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The role of audit quality in waste management behavior

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ABSTRACT

The entire world is facing the issue of climate change. Due to rapid industrialization, enormous waste generation is aggravating the situation. In this study, we investigate the role of audit quality in promoting sustainable waste management in firms. Using a sample of 8100 firm-year observations for the period 2002–2017 from 34 countries, we provide novel empirical evidence that good audit quality significantly reduces total corporate waste production. Further, our results are robust to alternate proxies of audit quality, and waste management, and only appear with unqualified audit reports. To alleviate the endogeneity issue, we use two different identification strategies; namely, PSM and GMM. Altogether, these findings demonstrate that Big4 auditing firms ensure the credibility and reliability of the non-financial disclosures of their auditees as apparent by their rigorous auditing processes. Moreover, the main implication of our study is that firms are subject to a decrease in their overall waste production when their external assurer is one of the BIG4 auditing firms.

1. Introduction

The word 'Sustainability' has received immense global attention over the last decade, as obvious by its evident visibility in, corporate mission and vision statements (Meppem & Gill, 1998). Hereby, many internationally approved climate agreements, such as the Paris Agreement, and the Sustainable Development Goals (SDGs), etc., have been used as a source for embedding sustainable development in the core strategies of both developed and developing economies (Alam et al., 2019). According to these agreements, immense greenhouse gas (GHG) emissions are regarded as the prime reason for the present environmental degradation (Alam et al., 2019). Besides, these statistics by the World Bank (2012) state that the annual amount of solid waste produced by our global economy amounts to one billion tons, thus highlighting the increased contribution of the waste sector to the increase in global temperatures. Conversely, the United Nations Environmental Programme (2010) in its report on waste and climate change states that the waste sector can move its position from a minor contributor to a major saver of emissions, as it reports only a 3–5% contribution of the waste sector in GHG emission production. These statistics point toward the development of a circular economy through improvement in the waste management practices of firms in the last 40 years (Romero-Hernández & Romero, 2018).

Moving forward, these global environmental concerns have entailed primary pressure on corporates as they are subject to the

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generation of a massive amount of waste during the production of goods and services (Gull, Atif, & Hussain, 2022; Hirsch, 2019). Further, firms in response to the pressure entailed by certain internal and external stakeholders are moving towards more sustainable practices, like waste management, recycling, reusing, etc. (Alam et al., 2019). These sustainable business practices are costly to introduce and maintain and therefore depend on the strength of a firm's governance structure, as strong governance structures predict the level of waste produced by firms (Gull, Atif, & Hussain, 2022; Shahab et al., 2022). For this reason, prior research has extensively highlighted the importance of a firm's external and internal governance in the promotion of corporate sustainability (Bacha et al., 2020; Earnhart & Harrington, 2021; Hussain et al., 2018; Jo et al., 2015; Saeed et al., 2022).

Furthermore, the implementation of strong corporate governance is a complicated task for firms as it requires fairness, transparency, and accountability in their business practices (Kemp et al., 2012). Hence, to ensure legitimacy and avoid material misstatements firms often seek external assurance of their financial and non-financial disclosures (Earnhart & Harrington, 2021; Xiao et al., 2020). Broad literature on corporate social responsibility highlights the importance of audit quality in enhancing corporate sustainability (Braam et al., 2016; Dicu et al., 2020; Earnhart & Harrington, 2021; Handayati et al., 2022). Such as Dakhli (2021) analyse that large audit firms like BIG4 enhance corporate environmental performance. Fernandez-Feijoo et al. (2018) analysed the positive role of the BIG4 auditors in promoting sustainable activities in their auditees. As these auditing firms employ more developed test methodologies and assure a wide range of CSR issues (Maroun, 2019). Moreover, BIG4 auditors also find a competitive advantage in entering the sustainability assurance market, as they encourage their financial auditing clients to get assurance of their non-financial disclosure (Fernandez-Feijoo et al., 2016).

However, when we refer to the importance of audit quality in promoting sustainable development, we find very limited empirical evidence which performs an in-depth analysis of how audit quality deals with different issues of corporate social responsibility (Braam et al., 2016; Fernandez-Feijoo et al., 2016; Zahid et al., 2022). Such as Earnhart and Harrington (2021) studied the impact of audit quality on environmental compliance, Dakhli (2021) studied the relationship between audit quality and corporate sustainability performance, and Fernandez-Feijoo et al. (2016) analyse the role of audit quality in sustainability reporting. Therefore, here in this research, we contribute to prior environmental sciences literature and study the impact of audit quality on an emerging issue of corporate social responsibility i.e. waste management.

Hence, to study the impact of audit quality on our variable of interest (waste management), we employ 8100 firm-year observations from various databases such as Thomas Reuters ASSET4, Worldscope, and DataStream. Our study covers data from 34 developed and developing countries and spreads from 2002 through 2017. To study waste management, we use the proxy of total waste from the environmental pillar of ASSET4. While we analyse audit quality as a binary variable from the DataStream database. Our empirical findings, thus confirm the theoretical assumptions of this research and prove that better audit quality can be used as a catalyst for decreasing a firm's overall waste production. These findings were found persistent with the prior literature on corporate environmental behaviour and practices (Ackers, 2009; Fernandez-Feijoo et al., 2018; Maroun, 2019).

Moreover, to further check for the robustness of our results we use several alternate proxies for waste management (*WRI* and *EWRI*) and audit quality (*AUD_FEE)*. Also, we conducted additional analysis and used propensity score matching (PSM) and generalized methods of moments (*GMM*) to confirm the absence of certain endogeneity concerns. Our additional analysis aimed to check whether the nature of the industry in which the firm operates, external and internal governance, natural/rest of the industries, and the presence of a CSR committee strengthen the relationship between audit quality and waste management.

Our study contributes to the prior literature on corporate environmental practices. Primarily, it is the first study to examine the impact of audit quality on corporate waste management practices. It empirically clarifies the role audit quality plays in the promotion of sustainable development. Despite, Kemp et al. (2012) and Earnhart and Harrington (2021) stating that audit improves environmental performance a few empirical analysis has focused on the impact of audit quality on a firm's environmental performance. These studies have analysed overall environmental performance through the lens of audit quality, audit culture, frequency, etc. (Earnhart & Harrington, 2021; Kemp et al., 2012; Xiao et al., 2020). However, our study provides important implications for policymakers and explores the positive role that audit quality plays in improving a firm's waste management practices.

Secondly, it adds to the literature on corporate environmental behaviours (Gull, Saeed, et al., 2022; Jiang et al., 2022; Shahab et al., 2022), by investigating the role of BIG4 auditors in enhancing corporate waste management. It provides practical implications by analysing the role BIG4 auditing firms play in reducing their client's overall waste production. Also, we extend the literature on corporate environmental reporting (Fernandez-Feijoo et al., 2018; Gallego-álvarez, 2019) and present, a significant relationship between BIG4 auditing services and the firm's waste reduction initiatives. Lastly, our study addresses the gap in the corporate sustainability literature by elaborating on the importance of company and industry-level factors in enhancing the relationship between auditor performance and corporate sustainable development.

The rest of the paper proceeds as follows. Section 2, reviews prior literature and formulates a hypothesis. Section 3 describes our sample selection and research method. Section 4 presents the research findings and checks for the robustness of our results. Section 5 performs the additional analysis. Lastly, Section 6 gives the concluding remarks and states the practical implications.

2. Literature review

In this section first, we provide the theoretical background to our main relationship. Second, we evaluate prior studies to check for the possible impact of audit quality on waste management in firms.

According to legitimacy theory, firms ensure that their operations are in line with the norms and laws of society. Pertaining to this view if the community expects environmental protection from the business then firms will voluntarily fulfill their environmental responsibilities (Braam et al., 2016). Tarigan et al. (2022) state that firms have to manage their operations regularly to maintain their

legitimacy with the norms and policies of society because low legitimacy might question the authenticity of their license to operate. Moreover, firms often maintain and ensure the legitimacy of their environmental responsibilities by giving social and environmental disclosures on company websites and annual reports. Further, prior research highlights that according to legitimacy theory, a firm's engagement in CSR activities helps in fulfilling its intention of meeting CSR goals and proving the legitimacy used by the social agents of the firm (Bacha et al., 2020). Moreover, Braam et al. (2016) states that legitimacy theory assumes a social contract between a firm and the environment in which it operates. Hence under this social contract, firms should be sensitive to the changes in the dynamics and conditions of the environment. Also, for this reason companies with low sustainability performance make use of third-party assurance in face of legitimacy threats and pressure from the public.

On the other hand, stakeholder theory assumes stakeholders to be part of the corporate environment, thus requiring a firm's sincere commitment to the moral values of the society and environment (Tarigan et al., 2022). For instance, stakeholder theory recognizes the role of each stakeholder in creating economic value for the firm. Here a firm's CSR engagement is often used as a tool to moderate the relationship between management and stakeholders (Jo et al., 2015). Like, Bacha et al. (2020) also state that CSR improves the social relationship between a firm and its stakeholders thus enabling a greater level of commitment and loyalty from its stakeholders. However, a firm's CSR practices are often regarded as corporate ethical behaviour, thus helping in generating positive social capital for the firm. Further, Oh et al. (2017) state that environmentally sustainable practices are used to achieve stakeholder satisfaction. Just as they refer stakeholder to be as a source of generating sustainable earnings and achieving overall organizational goals.

Moving forward, prior research state that an audit improves a firm's environmental performance (Bacha et al., 2020; Tarigan et al., 2022). However, the quality of audits is considered to be an important factor because not all facilities conduct an audit on equal levels (Earnhart & Harrington, 2021). As a result of these considerations over audit quality prior research has extensively analysed the difference between the quality of different auditors (Bacha et al., 2020; Sìmnett et al., 2009; Tarigan et al., 2022). For instance, Tarigan et al. (2022) provide empirical evidence that BIG4 auditors provide higher quality audits as compared to non-BIG4 auditors. Also, it states that firms audited by BIG4 auditors are more likely to disclose their environment-sensitive information because BIG4 auditors require their clients to disclose a maximum amount of information to avoid deception and theft. This might be possible because BIG4 auditing firms have a greater number of clients, trained staff, better and high-quality technology, and more risk to their reputational capital (Tarigan et al., 2022). Furthermore, Sìmnett et al. (2009) state that BIG4 firms are less likely to act opportunistically as compared to their counter-auditing firms, hence comprising better monitoring mechanisms and structure. However, prior research also argues that BIG4 auditors promote innovative practices such as CSR practices in a firm and show increased concern over environmental sustainability (Bacha et al., 2020). This increased concern is pertinent to the global efforts for the development of a sustainable environment which has forced corporations to engage in sustainable practices such as recycling and reusing (Alam et al., 2019).

Further, prior research has emphasized the importance of several corporate sustainable practices in the development of sustainable corporations (Bhaskar & Kumar, 2019; Ebeid & Zakaria, 2021). Among these sustainable practices, waste management is an emerging issue of corporate social responsibility, which has been recognized previously by several environmental researchers (Gull, Atif, & Hussain, 2022; Shahab et al., 2022). Additionally, waste management is among the key issues of environmental responsibility and includes activities and actions required to manage waste from its inception to disposal (Ebeid & Zakaria, 2021; Jamali et al., 2008). Moreover, waste management has also been recognized globally as it is found among the key interest factors of the Kyoto Protocol (Limited, 1997). Also, subsequent agreements such as Paris Agreement and sustainable development goals have increased corporate interest in sustainable waste management (Alam et al., 2019). Consequently, today's corporates believe that waste management is important for continuing as socially responsible corporations. Henry et al. (2019) state that keeping economic, social, and environmental factors equal is a challenge for corporations. Furthermore, while refereeing to the increased global attention towards the importance of corporate sustainability auditors like BIG4 require their client firms to disclose more non-financial information and demand fulfilment of environmental responsibilities more rigorously (Tarigan et al., 2022).

Moreover, Fernandez-Feijoo et al. (2016) state that BIG4 auditors find a certain competitive advantage in entering the sustainability assurance market. As they encourage their financial audit clients to conduct sustainability reporting along with financial reporting. Further, Fernandez-Feijoo et al. (2018) state that sustainability reports of firms that are audited by BIG4 are found to be more accurate and credible. Likewise, while analysing a panel data set of 200 French firms Dakhli (2021) states that the relationship between a firm's CSR performance and financial performance is more positively pronounced in the presence of a BIG4 auditor. Similarly, Timbate and Park (2018) state that socially responsible firms which are audited by the BIG 4 auditing firms are less likely to manage their earnings.

Moving forward, up till now, research has evaluated the firm's environmental sustainability in relation to audit quality use, CSR disclosure, CSR reporting, carbon emission performance, etc (Lu & Wang, 2021; among others). In other words, prior research lacks to test the relation between audit quality and different prevailing issues of corporate social responsibility such as waste management. For instance, Braam et al. (2016) while analysing a sample of Dutch companies state that external assurance positively impacts corporate environmental reporting. Also, Tarigan et al. (2022) found a positive relationship between audit quality and carbon emission disclosure using 108 sustainability reports of non-financial firms from the Indonesian Stock Exchange.

However, while analysing the above literature we found a positive relationship between a firm's audit quality and environmental performance (Braam et al., 2016; Dakhli, 2021; Fernandez-Feijoo et al., 2018). Therefore, based on the claims and arguments of stakeholder theory, legitimacy theory, and prior research, we hypothesize that firms with better audit quality i.e. whose auditors are among the BIG4 firms demand high-quality environmental reporting from their clients. On the whole, the firms which are audited by the BIG4 auditing firms control and reduce the amount of waste produced by their firms.

3. Data and methodology

3.1. Sample

Our sample is drawn from multiple databases, for instance, an initial sample of 15,211 firm-year observations was created from the Thomas Reuters ASSET4 database, which provides us with data for the total waste produced. While data for audit quality (*BIG4)* and the control variables were collected from Worldscope and DataStream databases. Then, we used single-digit Standard Industrial Classification (*SIC*) to define our industries under observation. While, our final sample was obtained after applying certain exclusion criteria to our initial sample such as, first, we excluded the financial sector (SIC 6000 to 6999) following their minimal contribution to waste production (Harper & Sun, 2019), second, we deleted observations with missing data on any of the main variables and lastly, in consistency with prior literature, we removed those countries from our sample whose number of firm-year observations were less than twenty (Gull, Atif, & Hussain, 2022). Thus, resultantly after applying the exclusion criteria, we extract 8100 firm-year observations from 34 countries for the period 2002–2017.

3.2. Measurement of main variables

Our dependent variable of interest is waste management, which we evaluate by applying proxy i.e. total waste (*ENERDP045*) from the environmental pillar of the ASSET4 database. Prior literature has been using total waste (*T_WASTE)* as a measure of corporate environment operational performance (Bisig & Hummel, 2017). ASSET4 has been known as a premier source of ESG information since its inception and acquisition. It provides relevant and systematic information on social, environmental, and governance (ESG) factors based on 250 key performance indicators and 750 individual data points. It uses publicly available information about firms such as annual reports and CSR reports, etc. (Thomson Reuters ASSET4, 2013).

Our independent variable is audit quality (*BIG4*) we measure audit quality as a binary variable (i.e. it takes the value 1 if the company is audited by one of the BIG4 auditing firms, otherwise 0) from the Worldscope database. Prior literature has been evaluating audit quality using data on various dimensions such as audit fees and large audit firms such as BIG4, etc. from the Worldscope database (Bacha et al., 2020; Saeed et al., 2022). However, Worldscope's goal is to improve the comparability of financial data of publicly traded companies that belong to different countries and industries across periods. Worldscope's analysts use primary source documents and news clippings and extract them to global templates which are specific for different industry groups (Financial, 2007).

3.3. Empirical model

We use the following model to test the relationship between audit quality and waste management:

$$\begin{aligned} \text{T\_WASTE}_{i,t} = {} & \alpha_0 + \beta_1\ \text{BIG4}_{i,t} + \beta_2\ \text{SIZE}_{i,t} + \beta_3\ \text{ROA}_{i,t} + \beta_4\ \text{VOL}_{i,t} + \beta_5\ \text{LEV}_{i,t} + \beta_6\ \text{DIV}_{i,t} + \beta_7\ \text{TANG}_{i,t} + \sum_{k=1}^{16} \gamma_k Year \\ & + \sum_{k=1}^{7} \gamma_k \text{Industry} + \sum_{k=1}^{34} \gamma_k \text{Country} + \varepsilon_{i,t} \end{aligned} \quad (1)$$

Where *T_WASTE* represents our proxy for waste management (total waste) and *BIG4* represents the audit quality of firms in equation (1). Further, consistency with prior studies (e.g., Dakhli, 2021; Gull, Atif, & Hussain, 2022; Uyar et al., 2021) equation (1) controls for firm size (*SIZE*), return on assets (*ROA*), volatility (*VOL*), dividend dummy (*DIV*), asset tangibility (*TANG*), along with year, industry and country fixed effects.[1]

4. Results and discussion

4.1. Year-wise and country-wise summary

We present the year-wise and country-wise summary of our variable in Panel A and B of Table 1, respectively. The results in Panel A present a significant increase in our sample size over the period (2002–2017). This increase is attributed to the acquisition of ASSET4 by Thomson Reuters in 2009 (Ribando & Bonne, 2010). Further, in Panel B we divide our sample of firms into 34 countries which are included in the ASSET4. Here we analyse that the major proportions of firms are from the United States (25.48%), United Kingdom (12.64%), and France (7.68%). These proportions can be attributed to the stakeholder-oriented approach of European countries and the issuance of large proportions of sustainability reports by firms in these countries (Sìmnett et al., 2009).

4.2. Descriptive statistics

The descriptive statistics for our regression variables (dependent, independent, control, and additional variables) are presented in Table 2. First, we present the statistics for our main variable of interest (*T_*WASTE) and dependent variable (*BIG4*) in Table 2. Here we analyse that with a root mean square deviation of 2.84, our sample firms produce a total of 11.15 tonnes of waste on average. However,

[1] To alleviate the effect of outliers, all the continuous variables are winsorized at 1% and 99% levels.

our results were found consistent with Gull, Atif, and Hussain (2022) who use total waste as one of the proxies for waste management. While statistics for audit quality state that 63% of our sample firms get their audit done by the BIG4 auditing firms. Here we found consistency with the findings of Sarquis et al. (2021) who found 78.6% firm compliance with BIG4 auditing services. Second, we summarize the statistics for our control variables in Table 2. Table 2 presents, that our sample firm constitutes 16.67 firm sizes and 6.53 *ROA* on average. Moreover, the firms in our sample have high volatility, low leverage on average, pay dividends to their shareholders (86%), and constitute tangible assets (33%). Lastly, Table 2 also presents the statistics for additional variables.

4.3. Correlation analysis and variance inflation factor (VIF)

Table 3 presents the Pearson correlation coefficients for our regression variables. Here we analyse that the correlation coefficients and variance inflation factor of our variables indicate the absence of multicollinearity, thus meeting the minimum thresholds of corporate finance i.e. <0.7, and <10, respectively (Galletta et al., 2021). Furthermore, as prior literature states that hiring BIG4 audit firms, ensures the credibility of a firm's financial and non-financial disclosures and eliminates doubts related to CSR performance (Bacha et al., 2020). We also analyse a significant and negative correlation between our main variables i.e. waste management and audit quality. This indicates that firms with better audit quality are more likely to reduce their overall waste production.

4.4. Regression results

4.4.1. Audit quality and waste management

Table 4 presents our main regression results, here our principal independent variable is audit quality (*BIG4*) and the main variable of interest is waste management (*T_WASTE*). Our results in compliance with the stakeholder and legitimacy theories present a negative and statistically significant relationship between *BIG4* and *T_WASTE*. These findings confirm that BIG4 auditing firms pertinent to their rigorous auditing services are presumably better able to reduce their client's overall waste production.[2] However, these results were found consistent with prior studies which state that an audit by the BIG4 auditing firms is associated with high-quality reporting and that the BIG4 firms are the dominant sustainability assurance providers, respectively (Ackers, 2009; Maroun, 2019). Likewise, Fernandez-Feijoo et al. (2018) also analysed an increase in the number and credibility of sustainability reports in the case of BIG4 auditors. Moreover, to check for the robustness of our results we apply the firm-level cluster, to analyse the fluctuations around the mean for each firm-year observation, and the Newey-West technique to eliminate the issue of possible autocorrelation (Gull, Saeed, et al., 2022). Both the techniques applied present a significantly negative relationship between our key variables and confirm our prior findings. Resultantly, the results in Table 4 support our hypothesis i.e. better audit quality improves a firm's overall waste management.[3]

Moving forward, the results of our control variables also support our main regression results as they are found to be in accordance with our expectations. First, we found a positive and significant relationship between waste management with firm size, volatility, dividend dummy, and asset tangibility. These results, interpret that a corresponding increase in the value of these variables increases a firm's overall waste production. Moreover, the behaviour of these variables has also been confirmed in the domain of corporate sustainability (Bacha et al., 2020; Gull, Atif, et al., 2022). Secondly, consistent with the findings of Gull, Atif, et al. (2022), we found a negative relationship between a firm's profitability and its total waste generation. This interprets a positive link between a firm's financial soundness and its environmental sustainability. Lastly, we detect no relationship between a firm's leverage and its waste management, these results are also confirmed by Sìmnett et al. (2009) who made an effort to analyse the assurance market for sustainability reporting.

4.4.2. Regression with alternate proxies

In Table 5 we check the robustness of our results to alternate proxies of our main variable of interest (*T_WASTE*). For this, we employ waste reduction initiatives (*WRI*) and e-waste reduction initiatives (*EWRI*) from the environmental management practices of ASSET4. Our choice of proxies was found consistent with Hardcopf et al. (2021) who found environmental disclosures as an important source for the development of corporate sustainable behaviour. Moreover, concerning the binary nature of our alternate variables, i.e. (take value 1 if the company gives environmental disclosure, otherwise 0), we applied the probit regression model in columns (1) and (2), respectively to analyse the relationship of *BIG4* with *WRI* and *EWRI*.

The empirical results presented in Table 5 predictably present a significantly positive relationship between *BIG4* with *WRI*. These results, however, confirm the empirical findings of Sìmnett et al. (2009) who state that firms to build better corporate reputation and credibility get their sustainability reports assured. While an insignificant relationship of *BIG4* was found with *EWRI*, perhaps because many firms do not consider e-waste management as part of their sustainable development process (Bhaskar & Kumar, 2019). Prior literature also used total waste recycled as a proxy of waste management (Gull, Atif, et al., 2022; Shahab et al., 2022; among others). In this part, we replace our dependent variable with total waste recycling (*WAS_RC*), and the results robust with our main findings in column (3).

Lastly, we analysed the relationship of audit fees with total waste produced in a firm in column (4). Here the results also confirm our

[2] The economic significance is also important. For example, an increase in BIG4 score by one (sample) standard deviation, decreases total waste production by approximately −0.77% [BIG4 (0.25) × −0.343/T_WASTE (11.15) = −0.0077].

[3] Furthermore, we also assure the consistency of our findings by using the panel fixed effect regression (unreported results). This technique is more appropriate to control the correlation variations.

anticipations and present a positive and significant relationship between audit fees and waste management. Considering this we infer that higher audit quality requires a greater amount of effort, expertise, and time, that's why it comes with high auditing fees. Also, Maroun (2019) confirms that BIG4 auditors ensure compliance with principles of materiality, responsiveness, and inclusivity when subject to the disclosure reports of social and environmental sustainability. For this reason, they charge an audit fee premium from their clients pertaining to the greater amount of time, skilled labour, and modern technology invested in the auditing process (Bacha et al., 2020).

4.4.3. Regression with alternate proxies of audit quality

Audit opinions reflect the wisdom of auditors regarding audit risk (Xiao et al., 2020). As per the auditing standard number 700 auditors often give four types of opinions on a firm's financial statements i.e. qualified; unqualified; refuse to give any comment on statements; refuse to accept the financial statements. While the most desired opinion by the firms is an unqualified audit opinion, which classifies a firm's statements as fair and accurate (Nguyen & Trinh, 2020). In addition, prior research also highlights that investors often prefer CSR-oriented companies for investments, as firms with low levels of CSR are considered riskier investments (Brogi et al., 2022; Faller & zu Knyphausen-Aufseß, 2018). Pertaining to this, BIG4 auditors encourage improvements in the quality of financial and sustainability reporting in their client firms, thus providing them with unqualified opinions over their reports (Fernandez-Feijoo et al., 2018).

In this study, we examine the impact of unqualified and qualified audit opinions by the BIG4 on a firm's waste management in columns (1) and (2) of Table 6, respectively. Undoubtedly, we found the relationship between audit quality and waste management to prevail only in the case of unqualified opinions by the BIG4 audit firms. These findings were found consistent with Nguyen and Trinh (2020) who state that financial statements issued by CSR-oriented firms are more likely to receive an unqualified opinion. Similarly, our results were also found consistent with Dicu et al. (2020), who found the ratio of unqualified opinions to be high in more environmentally sustainable firms.

4.4.4. Endogeneity concerns

Our findings might be prejudiced towards certain endogeneity concerns. Therefore, to address this problem we first apply the propensity score matching (*PSM*) technique in column (2) of Table 7. Previously, *PSM* has been achieving increased attention in social studies (Gull, Hussain, et al., 2022; Jo et al., 2015), for dealing with potential endogeneity concerns. Here in this study, *PSM* controls for the variations in attributes of firms with BIG4 external assurers to firms with non-BIG4 external assurers. The difference in the percentage of firms audited by BIG4 and non-BIG auditors in Table 2 might elevate possible endogeneity concerns.

Therefore, to segregate the impact of audit quality on waste management, we execute *PSM* using a matched sample with similar firm characteristics. In column (1) we estimate the likelihood of a firm's high audit quality using a propensity score computed through a probit regression model and match each firm with high audit quality to a firm with low audit quality. The probit model, however, uses a dummy variable of audit quality (*BIG4*) in place of the dependent variable which takes a value of 1 if a company is audited by BIG4 consulting firms, and 0 otherwise. Moving forward, in column (2) we rerun our main regression using the matched sample of 4402 firm-year observations produced using the *PSM* technique. Predictably, the *PSM*-matched sample reveals similar results as our main analysis and presents a negative relationship between audit quality and total waste produced.

Furthermore, following prior studies (Gull, Hussain, et al., 2022; Jo et al., 2015) we also employ the generalized methods of moments (*GMM*) in column (3) to overrule certain dynamic endogeneity and reverse causality problems (Haque & Ntim, 2018). *GMM* considers the use of one-year lagged values of our dependent variable as instruments. While we confirm the accuracy of our *GMM* using the Arellano-Bond test for *AR(1)*, the Arellano-Bond test for *AR(2)*, and the Hansen test for over-identification (Boubaker et al., 2020; Jo et al., 2015). The results explain a significant and negative relationship between audit quality and waste management. Likewise, the significance of the *AR(1)* test and the corresponding insignificance of the *AR (2)* test and Hansen test of over-identification restrictions prove the absence of serial correlation. Therefore, our hypothesis holds even after accounting for potential endogeneity concerns, i.e. better audit quality significantly reduces overall waste generation in firms.

5. Additional analysis

5.1. External and internal governance

Up to now, we analyse a negative relationship between audit quality (*BIG4*) and a firm's total waste production (*T_WASTE*). These results signify the role of BIG4 auditors in improving its client firm's overall waste management. However, to further elaborate on the effectiveness of our results we present additional analysis in Table 8 and test the impact of various firm-level attributes, on the relation between *BIG4* and *T_WASTE*. Prior studies extensively highlight the role of corporate governance in developing a sustainable corporation (Gull, Atif, & Hussain, 2022; Haque & Ntim, 2018; Mahmood et al., 2018). Therefore, we examine the role of corporate governance in influencing the relationship between audit quality and total waste. For this, we perform a sub-sample analysis and divide our sample firms in reference to governance strength; i.e. weak and strong governance, in columns (1) and (2), respectively. Whereas, the governance strength is measured as deviation from the average governance score in the ASSET4 database (Saeed et al., 2022). Foreseeably, our empirical findings present a significant relationship between audit quality and waste management only in the presence of a strong governance structure. This might be because, strong and sustainable governance structures ensure the occurrence of fewer key audit matters during the auditing process (Fera et al., 2022).

Moving forward, prior research on corporate social responsibility has been analysing a non-linear relationship between

institutional ownership and corporate sustainability (Harjoto et al., 2017; Oh et al., 2017). That is, institutional owners pertaining to the value maximization theory consider CSR expenditure as a direct cost and consequently limit the firms spending on CSR activities (Harjoto et al., 2017). Therefore, consistent with the findings of prior research, we realize the significance of institutional investors and test their impact on our key relationship by performing sub-sample analysis in columns (3) and (4). Where, column (3) presents firms with low institutional ownership, and column (4) presents firms with high institutional ownership. Predictably, our results confirm the findings of Oh et al. (2017) and Faller and zu Knyphausen-Aufseß (2018) and present a significant relationship between audit quality and total waste only in the case of low institutional ownership.

5.2. Sub-sample analysis of CSR committee, and industry nature

Prior research on sustainability disclosure considers CSR committees as relevant corporate governance matters which help magnify corporate sustainability disclosures (Gallego-álvarez, 2019; Mahmood et al., 2018; Uyar et al., 2021). As Mahmood et al. (2018) and Uyar et al. (2021) state CSR committees are better able to control and manage sustainability-related corporate decisions, and thus are beneficial to corporate structure. Therefore, pertinent to the prior findings we analyse the significance of our relationship in firms that hold CSR committees, and that don't hold CSR committees in columns (3) and (4), of Table 9, respectively. To analyse this, we employ the CSR committee variable from the BoardEx database which holds 1 in case of the presence of a CSR committee and, 0 otherwise. Consequently, in coherence with the findings of prior research (Mahmood et al., 2018; Uyar et al., 2021) our relationship holds significance only in firms that hold CSR committees.

Moving forward, a significant difference has been realized in the CSR reporting quality of various industries, as each industry's characteristics define how its firms report their CSR initiatives (Hawn & Ioannou, 2016). Such as firms in non-environmentally sensitive industries are often expected to conceal their poor environmental performance with positive environmental disclosures (Gull, Hussain, et al., 2022). Whereas, firms in environmentally sensitive industries, disclose more non-financial information under the pressure entailed by various stakeholders in society (Hawn & Ioannou, 2016). Consequently, we assume possible variations in the impact of audit quality on waste management, across various industries. For this, consistence with Gull, Hussain, et al. (2022) and Nadeem et al. (2020), we distinguish natural industries from the rest of the industries in columns (5) and (6) of Table 9, respectively. Here we found the relationship between audit quality and waste management to prevail only in the case of non-natural industries. This might be because referring to the nature of their practices firms in natural industries, ideally perform better in corporate social responsibility (Hawn & Ioannou, 2016). On the whole, our findings ensure the variations in the impact of audit quality on a firm's environmental performance vary across industries.

6. Conclusion

The immense increase in global temperatures has become a substantial concern and emerged as a real-world phenomenon in recent years (Alam et al., 2019). The increase in global annual waste production further ruins the situation (World Bank, 2012). For this reason, firms have increased their attention toward sustainable development in the face of the pressure entailed by the governments, policymakers, stakeholders, and external assurers of a firm (Alam et al., 2019; Saeed et al., 2022). Prior research has extensively studied the impact of external stakeholders on a firm's environmental sustainability (Dakhli, 2021; Dicu et al., 2020). As Braam et al. (2016) and Earnhart and Harrington (2021) also analyse the importance of audit quality in enhancing corporate environmental performance. While prior literature lacks to define the role of audit quality in improving several other dimensions of corporate social responsibility such as waste management. Therefore, concerning the importance of waste management, our study fills this void and provides robust empirical evidence on the impact of audit quality on waste management.

This study employs a panel data set of 8100 firm-year observations from 34 countries between 2002 and 2017 and finds a negative relationship between audit quality (*BIG4*) and total waste generation (*T_WASTE*) (Earnhart & Harrington, 2021). Our results are robust to the use of several alternate proxies of waste management and audit quality. Moreover, we found our relationship to be more pronounced in firms that constitute CSR committees, have strong governance structures, have low institutional ownership, and are with high CSR intensity. While, in addition, we drive that audit quality is subject to reducing a firm's overall waste generation only in the case of non-natural industries. Furthermore, to the extent possible, we rule out certain endogeneity concerns through the propensity score matching (*PSM*) and generalized methods of moments (*GMM*) techniques and analyse consistent results. Ultimately, our findings indicate that high audit quality plays the role of external governance helps firms to reduce their waste production.

Our study provides implications for policymakers and academic researchers in two ways. First, concerning the increased corporate attention towards sustainable development, audit quality is a significant source of positive impact on the environment. Second, global waste generation is an emerging source of environmental degradation, thus covering less identification in the business management literature (Gull, Saeed, et al., 2022; Gull, Atif, & Hussain, 2022mong others). Our study, therefore, implies the role of audit quality in decreasing total waste production of firms, by playing the role of external governance and encouraging sustainable business practices.

Moreover, we also propose the limitations of this work as future research directions. First, it includes only those countries that are included in the Asset4 database, as varying results might occur in the case of other databases such as the MSCI ESG. Second, we study the impact of audit quality on the waste generation of firms and not measure its impact on the implementation of corresponding waste management practices. Hence, future studies can examine the impact of audit quality on the execution of certain waste management practices, such as recycling, reuse, and remanufacturing, etc. (Gull, Hussain, et al., 2022; Nadeem et al., 2020).

Data availability

The authors do not have permission to share data.

Appendix. Definitions and sources of variables

Variable	Symbol	Definition	Source
Dependent Variable			
Waste Management	*T_WASTE*	Natural logarithm of the total amount of waste produced.	Asset4 ESG
Independent Variable			
Audit Quality	*BIG4*	Takes a value of 1 if a company was audited by one of the Big 4 auditing firms, and 0 otherwise.	Worldscope
Control Variables			
Firm Size	*SIZE*	The natural logarithm of total assets.	Worldscope
Return on Assets	*ROA*	Net income divided by Total Assets.	Worldscope
Volatility	*VOL*	Volatility is the standard deviation of monthly stock returns.	DataStream
Leverage	*LEV*	Total Debt to Total Equity.	Worldscope
Dividend Dummy	*DIV*	Dividend dummy variable either the company paying a dividend in the current year or not.	Worldscope
Asset Tangibility	*TANG*	Tangibility is total fixed assets scaled by total assets.	Worldscope
Additional Variables			
Waste reduction initiatives	*WRI*	Takes a value of 1 if the company reports on its recycle, reduce, reuse, substitute, treat, or phase out any type of waste, 0 otherwise.	Asset4 ESG
E-waste reduction initiatives	*EWRI*	Takes a value of 1 if the company reports on its recycling, reducing, reusing, substituting, treating, or phasing out e-waste, and 0 otherwise.	Asset4 ESG
Waste Recycling	*WAS_REC*	Natural logarithm of the total amount of waste recycled.	Asset4 ESG
Audit Fees	*AUD_FEE*	Natural logarithm of the firm current year audit fee.	Worldscope
Unqualified Audit Opinion	*UA*	Audit opinion which presents a true and fair view of a firm's financial statements.	Worldscope
Qualified Audit Opinion	*QA*	Audit opinion which presents a fair view of financial statements with the exception of specified areas of auditor's concern.	Worldscope
Corporate Governance	*GOV*	We obtain corporate governance data from the CG pillar of the Asset4 database.	Asset4 ESG
Institutional Ownership	*INS_OWN*	Takes a value of 1 if the firm has more than 5% of shares held by institutional investors, and 0 otherwise.	Worldscope
Corporate Social Responsibility	*CSR*	Average of the environmental and social metrics of the Asset4	Asset4 ESG
CSR Committee	*CSR_COM*	Takes the value of 1 when the company has a corporate social responsibility committee or team, and 0 otherwise.	BoardEx

Table 1
Sample distribution by year and country.

Panel A: Sample by Year			Panel B: Sample by Country		
Year	Observations	%	Country	Observations	%
2002	54	0.67	*FINLAND*	183	2.26
2003	86	1.07	*FRANCE*	622	7.68
2004	120	1.48	*GERMANY*	393	4.85
2005	191	2.36	*GREECE*	26	0.32
2006	223	2.75	*HONG KONG*	150	1.85
2007	314	3.87	*INDIA*	160	1.98
2008	385	4.76	*ITALY*	97	1.2
2009	460	5.68	*JAPAN*	112	1.38
2010	536	6.62	*MALAYSIA*	60	0.74
2011	619	7.64	*MEXICO*	55	0.68
2012	686	8.47	*NETHERLANDS*	186	2.3
2013	768	9.48	*NORWAY*	99	1.22
2014	817	10.09	*POLAND*	48	0.59
2015	902	11.13	*PORTUGAL*	48	0.59
2016	984	12.15	*RUSSIA*	136	1.68
2017	953	11.77	*SINGAPORE*	73	0.9
Total	8100	100	*SOUTH AFRICA*	202	2.49
Panel B: Sample by Country			*SOUTH KOREA*	144	1.78
Country	**Observations**	**%**	*SPAIN*	271	3.35
AUSTRALIA	319	3.94	*SWEDEN*	213	2.63

(*continued on next page*)

Table 1 (*continued*)

Panel A: Sample by Year			Panel B: Sample by Country		
Year	Observations	%	Country	Observations	%
AUSTRIA	58	0.72	*SWITZERLAND*	287	3.54
BELGIUM	105	1.3	*TAIWAN*	113	1.4
BRAZIL	91	1.12	*THAILAND*	79	0.98
CANADA	466	5.75	*TURKEY*	45	0.56
CHINA	46	0.57	*UNITED KINGDOM*	1024	12.6
COLOMBIA	29	0.36	*UNITED STATES*	2064	25.5
DENMARK	96	1.19	Total	8100	100

Note: Table 1 reports the year and country-wise distribution. The final sample comprises 8100 firm-year observations from 34 countries between 2002 and 2017.

Table 2
Descriptive statistics

Variables	Mean	Standard deviation	Minimum	1st quartile	Median	3rd quartile	Maximum
Dependent variable							
T_WASTE	11.15	2.84	4.44	9.31	10.86	12.74	19.20
Variable of interest							
BIG4	0.63	0.25	0.00	0.00	0.00	1.00	1.00
Control variables							
SIZE	16.67	2.06	11.20	15.29	16.43	17.61	23.75
ROA	6.53	7.86	−66.05	3.32	6.19	10.03	35.86
LEV	0.21	0.14	0.00	0.11	0.20	0.29	0.82
VOL	15.75	5.39	2.00	16.00	17.00	18.00	22.00
DIV	0.86	0.34	0.00	1.00	1.00	1.00	1.00
TANG	0.33	0.23	0.00	0.14	0.28	0.50	0.95
Additional Variables							
WRI	0.85	0.35	0.00	1.00	1.00	1.00	1.00
EWRI	0.23	0.42	0.00	0.00	0.00	0.00	1.00
WAS_REC	10.23	2.48	2.89	8.64	10.21	11.83	16.52
AUD_FEE	8.79	1.61	4.69	7.74	8.67	9.64	14.13
UA	0.83	0.36	0.00	1.00	1.00	1.00	1.00
QA	0.16	0.36	0.00	0.00	0.00	0.00	1.00
GOV	67.45	25.37	2.33	49.32	75.72	88.78	98.77
INS_OWN	0.45	0.50	0.00	0.00	0.00	1.00	1.00
CSR	80.44	18.53	4.65	75.20	87.49	93.22	98.45
CSR_COM	0.34	0.47	0.00	0.00	0.00	1.00	1.00

Note: This table shows the summary statistics of dependent, independent, control, and other variables used in this study. *T_WASTE* (dependent) is the natural logarithm of the total amount of waste produced in the current year. *BIG4* (independent) is a dummy variable that takes a value of 1 if a company was audited by one of the Big 4 auditing firms, and 0 otherwise. The detailed definition of all the variables and data sources is shown in the 'Appendix'.

Table 3
Pearson correlation matrix and variance inflation factor (*VIF*)

VAR	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	*VIF*
(1) T_WASTE	1.000								
(2) BIG4	−0.029*	1.000							1.47
(3) SIZE	0.279*	−0.120*	1.000						2.97
(4) ROA	−0.126*	−0.005	−0.003	1.000					1.21
(5) LEV	0.003	0.011	0.040*	−0.125*	1.000				1.29
(6) VOL	0.078*	−0.035*	0.122*	0.036*	−0.001	1.000			1.07
(7) DIV	0.079*	−0.037*	0.168*	0.222*	−0.048*	0.070*	1.000		1.18
(8) TANG	0.339*	−0.030*	0.143*	−0.137*	0.174*	0.021	−0.019	1.000	1.59

Note: This table shows the Pearson correlation and VIF of dependent, independent, and control variables used in this study. *T_WASTE* (dependent) is the natural logarithm of the total amount of waste produced in the current year. *BIG4* (independent) is a dummy variabl that takes a value of 1 if a company was audited by one of the Big 4 auditing firms, and 0 otherwise. The detailed definition of all the variables and data sources is shown in the 'Appendix'. * represent significance at the 0.01 level.

Table 4
Audit quality and waste management

VAR	(1)	(2)	(3)	(4)
	Without Fixed Effects	With Fixed Effects	Cluster Effect	Newey-West
T_WASTE				
BIG4	−0.437***	−0.343***	− 0.343***	−0.437***

(*continued on next page*)

Table 4 (*continued*)

VAR	(1)	(2)	(3)	(4)
	Without Fixed Effects	With Fixed Effects	Cluster Effect	Newey-West
	(−4.92)	(−2.92)	(−5.97)	(−3.86)
SIZE	0.092***	0.801***	0.801***	0.092***
	(10.78)	(40.2)	(60.93)	(8.21)
ROA	−0.010***	−0.025***	−0.025***	−0.010**
	(−3.16)	(−7.58)	(−3.65)	(−2.20)
LEV	−0.123	−0.653***	−0.653***	−0.123
	(−0.77)	(−3.44)	(−3.46)	(−0.55)
VOL	0.017***	0.018***	0.018***	0.017***
	(3.86)	(3.9)	(3.86)	(2.91)
DIV	0.304***	0.331***	0.331***	0.304***
	(4.19)	(4.37)	(4.79)	(3.16)
TANG	4.381***	3.711***	3.711***	4.381***
	(46)	(28.31)	(33.62)	(28.85)
Constant	7.569***	−2.272***	−2.272***	7.569***
	(39.31)	(−3.58)	(−6.57)	(29.68)
Observations	8100	8100	8100	8100
Fixed Effects	No	Year, Industry & Country	Year, Industry & Country	No
Adjusted R^2	0.147	0.429	0.429	–
F-stat	363.7	98.95	66.56	178.11

Note: This table presents the relationship between *T_WASTE* and *BIG4*. *T_WASTE* (dependent) is the natural logarithm of the total amount of waste produced in the current year. *BIG4* (independent) is a dummy variable that takes a value of 1 if a company was audited by one of the Big 4 auditing firms, and 0 otherwise. The detailed definition of all the variables and data sources is shown in the 'Appendix'. *, **, and, *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table 5
Regression with alternative proxies

VAR	(1)	(2)	(3)	(4)
	WRI	EWRI	WAS_REC	T_WASTE
BIG4	0.080***	0.001	0.167**	
	(4.43)	(0.06)	(2.53)	
AUD_FEE				0.020***
				(3.92)
SIZE	0.046***	0.027***	0.904***	0.034***
	(15.19)	(7.48)	(40.79)	(7.95)
ROA	0.000	0.003***	−0.015***	−0.000
	(0.28)	(4.18)	(-4.07)	(−0.75)
LEV	−0.089***	−0.059*	0.183	−0.025
	(−3.06)	(−1.73)	(0.88)	(−0.82)
VOL	0.002***	−0.002***	0.014***	0.002***
	(2.70)	(−2.82)	(2.88)	(2.80)
DIV	0.058***	0.005	0.437***	0.066***
	(5.01)	(0.38)	(5.28)	(5.34)
TANG	0.029	−0.231***	2.055***	−0.018
	(1.46)	(−9.77)	(14.19)	(−0.84)
Constant	−0.385***	−0.423***	−3.606***	0.190*
	(−3.94)	(−3.69)	(-5.00)	(1.82)
Observations	8100	8100	5763	7021
Fixed Effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.133	0.157	0.388	0.0985
F-stat	21.03	25.34	59.84	27.45

Note: This table presents the relationship between *T_WASTE* and *BIG4 with alternate proxies*. *T_WASTE* (dependent) is the natural logarithm of the total amount of waste produced in the current year. *BIG4* (independent) is a dummy variable that takes a value of 1 if a company was audited by one of the Big 4 auditing firms, and 0 otherwise. The detailed definition of all the variables and data sources is shown in the 'Appendix'. *, **, and, *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table 6
Regressions with alternative proxies of audit quality (*UQ and QA*)

VAR	(1)	(2)
	UQ	QA
BIG4	−0.303**	−0.343
	(−2.34)	(−1.39)

(*continued on next page*)

Table 6 (*continued*)

VAR	(1)	(2)
	UQ	QA
SIZE	0.818***	0.238***
	(37.83)	(7.98)
ROA	−0.022***	−0.057***
	(−6.07)	(−6.09)
LEV	−0.685***	0.161
	(−3.31)	(0.33)
VOL	0.016***	0.012
	(3.37)	(0.65)
DIV	0.336***	0.735***
	(4.07)	(3.67)
TANG	3.631***	3.621***
	(25.29)	(10.98)
Constant	−2.491***	6.967***
	(−3.68)	(4.23)
Observations	7820	280
Fixed Effects	Yes	Yes
Adjusted R^2	0.431	0.336
F−stat	84.14	27.45

Note: This table presents the relationship between *T_WASTE* and *BIG4 with auditor opinion types*. *T_WASTE* (dependent) is the natural logarithm of the total amount of waste produced in the current year. *BIG4* (independent) is a dummy variable that takes a value of 1 if a company was audited by one of the Big 4 auditing firms, and 0 otherwise. The detailed definition of all the variables and data sources is shown in the 'Appendix'. *, **, and, *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table 7
Endogeneity concerns

VAR	(1)	(2)	(3)
	PSM		GMM
	Probit	*Matched Sample*	
BIG4		0.527**	−0.382**
		(2.04)	(−2.55)
SIZE	−0.087***	0.999***	0.022*
	(−8.43)	(14.66)	(1.79)
ROA	−0.002	−0.068***	0.010***
	(−0.70)	(−5.60)	(5.44)
LEV	0.457***	−0.811	−0.038
	(2.58)	(−1.29)	(−0.29)
VOL	−0.007	0.027	0.003
	(−1.48)	(1.50)	(0.79)
DIV	−0.137*	0.538**	0.058
	(−1.77)	(1.97)	(1.21)
TANG	−0.145	4.167***	0.249**
	(−1.25)	(9.98)	(2.3)
LAG(T_WASTE)			0.968***
			(96.53)
Constant	2.655***	−8.123***	1.023
	(5.31)	(−3.19)	(1.22)
Observations	8100	4402	6711
Fixed Effects	Yes	Yes	Yes
Pseudo R^2	0.0708		
CHI-2	276.4		
Adjusted R^2		0.432	
F-stat		14.39	1494
Number of NID			1230
AR (1) test (p-value)			0.000
AR (2) test (p-value)			0.971
Over identification Statistics			
Hansen test			0.887

Note: This table presents the relationship between *T_WASTE* and *BIG4 with PSM and GMM identification strategies*. *T_WASTE* (dependent) is the natural logarithm of the total amount of waste produced in the current year. *BIG4* (independent) is a dummy variable that takes a value of 1 if a company was audited by one of the Big 4 auditing firms,

and 0 otherwise. The detailed definition of all the variables and data sources is shown in the 'Appendix'. *, **, and, *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table 8
Internal and external governance

VAR	Corporate Governance		Institutional Ownership	
	(1)	(2)	(3)	(4)
	GOV < mean	*GOV* > mean	*INS_OWN* < 5%	*INS_OWN* > 5%
BIG4	−0.183	−0.529***	−0.375**	−0.299
	(−1.12)	(−3.07)	(−2.53)	(−1.46)
SIZE	0.854***	0.730***	0.801***	0.798***
	(26.78)	(27.46)	(29.12)	(26.03)
ROA	−0.011**	−0.035***	−0.022***	−0.024***
	(−2.09)	(−8.00)	(−4.57)	(−5.25)
LEV	−0.239	−1.052***	−0.410	−0.658**
	(−0.82)	(−4.21)	(−1.50)	(−2.47)
VOL	−0.008	0.039***	0.020***	0.017***
	(−1.16)	(6.36)	(2.93)	(2.71)
DIV	0.410***	0.239**	0.354***	0.309***
	(3.66)	(2.31)	(3.08)	(3.12)
TANG	2.956***	4.110***	3.458***	4.067***
	(14.10)	(24.39)	(18.83)	(21.51)
Constant	−2.151**	−1.691**	−2.379***	−2.682***
	(−1.98)	(−2.14)	(−2.78)	(−2.72)
Observations	3311	4789	4426	3625
Fixed Effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.404	0.452	0.428	0.442
F−stat	37.13	64.67	54.45	49.62

Note: This table presents the relationship between *T_WASTE* and *BIG4 with corporate governance and institutional ownership levels*. *T_WASTE* (dependent) is the natural logarithm of the total amount of waste produced in the current year. *BIG4* (independent) is a dummy variable that takes a value of 1 if a company was audited by one of the Big 4 auditing firms, and 0 otherwise. The detailed definition of all the variables and data sources is shown in the 'Appendix'. *, **, and, *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

Table 9
Sub-sample analysis of CSR committee, and industry nature

VAR	CSR Committee		Industry Type	
	(1)	(2)	(3)	(4)
	CSR_COM = 1	*CSR_COM* = 0	Natural Industries	Rest of Industries
BIG4	−0.597***	0.451	2.160	−0.382***
	(−5.22)	(1.40)	(1.00)	(−3.59)
SIZE	0.827***	0.664***	0.672***	0.821***
	(38.66)	(15.32)	(4.33)	(44.35)
ROA	−0.025***	−0.021***	0.003	−0.026***
	(−6.87)	(−3.14)	(0.20)	(−8.02)
LEV	−0.443**	−0.471	1.057	−0.157
	(−2.25)	(−1.12)	(0.71)	(−0.89)
VOL	0.017***	0.021**	0.034	0.018***
	(3.61)	(2.13)	(1.44)	(4.08)
DIV	0.460***	−0.043	−0.651*	0.574***
	(5.75)	(−0.27)	(−1.71)	(7.94)
TANG	3.722***	3.077***	3.454***	3.102***
	(25.43)	(11.62)	(3.31)	(25.46)
Constant	−3.051***	−0.850	3.192	−2.267***
	(−3.95)	(−0.71)	(0.78)	(−3.90)
Observations	5331	2769	401	7699
Fixed Effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.441	0.372	0.158	0.403
F-stat	68.75	28.34	3.429	84.78

Note: This table presents the relationship between *T_WASTE* and *BIG4 with CSR committee and industry type*. *T_WASTE* (dependent) is the natural logarithm of the total amount of waste produced in the current year. *BIG4* (independent) is a dummy variable that takes a value of 1 if a company was audited by one of the Big 4 auditing firms, and 0 otherwise. The detailed definition of all the variables and data sources is shown in the 'Appendix'. *, **, and, *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

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