have largely examined how such institutions influence corporate outcomes through financial audits, we highlight the role of sustainability audit quality in enhancing corporate climate change performance. Specifically, we provide empirical evidence that firms that engage in sustainability audit quality disclose emissions more accurately, which often results in more transparent reported total emission intensity. Second, this study also investigates how firm-level governance quality moderates the relationship between sustainability audit quality and corporate climate change performance. Our findings reveal that stronger governance frameworks weaken the extent to which sustainability audit quality improves corporate climate performance; strong, robust institutions substitute for sustainability audit quality, underscoring the complex interplay between governance quality and corporate sustainability practices. Third, we introduce greenwashing as an additional moderating factor in the relationship. We empirically demonstrate that greenwashing exerts a significant positive effect on the link between sustainability audit quality and corporate climate change performance, highlighting the risks of impression management in undermining the credibility of sustainability disclosures. Collectively, these findings advance the literature by offering novel insights into the intersection of sustainability audit quality, institutional quality and greenwashing, thereby deepening understanding of the mechanisms that shape corporate climate strategies. Institutional bodies should strengthen verification and disclosure requirements to discourage greenwashing practices and improve the credibility of sustainability assurance processes. They can leverage these insights to plan more transparent and accountable sustainability auditing processes.

The rest of the study is structured as follows: Section 2 reviews the relevant literature on sustainability assurance and climate change, and Section 3 details the methodology, including data sources, variable construction and empirical models. Section 4 presents and discusses the results of the empirical analysis, and Section 5 concludes the study, offering policy implications and suggestions for future research.

2 | Theoretical Framework, Literature Review and Hypothesis Development

2.1 | Theoretical Framework

The study of sustainability audit quality on corporate climate change performance tends to draw on multiple theoretical frameworks as it spans corporate governance, institutional contexts and sustainability disclosure dynamics. Previous papers on climate change tend to adopt theories like stakeholder, agency, legitimacy and critical mass theory and have been used to determine corporate climate change performance (Elsayih et al. 2021; Lu and Herremans 2019; Oyewo 2023). However, this study integrates stakeholder–agency and impression management theories. The framework posits that climate change performance is a corporate strategy for enhancing transparency and accountability (Ghosh and Wolf 2021). In practice, executives often prioritise their interests over those of shareholders, particularly regarding the company's accountability for non-financial matters, such as sustainability.

The stakeholder–agency theory elaborates on agency theory by considering the interests and influence of a large range of

stakeholders beyond shareholders (Hill and Jones 1992). This view of the firm touches all key stakeholders, regulators, customers and communities whose expectations shape corporate sustainability behaviour. Sustainability assurance, therefore, serves as a governance mechanism that aligns managerial behaviour with stakeholder expectations through transparency and accountability in sustainability reporting (Alaamri et al. 2023). Using sustainability disclosures as a tool for external verification, firms may reduce information asymmetry and signal their commitment to responsible sustainability practices, thereby reducing agency conflicts and legitimacy risks (Ben-Amar et al. 2017; Ghosh and Wolf 2021). The effectiveness of sustainability assurance mechanisms is not uniform across organisational contexts. In this study, governance quality is conceptualised as a firm-level governance quality construct that conditions the effectiveness of sustainability assurance in influencing corporate climate change performance (Larcker et al. 2007). This conceptualisation is consistent with prior governance and institutional literature suggesting that firm-level governance mechanisms constitute an important internal institutional environment shaping corporate transparency, monitoring effectiveness, accountability and strategic decision-making (Durnev and Kim 2005).

Impression management includes disclosing and communicating positive activities, but downplaying negative information about the climate change performance of a firm (Siano 2024). Impression management theory focuses on deliberate disclosure actions intentionally developed to manipulate or influence how firms are perceived (Bolino et al. 2016). The act of greenwashing should be explained within the context of impression management theory (Hassan et al. 2020; Monteiro and de Souza Gonçalves 2025). Compared with costly ESG practices, ESG greenwashing is a low-cost behavioural strategy with controllable risks and may therefore be a rational choice for firms to conduct impression management in the face of social media pressure (Long et al. 2024). Impression management has been used by psychologists to describe the self-promotional strategy used by firms to create a social image (Tetlock and Manstead 1985). Also, prior studies suggested that firms use impression management strategies to manipulate the perceptions of stakeholders (Cho et al. 2012; Sandberg and Holmlund 2015). An investigation focused on information campaigns conducted by GHG emitters to sway public views and affect policy debates (Talbot and Boiral 2018).

Impression management strategies in communicating sustainability activities are categorised as proactive methods, like acclamation, self-promotion and defensive tactics, like excuses and justifications. However, this may lead to deceptive communication solutions (Hamza and Jarboui 2024). Studies suggested that firms used impression management as a strategy to influence stakeholders' way of thinking about their activities (Al-Sayani et al. 2020; Talbot and Boiral 2015). A limited number of studies have examined the impression management strategy firms devise to shape stakeholders' mindset on climate change and external pressures related to sustainability (Callagher and Garnevska 2023). Firms work tirelessly to influence the impressions that others might perceive of them by manipulating data or information (Miller et al. 2020). Previous studies suggested that firms with the worst performance present the greatest amount of information (Corazza et al. 2020; Cowan and Deegan 2011; Prado-Lorenzo and Garcia-Sanchez 2010). Quality sustainability disclosures may have a positive effect on corporations' competitiveness and value (Raimo et al. 2021).

2.2 | Sustainability Audit Quality and Corporate Climate Change Performance

Sustainability assurance plays a critical role in addressing climate-related challenges and enhancing administrative practices (Al-Shaer 2020; Christensen et al. 2024; Kolk 2008; Ntow-Gyamfi et al. 2020). The 2019 revisions to International Auditing Standards (ISAs) highlighted the importance of climate risks, with ISA 315 allowing auditors to consider these risks when assessing an entity, and ISA 320 enabling their integration into materiality determinations (Kamarudin et al. 2023). Supreme Audit Institutions (SAIs) are instrumental in combating corporate climate change through performance audits, which improve accountability, transparency and the effectiveness of public policies and programs (Eltweri et al. 2022). Sustainability, or 'green accounting', serves as a vital tool for advancing sustainable development and addressing climate change (Aladwan 2018). The ECA has concentrated on climate change, producing comprehensive reports on issues such as flood risks and GHG accounting (Mılıonıs et al. 2021; Mohy-ud-Din et al. 2024). The 2019 ISA revisions, especially ISA 315, highlight the growing emphasis on climate risks within auditing, signalling a global shift towards a greater sustainability focus (Borghei 2021).

In the sustainability assurance literature, audit quality is commonly associated with the credibility, independence, competence and monitoring effectiveness of the assurance process (Hodge et al. 2009; Simnett et al. 2009). Consistent with prior studies, this study measures sustainability audit quality using a principal component analysis (PCA)–based index constructed from three key assurance attributes: (i) the existence of external sustainability assurance, (ii) whether the assurance provider is a Big Four accounting firm and (iii) whether the assurance provider is a professional accounting or assurance organisation. These attributes were selected because they capture the core dimensions of assurance quality most frequently emphasised in prior assurance and auditing research, namely external verification, auditor expertise, professional competence and assurance credibility (Casey and Grenier 2015; Martínez-Ferrero and García-Sánchez 2017).

The presence of external assurance reflects an independent verification mechanism that enhances the reliability and transparency of sustainability disclosures while reducing information asymmetry between firms and stakeholders (Simnett et al. 2009). Similarly, assurance provided by Big Four accounting firms is widely regarded as a proxy for higher audit quality due to their stronger reputational incentives, greater technical expertise, industry specialisation and more rigorous assurance procedures (DeAngelo 1981; Francis 2004). In addition, the involvement of professional accounting or assurance organisations signals adherence to recognised assurance standards, ethical guidelines and professional competence requirements,

thereby strengthening the credibility and consistency of sustainability assurance engagements (Hodge et al. 2009; O'Dwyer and Owen 2005).

Previous studies suggest that sustainability audits, alongside sustainability committees, significantly enhance climate change mitigation strategies and address uncertainties in climate risk and policy (Mohy-ud-Din et al. 2024). Again, prior research indicates that the establishment of an environmental committee within a company reflects its commitment to addressing climate change issues (Liao 2018; Peters and Romi 2015). Sustainability committees are important resources that foster responsible management practices and drive organisational action on environmental matters. Also, the sustainability committee serves as a governance mechanism within the organisation, playing either a symbolic role in compliance or a substantive role in actively addressing challenges (Amran et al. 2014; Rodrigue et al. 2013). As companies increasingly recognise the detrimental impact of their operations on the environment and the potential risks to their long-term performance in tackling climate-related challenges, they have become a key part of corporate strategy (Ngo et al. 2024; Tingbani et al. 2020). Companies are increasingly aware of the financial benefits of high-quality non-financial audit in managing their climate responsibilities (Gitsham et al. 2021).

Additionally, sustainability auditing can influence firms' strategies and outcomes (Christensen et al. 2024). The role of sustainability audit quality in addressing corporate climate change performance has become a major focus in recent academic and policy discussions (Mohy-ud-Din et al. 2024). Better audit quality encourages firms to invest in green policies (Alaamri et al. 2023). Sustainability assurance has become an essential method for evaluating climate change performance (Jamtsho 2005). Green audits are widely recognised as effective tools for tackling climate challenges (Indarto and Ani 2023). Additionally, systematic auditing enhances administrative practices in reducing climate change impacts (Gulluscio et al. 2020). The collaboration between sustainability assurance teams and audit engagement teams indicates that green audits can improve the effectiveness of financial audits, which in turn influences climate change performance (Al-Shaer 2020). Studies (Al Ani et al. 2024; Erin and Ackers 2024) show that the involvement of audit committee members and corporate boards significantly enhances the quality of sustainability reporting, supporting climate change mitigation efforts. Climate-related risks are becoming increasingly important in auditors' assessments of materiality and performance materiality under ISA 320, with auditors adopting a more cautious approach in dealing with climate-related conflicts of interest due to heightened moral awareness (Çalıyurt 2020).

Studies have identified a positive connection between financial audit quality and climate change performance. The impact of sustainability audit quality and corporate climate change performance remains underexplored (Alaamri et al. 2023). Increased engagement of audit committees in non-financial disclosures, such as climate change, often correlates with a larger committee size and higher fees for conducting thorough audits related to corporate accountability towards environmental and social issues (Ghafran and O'Sullivan 2017). The quality of audits, therefore, plays a significant role in determining a company's transparency in areas like climate change disclosures, which affects overall corporate performance (Brammer and Pavelin 2008). Recent studies have suggested that sustainability audit influences Environmental, Social and Governance (ESG) factors in corporate financial performance in Western European markets (Zahid et al. 2022). These findings emphasise that sustainability auditing is crucial in driving robust sustainability performance. However, the exact mechanisms through which sustainability audit quality affects climate change performance and corporate performance require further investigation (Alaamri et al. 2023).

There is a pressing need for comparative studies across different countries and regions to explore how corporate governance mechanisms affect climate change performance (Dong et al. 2022). Cross-country studies could help address challenges related to climate change performance and offer a more comprehensive understanding of how different regions and industries approach the issue (Khan et al. 2022). Corporate responsibility towards climate change can be assessed by comparing a firm's non-financial reporting with that of its peers (Stolowy and Paugam 2023). High-quality, credible and comparable non-financial reports enable companies to differentiate themselves in the market and their performance (Sharma and Bhardwaj 2022). Audit quality strengthens the link between corporate non-financial reporting and overall performance (Yuniarti 2011). Firms can communicate their environmental initiatives, such as green energy efforts, to stakeholders (Bannier et al. 2023). Regulatory bodies have increasingly incorporated climate change considerations into business policies (Maji and Kalita 2022), highlighting the urgent need for firms.

This is essential for achieving the United Nations' SDGs by 2030, which include transitioning to renewable energy sources and reducing carbon emissions (Alaamri et al. 2023). Despite the growing emphasis on sustainability assurance, companies face significant challenges in reducing carbon emissions intensity due to the substantial investment required to switch from fossil fuels to green energy (Gibson et al. 2017; Michalisin and Stinchfield 2010). The marginal financial benefits of adopting alternative energy sources and the regulatory demands for disclosure can act as barriers to climate change initiatives and performance (Bachner et al. 2019; Fu and Waltman 2022). Various factors influence the quality of sustainability audits (Christensen et al. 2019) and are critical determinants of effective corporate governance (Holm and Zaman 2012). Many companies are now more aware of the adverse environmental impact of their operations and the potential consequences for their long-term climate change performance (Amran et al. 2016; Ngo 2022). As businesses face increasing pressure to adopt sustainable practices, the quality of sustainability audits in guiding and validating their climate-related performance becomes even more important. It is hypothesised that

Hypothesis 1. *Sustainability audit quality is negatively associated with firms' total emissions intensity, indicating improved corporate climate change performance.*

2.3 | Sustainability Audit Quality, Governance Quality and Corporate Climate Change Performance

Over time, it has become widely acknowledged that institutions are essential for maintaining sustainability quality, particularly in developing nations (Barrett and Graddy 2000). Although there has been an increase in studies on climate change performance, the role of governance qualities in the relationship between a firm's sustainability audit quality and corporate climate change performance remains largely unknown and understudied. The impact of governance quality on environmental pollution has received limited attention from academics, policymakers and administrators. This paper suggests that the role of governance quality could influence the impact of sustainability audit quality on corporate climate change performance. The effectiveness of sustainability assurance in mitigating climate change may be hindered or enhanced depending on a country's institutions.

In this context, governance quality refers to formal rules established by firms. Quality institutions promote the efficient use of state resources by controlling corruption, maintaining law and order and ensuring freedom of expression (Cao et al. 2022). Quality governance enables firms to promote sustainable development effectively and may result in the reduction of carbon emissions intensity. However, weak governance characterised by corruption and lawlessness often redirects resources from eco-friendly projects to harmful ones (Hunjra et al. 2020). These institutions may neglect to implement policies that encourage a transition from biomass to renewable energy sources, such as solar, wind and ocean energy, to reduce carbon emissions (Gallego-Álvarez et al. 2014; Ntow-Gyamfi et al. 2020). Institutional quality is considered essential for addressing climate change-related challenges in various ways, including the implementation of strict sustainability policies and governing rules (Chhabra et al. 2023). High institutional quality is essential for improving environmental quality and climate change mitigation (Muhammad and Long 2021). It is hypothesised that

Hypothesis 2. *Governance quality moderates the relationship between sustainability audit quality and corporate climate change performance.*

2.4 | Sustainability Audit Quality, Greenwashing and Corporate Climate Change Performance

Greenwashing is becoming a strategy that corporations adopt to cope with political, economic and environmental pressures (Torelli et al. 2020; Zhang and Zhang 2024). However, from the perspective of impression management theory, the authenticity, integrity and reliability of information are affected by management (Tata and Prasad 2015). The knowledge of the actual environmental quality of a firm's operations, processes and environmental footprint is not directly known to external stakeholders. This prompts the challenges investors face from information manipulation behaviour, voluntary initiative of information disclosure and sustainability information having high emotional resilience and ambiguity (He et al. 2022).

This paper suggests that the role of greenwashing could influence the impact of sustainability audit quality on corporate climate change performance. The effectiveness of sustainability auditing in mitigating climate change may be hindered or enhanced depending on the strength of a country's reporting standards. In this context, greenwashers are firms that seem very transparent and report a huge amount of information on ESG but perform poorly in sustainability activities. Also, greenwashing is a deceptive disclosure in all sustainability factors of the ESG (Yu et al. 2020). Marquis et al. (2016) and Yu et al. (2020) suggested that firms with superior environmental performance may practice less greenwashing because they have little to hide. Radu and Francoeur (2017) empirically suggested that environmental performance is positively associated with environmental disclosure. A previous study argued that sustainability greenwashing practices can be stopped due to the strict scrutiny of environmental activists (Lyon and Montgomery 2013). However, recent literature empirically suggested that strict scrutiny and regulations by stakeholders can reduce sustainability greenwashing (Delmas and Burbano 2011; Kim and Lyon 2015). Firms in countries with stringent climate-related regulations are less likely to participate in greenwashing practices (Mateo-Márquez et al. 2022). Conversely, Marquis et al. (2016) suggested that firms are unlikely to be selective in their disclosures if they are under global regulators and scrutiny.

Also, studies suggest that the members of the United Nations Global Compact (UNGC) sometimes show commitments towards sustainability, whereas their environmental practices are abysmal, to earn a reputation for being seen as green (Berliner and Prakash 2012; Yu et al. 2020). The study of US electric utility company data claims firms may use communication skills to downplay their sustainability achievements (brownwashing) (Kim and Lyon 2015). Greenwashing is the method of selective reporting techniques that show positive sustainability information, whereas the reality is withheld (Lyon and Maxwell 2011; Marquis et al. 2016). We find evidence that greenwashing behaviour in sustainability dimensions can be deterred by scrutiny from independent directors, institutional investors, influential public interests, via a less corrupt country system and being cross-listed. Prior studies suggest that the two firm-level governance factors are most effective at attenuating firms' misleading disclosure relating to sustainability dimensions (Yu et al. 2020). The study suggests that firms can overstate the sustainability benefits of a product to attract more purchases (Delmas and Burbano 2011). As suggested by Bowen and Aragon-Correa (2014), greenwashing is an intentional information disclosure decision initiated by companies that may be beneficial to them but harmful to the environment. It is hypothesised that

Hypothesis 3. *Greenwashing moderates the relationship between sustainability audit quality and corporate climate change performance.*

3 | Methodology and Data

3.1 | Empirical Model

To examine whether sustainability audit quality affects corporate climate change performance, we estimate the following models:

$$Totalemissionintensity_{Ijkt} = \beta_o + \beta_1\, Sustainabilityauditquality_{kt} + B_2 controls_{it} + \varphi_t + \varphi_j + \varepsilon_{ijkt} \quad (1)$$

where I index is for firms, J connotes industries, K connotes countries, T connotes year (time), X is the vector of time-varying firm control variables and φ is a set of fixed effects. $Totalemissionintensity_{Ijkt}$ is the dependent variable, and β_o is a constant. $Sustainabilityauditquality_{kt}$ and $\beta_2 controls_{it}$ are vectors of coefficients to be estimated. Sustainability audit quality is measured using a PCA-based assurance quality index, constructed from assurance presence, Big 4 and provider quality. $B_2 controls_{it}$ is a vector of firm- and country-specific control variables. φ_t and φ_j are industry and year fixed effects, respectively. Finally, ε_{ijkt} is the firm-year-specific error term. $B_2 controls_{it}$, the vector of the firm- and country-specific control variables, includes firm size, market presence, profitability, leverage, liquidity, environment pillar score, emission scores, board size, number of board meetings, independent board member, societal secrecy, long-term orientation and economic development (Chen et al. 2017; Oyewo 2023).

Next, we build on and extend our analysis by exploring the moderating effect of institutional quality on the relationship between sustainability audit quality and corporate climate change performance. Specifically, we estimate the following augmented empirical model:

$$Totalemissionintensity_{Ijkt} = \beta_o + \beta_1\, Sustainabilityauditquality_{kt} + \beta_2 controls_{it} + \beta_3\,(Sustainabilityauditquality_{kt} \times governancequality_{kt}) + \varphi_t + \varphi_j + \varepsilon_{ijkt} \quad (2)$$

where I index is for firms, J connotes industries, K connotes countries, T connotes year (time), X is the vector of time-varying firm control variables and φ is a set of fixed effects. $Totalemissionintensity_{Ijkt}$ is the dependent variable, and β_o is a constant. $Sustainabilityauditquality_{kt}$ and $\beta_2 controls_{it}$ are vectors of coefficients to be estimated. $Sustainabilityauditquality \times governancequality$ is the interaction term between sustainability audit quality and governance quality. $B_2 controls_{it}$ is a vector of firm- and country-specific control variables. φ_t and φ_j are industry and year fixed effects, respectively. Finally, ε_{ijkt} is the firm-year-specific error term. $B_2 controls_{it}$, the vector of the firm and country-specific control variables, is defined in Equation (1) (Islam et al. 2020).

Also, we build on and extend our analysis by exploring the moderating effect of greenwashing on the relationship between sustainability audit and corporate climate change performance. Specifically, we estimate the following augmented empirical model:

$$Totalemissionintensity_{Ijkt} = \beta_o + \beta_1\, Sustainabilityauditquality_{kt} + \beta_2 controls_{it} + \beta_3\,(Sustainabilityauditquality_{kt} \times Greenwashing_{kt}) + \varphi_t + \varphi_j + \varepsilon_{ijkt} \quad (3)$$

where I index is for firms, J connotes industries, K connotes countries, T connotes year (time), X is the vector of time-varying firm control variables and φ is a set of fixed effects. $Totalemission_{Ijkt}$ is the dependent variable, and β_o is a constant. $Sustainabilityauditquality_{kt}$ and $\beta_2 controls_{it}$ are vectors of coefficients to be estimated. $Sustainabilityauditing \times greenwashing$ is the interaction term between sustainability audit quality and greenwashing. $B_2 controls_{it}$ is a vector of firm- and country-specific control variables. φ_t and φ_j are industry and year fixed effects, respectively. Finally, ε_{ijkt} is the firm-year-specific error term. $B_2 controls_{it}$, the vector of the firm and country-specific control variables (Mateo-Márquez et al. 2022; Yu et al. 2020). We estimate Equations (1), (2) and (3) via ordinary least squares (OLS) with industry and year-fixed effects to control for heterogeneity across industries and time. Appendix 1 provides detailed definitions for all variables in this international study.

3.2 | Variables

Our firm-level dataset is drawn from Refinitiv DataStream. This study also draws on datasets for governance quality indicators (Cek and Kalmaz 2025) and the greenwashing variable (Du 2015; Marquis et al. 2016) from Refinitiv DataStream. The primary independent variable for this research is the sustainability audit quality measured using a PCA-based assurance quality index, constructed from assurance presence, Big 4 and provider quality (Barzegar and Kazemi 2025; Wu and Yu 2025; Zeng et al. 2022). We apply several filters to our firm-level dataset. This study excludes firms with missing data on the key variables and countries with missing macroeconomic indicators. Finally, this study winsorizes all firm-level variables at the upper and lower one percentiles to reduce the effect of outliers. Our final sample 6140 observations from 39 countries from 2008 to 2023.

3.2.1 | Dependent Variable

Climate change performance is proxied by total emission intensity, measured as Scope 1 and Scope 2 emissions scaled by total revenue. The Refinitiv database follows the Greenhouse Gas (GHG) protocol for categorising emissions by type. The decision to focus on total Scope 1 and Scope 2 emissions is because it offers a comprehensive measure of both direct and indirect emissions associated with firms. Previous studies have used the total emissions scaled by total revenue as a proxy for climate change performance (Berg et al. 2024; Busch and Hoffmann 2011; Busch et al. 2012; Busch and Lewandowski 2018). The amount of carbon emissions has a negative polarity, meaning a lower rate indicates better performance in mitigating emissions (Oyewo 2023). Total emission intensity is calculated as the sum of Scope 1 and Scope 2 emissions scaled by total revenue. Scope 1 represents direct emissions that firms generate during business operations, whereas Scope 2 accounts for indirect emissions from energy purchases.

3.2.2 | Variable of Interest

The primary independent variable in this study is sustainability audit quality. Consistent with prior sustainability assurance and auditing literature, sustainability audit quality is measured using a PCA-based sustainability audit quality index constructed from three assurance-related attributes: (i) the presence of external sustainability assurance, (ii) whether the assurance provider is a Big Four accounting firm and (iii)

the quality and professional standing of the assurance provider (Barzegar and Kazemi 2025; Wu and Yu 2025; Zeng et al. 2022). These dimensions were selected because they capture the core monitoring, competence and credibility commonly associated with high-quality sustainability assurance engagements (Hodge et al. 2009; Simnett et al. 2009). These three attributes were selected because they are the only assurance-quality characteristics consistently available across firms, industries and countries throughout the sample period. Other assurance characteristics, including assurance scope, assurance level and engagement procedures, are not consistently reported internationally and would substantially reduce sample coverage and comparability.

This study constructed the sustainability audit quality index using a combination of PCA and exploratory factor analysis (EFA) to ensure robustness and construct validity. Before index construction, we assessed the suitability of the data for dimension reduction using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity (Bartlett 1954; Kaiser 1974). The KMO statistic indicates marginal but acceptable sampling adequacy for exploratory analysis (KMO = 0.50), and Bartlett's test of sphericity rejects the null hypothesis of an identity correlation matrix ($x^2 = 33{,}000$, $p = 0.001$), confirming sufficient intercorrelation among variables. PCA results show a dominant first component with an eigenvalue of 1.97, explaining approximately 65.8% of the total variance, consistent with common criteria for component retention (Jolliffe 2002). Examination of component loadings indicates that Big 4 affiliation and provider quality load strongly on the first component, whereas sustainability audit occurrence loads weakly and separately, suggesting partial multidimensionality. To further assess construct validity, EFA was conducted, which provides additional diagnostics including factor loadings and communalities (Fabrigar and Wegener 2012; Fabrigar et al. 1999; Hair et al. 2019). The combined PCA and EFA results support a composite index derived from the observed dimensions rather than a strictly unidimensional latent construct. The sustainability audit quality index is constructed using the first principal component extracted from PCA. EFA is reported solely as a complementary assessment of construct validity and is not used to derive the index.

The first moderating variable, governance quality, was constructed using PCA based on governance-related indicators from the Refinitiv DataStream, including the governance pillar score, policy business ethics score, board management theme score and CSR strategy score. These variables jointly capture multiple dimensions of firms' governance quality, including board effectiveness and managerial oversight, ethical business conduct and firms' strategic orientation towards sustainability and responsible business practices.

To assess whether the selected governance dimensions could be combined into meaningful composite constructs. Before PCA, the suitability of the data for dimension reduction was assessed using the KMO measure of sampling adequacy and Bartlett's test of sphericity (Bartlett 1954; Kaiser 1974). The KMO statistic indicates marginal but acceptable sampling adequacy for exploratory analysis (KMO = 0.577), and Bartlett's test of sphericity rejects the null hypothesis of an identity correlation matrix ($x^2 = 10{,}655.814,\ 0.001$), confirming sufficient intercorrelation among the governance quality indicators. PCA results identify a dominant first component with an eigenvalue of 1.89, explaining 47.36% of the total variance, whereas the first two components jointly account for 70.31% of the variance. Examination of component loadings shows that the first component captures a broad institutional quality dimension, with positive loadings across governance pillar score (0.591), board management score (0.524), business ethics policy (0.404) and CSR strategy score (0.462). Further assessment using varimax rotation reveals two interpretable governance dimensions: governance strategy and responsibility dimension, characterised by strong loadings from governance pillar score and CSR strategy score, and a governance systems and control dimension, characterised by strong loadings from board management and business ethics policy. These findings suggest that governance quality indicators exhibit multidimensionality rather than representing a purely unidimensional construct.

The second moderating variable, greenwashing, was constructed using Refinitiv DataStream indicators. Greenwashing is constructed as the discrepancy between emissions-related performance and disclosure score (emission score) and firms' actual carbon-emissions performance, measured by carbon emissions intensity (logarithm of Scope 1 plus Scope 2 emissions scaled by total revenue) (Kim and Lyon 2015; Marquis et al. 2016; Walker and Wan 2012). This measure captures the extent to which firms engage in impression management by overstating environmental commitment relative to actual performance. This disclosure–performance gap follows the conceptualisation of greenwashing proposed by Marquis et al. (2016) and Walker and Wan (2012), whereby greenwashing reflects divergence between communicated environmental commitment and realised environmental performance. Detailed definitions of this variable are also presented in Table 1.

Therefore, greenwashing = Emissions performance and disclosure Score
– Emissions Performance
(total carbon emissions intensity).

3.2.3 | Control Variables

Consistent with previous research, firm-level variables were included as control variables to account for factors that influence climate change performance, like size, leverage, liquidity, market presence and profitability (Oyewo 2023; Tingbani et al. 2020). Research indicates that country-level governance and national culture influence climate change performance. Therefore, this study also included country-level and corporate governance control variables consistent with previous studies on environmental sustainability practices (Chen et al. 2017; Lenssen et al. 2014). Variable measurements and data sources are summarised in Table 1.

3.3 | Descriptive Statistics

Table 1 presents descriptive statistics, which provide an essential foundation for understanding the characteristics of the dataset and assessing climate change performance across a global sample of firms, supporting robust empirical analysis.

TABLE 1 | Descriptive statistics.

Variables	Obs	Mean	Std dev	Min	Max	p1	p99	Skew	Kurt
Climate change performance	16,464	0.734	0.158	0.333	1.104	0.333	1.104	−0.003	2.77
Sustainability audit quality	11,338	0	1	−2.024	0.538	−2.024	0.538	−1.433	3.105
Size	60,616	16.464	2.983	10.29	24.107	10.324	23.956	0.294	2.574
Market presence	59,533	16.071	2.774	10.291	23.383	10.291	23.327	0.318	2.623
Leverage	60,520	82.558	145.552	−273.03	915.3	−273.03	885.93	3.029	16.355
Liquidity	52,011	2.37	2.533	0.24	18.15	0.25	17.62	3.863	21.236
Profitability	59,924	4.181	11.424	−55.99	34.62	−54.01	34.62	−2.055	12.793
Environment pillar score	30,062	39.189	28.553	0	93.7	0	93.7	0.181	1.78
Board independence	29,488	57.43	25.781	0	100	0	100	−0.371	2.203
Emission score	30,062	41.629	33.558	0	98.85	0	98.85	0.15	1.604
No board meetings	26,176	9.342	4.758	4	28	4	28	1.424	5.449
Board size	30,001	9.836	3.385	4	21	4	21	0.875	3.936
Societal secrecy	63,400	54.54	49.996	−19	140	−19	137	−0.059	1.382
Long-term orientation	63,400	55.599	26.371	21	100	21	100	0.194	1.485
Economic development	63,400	28.614	1.382	26.054	30.94	26.079	30.94	−0.098	2.032

Note: The table presents descriptive statistics for variables in our analysis. All variables are fully defined in Appendix 1.

The dependent variable, total emissions intensity, has a mean of 0.734 with a standard deviation of 0.158, suggesting moderate but relatively concentrated performance differences across firms. Firm characteristics show expected heterogeneity. Size and market presence exhibit wide distributions, reflecting the presence of both small and very large firms. Financial variables such as leverage and liquidity display strong skewness and high kurtosis, indicating outliers and non-normal distributions, which is typical in firm-level financial data (Semykina and Wooldridge 2010). Profitability also shows substantial variation, including negative values, reflecting loss-making firms in the sample. Environmental pillar scores and emission scores span a wide range, indicating significant cross-firm differences in sustainability performance. Governance variables (board independence, board size and meeting frequency) also vary meaningfully, supporting their inclusion as explanatory controls. The dataset is sufficiently heterogeneous across financial, governance, ESG and institutional dimensions for further analysis.

3.4 | Pairwise

Table 2 presents the pairwise correlations between firm-level characteristics, governance mechanisms, country-level factors, sustainability audit quality and climate change performance. The results show that sustainability audit quality is negatively and insignificantly associated with climate change performance (−0.003, 0.741). This suggests that, at the bivariate level, there is no evidence that higher sustainability audit quality translates into better climate performance, and the relationship is statistically insignificant. This may reflect that sustainability audit quality is primarily compliance-driven rather than performance-enhancing in practice (DeFond and Zhang 2014; Simnett et al. 2009). Firm characteristics show clearer patterns. Firm size (−0.409) and market presence (−0.393) are strongly negatively correlated, indicating that larger firms tend to exhibit weaker climate outcomes. Financial variables such as leverage, liquidity and ROA show weak negative correlations, suggesting a limited relationship with climate change performance. Governance variables show mixed effects. Board independence is positively correlated (0.272), whereas board size and board meetings show weak or negative relationships. Environmental and emission scores show only weak positive correlations with climate change performance. At the country level, societal secrecy (−0.323) and long-term orientation (−0.315) are strongly negatively correlated, whereas economic development shows no meaningful relationship. All correlation coefficients are below 0.8, indicating no multicollinearity concerns among the variables.

4 | Empirical Results

4.1 | Baseline Results

Table 3 presents the baseline results for Equation (1) by examining the relationship between sustainability audit quality and corporate climate change performance. Climate change performance is proxied by total emission intensity, measured as the logarithm of Scope 1 and Scope 2 emissions scaled by total revenue. Sustainability audit quality is measured using a PCA-based assurance quality index, constructed from assurance presence, Big 4 and provider quality. To effectively capture the impact of the relationship, we split the estimation into four columns, adjusting for other factors, industry and year fixed effects. In Column (1), we present the result,

TABLE 2 | Pairwise correlations.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) Climate change performance	1.000														
(2) Sustainability audit quality	−0.003	1.000													
	(0.741)														
(3) Size	−0.409*	−0.054*	1.000												
	(0.000)	(0.000)													
(4) Market presence	−0.393*	−0.065*	0.901*	1.000											
	(0.000)	(0.000)	(0.000)												
(5) Leverage	−0.045*	0.006	0.144*	0.031*	1.000										
	(0.000)	(0.520)	(0.000)	(0.000)											
(6) Liquidity	−0.059*	0.007	−0.209*	−0.152*	−0.196*	1.000									
	(0.000)	(0.508)	(0.000)	(0.000)	(0.000)										
(7) Profitability	−0.075*	−0.094*	0.149*	0.212*	−0.013*	−0.135*	1.000								
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)									
(8) Environment pillar score	0.048*	0.012	0.351*	0.319*	0.119*	−0.206*	0.063*	1.000							
	(0.000)	(0.232)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)								
(9) Board independence	0.272*	0.123*	−0.422*	−0.394*	−0.019*	0.046*	−0.018*	−0.066*	1.000						
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.002)	(0.000)							
(10) Emission score	0.047*	0.016	0.324*	0.320*	0.082*	−0.201*	0.071*	0.898*	−0.077*	1.000					
	(0.000)	(0.109)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)						
(11) No board meetings	−0.151*	0.067*	0.142*	0.094*	0.077*	−0.006	−0.112*	0.096*	−0.081*	0.099*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.347)	(0.000)	(0.000)	(0.000)	(0.000)					
(12) Board size	−0.006	−0.059*	0.362*	0.303*	0.144*	−0.219*	0.039*	0.317*	−0.220*	0.275*	−0.040*	1.000			
	(0.515)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				

(Continues)

TABLE 2 | (Continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(13) Societal secrecy	−0.323*	−0.198*	0.645*	0.613*	0.021*	−0.103*	0.083*	0.196*	−0.618*	0.216*	0.137*	0.221*	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
(14) Long-term orientation	−0.315*	−0.157*	0.571*	0.541*	−0.011*	−0.099*	0.055*	0.234*	−0.547*	0.245*	0.061*	0.245*	0.712*	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
(15) Economic development	−0.009	0.013	−0.098*	−0.067*	−0.046*	0.046*	−0.061*	−0.163*	0.212*	−0.171*	−0.052*	0.049*	−0.287*	−0.037*	1.000
	(0.229)	(0.182)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

Note: Appendix 1 defines all variables used.
*Shows significance at $p < 0.05$.

including year and industry fixed effects, but excluding all the control variables. The rationale is to isolate the impact of these fixed effects on the relationship between climate change performance and sustainability audit quality without the interference of other variables. By excluding control variables, the analysis focuses solely on understanding how the fixed effects, which account for time-invariant heterogeneity across industries and changes over time, independently influence the model. This approach helps in identifying whether and how these fixed factors contribute to variance that might otherwise be attributed to more variable-specific factors if control variables were included. In Column (2), we re-estimated Equation (1), controlling for only firm-level characteristics. In Column (3), we included corporate governance controls, excluding country-level controls. Finally, in Column (4), we re-estimated our baseline model controlling for all control variables (firm, corporate governance and country-level controls).

The results show a negative and significant relationship between sustainability audit quality and total emission intensity, supporting our Hypothesis 1, which implies that firms engaging in higher quality sustainability assurance will lead to lower emissions due to their accountability, transparency and proper disclosure of their operations. The analysis across model specifications provides further insight into the relationship. The sustainability audit quality coefficient is not statistically significant in exclusion models but becomes significant after the inclusion of comprehensive controls. This suggests that the effect of audit quality on total emissions intensity is conditional on firm characteristics, governance structures and country factors. The explanatory power of the model also increases substantially across specifications, with *R*-square rising from 0.274 to 0.513, indicating that the fully specified model captures a significant portion of variation in total emission intensity. These results highlight the importance of controlling for confounding factors when examining the environmental impact of sustainability assurance. The result is negatively related to total emission intensity (−0.00396, 0.01), indicating that firms with higher quality sustainability assurance exhibit lower emission intensity. This finding provides evidence that sustainability audit quality is related to improved corporate climate change performance outcomes, rather than merely enhanced disclosure practices.

The findings suggest that a one-unit increase in sustainability audit quality is associated with a 0.396% decrease in total emissions intensity, indicating that firms in the circle of sustainability assurance countries emit, on average, 0.396% less CO_2 emissions intensity compared to firms that do not engage in high-quality sustainability assurance services, while holding all other factors constant. This finding supports Hypothesis 1. The negative relationship between sustainability audit quality and total emission intensity suggests that sustainability auditing functions as an effective governance mechanism that promotes sustainability accountability. Also, high-quality assurance enhances the credibility and reliability of environmental disclosures, thereby strengthening stakeholder monitoring and reducing information asymmetry, and firms face increased pressure to align reported environmental performance with actual operational practices (Simnett et al. 2009). Again, the

TABLE 3 | Sustainability audit quality and corporate climate change performance.

Variables	(1) Climate change performance	(2) Climate change performance	(3) Climate change performance	(4) Climate change performance
Sustainability audit quality	0.0000552	−0.00144	−0.000972	−0.00396***
Size		−0.0174***	−0.0130***	−0.00952***
Market presence		−0.00620***	−0.00742***	−0.00882***
Leverage		0.0000196*	0.0000488***	0.0000448***
Liquidity		−0.00976***	−0.00458*	−0.00475**
Profitability		−0.00138***	−0.00127***	−0.00138***
Environment pillar score			0.000610***	0.000589***
Board independence			0.000971***	0.000648***
Emission score			−0.000348***	−0.000289***
No board meetings			−0.00137***	−0.00133***
Board size			0.00725***	0.00680***
Societal secrecy				−0.000144***
Long-term orientation				−0.000592***
Economic development				0.00648***
Constant	0.740***	1.190***	0.999***	0.841***
No of obs.	9860	8298	6140	6140
R-square	0.274	0.427	0.503	0.513
Adj *r*-square	0.271	0.424	0.499	0.509
F-statistic	0.00	466.00	257.27	225.00
Year fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes
Country controls	Yes	Yes	Yes	Yes

Note: This table presents the baseline results of the relationship between sustainability auditing and climate change performance (total emissions). Column (1) includes only sustainability auditing as the explanatory variable. Column (2) adds firm-level financial controls (size, market presence, leverage, liquidity and profitability). Column (3) further includes governance and environmental variables (environmental pillar scores, board independence, emission scores, board meetings and board size). Column (4) additionally incorporates societal secrecy and country-level macro controls (long-term orientation and economic development). All regressions include year and industry fixed effects. Robust *t*-statistics are reported in parentheses.
***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

findings are consistent with previous studies, which emphasise the role of auditor reputation and expertise in ensuring reporting quality. High-quality assurance providers, Big 4 auditors, possess stronger reputational incentives and greater technical capabilities, leading to more rigorous verification processes and reduced scope for opportunistic or symbolic environmental reporting (DeAngelo 1981; Francis 2004). Importantly, the PCA-based measurement of sustainability audit quality reveals that the relationship is driven primarily by qualitative differences in the audit framework, rather than the mere existence of assurance services.

This finding reinforces the limitation of binary assurance measures and supports the use of a multidimensional index to capture variation in sustainability audit quality. Similarly, the study finds a significant relationship between our key dependent variable and the relevant control variables, similar to evidence from other prior studies (Khan et al. 2022; Oyewo 2023). For instance, we find total emission intensity to be positively correlated with leverage, environment pillar score, board independence, board size and economic development and negatively correlated with firm size, market presence, liquidity, profitability, emission scores, number of board meetings, societal secrecy and long-term orientation. For brevity, we do not delve into the control variable results.

4.2 | The Moderating Effect of Governance Quality

Table 4 extends our analysis by examining the moderating effects of governance quality on the relationship between sustainability audit quality and corporate climate change performance.

TABLE 4 | Sustainability audit quality, governance quality and corporate climate change performance.

Variables	(1) Climate change performance	(2) Climate change performance	(3) Climate change performance
Interaction			0.00674*
Sustainability audit quality	−0.00400***	−0.00851**	−0.0113***
Governance quality		0.0161***	0.0162***
Size	−0.00947***	−0.00485	−0.00499
Market presence	−0.00890***	−0.0103***	−0.0102***
Leverage	0.0000447***	0.0000380*	0.0000373*
Liquidity	−0.00474**	0.00420	0.00410
Profitability	−0.00137***	−0.000718	−0.000752
Environment pillar score	0.000584***	0.000534*	0.000557**
Board independence	0.000638***	0.000280*	0.000281*
Emission score	−0.000291***	−0.000256	−0.000266
No board meetings	−0.00131***	−0.00212***	−0.00216***
Board size	0.00675***	0.00598***	0.00616***
Societal secrecy	−0.000142***	−0.000247**	−0.000245**
Long-term orientation	−0.000593***	−0.000705***	−0.000690***
Economic development	0.00647***	0.00242	0.00157
Constant	0.843***	0.922***	0.944***
No. of obs.	6146	1125	1125
R-square	0.512	0.577	0.578
Adj *r*-square	0.508	0.556	0.557
F-statistic	224.0	34.7	33.4
Year fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes
Country controls	Yes	Yes	Yes

Note: The table presents the results of the moderating effect of governance quality on the relationship between sustainability auditing and climate change performance, estimated using Equation (2). Column (1) reports the baseline model, inclusive of all control variables. Column (2) reports the baseline regression, including governance quality, together with all control variables. Column (3) reports the regression analysis of the interaction term between sustainability auditing and governance quality with all control variables. All regressions are panel models with year and industry fixed effects. Robust *t*-statistics are shown in parentheses.
***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

Specifically, we estimate Equation (2), which includes the sustainability audit quality measured using PCA, an indicator variable for firm-level governance quality that captures governance pillar score, board and management theme score, policy business ethics score and CSR strategy score. These variables jointly capture multiple dimensions of firms' governance quality, including board effectiveness and managerial oversight, ethical business conduct and firms' strategic orientation towards sustainability and responsible business practices, as well as the interaction term between the indicator variable for institutional quality and the sustainability audit quality (sustainability audit quality × governance quality). Based on our hypothesis and prior research (Hunjra et al. 2020; Maduka et al. 2022). The study expects the coefficient on the interaction term to be positive and significant.

The results indicate that sustainability audit quality remains negative and statistically significant with carbon emissions intensity (−0.0113, 0.01), suggesting that stronger sustainability assurance mechanisms contribute to improved corporate climate change performance through lower emission intensity. Governance quality itself exhibits a positive and statistically significant relationship with emissions intensity (0.0162, 0.001), potentially reflecting higher disclosure transparency and more comprehensive emissions reporting among firms operating within stronger governance environments.

The interaction term between sustainability audit quality and governance quality is positive and marginally significant (0.0067, 0.10). Given the negative direct effect of sustainability audit quality, this result suggests that the emissions-reducing impact of audit quality becomes weaker as governance quality increases. In other words, sustainability audit quality is more effective in weaker institutional environments, whereas marginal contribution declines in stronger governance settings. This pattern is consistent with the idea that different governance mechanisms may partially overlap in their monitoring and enforcement roles, leading to diminishing incremental effects when institutional structures are already strong (Durnev and Kim 2005; Larcker et al. 2007).

The evidence indicates a substitution-type relationship between governance quality and sustainability audit quality in environmental performance. Although the moderating effect remains statistically modest, the consistency in coefficient direction across alternative governance quality constructions strengthens confidence in the underlying theoretical relationship. The findings suggest that sustainability audit quality remains an important mechanism for improving corporate climate change performance and the effectiveness of such assurance may vary depending on firms' broader institutional governance environments.

The study finds a significant relationship between our key dependent variable and the relevant control variables, similar to evidence from other prior studies (Khan et al. 2022; Oyewo 2023). For instance, we find total emission intensity to be positively correlated with leverage, liquidity, environment pillar score, board independence, board size and economic development and negatively correlated with firm size, market presence, profitability, emission scores, number of board meetings, societal secrecy and long-term orientation. Overall, the results provide clear evidence that institutional quality moderates the effect of sustainability audit quality on corporate climate change performance, consistent with our theoretical predictions.

4.3 | The Moderating Effect of Greenwashing

Table 5 provides a robust test by examining the moderating effects of greenwashing on the relationship between sustainability audit quality and corporate climate change performance. Specifically, this study measured greenwashing as the discrepancy between emissions-related performance and disclosure score (emission score) and firms' actual carbon-emissions performance, measured by carbon emissions intensity Scope 1 plus Scope 2 emissions scaled by total revenue (Kim and Lyon 2015; Marquis et al. 2016; Walker and Wan 2012). Greenwashing is conceptualised as the extent of deviation between symbolic environmental disclosure and substantive emissions performance, consistent with impression management theories (Marquis et al. 2016).

Table 5 reports the regression results across three specifications. The baseline model (Column 1) includes only control variables and indicates a reasonable explanatory power of corporate emissions intensity ($R^2 = 0.513$). The inclusion of key explanatory variables in Column (2) substantially improves model fit ($R^2 = 0.851$), suggesting that sustainability governance variables explain a significant proportion of variation in emissions intensity. The full moderation model in Column (3) introduces the interaction between sustainability audit quality and greenwashing.

The results indicate that sustainability audit quality is significantly and negatively associated with carbon emissions intensity (−0.00231, 0.05), suggesting that higher quality sustainability audit mechanisms are associated with improved climate performance through lower emissions intensity. This finding supports the view that stronger assurance and monitoring mechanisms enhance the credibility and effectiveness of corporate environmental governance (Casey and Grenier 2015; Simnett et al. 2009). The result is also consistent with prior evidence suggesting that high-quality sustainability assurance strengthens stakeholder confidence, improves reporting reliability and promotes better environmental performance outcomes (Kend 2015; Martínez-Ferrero and García-Sánchez 2017).

Conversely, greenwashing exhibits a strong and highly significant positive association with emissions intensity (0.112, 0.001), indicating that firms engaging in higher levels of symbolic environmental disclosure tend to exhibit substantially worse environmental performance. This result is consistent with the impression management perspective, which argues that greenwashing reflects a decoupling between disclosure and substantive environmental action (Delmas and Burbano 2011; Walker and Wan 2012). The result further supports prior evidence suggesting that greenwashing is associated with weaker environmental accountability, lower transparency and poorer sustainability outcomes, particularly where disclosure practices become decoupled from actual environmental performance (Lyon and Montgomery 2015; Marquis et al. 2016).

The interaction term between sustainability audit quality and greenwashing is positive and marginally significant (0.000972, 0.10). Given that the main effect of sustainability audit quality is negative, this result provides weak evidence that greenwashing attenuates the beneficial impact of sustainability audit quality on emissions intensity. In economic terms, the effectiveness of audit quality in reducing carbon emissions appears weaker among firms exhibiting higher levels of symbolic sustainability disclosure. This finding is broadly consistent with impression management theories, which suggest that symbolic disclosure practices can constrain the effectiveness of external monitoring and assurance mechanisms by masking underlying environmental weaknesses (Delmas and Burbano 2011; Marquis et al. 2016). The result is also consistent with prior studies indicating that sustainability assurance may be less effective when firms engage in decoupling behaviour between ESG disclosure and substantive environmental practices (Kim and Lyon 2015; Lyon and Montgomery 2015; Walker and Wan 2012). Again, the statistical significance of the moderating effect remains relatively weak, suggesting that the conditional relationship should be interpreted cautiously and may reflect the inherently complex and context-dependent nature of greenwashing behaviour.

Similarly, the study finds a significant relationship between our key dependent variable and the relevant control variables, similar to evidence from other prior studies (Khan et al. 2022;

TABLE 5 | Sustainability audit quality, greenwashing and corporate climate change performance.

Variables	(1) Climate change performance	(2) Climate change performance	(3) Climate change performance
Interaction			0.000972*
Sustainability audit quality	−0.00400***	−0.00135*	−0.00231**
Greenwashing		0.112***	0.112***
Size	−0.00963***	−0.00411***	−0.00416***
Market presence	−0.00872***	−0.00117	−0.00119
Leverage	0.0000464***	0.0000309***	0.0000310***
Liquidity	−0.00468*	−0.000738	−0.000717
Profitability	−0.00140***	−0.000601***	−0.000606***
Environment pillar score	0.000311***	−0.00312***	−0.00312***
Board independence	0.000637***	0.0000542	0.0000531
No board meetings	−0.00139***	−0.00111***	−0.00110***
Board size	0.00679***	0.00187***	0.00191***
Societal secrecy	−0.000158***	−0.000196***	−0.000199***
Long-term orientation	−0.000595***	−0.000198***	−0.000189***
Economic development	0.00629***	−0.0000678	−0.000151
Constant	0.846***	0.951***	0.953***
No. of obs.	6140	6140	6140
R-square	0.513	0.851	0.851
Adj *r*-square	0.506	0.850	0.850
F-statistic	238.8	1507.5	1408.6
Year fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes
Country controls	Yes	Yes	Yes

Note: The table presents the results of the moderating impact of greenwashing on the relationship between sustainability auditing and climate change performance using Equation (3). Column (1) reports the baseline model inclusive of all control variables only. Column (2) reports the regression of the baseline including greenwashing together with all control variables. Column (3) reports the regression analysis of the interaction term between sustainability auditing and greenwashing with all control variables. All regressions are panel models with year and industry fixed effects. Robust *t*-statistics are shown in parentheses.
***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

Oyewo 2023). For instance, we find total emission intensity to be positively correlated with leverage, board independence, board size and negatively correlated with firm size, market presence, liquidity, profitability, environmental pillar score, number of board meetings, societal secrecy, long-term orientation and economic development. For brevity, we do not delve into the control variable results.

4.4 | Mediation Analysis: The Role of Greenwashing

Table 6 examines greenwashing as a mediating channel through which sustainability audit quality may influence corporate climate change performance. The rationale for this approach lies in the dual role of sustainability assurance; although intended to enhance credibility and transparency, its effectiveness can be undermined if companies simultaneously engage in impression management practices (Marquis et al. 2016). Greenwashing is defined as the strategic misrepresentation of environmental commitment to represent a plausible pathway through which the intended benefits of sustainability auditing are diluted. Also, by overstating sustainability achievements or disclosing selectively favourable information, firms may leverage the credibility associated with auditing while continuing to pursue environmentally detrimental activities and practices (Delmas and Burbano 2011).

The mediation analysis provides evidence that sustainability audit quality significantly reduces firms' engagement in

TABLE 6 | Mediation analysis: The role of greenwashing.

	(1)	(2)	(3)
Variables	**Greenwashing**	**Climate change performance**	**Climate change performance**
Greenwashing			0.156***
Sustainability audit quality	−0.0272***	−0.00400***	0.000239**
Size	−0.0591***	−0.00947***	−0.000244**
Market presence	−0.0577***	−0.00890***	0.000107
Leverage	0.000293***	0.0000447***	−0.00000105
Liquidity	−0.0281*	−0.00474**	−0.000355***
Profitability	−0.00893***	−0.00137***	0.0000201
Environment pillar score	0.00382***	0.000584***	−0.0000119
Board independence	0.00414***	0.000638***	−0.00000713
Emission score	0.0278***	−0.000291***	−0.00464***
No board meetings	−0.00854***	−0.00131***	0.0000279
Board size	0.0432***	0.00675***	0.00000344
Societal secrecy	−0.000927***	−0.000142***	0.00000237
Long-term orientation	−0.00380***	−0.000593***	−8.59e-09
Economic development	0.0389***	0.00647***	0.000404***
Constant	−0.498**	0.843***	0.921***
No. of obs.	6146	6146	6146
R-square	0.713	0.512	0.997
Adj *r*-square	0.710	0.508	0.997
F-statistic	705.0	224.0	45032.7
Year fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes
Country controls	Yes	Yes	Yes

Note: The table presents the results of the mediating impact of greenwashing on the relationship between sustainability auditing and climate change performance using regression analysis. The column reports the mediating effect of greenwashing, inclusive of all control variables. All regressions are panel models with year and industry fixed effects. Robust *t*-statistics are shown in parentheses.
***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

greenwashing practices. Specifically, sustainability audit quality exhibits a negative and statistically significant association with greenwashing (−0.0272, 0.01), suggesting that stronger sustainability auditing constrains symbolic environmental disclosure and improves the credibility of firms' sustainability reporting and disclosure. This finding is consistent with prior studies arguing that external sustainability auditing enhances reporting transparency and reduces opportunistic disclosure behaviour by strengthening monitoring and accountability mechanisms (Cho et al. 2013; Simnett et al. 2009).

The baseline analysis further shows that sustainability audit quality is negatively associated with carbon emissions intensity (−0.0040, 0.01), indicating that firms with quality sustainability audit mechanisms tend to demonstrate superior environmental performance through lower emissions intensity. This finding supports the broader governance and assurance literature suggesting that credible sustainability auditing improves environmental transparency, accountability and encourages substantive climate-related actions (Martínez-Ferrero and García-Sánchez 2017; Peters and Romi 2015).

Overall, the regression model that involves greenwashing and sustainability audit quality with climate change performance, greenwashing exhibits a strong positive association with carbon emissions intensity (0.1119, 0.001), indicating that firms engaging in higher levels of symbolic environmental disclosure tend to exhibit significantly poorer environmental performance. This result aligns with impression management theory perspectives, which argue that greenwashing reflects a decoupling between symbolic sustainability communication and substantive environmental action (Delmas and Burbano 2011; Marquis et al. 2016).

4.5 | Robustness

A key concern we foresee with our baseline results is the potential presence of endogeneity concerns, which may arise due to reverse causality, omitted variable bias and self-selection. However, this is likely to be a problem in our investigation of the effect of sustainability auditing, since sustainability assurance may be influenced by climate change performance (Alaamri et al. 2023). To address endogeneity concerns and ensure the robustness of our findings, we employ various analyses. These robust tests include checking the sensitivity of the results using propensity score matching (PSM), as well as alternative measures for the dependent and independent variables, and subsamples that exclude certain countries from the observation.

4.5.1 | Additional Variables

In Table 7, we acknowledge that although our empirical models include a comprehensive set of firm- and country-specific control variables, omitted variable bias remains a concern. Therefore, we included alternative measures of the dependent variable to determine the sensitivity of our findings. In Column (1) of Table 7, we introduce total emissions by adding Scopes 1 and 2 as alternative variables. Scope 1 is the direct emissions emitted by a firm during its operation, and Scope 2 is the indirect emissions that occur due to the purchase of energy. Also, the study introduced Big 4 assurance providers as an alternative for the independent variable, measured as 1 for firms that engage in the service of a Big 4 audit firm and 0 otherwise. The results from both alternative variables remain consistent with the baseline, in line with the hypothesis that firms engaging in higher quality sustainability assurance will lead to lower emissions due to their accountability, transparency and proper disclosure of their operations. Overall, these findings confirm the robustness of the baseline results when alternative variables are used.

4.5.2 | Subsample With-Country Analyses

Table 8 addresses concerns of sample-driven potential bias driven by dominant economies; this study re-estimates the baseline model by excluding firms from the United States, the United Kingdom and China. These countries represent major capital markets with advanced ESG disclosure and could disproportionately influence the relationship between sustainability audit quality and climate change performance. The result across Columns (1–3) demonstrates that the main findings remain consistent and statistically robust, confirming that the relationship is not driven solely by firms from these large observations but instead reflects a broader, systematic association observable across diverse institutional environments, and the consistency in sign and significance suggests that sustainability audit quality functions as an effective monitoring mechanism that improves sustainability accountability, with effect sizes ranging between −0.00275 and −0.00404.

The variation in coefficient magnitudes offers important comparative insights. The relatively smaller effect when excluding the United States (−0.00304) suggests that American firms, operating in a disclosure environment characterised by market-driven assurance practices (Casey and Grenier 2015; Simnett et al. 2009), may already derive stronger climate benefits from sustainability audits. Conversely, the higher coefficient observed when the United Kingdom is excluded (−0.00404) may reflect the maturity of audit cultures and regulatory frameworks in the United Kingdom, where sustainability assurance

TABLE 7 | Alternative measurements.

Variables	(1) Climate change performance	(2) Total emissions
Big 4	−0.00555*	
Sustainability audit quality		−0.0928***
Size	−0.00936***	0.467***
Market presence	−0.00856***	−0.100***
Leverage	0.0000402***	0.000510***
Liquidity	−0.00406***	−0.161***
Profitability	−0.00132***	−0.00646**
Environmental pillar score	0.000789***	0.0113***
Board independence	0.000627***	0.00927***
Emission score	−0.000312***	−0.00540***
No board meetings	−0.00181***	−0.0222***
Board size	0.00646***	0.129***
Societal secrecy	−0.0000989**	−0.00277***
Long-term orientation	−0.000620***	−0.00855***
Economic development	0.00455***	0.129***
Constant	0.883***	1.658***
No of obs.	10,073	6162
R-square	0.469	0.510
Adj *r*-square	0.466	0.506
F-statistic	306.53	201.62
Year fixed effect	Yes	Yes
Industry fixed effect	Yes	Yes
Firm controls	Yes	Yes
Country controls	Yes	Yes

Note: This table presents the results of the impact of sustainability auditing on climate change performance, using an alternative measure of total emissions. Columns (1)–(2) use alternative measures of climate change performance (Scope 1 and Scope 2 emissions). All regressions estimate Equation (1) using panel models with fixed effects. Robust *t*-statistics are reported in parentheses. ***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

TABLE 8 | Robustness checks.

Variables	(1) Climate change performance (United States)	(2) Climate change Performance (United Kingdom)	(3) Climate change performance (China)
Sustainability audit quality	−0.00304**	−0.00404***	−0.00275*
Size	−0.00933***	−0.00878***	−0.00763***
Market presence	−0.00920***	−0.00944***	−0.0100***
Leverage	0.0000534***	0.0000482***	0.0000518***
Liquidity	−0.00347	−0.00421*	−0.00315
Profitability	−0.00136***	−0.00150***	−0.00155***
Environmental pillar score	0.000706***	0.000431***	0.000551***
Board independence	0.000760***	0.000707***	0.000657***
Emission score	−0.000378***	−0.000227**	−0.000165
No board meetings	−0.00185***	−0.00131***	−0.00149***
Board size	0.00687***	0.00707***	0.00728***
Societal secrecy	−0.0000999**	−0.0000832*	−0.000183***
Long-term orientation	−0.000805***	−0.000651***	−0.000712***
Economic development	0.0128***	0.00638***	0.00251*
Constant	0.674***	0.840***	0.934***
No of obs.	5620	5807	5978
R-square	0.526	0.525	0.523
Adj *r*-square	0.522	0.520	0.519
F-statistic	215.74	212.79	242.00
Year fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes
Country controls	Yes	Yes	Yes

Note: This table presents the results of robustness estimations for Equation 1. Columns (1)–(3) report robustness checks excluding major countries (United States, United Kingdom and China) from the sample. All regressions are panel models with fixed effects. Robust *t*-statistics are in parentheses.
***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

is deeply institutionalised (Gürtürk and Hahn 2016; Kolk and Perego 2010). The intermediate effect when China is excluded (−0.00275) highlights the increasing but still heterogeneous role of sustainability audit quality in emerging markets, where regulatory enforcement and assurance practices are still consolidating (Luo et al. 2020; Marquis and Qian 2014). Together, these patterns underscore the interplay between institutional environments and the effectiveness of assurance mechanisms.

The robustness checks demonstrate that the beneficial effect of sustainability audit quality on corporate climate change performance is generalisable and not merely driven by the reporting intensity or institutional dominance of large economies. At the same time, the cross-country variation in effect sizes suggests that institutional environments such as audit traditions, regulatory regimes and assurance cultures mediate the strength of this relationship. This finding contributes to ongoing debates in the literature on how institutional heterogeneity shapes the effectiveness of sustainability governance mechanisms (Aguilera et al. 2019; Ioannou and Serafeim 2015, 2019) and highlights the need for global standard-setting bodies to consider contextual differences when designing assurance frameworks for climate-related disclosures.

4.5.3 | PSM

Table 9 ensures that our findings are not driven by model specification or selection bias. We conduct a series of robustness checks using alternative estimation techniques and sample constructions. This approach enables the comparison of firms with similar observable features that differ in their level of audit quality, thereby reducing bias due to observable heterogeneity (Rosenbaum and Rubin 1983). This issue is common in empirical

TABLE 9 | Endogeneity tests.

Variables	(1) Baseline	(2) PSM (ATT)	(3) Matched regression	(4) Weighted matched regression
Sustainability audit quality	−0.00396***	−0.0216***	−0.0194***	−0.0221***
	(−2.86)	(−3.10)	(−7.57)	(−3.66)
Constant	0.841***	−1.504***	0.859***	0.800***
	(25.67)	(−3.88)	(32.70)	(13.22)
No of obs.	6140	10,073	10,073	6706
R-square	0.513		0.4717	0.4341
Adjusted *r*-square	0.509		0.4689	0.4296
Pseudo R^2		0.2427		
LR chi^2		3386.23		
F-statistic	225.00		199.26	64.45
Year fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes
Country controls	Yes	Yes	Yes	Yes

Note: Propensity score matching (PSM) estimates the Equation using a matched sample to address endogeneity. All regressions are panel models with fixed effects. Robust *t*-statistics are in parentheses.
***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

research on cross-country analysis; treating each firm-year as an independent observation may result in overstated *t*-statistics (Chen et al. 2017; Petersen 2008). To mitigate this concern, we cluster standard errors at the country level across all relevant specifications. The table presents results based on alternative estimation approaches designed to address potential biases arising from sample imbalance.

The sustainability audit quality measure is constructed as a continuous index using PCA. The study adopted prior studies by converting the index into a binary treatment variable to facilitate causal inference using matching techniques. Specifically, firms are classified as having high audit quality (treatment group) if their PCA is above the sample median, and low audit quality (control group) otherwise. This approach is consistent with the PSM framework, which requires a dichotomous treatment indicator (Rosenbaum and Rubin 1983). Also, prior studies in accounting, finance and sustainability adopted median splits to distinguish between high- and low-quality firms (Bebchuk et al. 2009; Dimson et al. 2015). We estimate propensity scores using a probit model in which the treatment indicator is regressed on a comprehensive set of firm-level, governance and country control variables. In addition, year and industry fixed effects are included to account for temporal and sectoral heterogeneity. The estimated propensity scores represent the conditional probability of a firm exhibiting high sustainability assurance quality given its observable features.

Again, firms in the treatment group are matched to firms in the control group using nearest-neighbour matching without replacement, based on the estimated propensity scores. To ensure the quality of matches and avoid poor comparisons, we impose a calliper restriction of 0.05, which limits matches to those within a specified distance in propensity score space. The matching procedure is conducted within the region of common support to ensure that treated firms are only compared to control firms with sufficiently similar propensity scores. To assess the effectiveness of the matching method, we conduct a series of balance diagnostics. Specifically, we compare the distribution of covariates between treated and control groups before and after matching. The results indicate a substantial reduction in covariate imbalance, with the mean standardised bias decreasing from 41.1% before matching to 5.5% after matching. Additionally, the pseudo-*R*-squared declines from 0.200 to 0.007, suggesting that observable differences between the two groups are largely eliminated. We also verify that all observations lie within the region of common support, confirming the validity of the matching procedure.

The average treatment effect on the treated (ATT) indicates that firms with higher sustainability audit quality exhibit significantly lower carbon emission intensity compared to matched firms (−0.0216, 0.01). The result is consistent with the baseline regression and suggests that the negative relationship between sustainability audit quality and emissions intensity is not driven by observable firm characteristics. To further address residual imbalance, we re-estimate the model using regression analysis on the matched sample. This approach allows us to control for any remaining differences in covariates following the matching method. The results continue to show a negative and statistically significant relationship between sustainability audit quality and carbon emission intensity. Finally, we estimate a weighted regression model

using the matching weights generated from the PSM procedure. The approach places greater emphasis on well-matched observations and is considered a more efficient estimator in the presence of heterogeneous matching quality. The results indicate that sustainability audit quality remains negatively and statistically significantly related to carbon emission intensity (−0.0221, 0.001). The magnitude of the coefficient is consistent with both the baseline and matching estimates, providing strong evidence that the main findings are robust to alternative estimation approaches.

The robustness analyses consistently demonstrate that higher sustainability assurance quality is associated with better climate change performance. The stability of the results across matching, regression adjustment and weighted estimation provides strong support for the validity of the findings. These approaches help mitigate concerns related to selection on observable features.

5 | Conclusion and Limitations of the Study

This study investigates the impact of sustainability audit quality on corporate climate change performance and the moderating roles of governance quality and greenwashing. Using a large international panel dataset, the findings show that higher sustainability audit quality is associated with lower emission intensity, indicating improved climate change performance. This confirms that sustainability assurance with high-quality assurance standards functions as an effective governance mechanism that enhances transparency and strengthens accountability. Beyond the baseline relationship, the study demonstrates that the effectiveness of sustainability audit quality is influenced by other factors. Governance quality weakens the relationship, highlighting the importance of strong regulatory frameworks and governance systems in substituting for the impact of weak institutional settings on sustainability assurance. Also, greenwashing weakens the relationship, suggesting that symbolic disclosure strategies undermine the effectiveness of audit procedures. The channel analysis further reinforces this insight by showing that firms engaging in greenwashing tend to exhibit lower sustainability audit quality, indicating that opportunistic reporting behaviour can dilute the objective of assurance.

This study makes several vital contributions to the literature. This study extends research on sustainability assurance by providing cross-country empirical evidence that assurance quality, rather than mere audit presence, plays a critical role in improving corporate climate change performance. This addresses a key gap in prior studies that often rely on binary measures of assurance. Also, the study contributes to the literature by integrating insights from stakeholder–agency and impression management theory to explain how sustainability audit quality operates within a broader governance framework. By doing so, it offers a more comprehensive understanding of the mechanisms through which sustainability assurance influences corporate behaviour. Again, this study introduces greenwashing as a critical moderating and mediating channel, demonstrating empirically how impression management practices can undermine the effectiveness of sustainability audits. This provides novel evidence on the limitations of assurance in the presence of strategic disclosure behaviour. Finally, the study offers practical insights for policymakers, firms, auditors and investors by highlighting the importance of high-quality sustainability audits, a strong institutional domain and credible sustainability practices in achieving meaningful climate outcomes.

Despite these contributions, several limitations should be acknowledged. The measurement of sustainability audit quality is based on a PCA-constructed index using available proxies. Although this improves upon binary measures, it may not fully capture qualitative aspects such as audit depth, auditor expertise or engagement rigour. Although the study employs fixed effects and multiple robustness checks, endogeneity concerns, including omitted variable bias, may persist. For instance, firms with better climate change performance may be more likely to adopt higher quality audits. The proxy for greenwashing, based on the disclosure performance gap, may not capture all forms of impression management, particularly qualitative or narrative manipulation in sustainability reporting. The cross-country design introduces institutional and cultural heterogeneity that may not be fully controlled, despite the inclusion of country-level variables. Differences in regulatory enforcement and reporting standards may influence the observed relationships. Finally, the study focuses primarily on Scope 1 and Scope 2 emissions scaled with total revenue as measures of climate change performance, which may not fully capture broader environmental impacts such as Scope 3 emissions or other sustainability dimensions.

These limitations provide avenues for future research. Further studies could develop more refined measures of audit quality, explore causal identification strategies such as natural experiments and examine additional dimensions of climate change performance. Further research could also investigate industry-specific effects and the evolving role of global sustainability reporting standards in shaping auditing practices. This study demonstrates that sustainability audit quality plays a significant role in improving corporate climate change performance. However, its effectiveness is contingent on institutional strength and the extent to which firms engage in genuine, rather than symbolic, sustainability practices. This underscores the importance of aligning assurance mechanisms with both strong institutional environments and credible corporate behaviour to achieve meaningful sustainability outcomes.

6 | Discussion of Theoretical and Practical Implications

This study set out to investigate the relationship between sustainability audit quality and corporate climate change performance, and how this association is conditioned by governance quality and greenwashing. The findings provide consistent evidence that higher sustainability audit quality is associated with lower emission intensity, indicating improved climate change performance. Also, the results reveal that this beneficial effect is context-dependent, weakened by institutional quality and greenwashing. This section interprets these findings through

the study's theoretical lenses and outlines their practical implications.

6.1 | Theoretical Implications

The negative association between sustainability audit quality and emission intensity reinforces the role of sustainability assurance as an effective governance mechanism. Drawing on stakeholder–agency theory, the findings suggest that higher sustainability audit quality mitigates information asymmetry between managers and stakeholders by enhancing the credibility of sustainability disclosures. This aligns with monitoring mechanisms that reduce managerial opportunism and align managerial actions with stakeholder interests (Jensen and Meckling 1976). Again, sustainability audits appear to function as a disciplinary device that constrains opportunistic environmental reporting and encourages substantive improvements in climate change performance. Also, the results extend prior literature by demonstrating that it is not merely the presence of auditing, but its quality, that drives sustainability outcomes. The use of a PCA-based audit quality index captures qualitative differences, thereby advancing the measurement of sustainability auditing in empirical studies.

The moderating effect of governance quality provides important insights into how the external governance domain shapes the effectiveness of sustainability assurance. Consistent with stakeholder–agency theory, the findings suggest that strong institutional frameworks are characterised by governance pillar score, board and management theme score, policy business ethics score, management score, shareholder score and CSR strategy score (Dhanda et al. 2022; Durnev and Kim 2005; Larcker et al. 2007). The overall pattern indicates that institutional quality operates primarily through cross-sectional differences across firms. This finding contributes to the literature by highlighting that the effectiveness of firm-level governance mechanisms, such as sustainability audits, is embedded within broader institutional contexts. Conversely, in weak institutional environments, even high-quality audits may have limited impact due to enforcement gaps and lower stakeholder scrutiny.

The results provide strong evidence that greenwashing undermines the effectiveness of sustainability audit quality. The positive interaction between sustainability audit quality and greenwashing indicates that the emissions-reducing effect of audits becomes weaker in firms engaging in higher levels of symbolic disclosure (Mateo-Márquez et al. 2022). This finding is consistent with impression management theory, which suggests that firms may strategically manipulate disclosures to influence stakeholder perceptions without making substantive operational changes (Talbot and Boiral 2018). Greenwashing represents a strategic distortion mechanism that reduces the informational value of audited sustainability reports, and sustainability audits are designed to enhance transparency and effectiveness contingent on the alignment between reported and actual performance (Delmas and Burbano 2011). In the event greenwashing is prevalent, assurance may be co-opted as symbolic compliance rather than substantive accountability to mitigate greenwashing.

6.2 | Practical Implications

Policymakers should emphasise the need for stronger regulation and enforcement to improve audit effectiveness and limit greenwashing. Also, the findings suggest evaluating sustainability reports cautiously, considering assurance quality and potential greenwashing risks. Sustainability assurance should be treated as a strategic governance tool, not just compliance, ensuring alignment between disclosures and actual performance. Firms should maintain high standards and independence to detect misleading disclosures. Again, the findings suggest that sustainability audit quality has the potential to significantly improve climate change performance through the effectiveness of unconditional institutional settings that firms engage in genuine sustainability practices rather than symbolic disclosure. This highlights a central tension in sustainability governance, and assurance mechanisms that enhance transparency of their impact ultimately rely on the integrity of both the institutional framework and firm-level behaviour.

Author Contributions

Muhammed Belly Ibrahim: conceptualization, investigation, methodology, formal analysis, data curation, writing – original draft, project administration, software, validation, writing – review and editing. **Ishmael Tingbani:** supervision, validation, writing – review and editing. **Hesham Bassyouny:** supervision, writing – review and editing.

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Appendix 1: Variable Definitions

Variables	Measurements	Sources
Climate change performance	The logarithm of total carbon emission intensity in metric tonnes (Berg et al. 2024; Busch and Hoffmann 2011; Busch et al. 2012; Busch and Lewandowski 2018)	Refinitiv/DataStream database
Sustainability audit quality	Principal component analysis (PCA)–based assurance quality index (Barzegar and Kazemi 2025; Wu and Yu 2025; Zeng et al. 2022)	Refinitiv/DataStream database
Board size	Total number of board size at the end of the fiscal year (Guest 2009)	Refinitiv/DataStream database
Number of board meetings	Number of board meetings annually (Buchdadi et al. 2019)	Refinitiv/DataStream database
Emission score	Scores are based on the commitment to reducing emissions (Lee et al. 2023).	Refinitiv/DataStream database
Environmental pillar score	Weighted average based on the disclosure of environmental information (Narula et al. 2024)	Refinitiv/DataStream database
Independent board member	Percentage of independent board members (Fuzi et al. 2016)	Refinitiv/DataStream database
Size	The logarithm of total assets (Choi et al. 2010)	Refinitiv/DataStream database
Leverage	Total debts are divided by total assets (Boykoff et al. 2010).	Refinitiv/DataStream database
Liquidity	Current ratios (Saleem and Rehman 2011)	Refinitiv/DataStream database
Market presence	Log of market capitalisation (Oyewo 2023)	Refinitiv/DataStream database
Profitability	Return on Equity (Nadyayani and Suarjaya 2021)	Refinitiv/DataStream database
Societal secrecy	Uncertainty avoidance plus power distance less individualism (Chen et al. 2022)	Hofstede cultural dimension: https://www.hofstede-insights.com
Economic development	The logarithm of GDP (Nuber and Velte 2021)	World Bank
Long-term orientation	Long-term orientation (Chen et al. 2017)	Hofstede cultural dimension: https://www.hofstede-insights.com
Governance quality	Principal component analysis (PCA) based on firm-level governance-related indicators (Durnev and Kim 2005; Larcker et al. 2007)	Refinitiv/DataStream database
Greenwashing	Measured as the gap between emission disclosure and performance scores and emission performance: Scope 1 and 2 emissions scaled by total revenue (Du 2015; Marquis et al. 2016)	Refinitiv/DataStream database