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Corruption Control and Corporate Hazardous Waste Emissions: Cross-Country Evidence and the Moderating Role of Agenda 2030

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ABSTRACT

The aim of this study is to examine the impact of corruption control, as a public institutional mechanism, on hazardous waste emissions of private sector entities. We also examine the extent to which Agenda 2030 moderates the relationship. We analyse data from the top 500 global companies. Our study covers 2006–2023, representing an 18-year period of Millennium Development Goals (MDGs)/pre–Sustainable Development Goals (SDGs) period (2006–2015) and SDGs period (2016–2023)/Agenda 2030. We use the Ordinary Least Square (OLS) fixed effects regression model and address potential endogeneity concerns using propensity score matching, the Heckman two-step procedure and the lagged variable approach. The results show that corruption control as an institutional mechanism significantly curbs the hazardous waste emissions of private sector entities. However, the impact is influenced by the cultural environment where organisations operate. Whereas the SDGs Agenda significantly moderates the relationship between corruption control and hazardous waste emissions, the coming into effect of Agenda 2030 has not enhanced the impact of corruption control in diminishing hazardous waste emissions. Our results are robust to an alternative measurement of variables and potential endogeneity concerns. We contribute to the literature on the association between corruption and environmental pollution, specifically hazardous waste emissions. Our study provides an exposition on the role of Agenda 2030 in moderating the relationship between corruption control and hazardous waste emissions. The international sample analysed in our study, covering a long timeframe, enhances the generalisability of our results.

1 | Introduction

Climate change has emerged as one of the most pressing issues of our time, with the Brundtland report of 1987 stating that excessive greenhouse gas (GHG) emissions pose a significant threat to sustainable development. The 2015 Paris Agreement represents an important step towards addressing global climate change, with world nations agreeing on a path forward to reduce GHG emissions and keep global warming below 2°C. Even though businesses were not directly involved in the Paris negotiations, more than 500 signed the Paris Pledge for Action (University of Cambridge Institute for Sustainability Leadership (CISL), 2015). Companies around the world have gradually begun to consider the significant risk of climate change—both the direct and indirect physical impacts on their operations and the climate change policies that alter consumption patterns (Abreu et al. 2022; Kutlu and Mao 2023; Alfi et al. 2024; Mora et al. 2024; Adebayo et al. 2025). While information on corporate strategies for reducing contributions to global warming and relative emission reduction targets can be useful, stakeholders are increasingly demanding data on absolute levels of GHG emissions to judge corporate performance on climate change.

Hazardous waste emissions are one of the most serious environmental threats affecting not only firms but the whole planet. Because of this, companies must react to the volatile and ever-changing environment as part of their business model and strategy (Cadez et al. 2019; Bongers and Casas 2022; Pilonato 2022). According to Lisciandra and Migliardo (2016) and Mitic et al. (2023), climate disclosure is an important act of climate action, which means that companies must measure and report information about their environmental performance and impacts so that investors can better understand their relevance to the future of the business. In the face of inimitable global challenges, acting on hazardous waste emissions is an important step in managing and reducing environmental impact. As the effects of hazardous waste emissions become more widespread, citizens are demanding environmental information to engage policymakers and companies to develop appropriate policies to reduce emissions (Aghabalayev and Ahmad 2023). It is crucial for companies to have climate change data to assess their progress and implement appropriate mitigation strategies against hazardous waste (Lapatinas et al. 2018). Therefore, there is now an intense interest in climate-related issues, especially hazardous emissions, because stakeholders recognise that climate risks have the potential to pose significant financial risks to organisations and their environment.

A few studies assert that institutional mechanisms like corruption are an important factor to consider in climate change action (Peerthum and Luckho 2020; Zhu and Peng 2012; Fhima et al. 2023). It is observed that corrupt practices such as organised crimes and bribery are the means through which organisations want to escape environmental enforcement. Similarly, big organisations may want to bribe their way through to under-report pollution levels like hazardous waste emissions. It is believed that the level of institutional environments (low corrupt or high corrupt) could influence climate change action like hazardous waste emissions (Munir and Ameer 2018; Lv and Gao 2021). Some studies argue that organisations operating in strong institutional environments and associated with low levels of corruption will do well to reduce their hazardous waste emissions (Setioningtyas et al. 2022; Asif et al. 2023), while others believe that organisations operating in weak institutional environments are associated with high levels of corruption, which will negatively affect hazardous waste emissions (Zhou and Li 2021; Wang et al. 2022). These empirical arguments provide an avenue for further research; therefore, this study contributes to the ongoing academic discourse as to whether corruption influences hazardous waste emissions from multiple institutional environments. This study seeks to address the research question: How do public institutional mechanisms for corruption control influence the hazardous waste emissions of multinational corporations and what implications does this have for addressing climate change challenges?

Mitigating against hazardous waste emissions is dependent on practical action, and businesses must be at the forefront of this (Peerthum and Luckho 2020). Companies have been at the centre of discourse because of increasing global urbanisation, as they are primarily responsible for global GHG emissions. As a result, by implementing emission reduction policies, organisations play an important role in reducing hazardous waste emissions (Pata et al. 2023). I. Khan, Hou, and Le (2021) and H. Z. Khan, Bose, et al. (2021) find that global multinational companies (MNCs) are among the top 'carbon majors' responsible for significant anthropogenic GHG emissions in recent times. Therefore, it is important for companies to mitigate hazardous emissions to understand their impact on climate change and track GHG emissions performance. While an increasing number of studies seek to explain climate change reporting by companies in various countries' contexts (Keig et al. 2015; Jayakody et al. 2023), studies on the impact of corruption on hazardous waste emissions remain limited in academic literature. Therefore, this presents a significant gap in the literature, limiting our current understanding of how corruption can affect hazardous waste emissions in the context of MNCs.

Furthermore, sustainable development has been a global affair for a while, highly sustained following the introduction of the Sustainable Development Goals (SDGs) by the United Nations (UN) in 2015. The idea behind the adoption of SDGs is to take care of difficult trade-offs favouring the economy to the detriment of social and environmental issues (Ha et al. 2021). In this context, the wide academic convergence on sustainable development (Habib et al. 2018) appears to have left the issue of corruption and climate change action unexplored, indicating that there are several questions seeking answers, including whether and, if so, how corruption affects hazardous waste emissions under the SDG period. It is, therefore, necessary to consider how the issue of corruption could contribute towards climate change action globally, considering that corruption control plays an important role in ensuring that organisations achieve their corporate objectives sustainably through engaging with important SDGs like SDG 13 (climate action).

Although some recent studies have examined climate change actions from different perspectives (Zhu and Peng 2012; Fhima et al. 2023; Román-Aso et al. 2024), the impact of corruption on hazardous waste emissions has not been rigorously investigated. For instance, Pei et al. (2021) examine the role of corporate governance on climate change action in Brazil, which offers an interesting perspective within the climate change literature. Similarly, Rahman et al. (2020) investigate the effect of institutional settings on GHG emissions in Australia; the study reveals that strong institutions do not necessarily reduce the negative effect of carbon emissions. In addition, Román-Aso et al. (2024) explore the role of corporate boards in carbon management of European firms and find that diverse boards exert a significant influence in controlling carbon emissions.

While several studies in the Asian context have examined environmental issues, their focus has largely been on corporate governance and sustainability outcomes. For instance, Saleh and Maigoshi (2024) investigate the relationship between ESG performance and environmental sustainability in Asian publicly listed firms (2005–2019), highlighting the moderating role of board gender diversity (BGD). Similarly, Mansour et al. (2024) explore the influence of female CEOs on green innovation in Asian industrial firms (2013–2022), finding a significant positive relationship, particularly in larger firms. These studies, along with related works (Khalaf et al. 2024; Saleh et al. 2025), emphasise the role of leadership diversity and governance mechanisms in advancing climate actions. However, the specific issue of corruption control and its implications for hazardous waste emissions remains underexplored. Moreover, limited attention has been given to the role of multinational firms operating across

diverse institutional environments. To address these gaps, cross-country analyses are essential to provide deeper insights into how corruption influences hazardous waste emissions globally.

The aim of this study is to examine the impact of corruption control (as a public institutional mechanism) on hazardous waste emissions of private sector entities by analysing empirical data from MNCs. This study makes important contributions to the literature. First, it highlights the significant contribution of how corruption exacerbates environmental issues, especially hazardous waste emissions. By examining this relationship, it could also reveal how institutional failures contribute directly or indirectly to sustainability and environmental challenges. Second, this study enriches our limited understanding of how the institutional mechanism (corruption control) influences climate change actions in the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) periods. Third, by investigating the influence of corruption control on hazardous waste emissions from different institutional settings, we contribute to the environmental and sustainability literature. This also provides interesting discourse on corporate accountability vis-à-vis its impact in managing environmental issues.

The remainder of this paper is organised into five sections. Section 2 reviews the relevant literature and develops the study's hypotheses. Section 3 outlines the research methods, while Section 4 presents the empirical results. Section 5 discusses the findings and highlights both the practical and theoretical implications. Finally, Section 6 concludes this paper.

2 | Literature Review and Hypotheses Development

2.1 | Theoretical Perspective

Studies on climate change and carbon emissions have used different theories (legitimacy theory, stakeholder theory, institutional theory and signalling theory) to provide valuable contributions to the academic literature. In this study, we believe that institutional theory provides a valuable framework for understanding how institutional mechanisms are used to manage hazardous waste emissions of private sector entities within different institutional contexts. There are many definitions of institutions—the one by Saha and Sen (2020) suffices for the purpose of this study. Institutions consist of regulatory, normative and cultural-cognitive elements that, along with associated activities and resources, give social life stability and significance (Saha and Sen 2020). This definition is helpful as it stresses the importance of organisational and social activities and resources. In this regard, Sadiq et al. (2023) reiterate that institutions are long-lasting social structures composed of symbolic components, social interactions and material resources. Institutional theory posits that organisations conform to and implement similar practices because of external pressure from at least three sources—regulatory, normative and cultural-cognitive elements (Chen et al. 2018). The first is coercive pressure from external entities, such as law or regulatory enforcement agencies or dependent organisations. The second is mimetic pressure, which arises from stakeholder and general societal or cultural values, in which organisations attempt to meet societal expectations by implementing structures and processes similar to those of others in society. The third has to do with normative or professional community-related expectations of consistency in structures and practices.

It is believed that multinational entities operate within the institutional structure, and they are expected to adhere to regulatory directives, including environmental issues. Biswas and Thum (2016) argue that multinational entities' approaches to hazardous waste management are shaped by a complex interplay of formal regulations, societal expectations and cultural beliefs. Similarly, Saidi and Rahman (2020) opine that institutions play a key role in facilitating and promoting a clean environment through the reduction of hazardous carbon emissions. As part of the global players in shaping sustainability issues, multinational entities are expected to prioritise environmental sustainability by reducing hazardous waste emissions and contribute to global environmental goals. Because different countries have varying levels of environmental concerns, strong institutions should prioritise environmental strategy, including reducing hazardous waste emissions. Because the regulatory pillar of institutional theory emphasises the role of formal regulation, MNCs are expected to comply with environmental laws, which include the management of climate change actions (hazardous waste emissions) (Vakulenko 2022).

Institutional theory provides a fundamental basis for corporate organisations to leverage on the strength of public institutions to control corruption that will improve environmental performance. Advocates of institutional theory believe that strong institutions can use their resources to curb environmental pollution and contribute to SDG 13 (climate action) (Fhima et al. 2023; Bilgili et al. 2024). Similarly, institutional theory affirms the strategic role that governments of nations play in regulating MNCs to focus on climate change. Within the context of environmental management, institutional theory demonstrates a positive synergy between controlling corruption and managing hazardous waste emissions (Setioningtyas et al. 2022; Asif et al. 2023). To reinforce the importance of MNCs within institutional theory boundaries, Shahbaz et al. (2017) argue that MNCs should take into consideration the social and environmental implications of corporate decisions. Institutions should give priority to value creation and environmental performance, which takes precedence over short-term profitability. The current study focuses on corruption control as one of the institutional mechanisms emplaced by the government to manage the activities of private sector entities (Tabash et al. 2023; Hung and Doanh 2024), particularly environmental pollution in relation to hazardous waste emissions.

2.2 | Hypotheses Development

2.2.1 | Corruption Control and Hazardous Waste Emissions

In the literature, corruption control is seen as a strong pillar for measuring institutional governance and quality (Zugravu-Soilita 2018; Wang and Wang 2021; Tabash et al. 2023; Hung and Doanh 2024). Academic discourse on the association between corruption and carbon waste emissions documents mixed

evidence. Furthermore, research on corruption control and hazardous waste emissions is limited in sustainability, environmental, ecological and public governance studies (Sinha et al. 2019). A few studies document a positive association between corruption and environmental performance (carbon waste emissions). Sultana et al. (2022) report that corruption control strengthens the institutional mechanism for regulating environmental pollution, which helps reduce hazardous waste emissions. Similarly, Wang et al. (2020) submit that the economic effects of corruption negatively affect environmental performance in countries where the institutional mechanism is weak. The authors argue that, once an organisation can control corruption, this will eventually reduce waste emissions.

In line with other studies investigating corruption control as a measure of institutional governance mechanism on environmental sustainability, Ahmed and Anifowose (2023) observe that corruption control has the capacity to reduce carbon emissions, which strengthens environmental governance and other ESG matters. It is believed that, when institutions curtail official corruption, the resultant effect would positively affect corporate sustainability programmes such as sustainable investments, waste recycling programmes and responsible waste management. The authors further argue that strong institutions play a crucial role in the supervision of social and environmental risk management processes, including the identification, evaluation and mitigation of sustainability and environmental risks.

Conversely, some studies on corruption control show a nonlinear relationship with environmental performance on issues relating to greenhouse emissions, degradation, waste emissions and biodiversity protection. Xu and Yi (2022) find an inverted U-shaped relationship between corruption and environmental performance (hazardous waste emissions), concluding that corruption control exerts no influence on carbon emissions. In addition, the findings of Xie et al. (2023) conclude that corruption has no significant impact on carbon and climate management. The authors argue that, once regulation is effective, this should ordinarily drive environmental compliance for corporate organisations. Xie et al. (2023) further argue that poor management and corporate decisions regarding sustainability and environmental issues contribute to hazardous waste emissions. However, it is evident from the literature that the ability to control corruption is synonymous with taking proactive steps in addressing emerging environmental risks such as hazardous waste emissions, biodiversity issues, climate change, environmental concerns and regulatory compliance issues (Zhu and Peng 2012; Alshehhi and Zervopoulos 2023, Erin et al. 2024). Therefore, based on the foregoing empirical discussion, we develop our first hypothesis:

Hypothesis 1. *Corruption control is negatively associated with hazardous waste emissions.*

2.2.2 Corruption Control, Hazardous Waste Emissions and Agenda 2030.

The Sustainable Development Goals (SDGs), also referred to as 'Agenda 2030', sensitise organisations to take action to address climate change, including hazardous waste emissions. Because corruption control is one of the institutional mechanisms used by government to regulate private sector organisations' environmental activities as a strategy for climate change action, such mechanisms should ordinarily be strengthened to ensure the achievement of SDGs in relation to addressing environmental challenges/climate change. The pronouncement of SDGs in 2016 has redefined the commitment of corporate organisations towards the three sustainability (economic, social and environmental) (Zhou and Li 2021; Wang et al. 2022). The intervention of SDGs has been a defining factor for corporate organisations—this has enabled them to take bold steps in addressing environmental issues such as climate change (Zakari et al. 2022; B. Oyewo 2023).

Agenda 2030 explicitly encourages governments, private sector entities and other stakeholders to participate more actively in implementing sustainable and environmental practices such as carbon emissions management (United Nations Conference on Trade and Development (UNCTAD) 2016). In this regard, governments of nations are expected to take the lead by strengthening public institutional mechanisms to ensure compliance and achievement.

Similarly, UNCTAD (2016) urges organisations to align their practices with Agenda 2030, especially on SDG 7 (affordable and clean energy), SDG 12 (responsible consumption and production) and SDG 13 (climate action). Therefore, organisations are expected to align with institutional reforms set by governments on corruption control to achieve climate change targets. However, we observe that little is known on how Agenda 2030 impacts institutional mechanisms and hazardous waste emissions in the SDGs period. Overall, we posit that Agenda 2030 should motivate governments to strengthen institutional mechanisms and to regulate hazardous waste emissions of private sector organisations. Therefore, it is believed that SDGs should strengthen the impact of corruption control in diminishing hazardous waste emissions. Based on the aforementioned discussion, we develop the second hypothesis:

Hypothesis 2. *The SDGs Agenda significantly enhances the impact of corruption control in diminishing hazardous waste emissions.*

3 | Research Methods

3.1 | Research Design and Data Sources

We adopt a quantitative research design, relying on secondary data from reputable databases. We use the Forbes 2000 global companies list as our sampling frame and took a sample of the first 25% firms, representing the top 500 companies. We exclude financial institution firms, leaving us with 338 non-financial firms with data on hazardous waste in the LSEG repository. Our study covers 2006–2023, representing an 18-year period of MDGs/pre-SDGs (2006–2015) and SDGs (2016–2023). We exclude the year 2024 because of insufficient data for many companies as of the time of conducting this research. We analyse a total of 5512 firm-year observations.

To achieve our research objectives, we collect data on hazardous waste emissions of private sector entities in the top 500,

institutional mechanisms, country-level data, firm-level data (e.g., corporate governance variables and firm attributes) and cultural orientation data. We compile our data from multiple sources. Data on hazardous waste emissions and firm-level variables were sourced from the LSEG database (formerly Refinitiv). Country-level data were collected from the World Bank database. Cultural orientation data were taken from the Hofstede Insight database.

3.2 | Variables and Measurement

3.2.1 | Dependent Variable

The LSEG database measures hazardous waste in terms of total amount of hazardous waste produced in tonnes. Hazardous wastes are those wastes that pose substantial or potential threats to public health or the environment and generally exhibit one or more of these characteristics: ignitable (i.e., flammable), oxidising, corrosive, toxic and radioactive. We derive our main dependent variable, hazardous waste emissions, by computing the ratio of hazardous waste emissions to firm revenue, called hazardous waste emissions intensity. This metric helps companies assess their environmental impact relative to their financial performance, providing insights into how efficiently they manage hazardous waste in relation to their revenue. Prior studies have used this approach (Konadu et al. 2021; B. Oyewo 2023).

To check the robustness of our results, we use three alternative measures:

a. Hazardous waste intensity to market capitalisation, computed as the ratio of hazardous waste emissions to a firm's market share capitalisation. This metric can help assess a company's environmental impact in relation to its market value, providing insights into how efficiently the company manages hazardous waste compared to its overall market worth.

b. Hazardous waste intensity to enterprise value, computed as the ratio of hazardous waste emissions to enterprise value. This metric helps assess a company's environmental impact in relation to its enterprise value, providing insights into how efficiently the company manages hazardous waste compared to its overall value.

c. Hazardous waste emissions rate taken as the total hazardous emissions generated by a company in a year measured in metric tonnes.

3.2.2 | Independent Variable

Our main independent variable, corruption control, was taken from the world governance indicators provided by the World Bank. According to the World Bank, corruption control captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests. The variable has a positive polarity, measured on a scale from 1 (low corruption control) to 100 (corruption control). It has a positive polarity, implying that higher values represent more desirable conditions. As the score increases from '1' to '100', corruption is perceived to be less prevalent, and public institutions are seen as more effective and trustworthy. A country scoring closer to 1 is perceived to have widespread corruption, while a country scoring closer to 100 is perceived to have transparent governance, strong rule of law and limited misuse of public office.

3.2.3 | Control Variables

Based on the extant literature, we include several control variables that may influence hazardous waste emissions/environmental pollution management, such as institutional mechanisms, firm-level variables and country-level variables (Konadu et al. 2021). We control for institutional mechanisms—notably, voice and accountability, political stability, government effectiveness, regulatory quality and rule of law. Our measurement of institutional mechanisms relies on World Bank data.

For the firm-level variables, we control for corporate governance variables (Board Independence, ESG Board and ESG Audit) that may influence environmental sustainability practice of companies, as well as firm attributes (size, profitability and liquidity) that affect the availability of resources to the organisation to implement environmental sustainability projects (El Saleh and Jurdi 2023; Al-Shaer et al. 2024). Finally, we control for country-level variables considering the cross-country nature of our research: Economic Development and Economic Output (Zaman et al. 2020; Alhossini et al. 2021). The variable measurements are summarised in Table 1.

3.3 | Model Specification and Data Analysis

To evaluate the impact of corruption control on hazardous waste emissions, we specify regression Model 1:

$$\text{HAZARD\_WASTE}_{i,t} = \beta_0 + \beta_1 \text{ x } \text{COC}_{i,t} + \beta \text{ x } \text{Controls}_{i,t} + \text{Industry FE} + \text{Year FE} + \text{Country FE} + \varepsilon_{i,t} \quad (1)$$

where $\text{HAZARD\_WASTE}_{i,t}$ is hazardous waste emissions for firm i in year t. The independent variable of interest, $\text{COC}_{i,t}$, is corruption control for firm i in year t. $\text{Controls}_{i,t}$ is the set of control variables discussed in Section 3.2.4. The model also incorporates industry fixed effects (Industry FE), year fixed effects (Year FE) and country fixed effects (Country FE) to account for unobserved factors specific to industries, macroeconomic conditions affecting all firms within a given year and countries. $\varepsilon_{i,t}$ represents the stochastic error term for firm i in year t.

To assess the moderating impact of the SDGs Agenda on the relationship between corruption control and hazardous waste emissions, we specify regression Model 2 to perform interaction analysis:

$$\text{HAZARD\_WASTE}_{i,t} = \beta_0 + \beta_1 \text{ x } \text{COC}_{i,t} + \beta_2 \text{ x } \text{SDG}_{i,t} + \beta_3 \text{ x } \text{SDG}^{*}\text{COC}_{i,t} + \beta \text{ x } \text{Controls}_{i,t} + \text{Industry FE} + \text{Year FE} + \text{Country FE} + \varepsilon_{i,t} \quad (2)$$

TABLE 1 | Measurement of variables.

Variable	Measurement
Hazardous waste emission	i. Main measurement: Hazardous waste intensity computed as the ratio of hazardous waste emissions to firm revenue. This metric helps companies assess their environmental impact relative to their financial performance, providing insights into how efficiently they manage hazardous waste in relation to their revenue. Alternative measurements: ii. Hazardous waste intensity to market capitalisation, computed as the ratio of hazardous waste emissions to firm market share capitalisation. This metric can help assess a company's environmental impact in relation to its market value, providing insights into how efficiently the company manages hazardous waste compared to its overall market worth. iii. Hazardous waste intensity to enterprise value, computed as the ratio of hazardous waste emissions to enterprise value. This metric can help assess a company's environmental impact in relation to enterprise value, providing insights into how efficiently the company manages hazardous waste compared to its overall value. iv. Hazardous waste emissions rate in metric tonnes.
Corruption control	Measured by the World Bank as perceptions of the extent to which public power is exercised for private gain on a scale from 1 (low control of corruption) to 100 (high control of corruption). It has a positive polarity, implying that higher values represent more desirable conditions. As the score increases from '1' to '100', corruption is perceived to be less prevalent, and public institutions are seen as more effective and trustworthy. A country scoring closer to 1 is perceived to have widespread corruption, while a country scoring closer to 100 is perceived to have transparent governance, strong rule of law and limited misuse of public office.
Voice and accountability	Measured by the World Bank as perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association and a free media, on a scale from 1 (low) to 100 (high).
Political stability	Measured by the World Bank as perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism, on a scale from 1 (low) to 100 (high).
Gov. effectiveness	Measured by the World Bank as perceptions of the quality of public services, the quality of policy formulation and implementation and the credibility of the government's commitment to such policies, on a scale from 1 (low) to 100 (high).
Regulatory quality	Measured by the World Bank as perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development, on a scale from 1 (low) to 100 (high).
Rule of law	Measured by the World Bank as perceptions of the extent to which agents have confidence in and abide by the rules of society, and particularly the quality of contract enforcement, on a scale from 1 (low) to 100 (high).
Board independence	Measured as the ratio of independent directors to total board members.
ESG board	Takes a binary value of 1 if company has ESG board in a year, otherwise 0.
ESG audit	Takes a binary value of 1 if company audits ESG report in a year, otherwise 0.
Firm size	Measured as the natural log of Market capitalisation.
Firm profitability	Measured as Return on Total Assets (ROTA).
Firm liquidity	Measured as ratio of current assets to current liabilities.
SDGs Agenda/Agenda 2030	Takes a binary value of 0 for MDGs/pre–SDGs period (2006–2015) and 1 for SDGs period (2016–2023).
Economic development	Measured as the natural log of Gross Domestic Product (GDP) per capita.
Economic output	Measured as the natural log of Gross Domestic Product (GDP).

Note: Firm-level data on carbon emissions, corporate governance and firm characteristics were obtained from the London Stock Exchange Group (LSEG) database (formerly Refinitiv). Country-level indicators of institutional quality, economic development and market size were sourced from the World Bank database. Data on the cultural environment were retrieved from The Culture Factor website's country comparison tool.

where $HAZARD\_WASTE_{i,t}$ is hazardous waste emissions for firm i in year t. The independent variable of interest, $COC_{i,t}$, is corruption control for firm i in year t. $SDG_{i,t}$ is SDGs Agenda for firm i in year t, $SDG*COC_{i,t}$ is the interaction term between corruption control and SDGs Agenda for firm i in year t, and $Controls_{i,t}$ is the set of control variables discussed in Section 3.2.4. The model also incorporates industry fixed effects (industry FE), year fixed effects (Year FE) and country fixed effects (Country FE) to account for unobserved factors specific to industries, macroeconomic conditions affecting all firms within a given year and countries. $\varepsilon_{i,t}$ represents the stochastic error term for firm i in year t.

Based on the Hausman test (p-value <0.05), we find that ordinary least square (OLS) regression with fixed effects is a better method of analysis for our panel data. We, therefore, run OLS fixed effects for industry, year and country effects. We correct for potential endogeneity using propensity score matching, the Heckman two-step procedure and the lagged variable approach. We use alternative measures of our dependent and independent variables to test the robustness of our results.

4 | Results

4.1 | Descriptive Statistics and Multicollinearity

Descriptive statistics (Table 2) show substantial variability in hazardous waste measures, with particularly wide dispersion in hazardous waste intensity and emissions, indicating large differences in environmental performance across firms. The average hazardous waste intensity to revenue is 82.717, although there is notable variation from this average (SD = 1391.297). The average hazardous waste emissions rate stood at 1,100,000 metric tonnes. The Corruption Control average index was 69.119, and there is a notable difference in the control of corruption rate among countries where multinationals operate (SD = 14.211). Governance indicators such as voice and accountability, political stability, government effectiveness, regulatory quality and rule of law all exhibit relatively high mean values with moderate variation, suggesting generally strong institutional environments within the sampled countries. Firm-level characteristics such as board independence, ESG board presence and ESG audit show moderate variation, while financial indicators like firm size, profitability and liquidity display wider dispersion, reflecting heterogeneity in firm scale and financial structure. Macroeconomic indicators—economic development and output—show low variability, indicating relative stability across the sampled countries. Overall, the statistics suggest a diverse sample across environmental-, governance- and firm-level dimensions.

The correlation matrix (Table 3) indicates generally low to moderate pairwise correlations between hazardous waste intensity and governance variables, with all correlations being positive but relatively small (ranging from 0.029 to 0.051), suggesting a limited direct association between firm environmental performance and governance indicators. Several governance indicators—such as corruption control, voice and accountability,

TABLE 2 | Descriptive statistics.

Variables	Mean	Std. Dev.	Min	Max	Skew.	Kurt.
Hazardous waste intensity to revenue	82.717	1391.297	1.75	47536.008	23.814	658.586
Hazardous waste intensity to market capitalisation	39.184	748.413	1.22	31129.455	30.135	1054.441
Hazardous waste intensity to enterprise value	28.592	490.514	1.09	17870.15	25.461	752.918
Hazardous waste emissions rate (metric tonnes)	1,100,000	14,600,000	2567	346,284,048	17.716	344.361
Corruption control	69.119	14.211	21	96	−1.417	4.334
Voice and accountability	81.543	14.549	2.35	99.53	−2.956	14.526
Political stability	66.165	15.584	9.48	99.05	−0.843	4.921
Gov. effectiveness	88.706	9.424	36.54	99.51	−3.207	14.086
Regulatory quality	87.452	10.909	32.21	99.05	−3.004	13.257
Rule of law	87.586	11.723	16.75	99.52	−3.631	17.859
Board independence	0.767	0.229	0	1	−1.696	5.443
ESG board	0.755	0.43	0	1	−1.187	2.409
ESG audit	0.531	0.499	0	1	−0.122	1.015
Firm size	4.603	0.445	1.988	6.385	0.062	4.191
Firm profitability	7.271	6.181	−9.21	41.32	1.743	7.233
Firm liquidity	1.581	1.275	0.09	31.84	7.395	113.947
Economic development	4.608	0.22	3.51	5.07	−2.042	7.431
Economic output	12.749	0.571	10.571	13.385	−0.855	2.849
N	5512	5512	5512	5512	5512	5512

TABLE 3 | Correlation matrix.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Hazardous waste intensity (1)	1														
Corruption control (2)	0.038**	1													
Voice and accountability (3)	0.044**	0.652***	1												
Political stability (4)	0.051**	0.480***	0.575***	1											
Gov. effectiveness (5)	0.029	0.422**	0.565**	0.686***	1										
Regulatory quality (6)	0.034*	0.374**	0.594***	0.327**	0.420**	1									
Rule of law (7)	0.034*	0.445**	0.519**	0.528**	0.544**	0.424**	1								
Board independence (8)	0.006	0.116**	0.148**	−0.256**	0.019	0.136**	0.091**	1							
ESG board (9)	0.042**	0.185**	0.140**	0.024	0.076**	0.037*	0.090**	0.046**	1						
ESG audit (10)	0.069**	0.101**	0.064**	−0.011	−0.047**	−0.072**	−0.041**	−0.005	0.431**	1					
Firm size (11)	0.005	0.092**	0.009	−0.151**	0.005	0.023	0.013	0.198**	0.256**	0.204**	1				
Firm profitability (12)	−0.015	−0.058**	−0.076**	−0.166**	−0.097**	−0.083**	−0.087**	0.086**	0.000	−0.064*	0.268**	1			
Firm liquidity (13)	0.023	−0.034*	−0.094**	−0.079**	−0.091**	−0.116**	−0.101**	−0.103**	−0.106**	−0.102*	−0.046**	0.251**	1		
Economic development (14)	0.062**	0.546***	0.290**	0.146**	0.486**	0.490**	0.485**	0.272**	0.160**	0.046**	0.213**	−0.058**	−0.014	1	
Economic output (15)	−0.077**	−0.263**	−0.077*	−0.306**	0.050**	0.040**	0.048**	0.068**	−0.104**	−0.309**	0.081**	0.073**	0.072**	−0.054**	1

*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

political stability, government effectiveness, regulatory quality, rule of law and economic development—show moderate-to-strong intercorrelations (e.g., 0.374–0.686), reflecting the interconnected nature of institutional quality. Among the firm-level variables, board independence, ESG board and ESG audit exhibit low-to-moderate correlations, while financial indicators like firm size, profitability and liquidity remain largely independent of governance measures. Overall, the correlation structure suggests no severe multicollinearity for the main explanatory variables, although moderate intercorrelations among governance indicators may warrant the use of variance inflation factors (VIFs) to formally assess collinearity in regression analyses. As a result, we calculated VIFs for all independent variables as a check for multicollinearity. All VIFs were below 5.0, well within the recommended threshold of 10.0 (Salmerón Gómez et al. 2016), indicating that multicollinearity is unlikely to be a concern.

4.2 | Baseline Result: Association Between Corruption Control and Hazardous Waste Emissions

We run multiple regression models as reported in Table 4. In Column 1, we include country-level control variables (i.e., governance quality variables, economic development and economic output) and run the regression with industry, year and country fixed effects. Corruption control is negatively associated with hazardous waste intensity. In our next model (Column 2), we include country-level control and firm-level control variables (i.e., corporate governance variables and firm attributes) with year fixed effect. Our result holds that corruption control is negatively associated with hazardous waste intensity (Column 2). In Column 3, we include country-level and firm-level controls, with industry and year fixed effects. The result shows that corruption control is negatively associated with hazardous waste intensity (Column 3). In Column 4, we include country-level (governance quality variables, economic development and economic output) and firm-level (corporate governance and firm attributes) controls with industry, year and country fixed effects. Our result persists that corruption control is negatively associated with hazardous waste intensity. Taken together, in Columns 1–4 (Table 4), corruption control has a significant negative impact on hazardous waste intensity in our various model specifications. This leads to the acceptance of Hypothesis 1.

4.3 | Corruption Control, Hazardous Waste Emissions and the SDGs Agenda

The results on the moderating impact of the SDGs Agenda presented in Table 5 show that corruption control is negatively associated with all measures of dependent variables in Columns 1–3. The SDGs Agenda has no significant impact in all three columns. The SDGs Agenda*Corruption Control is also not statistically significant for the main measurement of the dependent variable (Column 1) and alternative measurements (Columns 2 and 3). Based on this result, we reject Hypothesis 2. To conduct an additional analysis on the impact of the SDGs Agenda, we split our sample into MDGs and SDGs periods and rerun the analysis as reported in Table 6. The result shows that, in the MDGs period (Column 1), corruption control has a significant negative impact on hazardous waste emission. However, the impact is not significant in the SDGs period (Column 2). This provides additional evidence that the SDGs Agenda 2030 has not significantly enhanced the impact of corruption control in diminishing hazardous waste emissions.

4.4 | Robustness Checks and Endogeneity

4.4.1 | Alternative Measurement of the Dependent Variable

To check that our result is robust to the alternative measurement of the dependent variable or measurement error bias, we use three alternative measures of hazardous waste emissions. We use hazardous waste intensity to market capitalisation, hazardous waste intensity to enterprise value and hazardous waste emissions rate (as defined in Table 1). We rerun our regression with industry, year and country fixed effects using these three measures, as reported in Table 10. In Columns 1–3 (Table 7), corruption control has a significant negative impact on hazardous waste intensity to market capitalisation ($b = -5.248$, $p < 0.05$), hazardous waste intensity to enterprise value ($b = -4.146$, $p < 0.01$) and hazardous waste emissions rate ($b = -326004.6$, $p < 0.01$). This suggests that our baseline result is robust to the alternative measurement of hazardous waste emission, thus supporting the acceptance of Hypothesis 1.

4.4.2 | Addressing Endogeneity Using Two-Stage Least Squares (2SLS)

Whilst effective corruption control may curb hazardous waste emissions based on the literature (e.g., Wang et al. 2020; O. Oyewo et al. 2025), and as empirically established by our results, hazardous waste emissions may also influence corruption control, thereby giving rise to reverse causality. Increased pollution raises opportunities for corruption, possibly because, as hazardous waste grows, more permits, inspections and monitoring may be required. This bureaucratic interaction increases opportunities for bribery, especially if institutional mechanisms are weak (Tawiah 2023). Pollution itself creates a larger corruption 'market' in the sense that high-emission industries may bribe officials to weaken enforcement, influence policymakers to avoid strict regulations and/or fund political actors who protect polluting practices (Houqe and Monem 2016). Higher hazardous waste emissions may also trigger institutional reforms to strengthen the rule of law on corruption, thus tightening corruption control. To address potential reverse causality, we use the two-stage least squares (2SLS) following the approach applied in the literature (Ullah et al. 2021; Tawiah et al. 2024).

We use legal origin as the instrument for corruption control as it satisfies the two key conditions for the instrumental variable—relevance and exogeneity. Historical legal systems shape institutional quality and corruption levels (La Porta et al. 1998) but do not directly affect hazardous waste emissions. Legal origins are historical and exogenous, as they are not expected to directly affect modern emissions. In line with prior studies (La Porta et al. 1998; Dhaliwal et al. 2014), we use two broad categories of legal origin: legal origin common law (Category 1) and legal

TABLE 4 | Relationship between corruption control and hazardous waste emission.

	Hazardous waste intensity			
	(1)	(2)	(3)	(4)
Corruption control	−6.777	−9.004**	−8.774**	−11.71***
	(−1.65)	(−2.10)	(−2.04)	(−2.71)
Voice and accountability	7.345	2.055	2.139	7.319
	(1.42)	(0.67)	(0.69)	(1.39)
Political stability	0.131	0.718	0.565	−0.153
	(0.05)	(0.28)	(0.22)	(−0.05)
Gov. effectiveness	4.816	−0.461	−0.576	5.003
	(0.54)	(−0.05)	(−0.07)	(0.55)
Regulatory quality	−5.610	1.335	0.947	1.377
	(−0.89)	(0.20)	(0.14)	(0.21)
Rule of law	2.200	1.191	1.625	4.806
	(0.25)	(0.17)	(0.23)	(0.53)
Board independence	—	−73.07	−69.55	−311.2**
		(−0.64)	(−0.61)	(−2.37)
ESG board	—	96.17	89.31	104.6*
		(1.60)	(1.48)	(1.74)
ESG audit	—	245.4***	236.9***	307.8***
		(4.67)	(4.48)	(5.65)
Firm size	—	−177.4***	−173.6***	−176.2***
		(−3.19)	(−3.12)	(−3.16)
Firm profitability	—	−1.778	−1.181	−4.263
		(−0.44)	(−0.29)	(−1.05)
Firm liquidity	—	43.76**	40.97*	40.85**
		(2.45)	(2.28)	(2.27)
Economic development	209.2	655.3***	654.7***	21.33
	(0.89)	(3.18)	(3.18)	(0.09)
Economic output	−124.2*	98.14*	98.66*	−170.4**
	(−1.71)	(1.84)	(1.85)	(−2.20)
Intercept	383.0	−3272.4***	−3351.0***	2369.0
	(0.27)	(−3.46)	(−3.54)	(1.53)
Industry FE	YES	NO	YES	YES
Year FE	YES	YES	YES	YES
Country FE	YES	NO	NO	YES
Adj R^2	0.120	0.136	0.141	0.208
N	5512	5512	5512	5512

Note: t statistics in parentheses.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE 5 | Moderating impact of SDGs Agenda on the relationship between corruption control and hazardous waste emission.

	(1)	(2)	(3)
	Hazardous waste intensity	**Hazardous waste intensity to capitalisation**	**Hazardous waste intensity to enterprise value**
Corruption control	−11.45**	−5.032**	−4.008**
	(−2.57)	(−2.10)	(−2.55)
SDGs Agenda	−1.807	10.14	4.415
	(−0.01)	(0.07)	(0.05)
SDGs Agenda*corruption control	−0.749	−0.635	−0.407
	(−0.23)	(−0.36)	(−0.36)
Voice and accountability	7.183	3.043	2.313
	(1.35)	(1.06)	(1.24)
Political stability	−0.175	0.361	0.166
	(−0.06)	(0.24)	(0.17)
Gov. effectiveness	4.746	1.955	1.354
	(0.52)	(0.39)	(0.42)
Regulatory quality	1.488	−0.0733	0.149
	(0.23)	(−0.02)	(0.06)
Rule of law	5.018	2.319	1.923
	(0.55)	(0.47)	(0.60)
Board independence	308.6***	142.3***	102.3***
	(5.66)	(4.85)	(5.33)
ESG board	−176.4***	−93.93***	−61.26***
	(−3.17)	(−3.13)	(−3.12)
ESG audit	−4.215	−2.796	−1.785
	(−1.03)	(−1.27)	(−1.24)
Firm size	40.83**	19.55**	14.09**
	(2.27)	(2.02)	(2.23)
Firm profitability	21.49	31.82	30.43
	(0.09)	(0.24)	(0.35)
Firm liquidity	−171.4**	−66.62	−56.89**
	(−2.21)	(−1.59)	(−2.08)
Economic development	−312.2**	−113.3	−89.09
	(−2.37)	(−1.60)	(−1.93)
Economic output	104.3	47.60	34.34
	(1.73)	(1.47)	(1.62)
Intercept	2370.6	936.9	716.5
	(1.54)	(1.13)	(1.32)
Industry FE	YES	YES	YES
Year FE	YES	YES	YES

(Continues)

TABLE 5 | (Continued)

	(1) Hazardous waste intensity	(2) Hazardous waste intensity to capitalisation	(3) Hazardous waste intensity to enterprise value
Country FE	YES	YES	YES
Adj R^2	0.132	0.167	0.116
N	5512	5512	5512

Note: t statistics in parentheses.
**$p < 0.05$.
***$p < 0.01$.

origin non-common law (Category 2). Legal origin common law was measured as a binary variable that takes the value '1' if the regime is common law, and '0' otherwise (La Porta et al. 1998; Jardak et al. 2024). Legal origin non-common law was measured as a binary variable that takes the value '1' if the regime is not common law, and '0' otherwise.

In the first stage of the 2SLS, we regress corruption control on legal origin and control variables in our baseline model to generate the predicted values of corruption control. In the second stage, we rerun the baseline regression by replacing the endogenous variable with the predicted value of corruption control generated from the first stage. The result of the 2SLS is presented in Table 8. The first stage is reported in Column 1. The second stage is reported in Columns 2–5, using the main measurement of the dependent variable (Column 2) and alternative measurements (Columns 3–5). Diagnostic tests confirm instrument validity. The Anderson canonical correlation LM statistic has a *p*-value significant at the 1% level, the Cragg–Donald Wald *F* statistic exceeds the Stock–Yogo weak identification test critical values, and the Sargan statistic for the overidentification test is not statistically significant (Tawiah et al. 2024). The results in Table 8 (Columns 2–5) reveal a significant negative association between corruption control and hazardous waste emissions, confirming that our baseline result is robust to endogeneity concerns.

4.4.3 | Correcting for Endogeneity With Propensity Score Matching

To address any potential endogeneity bias where the effect of an independent variable on a dependent variable cannot be casually interpreted because it includes omitted causes leading to biased/inconsistent estimates (Antonakis et al. 2010), we employ propensity score matching (PSM), as reported in Table 9.

In the first stage of the PSM process, we derive *Corruption_Control_Dummy* by using the median score of corruption control to split our sample into treatment group (above median) and control group (median score and below). We then regress *Corruption_Control_Dummy* on control variables in our baseline model to generate the propensity scores using nearest neighbour/greedy matching. The nearest neighbour/greedy matching process involves running through the list of treatment units and selecting the closest eligible control unit to be paired with each treated unit. The result of the first stage of PSM is reported in Table 9 (Column 1). We compare the characteristics (in terms of mean scores) of the treatment and control groups, and, in the unreported result, *t*-test *p*-values reveal no significant difference across the dimensions of variables used as covariates in our model. This reveals that the treatment and control groups were well matched.

In the second stage of the PSM process, we replace the endogenous variable with the propensity score of corruption control derived in the first stage and rerun our regression using hazardous waste intensity as the dependent variable, as reported in Column 2. The result shows that corruption control is negatively associated with hazardous waste emissions, implying that our result persists after addressing endogeneity.

4.4.4 | Mitigating Endogeneity Using the Lagged Variable Approach

We use the lagged variable approach to address potential endogeneity. We take the 1-year lag (Column 1) and 2-year lag of the dependent variable (Hazardous Waste Intensity) and regress this on corruption control and control variables with fixed effects. By introducing lagged dependent variables (Hazardous Waste Intensity at *t*–1 and *t*–2), the model attempts to reduce simultaneity and reverse causality. Using past values of Hazardous Waste Intensity ensures that current corruption control cannot directly 'cause' those past values. This weakens the possibility that the dependent variable is contemporaneously driving the explanatory variable. Environmental intensity measures (like hazardous waste) often exhibit inertia—current year waste levels are influenced by previous year levels. Including lagged terms accounts for this dynamic structure, reducing omitted variable bias. Result in Table 10 shows a significant negative impact of corruption control on the two alternative measures of the dependent variable. This provides additional evidence that our result is robust to endogeneity threats.

4.5 | Handling Selection Bias Using the Heckman Two-Step Procedure

This study may be subject to endogeneity arising from unobserved heterogeneity (omitted variable bias). Countries with stronger corruption control are likely to differ systematically from others along unobserved dimensions—such as overall governance capacity, regulatory quality, or institutional

TABLE 6 | Relationship between corruption control and hazardous waste emissions in the MDGs and SDGs periods.

	Hazardous waste intensity	
	(1)	(2)
	MDGs period	SDGs period
Corruption control	−15.49**	−3.318
	(−2.36)	(−0.89)
Voice and accountability	2.343	5.613
	(0.26)	(1.23)
Political stability	0.702	0.0597
	(0.17)	(0.02)
Gov. effectiveness	1.903	6.062
	(0.14)	(0.70)
Regulatory quality	0.168	2.709
	(0.02)	(0.42)
Rule of law	12.59	3.178
	(0.89)	(0.40)
Board independence	−458.4**	204.3
	(−2.56)	(1.47)
ESG board	126.7	65.87
	(1.47)	(1.18)
ESG audit	403.7***	175.8***
	(4.93)	(3.82)
Firm size	−230.1***	−117.0**
	(−2.76)	(−2.46)
Firm profitability	−2.105	−9.437***
	(−0.35)	(−2.67)
Firm liquidity	21.72	119.2***
	(0.91)	(5.82)
Economic development	250.9	−552.9**
	(0.70)	(−2.24)
Economic output	−191.7	−207.0***
	(−1.66)	(−2.86)
Intercept	2282.9	4284.8***
	(1.03)	(2.71)
Industry FE	YES	YES
Year FE	YES	YES
Country FE	YES	YES
Adj R^2	0.118	0.249
N	2817	2695

Note: t statistics in parentheses.
**$p < 0.05$.
***$p < 0.01$.

culture—that may also directly affect hazardous waste intensity. If these latent country characteristics are not fully captured by the control variables, the corruption control measure may be correlated with the error term, leading to biased and inconsistent estimates. The Heckman two-step procedure is employed to address endogeneity arising from non-random selection into corruption control regimes. The Heckman approach corrects for this bias by explicitly modelling the selection mechanism in the first stage and incorporating it into the outcome equation in the second stage (Table 11). We construct the *Corruption_Control_Dummy* by splitting the sample at the median value of the corruption control score. Observations with scores above the median are classified as the treatment group, indicating more effective corruption control, while those with scores at or below the median form the control group. In the first stage (column 1), we regress *Corruption_Control_Dummy* on the covariates. This equation captures the probability that a country exhibits effective corruption control. To satisfy the exclusion criteria, we use legal origin as the instrument for corruption control (La Porta et al., 1998; Dhaliwal et al., 2014) in the first stage. We derive the Inverse Mills ratio which was applied in the second stage. The Inverse Mills ratio captures the expected value of the error term in the hazardous waste equation conditional on the selection into corruption control. In the second stage (column 2), we regress hazardous waste intensity on corruption control, Inverse Mills ratio, and covariates with industry, year, and country fixed effects. The inclusion of the Inverse Mills ratio explicitly controls for selection bias arising from non-random assignment into corruption control regimes. After accounting for this bias, corruption control remains negatively and significantly associated with hazardous waste emissions, suggesting that the baseline relationship is not driven by non-random selection into corruption control regimes.

4.6 | Alternate Sample Composition

4.6.1 | Cultural Environment

Cultural orientation can shape how corruption control affects hazardous waste emissions, because culture influences how societies view authority, rule-breaking, environmental responsibility, and collective welfare (Hofstede 1994; Naghavi et al. 2021). Cultural orientation affects how society responds to anti-corruption institutions and how firms behave regarding environmental regulation and waste disposal (Tsai et al. 2020; Griffin et al. 2021). Considering the international nature of this study, we perform subsample analysis based on cultural orientation to examine the association between corruption control and hazardous waste emissions in different cultural settings. We focus on three cultural orientations proposed by Hofstede (1984, 1994), which may uniquely affect environmental management/environmental sustainability—long-term orientation, masculinity (motivation towards achievement) and uncertainty avoidance.

Using the median score, we split the sample into high and low cultural dimensions as follows: (i) long-term orientation: high (> median score) versus low (≤ median score); (ii) masculinity/motivation towards achievement: high (> median score) versus low (≤ median score); and (iii) uncertainty avoidance: high (> median

TABLE 7 | Relationship between corruption control and hazardous waste emissions using alternative measurement of dependent variable.

	(1)	(2)	(3)
	Hazardous waste intensity to market capitalisation	**Hazardous waste intensity to enterprise value**	**Hazardous waste emissions rate**
Corruption control	−5.248**	−4.146***	−326004.6***
	(−2.26)	(−2.73)	(−7.24)
Voice and accountability	3.158	2.386	164315.4***
	(1.11)	(1.28)	(2.99)
Political stability	0.379	0.178	15614.8
	(0.25)	(0.18)	(0.53)
Gov. effectiveness	2.173	1.494	33556.5
	(0.44)	(0.46)	(0.35)
Regulatory quality	−0.167	0.0899	−60492.6
	(−0.05)	(0.04)	(−0.89)
Rule of law	2.140	1.808	184693.3*
	(0.44)	(0.56)	(1.94)
Board independence	−112.5	−88.57*	−2830716.2**
	(−1.59)	(−1.92)	(−2.07)
ESG board	47.80	34.48	640341.5
	(1.47)	(1.63)	(1.02)
ESG audit	141.6***	101.9***	2779280.2***
	(4.83)	(5.32)	(4.90)
Firm size	−93.75***	−61.16***	145468.9
	(−3.13)	(−3.12)	(0.25)
Firm profitability	−2.837	−1.812	−40154.1
	(−1.29)	(−1.26)	(−0.95)
Firm liquidity	19.56**	14.10**	417579.4**
	(2.02)	(2.23)	(2.23)
Economic development	31.69	30.34	8460929.4***
	(0.24)	(0.35)	(3.26)
Economic output	−65.77	−56.34**	−5988718.9***
	(−1.58)	(−2.06)	(−7.42)
Intercept	935.6	715.7	34143582.4**
	(1.13)	(1.32)	(2.12)
Industry FE	YES	YES	YES
Year FE	YES	YES	YES
Country FE	YES	YES	YES
Adj R^2	0.166	0.192	0.219
N	5512	5512	5512

Note: t statistics in parentheses.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE 8 | Two-stage least squares (2SLS) results on the relationship between corruption control and hazardous waste emission.

	First stage of 2SLS	Second stage of 2SLS			
	(1)	(2)	(3)	(4)	(5)
	Corruption control	Hazardous waste intensity	Hazardous waste intensity to market capitalisation	Hazardous waste intensity to enterprise value	Hazardous waste emissions rate
Legal origin common law	2.055***	—	—	—	—
	(4.45)				
Legal origin non-common law	3.232**	—	—	—	—
	(2.53)				
Corruption control (predicted)	—	−14.04***	−6.52***	−4.40***	−1598985.7***
		(−4.55)	(−3.65)	(−4.09)	(−4.95)
Voice and accountability	0.317***	−33.21***	−14.23***	−10.44***	−358163.9***
	(17.75)	(−4.22)	(−3.36)	(−3.77)	(−4.35)
Political stability	−0.0298***	2.001	1.251	0.855	58913.3**
	(−2.98)	(0.77)	(0.90)	(0.94)	(2.18)
Gov. effectiveness	0.454***	−65.88***	−28.60***	−21.09***	−830811.5***
	(14.53)	(−4.14)	(−3.34)	(−3.77)	(−4.99)
Regulatory quality	−0.466***	72.83***	30.73***	22.88***	838022.6***
	(−21.28)	(4.52)	(3.55)	(4.04)	(4.97)
Rule of law	0.415***	−61.31***	−26.31***	−19.39***	−682181.0***
	(13.23)	(−4.17)	(−3.33)	(−3.75)	(−4.43)
Board independence	−3.495***	330.2**	167.2**	116.0**	4205320.4***
	(−7.64)	(2.36)	(2.22)	(2.35)	(2.87)
ESG board	1.289***	−91.09	−36.72	−27.86	−1763806.2**
	(6.13)	(−1.29)	(−0.97)	(−1.12)	(−2.39)
ESG audit	1.217***	113.8*	57.57*	39.83	308089.6
	(6.41)	(1.95)	(1.83)	(1.93)	(0.50)
Firm size	0.419**	−234.3***	−118.7***	−79.72***	−693237.9
	(2.15)	(−4.12)	(−3.88)	(−3.98)	(−1.16)
Firm profitability	0.0268	−7.986	−4.448*	−2.981**	−81182.9*
	(1.88)	(−1.88)	(−1.95)	(−1.99)	(−1.82)
Firm liquidity	0.218***	7.622	5.206	3.515	11176.4
	(3.47)	(0.40)	(0.50)	(0.52)	(0.06)
Economic development	33.23***	−4779.5***	−2039.6***	−1499.2***	−53355301.5***
	(46.44)	(−4.22)	(−3.35)	(−3.76)	(−4.50)
Economic output	−6.061***	820.8***	363.7***	261.3***	6825959.2***
	(−23.68)	(5.22)	(4.30)	(4.73)	(4.15)

(Continues)

TABLE 8 | (Continued)

	First stage of 2SLS	Second stage of 2SLS			
	(1)	(2)	(3)	(4)	(5)
	Corruption control	Hazardous waste intensity	Hazardous waste intensity to market capitalisation	Hazardous waste intensity to enterprise value	Hazardous waste emissions rate
Intercept	−55.26***	9408.5***	3935.1***	2931.0***	125974792.0**
	(−10.70)	(3.39)	(2.63)	(3.00)	(4.33)
Industry FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES
Adj. R^2	0.382	0.113	0.180	0.198	0.173
Anderson LM statistic (underidentification test)	84.655***	—	—	—	—
Cragg–Donald Wald *F* statistic (weak identification test)	21.418	—	—	—	—
Sargan statistic *p*-value (overidentification test)	0.199	—	—	—	—
N	5512	5512	5512	5512	5512

Note: t statistics in parentheses. Stock–Yogo weak ID test critical values: 10% maximal IV size = 10.27; 15% maximal IV size = 8.96; 20% maximal IV size = 6.66; and 25% maximal IV size = 5.53.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

score) versus low (≤ median score). The results of the analysis are presented in Table 12 for long-term orientation (Columns 1 and 2), masculinity/motivation towards achievement (Columns 3 and 4) and uncertainty avoidance (Columns 5 and 6).

Table 12 shows that, in high long-term orientation societies, corruption control reduces hazardous waste emissions (Column 1), whereas it has no significant impact in short-term (i.e., low long-term) orientation societies (Column 2). This can be explained by the fact that high long-term orientation cultures value sustainability, planning and future outcomes (Hofstede 2011). Thus, society pressures firms to avoid environmentally harmful shortcuts. However, in cultures with low long-term (short-term) orientation, the pursuit of immediate profits and quick gains often drives decision-making (Hofstede 1994, 2011), which can, in turn, promote hazardous waste emissions. In short-term-oriented cultures, firms and policymakers prioritise quick profits, quarterly results or immediate cost savings. Environmental safeguards often require upfront investment (e.g., cleaner technologies and waste treatment facilities), which may be seen as reducing short-term profitability.

In both high-masculinity (Table 12, Column 3) and low-masculinity (femininity/consensus-oriented) cultural settings (Table 12, Column 4), corruption control is negatively associated with hazardous waste emissions. However, going by the beta coefficients and *t* statistics, corruption control has a stronger impact on reducing hazardous waste emissions in low-masculinity (femininity/consensus-oriented) cultures ($b = -17.44$, $t = -3.42$, $p < 0.01$) compared to high-masculinity ones ($b = -12.89$, $t = -1.73$, $p < 0.10$). Low-masculinity (femininity) cultures value cooperation, social responsibility and consensus (Tsai et al. 2020; Naghavi et al. 2021). When corruption is controlled, these cultures are more likely to channel resources into collective goods such as hazardous waste emission reduction for the purpose of environmental protection. Feminine cultures place higher importance on quality of life, community well-being and environmental sustainability. Thus, once corruption is curbed, there is stronger societal pressure to reduce hazardous waste emissions. Social sensitivity to harm may be more pronounced in high masculinity cultures where competition, achievement and material success dominate. Masculine cultures may tolerate environmental harm as a trade-off for industrial success, and, as such, corruption control may not translate directly into cleaner practices. Even with corruption control, firms may still prioritise aggressive growth strategies that generate waste, such that the reduction effect of corruption control is weaker. Masculine cultures, focused on short-term performance metrics (Hofstede 2001), may, therefore, not fully capitalise on the benefits of corruption control for environmental outcomes.

The result in Table 12 shows that corruption control has no significant impact on hazardous waste emissions in both high (Column 5) and low (Column 6) uncertainty avoidance cultural environments. This could possibly be explained by the reasoning

TABLE 9 | Propensity score matching results on the relationship between corruption control and hazardous waste emission.

	(1)	(2)
	Corruption_ Control_ Dummy	**Hazardous waste intensity**
Corruption control (pscore)	—	−4.118**
		(−2.06)
Voice and accountability	0.362***	5.377
	(11.54)	(0.98)
Political stability	0.071***	0.419
	(4.30)	(0.14)
Gov. effectiveness	0.258***	1.342
	(5.88)	(0.14)
Regulatory quality	0.281***	6.274
	(7.01)	(0.97)
Rule of law	−0.207***	−1.324
	(−3.98)	(−0.14)
Board independence	0.435	−282.0*
	(0.84)	(−2.11)
ESG board	−0.767**	92.63
	(−2.88)	(1.51)
ESG audit	−0.278	296.7***
	(−1.30)	(5.36)
Firm size	0.258	−180.2***
	(1.23)	(−3.19)
Firm profitability	−0.019	−4.676
	(−1.06)	(−1.12)
Firm liquidity	−0.098	39.75*
	(−1.60)	(2.15)
Economic development	35.376***	−285.0
	(11.49)	(−1.26)
Economic output	3.977***	−99.32
	(9.13)	(−1.35)
Intercept	−276.423***	2645.6
	(−12.88)	(1.64)
Industry FE	YES	YES
Year FE	YES	YES
Country FE	YES	YES
Pseudo R^2	0.229	—
Adj R^2	—	0.121
N	5512	3318

Note: t statistics in parentheses.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE 10 | Corruption control and hazardous waste emissions: Lagged-variable approach for mitigating endogeneity.

	(1)	(2)
	Hazardous waste intensity (1-year lag)	**Hazardous waste intensity (2-year lag)**
Corruption control	−11.46***	−10.59**
	(−2.65)	(−2.45)
Voice and accountability	7.428	10.33
	(1.41)	(1.96)
Political stability	0.122	3.321
	(0.04)	(1.16)
Gov. effectiveness	2.283	2.184
	(0.25)	(0.24)
Regulatory quality	2.792	2.094
	(0.43)	(0.32)
Rule of law	5.640	3.667
	(0.62)	(0.40)
Board independence	316.9***	319.4***
	(5.82)	(5.87)
ESG board	−161.7**	−144.1***
	(−2.90)	(−2.59)
ESG audit	−7.664*	−6.119
	(−1.88)	(−1.50)
Firm size	40.09**	51.69***
	(2.23)	(2.88)
Firm profitability	27.93	−221.4
	(0.11)	(−0.89)
Firm liquidity	−157.8**	−247.5***
	(−2.03)	(−3.19)
Economic development	−133.6	−110.2
	(−1.02)	(−0.84)
Economic output	126.7**	103.1*
	(2.10)	(1.71)
Intercept	2197.4	4038.1***
	(1.42)	(2.62)
Industry FE	YES	YES
Year FE	YES	YES
Country FE	YES	YES
Adj R^2	0.129	0.164
N	5512	5512

Note: t statistics in parentheses.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE 11 | Corruption control and hazardous waste emissions: Heckman two-step selection model to control endogeneity.

	(1)	(2)
	Corruption_ Control _Dummy	**Hazardous waste intensity**
Legal origin common law	1.572***	—
	(4.86)	
Legal origin non-common law	0.223***	—
	(4.73)	
Corruption control	—	−14.94***
		(−2.91)
Inverse Mills ratio	—	9.079
		(0.65)
Voice and accountability	0.363***	9.901
	(11.53)	(1.58)
Political stability	0.0709***	1.996
	(4.30)	(0.63)
Gov. effectiveness	0.258***	4.928
	(5.87)	(0.43)
Regulatory quality	0.282***	7.182
	(7.01)	(0.90)
Rule of law	−0.207***	1.677
	(−3.97)	(0.15)
Board independence	0.431	−361.7***
	(0.83)	(−2.62)
ESG board	−0.773**	100.4
	(−2.90)	(1.60)
ESG audit	−0.290	317.9***
	(−1.35)	(5.59)
Firm size	0.266	−174.7***
	(1.26)	(−3.02)
Firm profitability	−0.0200	−5.532
	(−1.06)	(−1.27)
Firm liquidity	−0.101	39.53**
	(−1.65)	(2.09)
Economic development	35.39***	438.9
	(11.51)	(1.00)
Economic output	3.983***	−127.9
	(9.13)	(−1.40)
Intercept	−276.6***	−449.6
	(−12.88)	(−0.14)
Industry FE	YES	YES
Year FE	YES	YES
Country FE	YES	YES
Pseudo R^2	0.192	—
Adj R^2	—	0.144
N	5512	5512

Note: t statistics in parentheses.
**$p < 0.05$.
***$p < 0.01$.

that corruption control works through institutional enforcement and universal incentives (O. Oyewo et al. 2025), which override cultural differences in risk tolerance. In sum, going by the results in Table 12, we conclude that the association between corruption control and hazardous waste emissions varies based on cultural environments.

4.6.2 | Environment Pollution/Environmental Sensitivity

Environment pollution intensity/environmental sensitivity can shape how corruption control affects hazardous waste emissions, because environmentally sensitive (high-polluting) industries are subject to more regulatory monitoring compared to less environmentally sensitive (low-polluting) industries. Environmental sensitivity of an industry refers to how significantly its operations impact the environment. Industries with high environmental sensitivity tend to generate more hazardous waste and are, therefore, subject to stricter regulatory oversight, monitoring and compliance requirements.

Considering the international nature of this study, we perform subsample analysis based on environmental pollution/sensitivity to examine the association between corruption control and hazardous waste emissions. We classify firms into environmentally sensitive (high-polluting) industries and less environmentally sensitive (low-polluting) industries following the approach used in the literature (Baboukardos 2017; Konadu et al. 2021). Industries such as chemicals, oil and gas, mining, metals, paper and pulp, pharmaceuticals and heavy manufacturing are grouped into environmentally sensitive (high-polluting) industries because their core operations generate substantial hazardous waste or pose significant environmental risks. Industries such as information technology and telecommunications, retail, professional services, hospitality, real estate and telecom are classified as less environmentally sensitive (low-polluting) industries because these industries generate comparatively lower levels of hazardous waste and have minimal direct environmental impact. The results of the analysis are presented in Table 13 using our main measurement of the dependent variable and alternative measurements.

The results in Table 13 show that corruption control is negatively associated with hazardous waste emissions in both

TABLE 12 | Analysis of relationship between corruption control and hazardous waste emissions based on cultural environment.

	Hazardous waste intensity					
	Long-/short-term orientation		Masculinity/femininity		Uncertainty avoidance	
	(1)	(2)	(3)	(4)	(5)	(6)
	Long-term orientation (high)	Long-term orientation (low)/short- term orientation	Masculinity (high)/motivation towards achievement	Masculinity (low)/femininity/ consensus-oriented	Uncertainty avoidance (high)	Uncertainty avoidance (low)
Corruption control	−8.050***	−5.854	−12.89*	−17.44***	−2.922	−12.79
	(−8.01)	(−0.30)	(−1.73)	(−3.42)	(−1.42)	(−1.10)
Voice and accountability	4.785***	−1.972	10.65	5.634*	−3.881*	10.17
	(3.20)	(−0.11)	(1.19)	(1.84)	(−1.76)	(1.11)
Political stability	3.747***	4.087	−2.399	5.787**	1.390	4.975
	(4.84)	(0.34)	(−0.59)	(2.53)	(1.49)	(0.65)
Gov. effectiveness	−4.004	2.426	3.172	−0.725	−5.704**	16.02
	(−1.54)	(0.10)	(0.22)	(−0.11)	(−2.15)	(0.62)
Regulatory quality	−3.633**	−5.345	−1.513	12.99**	4.958**	−9.248
	(−2.13)	(−0.23)	(−0.14)	(2.42)	(2.08)	(−0.42)
Rule of law	8.891***	14.67	8.206	−18.25**	3.520	−15.28
	(3.36)	(0.62)	(0.64)	(−2.21)	(1.35)	(−0.50)
Board independence	−88.64***	−1507.0***	−329.9**	−114.4	−92.32**	−843.0***
	(−2.73)	(−3.95)	(−2.01)	(−1.17)	(−2.15)	(−3.18)
ESG board	33.24*	257.1**	121.8*	−25.59	16.41	197.4**
	(1.73)	(2.36)	(1.72)	(−0.43)	(0.57)	(2.23)
ESG audit	24.68	500.0***	345.2***	28.72	5.927	450.1***
	(1.42)	(5.08)	(5.38)	(0.50)	(0.24)	(5.35)
Firm size	23.57	−322.5***	−219.1***	195.7***	87.60***	−278.9***
	(1.39)	(−3.07)	(−3.32)	(3.67)	(3.44)	(−3.40)
Firm profitability	0.306	−10.05	−5.685	−4.427	−2.072	−6.850
	(0.22)	(−1.38)	(−1.13)	(−1.52)	(−1.04)	(−1.17)
Firm liquidity	9.090	38.46	39.99*	18.41	5.907	45.16*
	(1.22)	(1.35)	(1.95)	(0.81)	(0.63)	(1.80)
Economic development	−46.39	−104.2	33.11	854.1***	574.3***	652.4
	(−0.67)	(−0.08)	(0.09)	(3.95)	(5.02)	(1.16)
Economic output	−269.5***	177.0	−154.4	−287.0***	−231.9***	19.26
	(−11.27)	(0.45)	(−1.36)	(−4.07)	(−8.38)	(0.09)
Intercept	3222.8***	23.85	2373.3	−499.4	236.6	−860.8
	(6.52)	(0.01)	(1.15)	(−0.33)	(0.34)	(−0.24)
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Adj R^2	0.135	0.197	0.131	0.154	0.116	0.177
N	2655	2857	4493	1019	2063	3449

Note: t statistics in parentheses.
**$p < 0.10$.
*$p < 0.05$.
***$p < 0.01$.

TABLE 13 | Analysis of relationship between corruption control and hazardous waste emissions based on environmental sensitivity/pollution intensity.

	Environmentally sensitive (high-polluting) industries			Less environmentally sensitive (low-polluting) industries		
	(1)	(2)	(3)	(4)	(5)	(6)
	Hazardous waste intensity	Hazardous waste intensity to capitalisation	Hazardous waste intensity to enterprise value	Hazardous waste intensity	Hazardous waste intensity to capitalisation	Hazardous waste intensity to enterprise value
Corruption control	−15.85***	−7.587**	−5.923***	−0.00212*	−0.00219*	−0.00149*
	(−2.77)	(−2.43)	(−2.91)	(−1.87)	(−1.93)	(−1.86)
Voice and accountability	9.077	2.945	2.296	0.00210	0.00346**	0.00221**
	(1.33)	(0.80)	(0.95)	(1.32)	(2.24)	(2.03)
Political stability	−0.0494	0.0202	−0.147	−0.000116	−0.000586	−0.000636
	(−0.01)	(0.01)	(−0.11)	(−0.16)	(−0.85)	(−1.30)
Gov. effectiveness	8.280	4.360	2.843	0.00394*	0.00510**	0.00378**
	(0.67)	(0.66)	(0.66)	(1.73)	(2.31)	(2.42)
Regulatory quality	4.118	−2.148	−0.967	−0.00274	−0.00114	−0.00103
	(0.46)	(−0.43)	(−0.30)	(−1.61)	(−0.68)	(−0.88)
Rule of law	5.603	4.250	3.397	−0.000247	−0.00291	−0.00102
	(0.46)	(0.65)	(0.79)	(−0.10)	(−1.23)	(−0.61)
Board independence	−405.7**	−133.7	−108.9*	0.0550	−0.00534	−0.000457
	(−2.31)	(−1.41)	(−1.75)	(1.68)	(−0.17)	(−0.02)
ESG board	170.1**	79.20*	56.28*	0.0247*	0.0286**	0.0217**
	(2.01)	(1.73)	(1.88)	(1.94)	(2.31)	(2.49)
ESG audit	416.5***	181.5***	130.7***	−0.00483	0.00526	0.0000581
	(5.60)	(4.53)	(5.00)	(−0.38)	(0.42)	(0.01)
Firm size	−265.4***	−142.0***	−93.58***	0.00583	−0.00192	0.00324
	(−3.22)	(−3.19)	(−3.21)	(0.52)	(−0.17)	(0.42)
Firm profitability	−6.833	−4.490	−3.005	0.00341***	0.00106	0.00133**
	(−1.16)	(−1.39)	(−1.42)	(3.82)	(1.21)	(2.16)
Firm liquidity	44.51*	13.07	9.416	−0.0140***	−0.00453	−0.00421
	(1.86)	(1.00)	(1.10)	(−3.05)	(−0.99)	(−1.30)
Economic development	−11.44	170.2	129.5	0.0827	0.0104	0.00457
	(−0.03)	(0.91)	(1.06)	(1.34)	(0.17)	(0.11)
Economic output	−219.1**	−58.24	−55.37	−0.0266	−0.0230	−0.0226
	(−2.08)	(−1.02)	(−1.48)	(−1.39)	(−1.21)	(−1.69)
Intercept	3220.3	614.9	519.7	−0.217	0.0194	0.0237
	(1.53)	(0.54)	(0.69)	(−0.56)	(0.05)	(0.09)
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Adj R^2	0.166	0.165	0.209	0.306	0.378	0.303
N	4025	4025	4025	1487	1487	1487

Note: t statistics in parentheses.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

environmentally sensitive (Columns 1–3) and less environmentally sensitive industries (Columns 4–6). However, the impact is greater in highly environmentally sensitive industries. When corruption control is strong in a country, regulatory enforcement is generally more effective, reducing opportunities for firms to bypass environmental rules. In environmentally sensitive industries, this effect is amplified because these firms are under closer scrutiny—even small lapses in compliance are more likely to be detected and penalised. Consequently, strong corruption control in combination with high environmental sensitivity can lead to a more pronounced reduction in hazardous waste emissions. Conversely, in less environmentally sensitive industries, regulatory monitoring is lighter, and enforcement may be weaker. Even if corruption control improves, the effect on hazardous waste emissions might be smaller because these firms produce relatively little hazardous waste and face less regulatory pressure. In sum, environmental sensitivity influences the association between corruption control and hazardous waste emissions. The more environmentally sensitive the industry, the stronger the influence of corruption control on reducing hazardous waste emissions, because of higher regulatory scrutiny and enforcement.

5 | Discussion of Findings and Implications

Our results show that corruption control is negatively associated with hazardous waste emissions. This result empirically validates the argument that corruption control strengthens the institutional mechanism for regulating environmental pollution, which helps reduce emissions of hazardous waste. Conversely, the economic effects of corruption negatively affect environmental performance in countries where the institutional mechanism is weak. This result reiterates the importance of government action in putting mechanisms in place to checkmate corruption and strengthen corruption control to effectively regulate the activities of private sector entities in polluting the environment. Considering that poor management and corporate decisions regarding sustainability and environmental issues contribute to hazardous waste emissions, the government has a key role to play in setting the tone for corporate entities to be deliberate about hazardous waste emissions. Corruption control by government signals taking proactive steps in addressing environmental risk issues (Zhu and Peng 2012; Alshehhi and Zervopoulos 2023).

The significant impact of corruption control on hazardous waste emissions validates the institutional theory that public institutions and regulatory environment influence environmental management activities of private sector entities (Saha and Sen 2020). Similarly, the difference in the impact of corruption control on hazardous waste emissions based on cultural environment equally validates the institutional theory that cultural-cognitive elements influence the environmental management practices of organisations (Biswas and Thum 2016; Chen et al. 2018). Our result on the negative association between corruption control and hazardous waste emissions aligns with prior related studies (e.g., Wang et al. 2020; Sultana et al. 2022; Ahmed and Anifowose 2023) and disagrees with other studies reporting no significant impact of corruption on environmental pollution (e.g., Xie et al. 2023).

The results show that the SDGs Agenda does not significantly moderate the relationship between corruption control and hazardous waste emissions (Table 5). Further analysis supports the inference that the coming into effect of SDGs has not significantly enhanced the impact of corruption control in diminishing hazardous waste emissions (Table 6). This may be due to several reasons. First, Agenda 2030 is largely voluntary and non-binding (Erin et al. 2022; Setioningtyas et al. 2022). Firms may signal commitment to SDGs without changing harmful practices (i.e., SDGs-washing/greenwashing practices). Multinationals may publish SDGs-aligned sustainability reports without fundamentally altering operations (H. Z. Khan, Bose, et al. 2021). Firms may also focus on more visible issues (carbon and gender equality) over less popular ones like hazardous waste (B. Oyewo 2023; Mansour et al. 2024; Saleh and Maigoshi 2024). Therefore, SDGs adoption may not complement—or may even dilute—the environmental impact of corruption control. Further, governments may adopt SDGs language but not implement strong regulatory reforms needed to reinforce corruption control. Second, there may be weak policy integration with anti-corruption systems. Agenda 2030 may not always align directly with national anti-corruption strategies. Whereas countries may pursue SDGs reporting without strengthening the institutional link between corruption control and environmental enforcement, environmental regulators and anti-corruption bodies may operate in silos. This weak integration means that the moderating effect might be limited. Third, SDGs implementation capacity varies widely across countries. The SDGs are global, but their implementation depends on local capacity and political will (Erin et al. 2022). Countries with low regulatory capacity, weak environmental monitoring or high political interference may not reinforce corruption control with SDGs initiatives. Thus, the moderating impact of Agenda 2030 may be uneven and weak in practice. Finally, Agenda 2030 prioritises broad sustainability goals, not specifically hazardous waste. Hazardous waste management falls mostly under SDG 12.4, which is only one target among many. Governments and firms may focus more on climate action (SDG 13), energy (SDG 7), poverty (SDG 1) and other prominent SDGs priorities such that hazardous waste receives less strategic attention, reducing the likelihood that Agenda 2030 amplifies the effect of corruption control in this regard.

One of the clearest practical implications is the urgent need to strengthen accountability mechanisms within environmental and waste management institutions. Public institutional mechanisms need to be strengthened to curtail hazardous waste emissions of private sector entities. Corruption may distort government regulation processes and activities on environmental protection such as licensing processes, environmental impact assessments and enforcement of waste regulations (Ha et al. 2021; Tawiah 2023). In practical terms, this suggests the need for more transparent procedures, including open data platforms that make information on waste permits, compliance and monitoring publicly accessible. For governments, this translates into creating robust auditing systems and empowering anti-corruption agencies to work together with environmental regulators. A further implication is that environmental policies cannot be designed in isolation from governance reforms. This study shows that, without addressing corruption, even well-crafted environmental regulations will fail. Policymakers should, therefore, embed anti-corruption safeguards such as

conflict of interest rules, whistleblower protections and independent oversight boards directly into hazardous waste management policies. This integrated approach would strengthen both governance and environmental protection.

Theoretically, this study advances the argument that hazardous waste management is not solely a technical or environmental challenge but fundamentally a governance issue (Sinha et al. 2019; Saha and Sen 2020). By demonstrating how corruption distorts regulatory processes, the findings expand the theoretical boundaries of environmental governance research. This shifts scholarly focus from purely technological solutions (e.g., better disposal methods) to institutional solutions that emphasise transparency, accountability and integrity. The findings also have implications for institutional theory, particularly the concept of institutional failure. This study demonstrates how corruption leads to regulatory capture and weak enforcement, illustrating the ways in which formal institutions diverge from their intended functions under the influence of vested interests (Kutlu and Mao 2023). This provides theoretical insights into how institutional isomorphism may be undermined in developing countries where corruption prevents convergence with global governance standards.

The findings of this study have significant practical and theoretical implications. Practically, they call for stronger institutional accountability, greater international cooperation, enhanced public participation, integration of anti-corruption frameworks into environmental policy and health-oriented oversight of waste management. Theoretically, this study reframes hazardous waste as a governance issue, integrates corruption into environmental governance theories, contributes to institutional theory, expands sustainability discourse and bridges disciplinary divides. By combining practical recommendations with theoretical innovations, this study not only enriches academic knowledge but also provides actionable guidance for policymakers and practitioners striving for accountable, transparent and sustainable hazardous waste management.

With respect to cultural environment, the results show that corruption control reduces hazardous waste emissions more strongly in low-masculinity (feminine/consensus-oriented) cultures than in high-masculinity cultures (Table 12). In consensus-oriented cultures, policymakers should leverage the strong public trust in institutions by pairing corruption-control initiatives with environmental policies, as these societies are more likely to comply with and support regulatory measures. Conversely, in more masculine cultures, where profit-driven industry influence may weaken enforcement even when corruption is reduced, regulators should adopt targeted strategies—such as stricter oversight, transparency requirements and independent monitoring—to prevent powerful sectors from undermining environmental policy objectives.

Considering that corruption control has a stronger effect in environmentally sensitive industries (Table 13), policymakers should prioritise strengthening anti-corruption mechanisms and regulatory enforcement in high-polluting sectors. Targeted oversight and stricter compliance monitoring in these industries can significantly reduce hazardous waste emissions and improve environmental outcomes.

6 | Conclusion

Based on these results, we conclude that corruption control as an institutional mechanism significantly curbs the hazardous waste emissions of private sector entities. However, the impact is influenced by the cultural environment where organisations operate. While the SDG Agenda significantly moderates the relationship between corruption control and hazardous waste emissions, the coming into effect of Agenda 2030 has not enhanced the impact of corruption control in diminishing hazardous waste emissions.

This study makes several unique contributions to the existing body of knowledge on corruption, hazardous waste management and sustainable development. First, we contribute to the literature on the association between corruption and environmental pollution, specifically hazardous waste emissions. While research on corruption has been extensive across the governance and development domains, and hazardous waste has been addressed largely from environmental science and policy perspectives, the intersection of the two remains underexplored. By bridging these domains, this study not only fills a critical research gap but also advances theoretical, empirical and policy-oriented discussions in novel ways. The existing literature often treats corruption and environmental management as separate spheres of inquiry (Zhou and Li 2021; Kutlu and Mao 2023). While there are studies on environmental and governance issues, only a few have systematically investigated how corruption directly fuels hazardous waste mismanagement. The limited studies in this area have reported mixed results (e.g., Wang et al. 2020; Sultana et al. 2022; Ahmed and Anifowose 2023; Xie et al. 2023). However, the current study provides empirical evidence that corruption control significantly diminishes hazardous waste emissions. Our research uniquely illuminates the pathways through which corrupt practices undermine hazardous waste governance, exacerbate environmental degradation and endanger public health. By drawing explicit links, this study extends our understanding beyond conventional corruption–development debates to the specific and urgent domain of hazardous waste.

Second, we provide an exposition on the role of SDGs (i.e., Agenda 2030) in moderating the relationship between corruption control and hazardous waste emissions, and this has implications for policy. Whilst our results show that the coming into effect of SDGs has not caused significant reduction in hazardous waste emissions through the institutional mechanism (i.e., corruption control), this knowledge presents evidence that governments of nations need to do more in strengthening institutional mechanisms to achieve Agenda 2030 relating to climate change. Thus, another unique contribution lies in the study's policy orientation. Rather than limiting itself to problem diagnosis, the research proposes actionable recommendations tailored to contexts where governance weaknesses and corruption are entrenched. Suggestions such as strengthening institutional accountability, promoting transparency in environmental regulation, fostering international cooperation to combat illegal waste trade and integrating anti-corruption frameworks into environmental policies move the discussion from theory to practice. This pragmatic focus is particularly valuable for policymakers, development agencies and advocacy organisations. By situating

corruption in hazardous waste management within the broader framework of sustainable development, this study contributes uniquely to SDG debates. It underscores how corruption undermines SDG 3 (good health and well-being), SDG 12 (responsible consumption and production) and SDG 16 (peace, justice and strong institutions). This integration is a novel way of showing that addressing corruption in hazardous waste governance is not only an environmental imperative but also a developmental necessity. It reframes hazardous waste mismanagement as both a corruption issue and a barrier to achieving global sustainability commitments.

Third, our use of an extensive international sample spanning a long timeframe strengthens the generalisability of the findings and offers a significant contribution to knowledge. By adopting a longitudinal approach that covers both the MDGs and SDGs periods, our study provides new insights into how the effectiveness of corruption control in reducing hazardous waste emissions has evolved over time. Notably, we find that corruption control was significantly associated with lower hazardous emissions during the MDGs period but shows no significant effect in the SDGs era. This temporal shift underscores the need for governments to reinvigorate public institutions and strengthen accountability mechanisms to ensure that private sector entities operate more sustainably. These insights—situating corruption control within the distinct contexts of the MDGs and SDGs over a long horizon—are essential for informing policy design and strategic actions aimed at combating environmental pollution and achieving the environmental targets of Agenda 2030.

Fourth, we provide insights into the influence of cultural environment on the relationship between corruption control and hazardous waste emissions. Whilst our study establishes that the impact of institutional mechanism on environmental pollution/control is contextual,

such knowledge could resolve some of the mixed results reported in prior studies. Whilst most of the related studies have been conducted in a country/region setting that affects generalisability of results (e.g., Rahman et al. 2020; Román-Aso et al. 2024; Saleh and Maigoshi 2024), the cross-country approach adopted by the current study presents a clearer picture of how contexts influence the association. This is in response to calls for cross-country studies to resolve or reconcile mixed results reported in sustainability studies (Zaman et al. 2020; Alhossini et al. 2021).

Finally, this study makes a unique contribution by bridging disciplinary silos. It brings together insights from environmental studies, political science, governance and anti-corruption research, creating a multi-disciplinary framework for understanding a complex problem. This holistic approach distinguishes it from narrower studies that remain confined within a single academic field. By reframing hazardous waste mismanagement as both a governance issue and a corruption issue, this study advances scholarly debates and provides practical insights for policymakers and practitioners. It contributes new perspectives that not only enrich academic understanding but also support efforts to build accountable, transparent and sustainable systems for hazardous waste management globally.

Despite its contributions, this study has some limitations that provide opportunities for future research. First, the analysis focuses on the top 500 global companies, which may limit the generalisability of the findings to smaller firms or firms operating exclusively in developing economies with weaker institutional environments. Future studies could extend the sample to include medium-sized enterprises or firms in high-polluting sectors not represented among global leaders. Second, although this study spans an 18-year period and captures both the MDGs and SDGs periods, the use of secondary data may omit unobservable organisational practices, informal institutional pressures or country-level enforcement dynamics that influence hazardous waste management. Researchers could complement quantitative approaches with qualitative case studies or mixed-methods designs to provide deeper insights into how corruption control interacts with organisational behaviour on the ground. Third, while several econometric techniques were employed to address endogeneity—including instrumental variable regression, propensity score matching, the Heckman two-step procedure and lagged variables—causal inference remains inherently limited in observational datasets. Future research could use natural experiments or quasi-experimental designs to strengthen causal claims. Fourth, the moderating role of Agenda 2030 was examined at a broad temporal level. However, the SDGs encompass multiple environmental, governance and institutional targets that may exert heterogeneous effects. Future studies could investigate how specific SDG policies, implementation strategies or country-level commitment levels influence the corruption–environment relationship. Finally, this study relies on global governance indicators to capture corruption control, which may not fully reflect sector-specific regulatory dynamics or firm-level exposure to corruption risks. Future research could incorporate more granular measures—such as industry-specific enforcement data, firm-level compliance records or local regulatory intensity—to refine the understanding of how institutional mechanisms shape hazardous waste emissions.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data for this study are available from the corresponding author upon reasonable request.

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