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Research article

Microplastics in aquatic bodies: Assessing the role of governance mechanisms in industrial wastewater management

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ABSTRACT

The purpose of this research is to examine the association between corporate governance mechanisms (board independence, board gender diversity, Chief Executive Officer (CEO) duality, and environmental, social and governance (ESG) linked compensation) and wastewater recycling as a strategy for managing the flow of microplastics into the aquatic environment. The study analysed an international sample of top companies on the Forbes 500 list over a 15-year period during the millennium development goals (MDGs) and sustainable development goals (SDGs) eras. Multiple regression analysis with fixed effect OLS, two-stage least squares regression, propensity score matching, and logistic regression were applied in the data analysis. The results show that, at the aggregate level, board gender diversity is positively associated with wastewater recycling, whilst CEO duality has a significant negative impact. When disaggregated into industries, board gender diversity is positively associated with wastewater recycling in high-polluting and low-polluting industries. In relation to the MDGs/SDGs eras, the impact of board gender diversity is more significant in the MDGs era than in the SDGs era. At the geographical region level, CEO duality has a significant negative impact on wastewater management in the America and Asia Pacific regions, whilst the effect of CEO duality is significantly positive in the Western Europe region. We also find that a minimum of two female directors is required to improve wastewater management practice. The study concludes that whilst board gender diversity is a notable driver of wastewater management, CEO duality diminishes the commitment of multinational entities (MNEs) to addressing wastewater management issues. Our result is robust to (i) alternative measures of wastewater management, (ii) alternate sample composition, (iii) alternate method of data analysis, and (iv) endogeneity checks. The study contributes to the limited literature on waste management and the circular economy, particularly governance mechanisms' role in wastewater management in an international context.

1. Introduction

Human activities continue to be a major source of ecosystem disruption, including water bodies' contamination. Water—an important natural resource that sustains life in terrestrial domains and aquatic habitats—is predicted to be in short supply in the foreseeable future (Committee on Climate Change, 2022; Fowler, 2023). The Global Commission on the Economics of Water (2023) forecasts that freshwater supply will fall short of demand by 40% before 2030. Some countries are now facing periods of drought due to acute water shortages. The Committee on Climate Change (2022) envisages that, by 2050, the demand for water in England will exceed supply by between 1.1 and 3.1 billion litres a day. The Centre for Research on the Epidemiology of Disasters, CRED (2022) reports that, in the year 2021, 15 drought events occurred, causing complex emergencies such as food shortage, economic crises, and human/livestock/crop diseases, with countries in Africa (Ethiopia, South Africa, Kenya, and Somalia) and Asia (Iran, Iraq, Syria, and Afghanistan) being the most impacted in terms of the number of people affected. The USA encountered persistent drought events in 2021, resulting in total economic costs of about US$ 9 billion (CRED, 2022). It is estimated that approximately 1,000,000 people die yearly from water-related diseases, with a lack of safe water supply causing more devastating effects in the world's most impoverished countries (World Health Organisation, WHO, 2022). According to the Global Commission on the Economics of Water (2023, p.9), "One child under five dies every 80 s from diseases caused by polluted water".

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In light of these developments, addressing water pollution and water scarcity have been of great concern to stakeholders in recent times (Saleh, 2021; Khan et al., 2022). Not surprisingly, water management issues feature prominently in the United Nations (UN) agenda for sustainable development 2030, especially sustainable development goal (SDG) 6 (clean water and sanitation) and SDG 14 (life below water). Targets for SDG 6 include (United Nations, 2016): (i) achieving universal and equitable access to safe and affordable drinking water for all; (ii) improving water quality by reducing pollution, eliminating dumping of toxic substance in water, and minimising release of hazardous chemicals and materials; (iii) halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally; and (iv) increasing water-use efficiency across all sectors and ensuring sustainable withdrawals and supply of freshwater to address water scarcity. Similarly, some of the targets for SDG 14 are (United Nations, 2016): (i) preventing and significantly reducing marine pollution of all kinds, particularly from land-based activities; (ii) sustainably managing and protecting marine and coastal ecosystems to avoid significant adverse impacts; and (iii) minimising and addressing the impacts of ocean acidification.

Wastewater recycling is a strategy that can simultaneously achieve SDG 6 and SDG 14 targets. This stems from the argument that wastewater recycling prevents the flow of toxic materials (including microplastics) into waterbodies, whilst also ensuring that waste usage is optimised, and wastage minimised (Greenwood, 2022; Thi-Minh-Tam LeTruong et al., 2023). Microplastics are a major source of water pollution because they endanger aquatic life and threaten the supply of clean water to sustain life below and above sea levels (Singh et al., 2023). They (microplastics) are extremely small pieces of plastic wastes in the environment arising from the breakdown of larger plastics, disposal of industrial wastes, and littering of consumer products (Priya et al., 2023). Microplastics pollutants could be harmful to aquatic animal health and the wider environment (Feng et al., 2023). A major source of microplastic emission is industrial waste (Altunışık, 2023), and organisations operating in primary and secondary industries are high offenders responsible for discharging enormous quantities of raw sewage, as well as microplastics, into aquatic bodies. Whilst wastewater recycling represents a major strategy for tackling water pollution challenge (Saleh, 2021), companies typically dodge their environmental responsibility of wastewater recycling. They excuse this action on constraints surrounding the acquisition of wastewater treatment plants because resource availability affects environmental innovation investments (Iqbal et al., 2022). To stem the tide in water scarcity, nations' governments are now enacting more legislation to promote the responsible use of water, including water reclamation/wastewater recycling (Greenwood, 2022).

Wastewater management is an important action plan for capturing microplastics before they are released into water bodies (Cesa et al., 2017; Poerio et al., 2019). Investment in efficient technologies that allow water recycle and wastewater reuse is, arguably, the best strategy to keep contaminated water out of the aquatic environment (Thi--Minh-Tam LeTruong et al., 2023). Although conventional wastewater treatment plants are not designed to completely remove microplastics from wastewaters in industrial settings (Cesa et al., 2017), technologies and techniques are now available that can typically remove 98% of microplastics from effluents in industrial processes (Poerio et al., 2019). Thus, wastewater treatment and recycling are effective strategies for addressing the growing concern of microplastics in aquatic bodies (Preisner and Smol, 2022; Thi-Minh-Tam LeTruong et al., 2023). Aside from the reluctance of corporate entities to invest in wastewater management initiatives, lapses in policy and lax regulation are also contributory to the abundance of microplastics in the environment (Priya et al., 2023). Considering that investment in wastewater treatment as an environmental management strategy is voluntary in many parts of the world (Khan et al., 2022), corporate governance is a major mechanism for policy formulation and strategic direction on environmental management issues (Tingbani et al., 2020; Konadu et al., 2021; Javed et al., 2023; Oyewo, 2023). Noting that lapses in organisational policy has contributed to the abundance of microplastics in the environment (Priya et al., 2023), concerned stakeholders have started questioning the attempts that multinational entities (MNEs) as major emitters of industrial wastes are making to address wastewater management through the oversight function domiciled in corporate governance. A growing number of studies have, therefore, linked corporate governance to waste management (e.g., Shahab et al., 2022; Gull et al., 2023). However, despite the widely acknowledged importance of governance mechanisms in waste management, the review of related literature on the subject reveals some gaps in relation to the association between governance mechanisms and wastewater management which the current study seeks to address.

First, there are limited studies on the role of governance structure on wastewater management, as most studies have examined waste recycling at the household and country levels (e.g., Ferrara and Missios, 2012; Aldieri et al., 2021; Wang et al., 2020). Corporate governance is a major mechanism for self-regulation in organisations—therefore, corporate governance mechanisms have been linked to waste management and environmental innovation (e.g., Shahab et al., 2022; Javed et al., 2023). However, there is a dearth of research on the role of governance in wastewater management. Second, most studies on the relevance of corporate governance mechanisms in environmental management have either focused on general environmental sustainability issues/corporate environmental performance, carbon emissions management, or waste management/waste recycle but not on wastewater management/wastewater recycle (e.g., Tingbani et al., 2020; Konadu et al., 2021). As wastewater is a form of environment waste distinct from solid waste, it is important to examine the association between governance mechanisms and commitment to wastewater management.

Third, studies on environmental pollution/waste management are limited in their scope of coverage in terms of jurisdiction, timeframe covered, and industries, as most studies have predominantly been either (a) conducted in a single-country/limited geographical region setting; (b) focus on short-to medium-timeframes, and (c) cover a specific/limited number of industries (e.g., Elsayih et al., 2021; Nuber and Velte, 2021). These features characterising prior studies limit the generalisability of results (Zaman et al., 2020). An international approach is required to document more comprehensive results of the efficacy of corporate governance mechanisms in tackling waste management issues. Considering that waterways intermingle across geographic regions, addressing water pollution through microplastic management requires a holistic approach because joints efforts and collaborations are required to minimise the flow of dirty/contaminated water from one part of the world to another in the aquatic ecosystem. The consideration that water covers most parts of the earth makes it compelling to address wastewater pollution in an integrated manner. Thus, an international study will provide a more comprehensive view on the impact of governance structures on wastewater management.

Fourth, in light of Agenda 2030 and the SDGs on water management (i.e., SDG 6 on clean water, and SDG 14 on life below water) little is known, based on empirical evidence, on how MNEs are tackling the water management crisis through wastewater recycling and reuse. Meanwhile, MNEs are major contributors to the emissions of effluents such as microplastics in industrial settings. Considering that microplastic is a major industrial output that pollutes wastewater and endangers aquatic life, MNEs have a greater environmental burden and more ethical responsibilities to address the issue of microplastics in the aquatic environment (Carroll, 1991). By so doing, they will be contributing to the achievement of the agenda for sustainable development set to expire by 2030 (Vasiljeva et al., 2023). However, there is limited knowledge on the commitment of MNEs in addressing the dangers of microplastics in waterways in the SDGs era in comparison to the MDGs (millennium development goals) era. Prior studies taking a longitudinal approach to examining the subject did not investigate how

corporate governance affects waste management between the MDGs and SDGs eras, respectively (e.g., Shahab et al., 2022; Gull et al., 2023). Meanwhile, knowledge on the measures that MNEs are taking as key partners in the sustainability discourse with respect to addressing water pollution and protecting life below water in the SDGs era in comparison to the MDGs era is crucial in assessing global readiness for the achievement of the SDGs.

Against this backdrop, the purpose of the current study is to investigate the association between corporate governance mechanisms and wastewater recycling as a strategy for addressing microplastics in the aquatic environment. The research gaps are addressed as follows. The first research gap with respect to limited studies on the role of governance structure on wastewater management is addressed by focusing on four corporate governance mechanisms that have been documented as determinants of environmental sustainability performance; notably, board independence, board gender diversity, Chief Executive Officer (CEO) duality, and environmental, social and governance (ESG) linked compensation (Shahab et al., 2022; Gull et al., 2023). The second research gap is addressed by examining wastewater recycling as a strategy for addressing wastes and microplastics flowing into waterways. The role of governance mechanisms in wastewater management is, thus, covered by the current study. The third research gap regarding limitation in scope of coverage in terms of jurisdiction, time frame, and industries is addressed by conducting the current study in an international setting, using a sample of 115 MNEs from 41 industries, 32 countries and 5 geographical regions, covering a 15-year timeframe (2006–2020). Results are disaggregated into industries and geographical regions for the purpose of performing a more detailed analysis and gaining deeper insights into the corporate governance determinants of wastewater recycling initiatives based on industry environmental sensitivity and jurisdictions. Finally, the fourth research gap is addressed by comparing the impact of governance mechanisms on wastewater management in the MDGs era (2006–2015) and the SDGs era (2016–2020) with a view towards assessing how governance apparatus impacts wastewater recycling differently in both eras.

The study analysed a sample of MNEs on the Forbes 500 list. The result shows that, at the aggregate level, board gender diversity is positively and significantly associated with wastewater recycling, whilst CEO duality has a significant negative impact. However, the impact of board independence and ESG-linked compensation is not statistically significant. When disaggregated into industries based on intensity of environmental pollution, board gender diversity is positively associated with wastewater recycling in both high-polluting and low-polluting industries, with greater impact on wastewater management in low-polluting industries. Whereas CEO duality has a significant negative impact in high-polluting industries, board independence and ESG-linked compensation have no significant impact on wastewater recycling in both industries. In relation to the MDGs/SDGs eras, board gender diversity has a significant positive impact on wastewater recycling in both the MDGs and SDGs era, whilst the influence of board independence, CEO duality, and ESG-linked compensation is not significant. However, the impact of board gender diversity is greater in the MDGs era in comparison to the SDGs era. At the geographical region level, CEO duality has a significant negative impact on wastewater management in the America region and the Asia Pacific region, whilst the impact is significantly positive in the Western Europe region. Whereas board independence has no significant impact on wastewater management in the America and Asia Pacific regions, the impact is positive in the Western Europe region. In all the three regions, board gender diversity evinces a positive but statistically insignificant impact on wastewater management. We also find that a minimum of two female directors is required to improve the wastewater management practice of MNEs. Our results are robust to (i) alternative measures of wastewater management, (ii) alternate sample composition, (iii) alternate method of data analysis, and (iv) endogeneity checks.

The study contributes to knowledge in five ways. First, it contributes to the limited literature on waste management and the circular economy, and particularly the role of governance mechanisms in wastewater management. Second, the study reveals the governance structures affecting wastewater management in an international context, thus closing some gaps in knowledge as to the impact of corporate governance on wastewater management rather than general environmental performance or carbon emissions performance. Third, the study contributes to the applicability/relevance of the stakeholder theory and the legitimacy theory by providing empirical evidence that wastewater management could be an effective strategy for gaining stakeholders' acceptance and entrenching corporate legitimacy. Fourth, the study presents empirical evidence on the progress that MNEs are making towards actualising the agenda for sustainable development 2030 in terms of the mechanisms they are putting in place to address environmental pollution from wastewater discharge. Finally, the study makes methodological contribution to the literature by using innovative statistical techniques to analyse data, such as two-stage least squares (2 S LS) regression and propensity score matching (PSM). As argued in the literature, there are limited studies on the governance–environmental sustainability nexus that have applied sophisticated techniques to provide a more nuanced analysis of the association, as well as addressed endogeneity concerns. The current study deploys sophisticated statistical techniques to ensure a well validated conclusion on the association between corporate governance and wastewater recycling.

The rest of the paper is organised as follows; the literature review and hypotheses development are covered in section 2. The methodology is explained in section 3, followed by the results in section 4, a robustness check in section 5, and a discussion of the findings in section 6. The paper is concluded in section 7.

2. Literature review and hypotheses development

2.1. Wastewater management as a strategy for curtailing flow of microplastics into aquatic bodies

One of the major ways that microplastics encroach into waterbodies is through wastewater flowing into the aquatic habitat (Priya et al., 2023). Improper waste management contributes to the abundance of microplastics in the environment. Therefore, an effective strategy for regulating the flow of microplastics into aquatic bodies is the treatment of wastewater through recycling strategies (Thi-Minh-Tam LeTruong et al., 2023). Water recycling involves the process of treating water or wastewater that would otherwise have been allowed to waste or would have been disposed of by using machines and chemicals to treat water for reuse in domestic or industrial cycles (Saleh, 2020; Preisner and Smol, 2022).

Wastewater recycle initiatives have been gaining traction in recent times because of the importance associated with water reclamation, such as helping to address water shortage, minimising environmental pollution arising from release of wastewater into the ecosystem, and the financial savings from reusing water that would have otherwise been allowed down the drain (Greenwood, 2022). Wastewater recycling also has financial gains such as reducing the amount paid for incoming water, reducing the expenditure on the disposal of wastewater, and reducing the cost of environmental clean-up because of water effluents spilled into the environment (Greenwood, 2022). Although people, organisations, society, and government all have a role to play in addressing water recycle issues, organisations are more culpable and have heavier environmental responsibility to recycle wastewater going by the quantum of water that they use in their operations and the corresponding volume of wastewater that they discharge into the environment (Altunışık, 2023).

Considering the environmental and financial benefits of wastewater recycling, there has been increasing interest in strategies for wastewater management and investment in wastewater treatment (Saleh, 2020; Singh et al., 2023). There are generally four stages of wastewater

treatment before water is fit for recycling—namely, the primary treatment, secondary treatment, tertiary treatment, and sludge treatment (Greenwood, 2022; Singh et al., 2023). These processes present opportunities to organisations to control the flow of microplastics into the aquatic environment. The primary treatment involves separation of suspended solids from wastewater, with about 70%–90% of materials (including microplastics) removed through flocculation, coagulation, settling, and flotation processes (Saleh, 2021; Greenwood, 2022). This is a critical stage of wastewater management that removes microplastics from wastewaters emitted by industrial process. The secondary treatment stage involves advanced biological treatment methods whereby chemicals are introduced to treat the water (Preisner and Smol, 2022). The tertiary treatment stage requires removing dissolved solids from purified water and disinfected wastewater. At the sludge treatment stage, materials removed during the treatment process can be used for commercial purposes (Greenwood, 2022; Thi-Minh-Tam LeTruong et al., 2023). This stage of wastewater treatment provides opportunity for organisations to responsibly dispose of microplastics, thereby avoiding the dumping of microplastics into water bodies. Mechanisms of microplastic transport and degradation can also be deployed at the sludge treatment stage to curtail the flow of microplastics into the marine environment (Kuok Ho, 2022). The primary treatment stage is more relevant to the segregation of microplastic from wastewater (Preisner and Smol, 2022; Thi-Minh-Tam LeTruong et al., 2023).

In sum, microplastics can be kept out of the aquatic environment by reducing wastewater flowing into water bodies, as well as re-using wastewater in both domestic and industrial settings. However, considering that industries release a large quantum of wastewater, organisations bear a greater environmental burden to treat and re-use wastewater. Investment in wastewater management technology can ensure that water wastes such as microplastics/microplastic wastes are responsibly disposed to minimise environmental pollution (Kuok Ho, 2022; Thi-Minh-Tam LeTruong et al., 2023). Wastewater recycling will, thus, be an effective strategy for regulating the flow of microplastic into water bodies. Wastewater management will imply that sediments, including microplastics, are segregated from the wastewater, and then such waters can be treated to be reused and re-absorbed into the water system for industrial use (Preisner and Smol, 2022; Feng et al., 2023). However, considering the capital-intensive nature of wastewater management projects and the long timeframe required for such investments to pay off, organisations that will invest in wastewater recycling initiatives will have to be deliberate about environmental innovation expenditure.

2.2. Theoretical framework underpinning the role of corporate governance in wastewater management

(a) Stakeholder theory

The stakeholder theory recognises that the activities of an organisation affect not only the owners/shareholders, but various parties that are directly or indirectly connected to the entity (Freeman, 1984; Lee and Raschke, 2023). When management is taking decisions, it should consider the far-reaching implications of such decisions on various stakeholders (Doni et al., 2021). Meanwhile, ESG issues are particularly pertinent to stakeholders (rather than shareholders) because elements of the ESG framework (i.e., environmental sustainability, social sustainability, and governance) de-emphasise economic benefits/financial performance which are typically of interest to owners/shareholders (Acabado et al., 2019; Fafaliou et al., 2022; Vasiljeva et al., 2023). In contextualising the stakeholder theory to the current study, corporate governance mechanisms such as appointment of independent directors to both expand the board size and strengthen board independence, holding regular board meetings to discuss environmental sustainability issues, and improving board diversity (in terms of gender, nationality. And cross directorship experience) are effective strategies for protecting the interests of stakeholders on sustainability issues (Zalata and Roberts, 2016; Lanis and Richardson, 2018).

(b) Legitimacy theory

The legitimacy theory posits that organisations strive to continue to function within the defined boundaries set by society so that their activities and operations are viewed as being "legitimate" (Archel et al., 2009; Deegan, 2019). Considering that wastewater management and microplastics in aquatic environment are of greater concerns to the society in recent times (Committee on Climate Change, 2022; Fowler, 2023), organisations would want to make sure that environmental pollution emanating from their wastewater emissions is deliberately addressed in the interest of the society. The launching of the SDGs targets covering clean water and sanitation (SDG 6) and life below water (SDG 14) behoves corporate entities to take responsibility to address the dangers created by microplastics in the aquatic environment as required by the implied social contract between organisations and the society. MNEs can demonstrate commitment to environmental sustainability as a strategy to preserve corporate legitimacy by satisfactorily addressing issues informing the formulation of SDG 6 and SDG 14 targets (Vasiljeva et al., 2023). These include equitable access to safe and affordable drinking water, improving water quality by reducing pollution, eliminating dumping, and minimising the release of hazardous chemicals and materials, substantially increasing recycling and safe reuse globally, preventing and significantly reducing marine pollution of all kinds, and sustainably managing and protecting marine and coastal ecosystems to avoid significant adverse impacts (United Nations, 2016). The need to preserve corporate legitimacy will motivate MNEs to emplace corporate governance mechanisms that uplift environmental performance such as the appointment of independent directors, the nomination of more female directors, the separation of the CEO functions from those of the Chairperson, and compensating executive directors based on environmental performance to achieve better wastewater management outcomes. In addition, these measures will be put in place to boost stakeholders' confidence and to demonstrate organisational commitment to sustainable development issues affecting the society, thereby gaining stakeholders' acceptance as a legitimising strategy (García-Sánchez et al., 2019).

2.3. Hypotheses development

(a) Board Independence

A board is typically constituted in such a manner that there is an adequate mix of executive and non-executive directors (Correa-Garcia et al., 2020). Whilst executive directors are employees of the company and are responsible for the daily operations of the organisation for their respective directorates/business units, non-executive/independent directors who are not employees of a company are expected to be more impartial and objective in decision making (Nicolò et al., 2022). Further, non-executive/independent directors use their skills and experience to support the executive directors and the organisation in general in achieving the best outcomes. Having a reasonable number of both executive and non-executive/independent directors may affect the environmental performance of an organisation, because an organisation can leverage on the skills mix and competencies of its board members as strategic assets in making the best decisions in the interests of its stakeholders, including decisions on wastewater management (Zalata and Roberts, 2016).

The stakeholder theory supports the argument that credible persons should be appointed to the board to oversee the activities of an organisation. How well the oversight function of governance is performed may be dependent on the number of independent board members, as it is expected that having a reasonable number of persons on the board should help an organisation to address environmental sustainability

issues (Lanis and Richardson, 2018). Having a higher number of independent board members has been associated with improved board performance (Agyemang et al., 2020; Correa-Garcia et al., 2020; Doni et al., 2021). Following on from the stakeholder theory, non-executive/independent directors are expected to checkmate the opportunistic tendencies of executive directors such as dodging environmental protection responsibilities/ environmental exploitation to the detriment of stakeholders (Zalata and Roberts, 2016). Studies have shown that board independence is positively associated with environmental performance (Disli et al., 2022; Shahab et al., 2022). This discussion informs the hypothesis that.

H1. Board independence is positively associated with wastewater recycling rate.

(b) Board gender diversity

Having a mix of male and female board members may influence the achievement of environmental sustainability outcomes (Cabeza-García et al., 2018; Nicolò et al., 2022). Arguments surrounding more stakeholder representation in line with stakeholder theory will support recruiting more female board members to ensure gender diversity on the board of directors (Nuber and Velte, 2021), as literature suggests that female directors are more eco-friendly (Gull et al., 2023; Javed et al., 2023). When there are more female board members, they can be more assertive in board meetings on measures that can improve environmental performance, such as wastewater recycling (Konadu et al., 2021). To ensure that the interests of stakeholders are protected, companies may deliberately recruit more female directors to achieve board gender diversity targets as a strategy for improving environmental performance and satisfying the demands of stakeholders (Shu and Chiang, 2020). Studies have shown that board gender diversity enhances environmental performance (Konadu et al., 2021; Gull et al., 2023; Javed et al., 2023). Therefore.

H2. Board gender diversity is positively associated with wastewater recycling rate.

(c) CEO duality

When the responsibilities of the Chairperson and the CEO are merged/combined in one person, this gives rise to CEO duality and may cause a conflict of interest, abuse of power, and moral hazard (Agyemang et al., 2020; Nuskiya et al., 2021). With respect to the wastewater management discourse, whilst the CEO may want to downplay serious environmental and social sustainability issues to minimise cost, maximise profit, and declare higher dividends/returns for shareholders, the Chairperson may be more concerned about the reputational damage that could be inflicted on the company owing to negligence in resolving environmental and social sustainability issues. The stakeholder theory supports that there should be checks and balances in place by having a separation of power between the Chairperson and the CEO, as such a structure may boost the quality of decision making, including decisions on waste management. Empirical evidence abounds that CEO duality erodes environmental performance (e.g., Agyemang et al., 2020; Harun et al., 2020; Lu and Wang, 2021; Nuskiya et al., 2021). This informs the hypothesis that.

H3. CEO duality is negatively associated with wastewater recycling rate.

(d) ESG-linked compensation

Performance-related pay has been shown to positively affect work engagement (Dale-Olsen, 2012; Kulikowski, 2018), and this reasoning underpins the increasing practice of linking directors' remuneration to environmental performance. Designing executive payments to align with meeting environmental targets is expected to motivate management to take decisions that are eco-friendly, thus contributing to environmental sustainability (Malik and Shim, 2022). However, such environmental targets should be sufficiently challenging as to ensure that achieving the targets will ultimately enhance the environmental performance of the organisation. ESG-linked compensation as a governance mechanism is burgeoning, as the practice of tying executive compensation to environmental performance is still uncommon among companies (Oyewo, 2023). However, linking executive compensation to environmental performance is becoming increasingly popular among US companies (Spierings, 2022). In 2021, about 19% of companies listed on the S&P 500 linked executive compensation to meeting sustainability targets (Spierings, 2022). In the previous year in 2020, about 10% of the companies paid executives based on meeting carbon emissions reduction targets.

Compensating executives based on environmental performance is a strategy for preserving corporate legitimacy as suggested by the legitimacy theory, because organisations want to be perceived as responsible corporate citizens (Moats et al., 2022). Ordinarily, executive directors may want to make decisions that maximise returns to owners/shareholders with little or no consideration for the impact of such decisions on the society and environment as typical of shareholderism (Adams et al., 2011). However, ESG-linked compensation can curtail this tendency since such a payment scheme may compel company executives to take decisions that benefit the society/minimise environmental pollution. The legitimacy theory underpins the motivation of companies in linking executive compensation to environmental performance such as minimising wastewater emissions into water bodies. Although there is limited literature on the impact of ESG-linked compensation on environmental performance, some studies have shown a positive association (e.g., Okafor and Ujah, 2020; Lu and Wang, 2021). The current study, thus, argues that environmental performance-based pay can improve the commitment of executive directors to taking eco-friendly decisions such as supporting wastewater recycling projects. This discussion informs the next hypothesis that.

H4. ESG-linked compensation is positively associated with wastewater recycling rate.

3. Methodology

3.1. Research design

The study adopts a quantitative research design, using panel data analysis covering a 15-year period (2006–2020). The use of a panel data set allows researcher(s) to overcome the limitations of cross-sectional (several companies in a period) and time-series analysis (one company for several periods). Panel data models provide greater consistency and explanatory power by considering several time periods (Jamil et al., 2021). The study focuses on top global companies/MNEs because of their visibility and universal impact (Ngu and Amran, 2019). The Forbes 500 companies list was used as the sampling frame. The financial service firms (160) were excluded because of the nature of their business and the way their financial results are presented (Tingbani et al., 2020), leaving a final sample of 340 non-financial firms. However, 4 firms have no ESG data on the Refinitiv database, thus diminishing the final sample to 336 firms. After expunging 221 firms with no data on wastewater recycling in the DataStream/Refinitiv databases, the final sample comprises 115 firms from 41 industries, 32 countries, and 5 geographical regions, covering a 15-year period (2006–2020) and resulting in 878 firm-year observations. The exclusion of financial service firms enables the generalisability of results to non-financial firms, thereby enhancing external validity of results (Davila, 2000; Ittner et al., 2003). Furthermore, the focus on Forbes 500 companies is important in exposing efforts top global companies are making to achieve environmental SDGs with reference to SDG 17 (partnerships for the goals).

3.2. Measurement of variables

3.2.1. Dependent variable

Wastewater management was operationalised using the amount of industrial water recycled or reused, measured in cubic metres (Babou-kardos, 2017; Konadu et al., 2021). Recycled or reused water refers to water being sourced internally by recycling or reusing, thereby avoiding further withdrawals. Water not used again by the company does not qualify as recycled water since countries/companies are required by regulations or environmental standards to treat wastewater before discharging it into the environment. To normalise the distribution, the natural logarithm was applied in the regression analysis in line with prior studies (e.g., Shahab et al., 2022; Gull et al., 2023). The variable (wastewater recycled) has a positive polarity, meaning that a higher value indicates better/more efficient wastewater management.

3.2.2. Independent variables

The study focuses on four corporate governance mechanisms that have been well documented as determinants of commitment to environmental sustainability—notably, board independence, board gender diversity, CEO duality, and ESG-linked compensation (Konadu et al., 2021; Shahab et al., 2022; Gull et al., 2023). They were measured using proxies applied in existing studies as shown in Table 1.

3.2.3. Control variables

A number of other governance-related variables (board meeting, board size, cross directorship, board nationality diversity, ESG audit, and ESG committee), firm-level control variables (firm size, market capitalisation, gearing, liquidity, and firm profitability), and country-level control variables (level of economic development and world governance indicators) that may affect environmental performance were included in the study as control variables (Acabado et al., 2019; Harun et al., 2020; Lu and Wang, 2021; Disli et al., 2022). The MDGs/SDGs eras as a dichotomous variable was also included as a control variable based on the argument that the agenda for sustainable development may influence corporate environmental practice (Oyewo, 2023; Vasiljeva et al., 2023). The summary of the variable measurements is furnished in Table 1.

3.3. Model specification

The panel data regression model is specified in equation (1) as follows:

$$WRC_{i,t} = \alpha_0 + BX_{i,t} + BZ_{i,t} + e_{i,t} \quad (1)$$

i = 1, ….,N, t = 1 ….., T

Where WRC represents wastewater recycle rate of firm *i,* at time *t. X* represents vector of independent variables (board independence, board gender diversity, CEO duality, and ESG-linked compensation), while *Z* is a vector for control variables such as firm-level governance factors, firm attributes, MDGs/SDGs eras, and country-level governance factors influencing wastewater recycling. $e_{i,t}$ represents the stochastic error term. All other variables are defined and measured in Table 1.

3.4. Data analysis techniques

Descriptive statistics, multiple regression analysis with fixed effect OLS, two-stage least squares regression (2 S LS)/instrumental variable (IV) regression, propensity score matching (PSM), and binary logistic regression were applied in the data analysis.

4. Results

4.1. Descriptive analysis and multicollinearity test

Descriptive statistics in Table 2 shows that firms operating in low environment-polluting and high environment-polluting industries significantly differ in terms of volume of wastewater recycled, and have different governance structures with respect to board independence, board diversity, CEO duality, and other governance-related mechanisms. They are also dissimilar in firm attributes such as market capitalisation, gearing, liquidity, and profitability levels. The analysis in Table 3 reveals significant differences in governance structure and firm attributes between the MDGs and SDGs eras. The result also shows that commitment to wastewater management, robustness of governance mechanisms, and firm attributes differ by geographical regions (Table 4). Taken together, the heterogeneity among the MNEs in terms of industry environmental pollution sensitivity (Table 2), the MDGs/SDGs eras (Table 3), and geographical regions (Table 4) provides a rich context for examining governance mechanisms affecting wastewater management by top-ranking MNEs.

The correlation matrix in Table 5 shows that none of the correlation coefficients amongst the independent variables is up to 0.80, implying that multicollinearity is not a serious concern as the correlation coefficients are generally low among the variables (Tingbani et al., 2020;

Table 1
Measurement of variables.

	Variable	Measurement and supporting literature
1	Wastewater Management	Proxy 1: Wastewater recycle rate (main measurement) measured as log of wastewater recycled (Shahab et al., 2022; Oyewo, 2023); has a positive polarity, meaning that a higher value indicates better/more efficient wastewater management. Proxy 2: Wastewater recycle intensity (alternative measurement), computed as the ratio of wastewater recycled to total revenue (Elsayih et al., 2021; Nuber and Velte, 2021); has positive polarity.
2	Board Independence	Proportion of Non-executive Directors (NEDs) to total board size (Elsayih et al., 2021)
3	Board Gender Diversity	Proportion of female directors to total board size (Tingbani et al., 2020).
4	CEO Duality	Chairperson as CEO = 1, else = 0 (Nuskiya et al., 2021).
5	ESG-linked Compensation	Linkage of executive pay to ESG performance = 1, else = 0 (Lu and Wang, 2021).
6	Board Meeting	Board meeting attendance rate in a year measured in % (Disli et al., 2022).
7	Board Size	Number of directors (Peel, 2018).
8	Cross Directorship	Average number of other corporate affiliations for directors (Ong and Djajadikerta, 2020).
9	Board Nationality Diversity	Number of nationalities on the board (Mathuva et al., 2019).
10	ESG Audit	ESG report is audited = 1, else = 0 (Giannarakis et al., 2018).
11	ESG Committee	If there is existence of ESG committee = 1, else = 0 (Doni et al., 2021).
12	Firm Size	Log of Revenue (Peel, 2018).
13	Market Capitalisation	Market capitalisation (log transformation) (Elsayih et al., 2021).
14	Gearing	Ratio of Total Debt to Total Assets (Martínez-Ferrero and García-Sánchez, 2017).
15	Liquidity	Ratio of current assets to current liabilities (Tingbani et al., 2020)
16	Firm Profitability	Return on Total Assets ratio (ROTA) (Doni et al., 2021).
17	MDGs/SDGs Eras	MDGs Era = 2006–2015; SDGs Era = 2016–2020.
18	Economic Development	Log of Gross Domestic Product (GDP) per capita, PPP (Nuber and Velte, 2021).
19	World Governance Indicators (Average of 6 items)	Average of WGI Measures provided by the World Bank on (i)Voice & Accountability; (ii) Political Stability and Lack of Violence; (iii) Government Effectiveness; (iv) Regulatory Quality; (v) Rule of Law; and (vi) Control of Corruption (WC) (Cuadrado-Ballesteros and Bisogno, 2020).

Table 2
Descriptive Analysis of Variables based on Industry Environmental Pollution Level.

Variable	Industry Type	N	Mean	Std. Deviation	F ratio
Water Recycled (cubic metres)	Low Polluting	96	1,231,941.470	1,909,451.030	8.820***
	High Polluting	782	485,950,569.500	1,598,303,731.530	
	Total	878	432,951,721.790	1,515,865,352.240	
Board Independence	Low Polluting	96	78.220%	14.960%	3.520*
	High Polluting	782	73.750%	22.720%	
	Total	878	74.240%	22.050%	
Board Gender Diversity	Low Polluting	96	20.050%	10.190%	17.590***
	High Polluting	782	14.360%	12.800%	
	Total	878	14.980%	12.660%	
CEO Duality	Low Polluting	96	0.630	0.480	17.550***
	High Polluting	782	0.400	0.490	
	Total	878	0.430	0.490	
ESG-linked Compensation	Low Polluting	96	0.340	0.470	0.150
	High Polluting	782	0.360	0.480	
	Total	878	0.360	0.480	
Board Meeting	Low Polluting	96	0.830	0.210	14.780***
	High Polluting	782	0.660	0.400	
	Total	878	0.680	0.390	
Board Size	Low Polluting	96	11.380	2.140	1.980
	High Polluting	782	11.910	3.620	
	Total	878	11.850	3.490	
Cross Directorship	Low Polluting	96	1.520	0.910	3.420*
	High Polluting	782	1.350	0.830	
	Total	878	1.370	0.840	
Board Nationality Diversity	Low Polluting	96	0.060	0.100	9.000***
	High Polluting	782	0.140	0.240	
	Total	878	0.130	0.230	
ESG Audit	Low Polluting	96	0.610	0.480	26.090***
	High Polluting	782	0.830	0.370	
	Total	878	0.810	0.390	
ESG Committee	Low Polluting	96	0.860	0.340	4.090**
	High Polluting	782	0.920	0.260	
	Total	878	0.920	0.275	
Firm Size (Revenue)	Low Polluting	96	53,527.340	40,434.810	0.039
	High Polluting	782	54,732.490	57,948.070	
	Total	878	54,600.720	56,281.870	
Market Capitalisation	Low Polluting	96	171,990.810	309,716.530	59.880***
	High Polluting	782	69,889.630	70,049.770	
	Total	878	81,155.960	125,999.970	
Total Debt Percentage of Total Assets (Gearing)	Low Polluting	96	19.540	14.800	16.560***
	High Polluting	782	25.080	12.290	
	Total	878	24.480	12.700	
Liquidity (Current Ratio)	Low Polluting	96	2.150	2.240	11.970***
	High Polluting	782	1.740	0.850	
	Total	878	1.780	1.090	
Profitability (ROTA)	Low Polluting	96	15.630	10.970	48.090***
	High Polluting	782	9.570	7.660	
	Total	878	10.230	8.300	
GDP 1: GDP per capita, PPP (current international $)	Low Polluting	96	40,654.510	21,462.900	1.090
	High Polluting	782	42,735.080	17,937.780	
	Total	878	42,507.590	18,353.870	
World Governance indicator average	Low Polluting	96	75.580	15.650	0.020
	High Polluting	782	75.310	17.630	
	Total	878	75.340	17.420	

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

Konadu et al., 2021).

4.2. Baseline result: governance mechanisms affecting wastewater management

The baseline result on the impact of governance mechanisms on wastewater management presented in Table 6 shows that board gender diversity is positively and significantly associated with wastewater recycling ($b = 0.378$, $p < 0.05$), whilst CEO duality has a significant negative impact ($b = -0.086$, $p < 0.05$). The impact of board independence ($b = -0.014$, $p > 0.10$) and ESG-linked compensation ($b = -0.009$, $p > 0.10$) is not statistically and economically significant. Based on this result, H2 and H3 are accepted, while H1 and H4 are rejected. With respect to the impact of the firm attributes on wastewater management, firm size has the greatest positive significant impact, suggesting that large-sized firms may have more resources to invest in wastewater management. Relatedly, the positive impact of firm liquidity on wastewater recycling supports the argument that the availability of liquid resources may affect the commitment of organisations to invest in wastewater treatment. Given that large-sized organisations have more economic resources to finance environmental sustainability projects, the positive impact of both firm size and firm liquidity establishes that resource availability is a key consideration influencing wastewater management.

Regarding the impact of other corporate governance variables on wastewater management, the result in Table 6 shows a weak relationship, connoting that the governance structure put in place by MNEs to address wastewater management is weak. In other words, there is little consideration given to wastewater management by MNEs in terms of their corporate governance structure. The MDGs/SDGs eras dichotomy

Table 3
Descriptive Analysis of Variables based on the MDGs and SDGs Eras.

Variable	Industry Type	N	Mean	Std. Deviation	F ratio
Water Recycled (cubic metres)	MDGs Era	495	378,025,297.710	1,396,572,604.040	1.490
	SDGs Era	383	503,940,181.100	1,656,562,402.180	
	Total	878	432,951,721.790	1,515,865,352.240	
Board Independence	MDGs Era	495	0.730	0.230	0.550***
	SDGs Era	383	0.740	0.200	
	Total	878	0.740	0.220	
Board Gender Diversity	MDGs Era	495	0.110	0.110	70.560***
	SDGs Era	383	0.180	0.130	
	Total	878	0.140	0.120	
CEO Duality	MDGs Era	495	0.420	0.490	0.220
	SDGs Era	383	0.440	0.490	
	Total	878	0.430	0.490	
ESG-linked Compensation	MDGs Era	495	0.420	0.490	15.640***
	SDGs Era	383	0.290	0.450	
	Total	878	0.360	0.480	
Board Meeting	MDGs Era	495	0.640	0.410	11.120***
	SDGs Era	383	0.730	0.360	
	Total	878	0.680	0.390	
Board Size	MDGs Era	495	12.070	3.660	4.440**
	SDGs Era	383	11.570	3.250	
	Total	878	11.850	3.490	
Cross Directorship	MDGs Era	495	1.240	0.830	28.350***
	SDGs Era	383	1.540	0.830	
	Total	878	1.370	0.840	
Board Nationality Diversity	MDGs Era	495	0.120	0.230	1.280
	SDGs Era	383	0.140	0.230	
	Total	878	0.130	0.230	
ESG Audit	MDGs Era	495	0.770	0.410	7.790***
	SDGs Era	383	0.850	0.350	
	Total	878	0.810	0.390	
ESG Committee	MDGs Era	495	0.890	0.310	9.550***
	SDGs Era	383	0.950	0.210	
	Total	878	0.920	0.270	
Firm Size (Revenue)	MDGs Era	495	56,347.910	63,065.470	1.090***
	SDGs Era	383	52,342.610	46,042.360	
	Total	878	54,600.720	56,281.870	
Market Capitalisation	MDGs Era	495	66,210.600	58,766.330	15.980***
	SDGs Era	383	100,337.810	176,676.380	
	Total	878	81,155.960	125,999.970	
Total Debt Percentage of Total Assets (Gearing)	MDGs Era	495	23.990	12.740	1.670
	SDGs Era	383	25.110	12.620	
	Total	878	24.480	12.700	
Liquidity (Current Ratio)	MDGs Era	495	1.820	1.080	1.120
	SDGs Era	383	1.740	1.110	
	Total	878	1.780	1.090	
Profitability (ROTA)	MDGs Era	495	10.590	8.360	2.040
	SDGs Era	383	9.780	8.210	
	Total	878	10.230	8.300	
GDP 1: GDP per capita, PPP (current international $)	MDGs Era	495	38,791.730	16,656.760	49.060***
	SDGs Era	383	47,310.080	19,327.890	
	Total	878	42,507.590	18,353.870	
World Governance indicator average	MDGs Era	495	75.290	18.220	.010
	SDGs Era	383	75.410	16.360	
	Total	878	75.340	17.420	

***$p < 0.01$, **$p < 0.05$.

Table 4
Descriptive statistics of variables for combined and geographical region analyses.

Variable	Overall/Combined	America Region	Asia Pacific Region	Western Europe Region
Water Recycled (cubic metres)	432,951,721.790	149,895,104.770	92,828,535.990	553,455,653.350
Board Independence	74.240%	85.420%	56.800%	83.630%
Board Gender Diversity	14.980%	22.090%	6.610%	21.110%
CEO Duality	0.430	0.640	0.450	0.140
ESG-linked Compensation	0.360	0.530	0.120	0.510
Board Meeting Attendance	68.500%	70.500%	57.670%	86.620%
Board Size	11.850	11.990	11.980	11.510
Cross Directorship	1.370	1.250	1.290	1.470
Board Nationality Diversity	13.360%	8.570%	4.340%	38.700%
ESG Audit	0.810	0.680	0.850	0.990
ESG Committee	0.920	0.930	0.940	0.980
Number of companies	115	47	40	20
N	878	315	323	180

Table 5
Correlation matrix and multicollinearity diagnostics.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Board Independence (1)	1																
Board Gender Diversity (2)	.494***	1															
CEO Duality (3)	.003	.045	1														
ESG-linked Compensation (4)	.388***	.297***	−.057	1													
Board Meeting (5)	.317***	.378***	−.025	.257***	1												
Board Size (6)	−.008	−.023	.111***	.025	−.119***	1											
Cross Directorship (7)	.147***	.015	−.117***	.009	.141***	−.018	1										
Board Nationality Diversity (8)	.259***	.258***	−.263***	.136***	.250***	−.138***	.143***	1									
ESG Audit (9)	−.030	−.010	−.195***	.063	.065	.011	.142***	.188***	1								
ESG Committee (10)	−.037	.150***	−.010	.052	−.002	.064	.063	.068**	.190***	1							
Firm Size (11)	.090***	−.065	−.062	.017	.081**	.058	.016	.142***	.164***	.026	1						
Market Capitalisation (12)	.268***	.242***	.070**	.093***	.184***	−.035	.087**	.130***	.031	.133***	.373***	1					
Gearing (13)	.095***	.085**	.059	.049	.041	.010	−.067**	.043	−.007	−.020	−.046	−.095***	1				
Liquidity (14)	−.053	.020	.161***	−.082**	−.125***	.089***	−.028	−.144***	−.112***	.057	−.279***	.135***	−.299***	1			
Profitability (15)	.109***	.075**	.016	−.042	.108***	−.115***	.181***	−.081**	−.064	.003	−.199***	.369***	−.262***	.364***	1		
GDP (16)	.172***	.398***	.065	.263***	.142***	−.034	−.186***	.157***	−.084**	.124***	.019	.051	.163***	−.019	−.214***	1	
World Governance indicator (17)	−.051	.323***	.087**	.136***	.224***	−.027	−.283***	.248***	−.013	.257***	−.050	−.006	.009	−.038	−.189***	.646***	1

***p < 0.01, **p < 0.05.

Table 6
Baseline result on the impact of governance mechanisms on wastewater management.

Variable	DV: Water Recycle Rate
Board Independence	−.014 (.108)
Board Gender Diversity	.378** (.182)
CEO Duality	−.086** (.041)
ESG-linked Compensation	−.009 (.031)
Governance Control	
Board Meeting	.039 (.042)
Board Size	.003 (.005)
Cross Directorship	−.024 (.021)
Board Nationality Diversity	−.025 (.106)
ESG Audit	.055 (.044)
ESG Committee	−8.690 (.048)
Firm Attributes	
Firm Size	.366*** (.112)
Market Capitalisation	.096 (.077)
Gearing	−.002 (.001)
Liquidity	.023* (.018)
Profitability (ROTA)	−.003 (.002)
Year (MDGs/SDGs)	−.011 (.034)
Country-level Control	
Economic Development	.748** (.351)
World Gov. Index (ave)	.008 (.005)
Year control	YES
Industry Control	YES
R^2	11.19%
N	878

Notes: This table reports the fixed effect regression result for the impact of governance mechanisms on wastewater management for the full sample. All variables are defined and measured in Table 1. Coefficients are stated, while standard errors are reported in brackets.
***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.

has no significant impact on wastewater management, suggesting that the agenda for the sustainable development goals 2030 has not notably influenced the commitment of MNEs to address wastewater management issues. The overall coefficient of determination (R^2) at 11.19% supports the initial submission that MNEs are not seriously addressing wastewater management issues through their corporate governance structure.

4.3. Governance mechanisms and wastewater management in low-polluting and high-polluting industries

Further analysis was performed to closely examine the impact of governance mechanisms on wastewater management based on industry environmental pollution rate/environmental sensitivity to wastewater emission. Using the classification applied in prior studies (e.g., Baboukardos, 2017; Konadu et al., 2021), MNEs were split into two groups of high-polluting and low-polluting industries. The results of the analysis are presented in Table 7.

The result shows that board gender diversity is positively associated with wastewater recycling in both high-polluting ($b = 0.176$, $p < 0.10$) and low-polluting ($b = 0.441$, $p < 0.10$) industries (Table 7). This validates the acceptance of H2. However, CEO duality evinces a significant negative impact in high-polluting industries ($b = -0.118$, $p < 0.05$), thus supporting acceptance of H3. Board independence and ESG-linked compensation have no significant impact on wastewater recycling as previously established in the baseline result (Table 6), thus validating the rejection of H1 and H4.

Comparing the effect size of board gender diversity on wastewater recycling in both groups shows that board gender diversity has a greater impact on wastewater management in the low-polluting industries ($b = 0.441$, $p < 0.10$) in comparison to the high-polluting industries ($b = 0.176$, $p < 0.10$). This may be attributable to more robust governance mechanisms in the low-polluting industries in comparison to the high-

Table 7
Impact of Governance Mechanisms on Wastewater Management based on Industry Environmental Pollution Rate.

Variable	High-polluting industries	Low-polluting industries
Board Independence	−.003 (.107)	−.544 (.715)
Board Gender Diversity	.176* (.189)	.441* (.604)
CEO Duality	−.118*** (.042)	.069 (.132)
ESG-linked Compensation	−.004 (.031)	−.121 (.108)
Governance Control		
Board Meeting	.060 (.042)	−.109 (.188)
Board Size	.005 (.004)	−.016 (.029)
Cross Directorship	−.035 (.022)	−.002 (.078)
Board Nationality Diversity	.092 (.107)	−1.048* (.619)
ESG Audit	.014 (.047)	.230* (.116)
ESG Committee	.026 (.051)	−.093 (.126)
Firm Attributes		
Firm Size	.168* (.116)	1.259** (.518)
Market Capitalisation	.060 (.077)	.405 (.390)
Gearing	−.001 (.002)	.002 (.009)
Liquidity	.020 (.023)	.060** (.030)
Profitability (ROTA)	−.004* (.002)	.013 (.013)
Year (MDGs/SDGs)	.033 (.036)	−.301** (.113)
Country-level Control		
Economic Development	.812** (.368)	.177 (1.348)
World Gov. Index (ave)	.006 (.005)	.015 (.017)
Year control	YES	YES
Industry Control	YES	YES
R^2	10.93%	64.95%
N	782	96

Notes: This table reports the fixed effect regression result for the impact of governance mechanisms on wastewater management in high-polluting and low-polluting industries. All variables are defined and measured in Table 1. Coefficients are stated, while standard errors are reported in brackets.
***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.

polluting industries (Table 2). For instance, board independence level in low-polluting industries (M = 78.22%) is significantly higher in comparison to high-polluting industries (M = 73.75%) in Table 2 (F ratio = 3.52, $p < 0.10$). Board gender diversity is also able to exert more influence on wastewater management in the low-polluting industries in comparison to the high-polluting industries (Table 7) because of the greater level of board gender diversity in MNEs operating in low-polluting industries (M = 20.05%), which contrasts sharply with the gender diversity ratio recorded by MNEs in the high-polluting industries (M = 14.36%) in Table 2. Board meetings are also well attended in low-polluting industries (M = 83.00%) in comparison to high-polluting industries (M = 66.00%). Expectedly, therefore, the impact of governance mechanisms on wastewater management is greater in low-polluting industries (R^2 = 64.95%) in comparison to the high-polluting industries (R^2 = 10.93%), meaning that strengthening governance mechanisms could be an effective strategy for minimising the flow of solid wastes such as microplastics into waterways.

Whereas CEO duality has a significant negative impact on wastewater management in high-polluting industries, the impact is not significant in the low-polluting industries (Table 7), meaning that the CEO doubling as board Chairperson is able to use their position to diminish wastewater management initiatives/dodge wastewater management issues in MNEs operating in high-polluting industries. This result provides additional corroborative evidence on less commitment by high environmental polluting companies to addressing environmental sustainability issues relating to wastewater recycling. The coefficient of determination of the regression model for low-polluting industries (R^2 = 64.95%) contrasts sharply with that of the high-polluting industries (R^2 = 10.93%), suggesting that MNEs operating in low-polluting industries have been generally more committed (in terms of strengthening governance structure and deploying more resources) to addressing wastewater management issues in comparison to MNEs operating in high-polluting industries.

4.4. Governance mechanisms and wastewater management in the MDGs and SDGs eras

The result in Table 6 shows that the MDGs/SDGs eras dichotomy has a negative impact on wastewater recycling, although the coefficient is not statistically significant (b = - 0.011, $p > 0.10$). Whilst the statistical insignificance connotes that the UN agenda for sustainable development has not appreciably affected the commitment of MNEs to addressing wastewater management, the negative coefficient suggests that MNEs were generally committed to wastewater management in the MDGs era when compared to the SDGs era. To gain more insight into this result, further analysis was performed by disaggregating the result into the MDGs and SDGs eras to assess governance mechanisms affecting wastewater management in these periods. The results of the analysis are presented in Table 8.

Board gender diversity has a positive significant impact on wastewater recycling in both the MDGs and SDGs eras, whilst the influence of board independence, CEO duality, and ESG-linked compensation is not statistically significant (Table 8). However, the economic impact of gender diversity is greater in the MDGs era (b = 0.777, $p < 0.05$) in comparison to the SDGs era (b = 0.636, $p < 0.10$), suggesting that MNEs were more committed to addressing wastewater management in the MDGs era than in the SDGs era, which explains the negative influence of the MDGs/SDGs eras dichotomy on wastewater recycling in Table 6. Furthermore, the coefficient of determination in the MDGs era (R^2 = 19.93%) is greater than that of the SDGs era (R^2 = 8.07%), thus providing additional evidence that MNEs were generally committed to addressing wastewater management issues (in terms of strengthening governance structure and deploying more resources) in the MDGs era in comparison to the SDGs era.

4.5. Governance mechanisms and wastewater management based on geographical regions

To perform a nuanced analysis of results by jurisdiction, we split our

Table 8
Impact of governance mechanisms on wastewater management in the MDGs and SDGs eras.

Variable	MDGs Era	SDGs Era
Board Independence	−.173 (.124)	−.041 (.233)
Board Gender Diversity	.777*** (.258)	.636** (.303)
CEO Duality	−.046 (.048)	−.113 (.100)
ESG-linked Compensation	−.004 (.035)	.022 (.056)
Governance Control		
Board Meeting	.097 (.066)	−.081 (.060)
Board Size	−.005 (.007)	−.006 (.010)
Cross Directorship	−.031 (.024)	−.031 (.054)
Board Nationality Diversity	−.096 (.123)	.691** (.269)
ESG Audit	.086 (.053)	.043 (.075)
ESG Committee	.019 (.056)	.055 (.092)
Firm Attributes		
Firm Size	.434*** (.146)	−.029 (.200)
Market Capitalisation	.072 (.097)	.111 (.140)
Gearing	−.001 (.002)	−.004 (.003)
Liquidity	.045 (.030)	.003 (.025)
Profitability (ROTA)	−.006 (.003)	−.001 (.003)
Country level Control		
Economic Development	1.194*** (.426)	−.111 (.757)
World Gov. Index (ave)	.012 (.011)	.008 (.007)
Year control	YES	YES
Industry Control	YES	YES
R^2	19.93%	8.07%
N	495	383

Notes: This table reports the fixed effect regression result for the impact of governance mechanisms on wastewater management in the MDGs and SDGs Eras. All variables are defined and measured in Table 1. Coefficients are stated, while standard errors are reported in brackets.
***, and ** indicate statistical significance at 1%, and 5%, respectively.

sample into the geographical regions—notably, the America region (315 firm-year observations, representing 35.9%), the Asia Pacific region (323 firm-year observations, representing 36.8%), the Western Europe region (180 firm-year observations, representing 20.5%), the Europe and Central Asia (ECA) region (54 firm-year observations, representing 6.2%), and the Middle East and North Africa (MENA) region (6 firm-year observations, representing 0.7%). However, regional analysis was restricted to the America, Asia Pacific, and Western Europe regions, respectively, because of the significant quantum of data (firm-year observations) emanating from these regions, accounting for a cumulative 93.2% of the firm-year observations. The results of the analysis are presented in Table 9.

The result shows that CEO duality has a significant negative impact on wastewater management in the America region and the Asia Pacific region, whilst the impact is significantly positive in the Western Europe region (Table 9). Whereas board independence has no significant impact on wastewater management in the America and Asia Pacific regions, the impact is positive in the Western Europe region. In all the three regions, board gender diversity evinces a positive but statistically insignificant impact on wastewater management. This means that board gender diversity can bolster wastewater management practice, but the female representation level should reach a noticeable threshold before female directors can exert a significant influence on corporate environmental practices. At the current level, the board gender diversity is generally low across MNEs operating in the 3 regions (Table 4). ESG-linked compensation has no significant impact on wastewater management in all the regions, understandably because linking executive pay to environment performance is less popular among MNEs given the nascent nature of the practice. Taken together, the result shows that the influence of governance mechanisms on wastewater management is contextual, depending on the environment.

Table 9
Impact of Governance Mechanisms on Wastewater Management based on Geographical Regions.

Variable	America Region	Asia Pacific Region	Western Europe Region
Board Independence	−.276 (.227)	.005 (.140)	.911** (.430)
Board Gender Diversity	.436 (.292)	.331 (.363)	.517 (.440)
CEO Duality	−.164** (.086)	−.101** (.047)	.356** (.161)
ESG-linked Compensation	−.022 (.047)	.070 (.071)	−.041 (.066)
Governance Control			
Board Meeting	.067 (.127)	−.040 (.050)	.355*** (.129)
Board Size	−.025** (.010)	.009 (.007)	−.039 (.024)
Cross Directorship	−.014 (.050)	−.071** (.031)	−.092 (.061)
Board Nationality Diversity	−.208 (.192)	−.287 (.209)	.064 (.240)
ESG Audit	.068 (.063)	.079 (.068)	−.012 (.422)
ESG Committee	.034 (.082)	−.135 (.082)	−.003 (.225)
Firm Attributes			
Firm Size	.759*** (.214)	.263 (.176)	.424 (.290)
Market Capitalisation	.039 (.126)	−.020 (.116)	.654*** (.216)
Gearing	−.001 (.002)	−.002 (.004)	.009* (.004)
Liquidity	.009 (.021)	.101*** (.035)	.104 (.090)
Profitability (ROTA)	−.004 (.003)	.001 (.004)	−.002 (.007)
Year (MDGs/SDGs)	.093 (.060)	−.045 (.051)	−.071 (.113)
Country level Control			
Economic Development	−1.983** (.791)	1.634*** (.510)	1.224 (1.307)
World Gov. Index (ave)	.010 (.008)	.014 (.012)	−.015 (.029)
Year control	YES	YES	YES
Industry Control	YES	YES	YES
R^2	13.79%	27.46%	26.44%
Number of companies	47	40	20
N	315	323	180

Notes: This table reports the fixed effect regression result for the impact of governance mechanisms on wastewater management in the America, Asia Pacific, and Western Europe Regions. All variables are defined and measured in Table 1. Coefficients are stated, while standard errors are reported in brackets. ***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.

5. Robustness check

5.1. Robustness check using alternative measure of wastewater management

To check the robustness of the result for sensitivity to alternative measure of wastewater management, wastewater recycle intensity was used as the dependent variable. The wastewater recycle intensity (has a positive polarity) was computed as the ratio of wastewater recycled to total revenue in line with prior studies (Elsayih et al., 2021; Nuber and Velte, 2021). The regression analysis was rerun using wastewater recycle intensity, and the results of the analysis are presented in Table 10.

The result shows that the impact of board gender diversity is positive and statistically significant, whilst CEO duality and ESG-linked compensation are negatively associated with wastewater recycling intensity (Table 10). The impact of board independence is not statistically significant. The result supports the acceptance of H2 and H3, as well as the rejection of H1 and H4. This is consistent with the baseline result (Table 6). The significant positive impact of firm liquidity on wastewater recycling intensity validates the argument that the availability of liquid resources may affect the commitment of organisations to wastewater management. The result also confirms that the MDGs/SDGs eras dichotomy has no significant impact on wastewater management, thus providing additional corroborative evidence that the United Nations agenda for sustainable development goals has not notably influenced the commitment of MNEs to addressing wastewater management issues. Overall, the results in Table 10 confirm that the baseline results (Table 6) are robust to an alternative measure of wastewater management.

Table 10
Impact of Governance Mechanisms on Wastewater Management using Alternative Measure of Wastewater Management.

Variable	DV: Wastewater Recycle Intensity
Board Independence	−241.976 (6719.203)
Board Gender Diversity	3760.34** (11,245.06)
CEO Duality	−10646.02*** (2560.773)
ESG-linked Compensation	−3405.162* (1927.596)
Governance Control	
Board Meeting	−2064.058 (2639.821)
Board Size	93.283 (331.019)
Cross Directorship	736.495 (1338.815)
Board Nationality Diversity	8960.448 (6595.816)
ESG Audit	7646.908*** (2717.593)
ESG Committee	1390.597 (3005.697)
Firm Attributes	
Firm Size	−7998.801* (7011.585)
Market Capitalisation	721.693 (4799.127)
Gearing	−9.063 (105.180)
Liquidity	3884.524*** (1127.972)
Profitability (ROTA)	−392.876** (152.207)
Year (MDGs/SDGs)	3291.473 (2170.053)
Country level Control	
Economic Development	−6424.482* (21,828.45)
World Gov. Index (ave)	54.304 (348.606)
Year control	YES
Industry Control	YES
R^2	8.69%
N	878

Notes: This table reports the fixed effect regression result for the impact of governance mechanisms on wastewater management using wastewater recycle intensity (has positive polarity) as an alternative measure of wastewater management. All variables are defined and measured in Table 1. Coefficients are stated, while standard errors are reported in brackets.
***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.

5.2. Treatment of endogeneity using two-stage least squares (2 S LS)/ instrumental variable (IV) regression

Literature suggests that there may be endogeneity between board gender diversity and environmental performance/environmental management variables (Gould et al., 2018). In other words, whilst board gender diversity may affect environmental performance variables on the one hand, environmental performance variables may also influence board gender diversity on the other hand (Konadu et al., 2021), thereby creating simultaneity endogeneity. To address endogeneity concerns, the study applied two-stage least squares (2 S LS)/instrumental variable (IV) regression (Elsayih et al., 2021; Ullah et al., 2021). An under-identification test was carried out using the Anderson canonical correlation LM statistic, whilst a weak identification test was conducted using the Stock–Yogo weak ID test (Stock and Yogo, 2005). In applying the two-stage least squares (2 S LS)/instrumental variable regression, two variables were applied as the instrument for board gender diversity as suggested by literature (Tingbani et al., 2020; Konadu et al., 2021): (a) strictly independent directors on the board [measured as total number of independent board members]; and (b) executive director (ED) gender diversity [measured as the ratio of female directors to total executive board size]. The analysis was rerun using the main measurement of wastewater management (wastewater recycle rate) as the dependent variable. The results of the analysis are presented in Table 11.

The under-identification test examines whether instrumental variables are less powerful than the endogenous variable (board gender diversity). Based on the Anderson canon. Corr. LM statistics for wastewater recycle rate of 48.953, $p < 0.01$, the test establishes that the model is not under-identified since the chi-square p value < 0.01. The weak identification test examines how strong the instrumental variables are in defining the endogenous variables, and the extent to which the instrumental variables are an appropriate replacement for the endogenous variables in the regression equation. The Cragg Donald Wald F statistics (25.223) is greater than each of the Stock–Yogo weak ID test critical values at 19.93, 11.59, 8.75, and 7.25. Since the Cragg Donald Wald F statistics is greater than the Stock–Yogo weak ID test critical values in all cases, the result confirms that there is no weak identification problem, implying that the instrumental variables are valid predictors for the endogenous variables in the regression equation. The result of the IV (2 S LS) regression is, thus, robust.

The result in Table 11 shows that the impact of board gender diversity on wastewater recycling is positive and statistically significant, whilst CEO duality has a significant negative impact. Firm size and firm liquidity are also significant positive drivers of wastewater management, whilst the MDGs/SDGs eras dichotomy has no significant impact. However, the negative coefficient of the MDGs/SDGs eras dichotomy upholds the argument that MNEs are showing less commitment to wastewater management in the SDGs era in comparison to the MDGs era. Overall, a comparison of the baseline result (Table 6) with the robustness check result using 2SLS/IV regression in Table 11 confirms that the result is robust to the endogeneity test, leading to the conclusion that, whilst board gender diversity is a notable driver of wastewater management, CEO duality diminishes the commitment of MNEs to addressing wastewater management issues.

Table 11
Two-stage least squares (2 S LS)/Instrumental variable (IV) regression result on impact of governance mechanisms on wastewater management.

Variable	DV: Water Recycle Rate
Board Independence	.058 (.359)
Board Gender Diversity	.427* (0.917)
CEO Duality	−.329*** (.083)
ESG-linked Compensation	.369* (.095)
Governance Control	
Board Meeting	.090 (.119)
Board Size	−.008 (.011)
Cross Directorship	.095* (.056)
Board Nationality Diversity	.198 (.240)
ESG Audit	.052 (.109)
ESG Committee	−.150 (.155)
Firm Attributes	
Firm Size	.438*** (.141)
Market Capitalisation	−.421*** (.136)
Gearing	−.015*** (.003)
Liquidity	.226*** (.041)
Profitability (ROTA)	−.023*** (.006)
Year (MDGs/SDGs)	−.173 (.154)
Country level Control	
Economic Development	.148*** (.238)
World Gov. Index (ave)	−.033*** (.004)
R^2	41.54%
N	878

Notes: This table reports the two-stage least squares (2 S LS)/instrumental variable (IV) regression result for the impact of governance mechanisms on wastewater management. All variables are defined and measured in Table 1. Coefficients are stated, while standard errors are reported in brackets. *** and * indicate statistical significance at 1%, and 10%, respectively.

5.3. Further robustness check using propensity score matching

5.3.1. Using the average treatment effects on the treated (ATT) approach

Board gender diversity consistently emerged as a notable driver of wastewater management. To check the robustness of the result in this respect, the median score (i.e., board gender diversity median score of 14%) was used to separate the sample into control group (i.e., firms with gender diversity ratio of 14% and below) and treatment group (i.e., firms with gender diversity ratio above 14%). Thereafter, the samples were matched using nearest neighbour (NN) matching/greedy matching. The NN matching procedure generated 452 cases for the treatment group and 411 cases for the control group. The highest match bias among the covariates (i.e., difference between the mean of the treatment and control groups for each of the governance factors and firm attributes) was 4.3%, which is below the recommended 5% threshold (Konadu et al., 2021). This implies that commitment to wastewater management can reasonably be attributable to differences in board gender diversity rate among companies. The results of the analysis are presented in Table 12.

The result on the average treatment effects on the treated (ATT) in Table 12 shows that, before the samples were matched, the difference in water recycle rate between the treatment (M = 6.864) and control (M = 7.282) group was −0.417. After the matching, the difference changed to 1.531, with the treatment group (M = 6.864) outperforming the control group (M = 5.333), confirming that board gender diversity is a notable driver of wastewater management.

5.3.2. Treatment of endogeneity using propensity score matching regression approach

To further address potential endogeneity concerns with respect to

Table 12
Impact of Governance Mechanisms on Wastewater Management using the Average treatment effects on the treated (ATT) Propensity Score Matching Approach.

Variable	Sample	Treated	Controls	Difference	Std Error	T-stat
Water recycle rate	Unmatched	6.864	7.282	−.417	.095	−4.35
	ATT	6.864	5.333	1.531	.403	−1.16

Notes: This table reports the result of propensity score matching using the average treatment effects on the treated (ATT). Before the samples were matched, the difference in water recycle rate between the treatment (M = 6.864) and control (M = 7.282) group was −0.417. After the matching, the difference changed to 1.531, with the treatment group (M = 6.864) outperforming the control group (M = 5.333), confirming that board gender diversity is a notable driver of wastewater management.

simultaneity bias between wastewater management and board gender diversity, propensity score matching with regression analysis was employed in line with prior studies (Peel, 2018; Tawiah et al., 2022).

The median score of board gender diversity at 14.0% was used to divide MNEs into the treatment group (above-median score) and the control group (with median/below-median score). Thereafter, the propensity scores (i.e., probability of being assigned to a treatment/control group) were generated by regressing the covariates on the binary categorisation of board gender diversity (code '0' for control group, and code '1' for treatment group). This procedure eliminates the potential endogeneity issue, whilst also minimising likely model misspecification (Titus, 2007; Tawiah et al., 2022). The propensity scores generated by the process were then substituted for board gender diversity, and the regression was rerun using wastewater recycle rate as the dependent variable. The results of the analysis are presented in Table 13.

The result shows that board gender diversity is the strongest driver of wastewater management, whilst the impact of CEO duality is negative. Board independence and ESG-linked compensation have no significant impact. Firm size and firm liquidity have a significant positive impact, thus establishing the argument that resource availability is a notable determinant of wastewater recycling initiatives. The MDGs/SDGs eras dichotomy evinces a significant negative coefficient, thereby confirming that commitment to wastewater management waned in the SDGs era in comparison to the MDGs era, and the UN agenda for sustainable development has not notably influenced MNEs to commit to wastewater management projects. The result also shows that the impact of other corporate governance variables on wastewater management is weak. The overall coefficient of determination (R^2) at 11.98% supports the conclusion that MNEs are not adequately addressing wastewater management issues through their corporate governance structure.

In sum, the PSM result in Table 13 is consistent with the baseline result in Table 6 in terms of the nature of the relationship between governance mechanisms, firm attributes, MDGs/SDGs eras dichotomy, and the overall model coefficient of determination (R^2), confirming that board gender diversity is a significant positive determinant of wastewater management, whilst CEO duality diminishes commitment to wastewater recycling as an environmental sustainability initiative.

5.4. Robustness check on governance factors affecting commitment to wastewater management initiative

To conduct a further robustness check, governance factors affecting commitment to wastewater management initiative were assessed by examining the determinants of disclosure/non-disclosure on wastewater recycling. From the 336 non-financial firms on the Forbes 500 list with environmental performance disclosure in the Refinitiv/DataStream databases (with 4550 firm-year observations for the 15-year period of 2006–2015), 115 firms (generating 878 firm-year observations) had disclosure on wastewater recycling in the period under investigation (i.e., 2006–2015). This represents 34.22% firms with wastewater management disclosure and 19.30% firm-year observations, establishing that the level of commitment to wastewater recycling is generally low among MNEs. Logistic regression analysis was employed to assess the governance factors affecting the commitment of MNEs to wastewater management disclosure. If there is a disclosure on volume of wastewater recycled by a firm in a year, a code of 1 is assigned to indicate commitment to wastewater management, and if no disclosure is made, a code of '0' is assigned to indicate no commitment to wastewater management (Tauringana et al., 2017). The result of the binary logistic regression analysis is presented in Table 14.

The regression result shows that board gender diversity (b = 0.253, *OR* = 1.288, p < 0.05) and ESG-linked compensation (b = 0.324, *OR* = 1.382, p < 0.01) are positively associated with wastewater management initiative, whilst the impact of board independence (b = −0.721, *OR* = 0.486, p < 0.01) and CEO duality (b = −0.295, *OR* = 0.745, p < 0.01) is negative. The odds ratio (*OR*) of 1.288 for board gender diversity as a binary variable implies that high gender-diverse boards are 128.8%

Table 13
Propensity score matching regression result on the impact of governance mechanisms on wastewater management.

Variable	DV: water recycle rate
Board Independence	−.167 (.119)
Board Gender Diversity (pscore)	.532*** (.161)
CEO Duality	−.105** (.041)
ESG-linked Compensation	−.019 (.031)
Governance Control	
Board Meeting	.031 (.042)
Board Size	.001 (.005)
Cross Directorship	−.004 (.022)
Board Nationality Diversity	−.093 (.109)
ESG Audit	.040 (.044)
ESG Committee	−.032 (.049)
Firm Attributes	
Firm Size	.461*** (.118)
Market Capitalisation	−.002 (.082)
Gearing	.001 (.002)
Liquidity	.034* (.018)
Profitability (ROTA)	.000 (.002)
Year (MDGs/SDGs)	−.094** (.044)
Country level Control	
Economic Development	.786** (.340)
World Gov. Index (ave)	.006 (.005)
Year control	YES
Industry Control	YES
R^2	11.98%
N	878

Notes: This table reports the propensity score matching regression result for the impact of governance mechanisms on wastewater management. All variables are defined and measured in Table 1. Coefficients are stated, while standard errors are reported in brackets.
***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 14
Logistic regression result on corporate governance determinants of commitment to wastewater management[a].

Variable	DV: Wastewater Recycle Commitment Propensity
Board Independence	.486*** (−.721)
Board Gender Diversity (binary)	1.288** (.253)
CEO Duality	.745*** (−.295)
ESG-linked Compensation	1.382*** (.324)
Governance Control	
Board Meeting	.984 (−.016)
Board Size	.952*** (−.049)
Cross Directorship	.905[a] (−.100)
Board Nationality Diversity	2.628*** (.966)
ESG Audit	3.631*** (1.289)
ESG Committee	3.504*** (1.254)
Firm Attributes	
Firm Size	1.174 (.161)
Market Capitalisation	1.240 (.215)
Gearing	.996 (−.004)
Liquidity	1.213*** (.193)
Profitability (ROTA)	1.004 (.004)
Year (MDGs/SDGs)	.163 (−1.813)
Country level Control	
Economic Development	1.342 (.294)
World Gov. Index (ave)	.954*** (−.048)
Cox & Snell R Square R^2	15.50%
Nagelkerke R Square R^2	24.70%
Classification Ratio	82.3%
N	4550

Notes: This table reports the logistic regression result on corporate governance determinants of commitment to wastewater management. All variables are defined and measured in Table 1. Board gender diversity takes a binary value of 0 (if gender diversity rate is ≤ Median of 14%), and 1 (if gender diversity rate is > Median of 14%)
***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.
[a] Odds ratio (OR) reported, with beta coefficients in brackets.

times more likely to commit to wastewater management initiatives in comparison to less gender-diverse boards. Similarly, the odds ratio of 0.745 for CEO duality connotes that boards with CEOs concurrently functioning as board Chairpersons are 74.50% times less likely to commit to wastewater management projects. Overall, the result confirms that board gender diversity is a notable driver of wastewater management and CEO duality diminishes the commitment of MNEs to wastewater management.

5.5. Further robustness check: board gender diversity and wastewater management

Board gender diversity consistently emerged as a notable determinant of wastewater management (Tables 6–8). To ascertain the number of female directors required to improve wastewater management, we conduct additional analysis using the binary classifications of board gender diversity at three levels. If there is at least one female director, a code of 1 is assigned, otherwise 0 (this represents the first stage of board gender diversity progression); if there are at least two female directors, code 1 is assigned, otherwise 0 (this represents the second stage of board gender diversity progression); and if there are at least three female directors, code 1 is assigned, otherwise 0 (this represents the third stage of board gender diversity progression). Prior studies have used a similar approach (Konadu et al., 2021; Nuber and Velte, 2021). We run the analysis for the full sample (Models 1–3), high-polluting industries (Models 4–6), and high-polluting industries (Models 7–9) in Table 15.

In the columns containing the result of the full sample (Models 1–3) in Table 15, the impact of board gender diversity on wastewater management increases from $b = 0.167$, $p < 0.01$ in Model 1 (when there is at least 1 female director) to $b = 0.168$, $p < 0.01$ in Model 2 (when there are at least 2 female directors), but declines to $b = -0.174$, $p < 0.01$ in Model 3 (when there are at least 3 female directors). This shows that, at the aggregate level, a minimum of two female directors are required to improve wastewater management. The result for high-polluting industries (Models 4–6) follows a similar trajectory to the full sample whereby the presence of at least one female director in Model 4 ($b = 0.144$, $p < 0.01$), and the presence of at least two female directors in Model 5 ($b = 0.116$, $p < 0.05$) improve wastewater management. However, the impact of board gender diversity on wastewater management starts declining in Model 6 ($b = -0.191$, $p < 0.01$). For low-polluting industries (Models 7–9; Table 15), the impact of 'at least 1 female' director is not significant in Model 7 ($b = -0.196$, $p > 0.10$), but this shifted to a significant, positive impact when there are at least two female directors in Model 8 ($b = 0.443$, $p < 0.10$). In sum, the result in Table 15 reveals that a critical mass of at least two female directors is required to significantly improve wastewater management, in line with prior studies (Konadu et al., 2021; Nuber and Velte, 2021). The result in Table 15 is also consistent with the baseline result that CEO duality erodes environmental performance in terms of wastewater management (Agyemang et al., 2020; Nuskiya et al., 2021).

6. Discussion

To ensure an exhaustive discussion, the findings are thematically discussed under three subheadings of (i) governance mechanisms affecting wastewater management; (ii) governance mechanisms affecting wastewater management based on environmental pollution intensity; and (iii) governance mechanisms affecting wastewater management in the MDGs and SDGs eras.

6.1. Governance mechanisms affecting wastewater management

The result in Table 6 shows that board gender diversity has a significant positive impact on wastewater recycling, leading to the acceptance of H2. The result is consistent with prior studies that gender-diverse boards with more female director representation enhances environmental performance (e.g.., Gull et al., 2023; Javed et al., 2023). The result on the positive impact of more female directors on wastewater recycling is buttressed by the robustness test results using an alternative measure of wastewater management (Table 10), as well as the treatment of endogeneity using 2SLS/IV regression (Table 11) and propensity score matching (Tables 12 and 13). Furthermore, the logistic regression results that gender-diverse boards have a higher propensity to commit to wastewater management initiatives (Table 14) buttresses the argument that women are generally more eco-friendly and would want to address environmental issues that could heighten human suffering in the society

Table 15
Robustness Check for impact of Board Gender Diversity Progression on Wastewater Management.

	Full Sample			High-polluting Industries			Low-polluting Industries		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Bd. Gender Div.									
At least 1 Female	.167*** (.051)			.144*** (.051)			−.196 (.362)		
At least 2 Females		.168*** (.052)			.116** (.053)			.443* (.239)	
At least 3 Females			−.174*** (.059)			−.191*** (.063)			−.022 (.132)
Board Independence	−.014 (.112)	.075 (.128)	−.025 (.111)	.002 (.110)	.066 (.129)	−.034 (.111)	−.515 (1.004)	.010 (.728)	−.427 (.714)
CEO Duality	−.077* (.042)	−.113** (.050)	−.088** (.042)	−.110** (.044)	−.139*** (.052)	−.121*** (.043)	.079 (.153)	.085 (.152)	.119 (.134)
ESG-linked Compensation	−.012 (.032)	−.020 (.036)	−.015 (.032)	−.006 (.032)	−.011 (.038)	−.005 (.033)	-. 275* (.142)	−.174** (.084)	−.203* (.109)
Control variables	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm Effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES	YES	YES	YES	YES	YES
R^2	11.66%	13.40%	12.09%	12.40%	13.10%	12.23%	23.07%	27.45%	22.76%
N	**878**	**878**	**878**	**782**	**782**	**782**	**96**	**96**	**96**

Notes: This table reports the fixed effect regression result for the impact of board gender diversity (Bd. Gender Div.) on wastewater management for the full sample, high-polluting industries, and low-polluting industries. The impact of board gender diversity (in terms of at least 1 female director, 2 female directors, and 3 female directors) is graduated in Models 1 to 9 to assess the required minimum number of female directors that exert an influence on wastewater management. Control variables are included in the regression analysis but not reported. All other variables are defined and measured in Table 1. Coefficients are stated, while standard errors are reported in brackets.
***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.

(Konadu et al., 2021; Gull et al., 2023). The result also supports the stakeholder theory that stakeholders would typically be interested in the appointment of more female directors to ensure that their interests in environmental management are well protected since women have better networking capabilities, are more concerned, and are more sympathetic in comparison to their male counterparts (Acabado et al., 2019; Fafaliou et al., 2022). As revealed by the result in Table 15, the presence of more female directors will anticipatorily deepen the commitment of organisations in addressing the challenges of microplastics in aquatic bodies by supporting water recycling practices and implementing initiatives on wastewater management. As a legitimisation strategy to gain acceptance by the society, organisations will seek to appoint more female directors (Archel et al., 2009). By so doing, they can be seen as implementing a best governance practice that enhances board performance, whilst promoting the implementation of environmental sustainability initiatives on wastewater recycling (Fowler, 2023). However, considering that the mean board gender diversity rate was 14.98% (which is considered low), the impact of board gender diversity on wastewater management could have been more assuming that the rate of board gender diversity is higher. The high dispersion in the rate of board gender diversity (as indicated by the SD = 12.66% in Table 4) may have also contributed to the overall low impact of board gender diversity on wastewater management. This informs the contention that boards should consider more female representation as a strategy to improve board performance and environmental sustainability practices.

The result also shows that CEO duality has a significant negative impact on wastewater recycling (Table 6), implying that CEOs functioning in the dual capacity of board Chairpersons may use such positions to dodge the environmental responsibility of addressing microplastics through wastewater recycling practices. The result supports prior studies on the negative association between CEO duality and environmental performance (e.g., Agyemang et al., 2020; Harun et al., 2020). From the stakeholder theory perspective, concerned stakeholders will want role of the CEO separated from that of the board Chairperson because such segregation of duties and power ensures proper checks and balance, and diminishes the opportunistic tendencies of executive directors in taking sub-optimal decisions that create moral hazards for owners and other stakeholders. Considering that legitimacy is deliberate and calculated (Archel et al., 2009), organisations seeking to gain stakeholders' acceptance will want to strengthen the governance structure by appointing independent directors to be seen by the public that they are concerned about environmental sustainability issues such as wastewater recycling. The results from various robustness checks equally establish that CEO duality erodes commitment to wastewater management (Tables 10-15) Whilst executive board members may want to understandably dodge investment in wastewater recycling, possibly because of the capital-intensive nature of such projects which may temporarily cause a dip in short-term financial performance, the long-term benefits of such projects should spur investments in wastewater recycling technologies. However, governance structures must be emplaced to monitor executive board members to take such decisions in the interest of the environment and society. A close examination of the results reveals that CEO duality exerts a significant negative influence on wastewater management because of the prevalence of CEO duality (M = 0.43; Table 4). To improve wastewater management, therefore, organisations may consider strengthening the governance structure by discouraging the appointment of directors into the dual role of board Chairperson and company CEO.

Board independence has no significant impact on wastewater management (Tables 6–8). In the meantime, board independence level among MNEs in terms of the ratio of independent board members to total board size is generally high (M = 74.24%; Table 4). This suggests that it is not the mere presence of independent directors that contributes to board performance; rather, it is active engagement with governance issues such as wastewater recycling that delivers the desired outcome of upscaling environmental performance. ESG-linked compensation has no significant impact on wastewater management (Table 6). This could partly be attributable to the lower popularity of linking executive compensation to environmental performance as revealed by the low mean score of 0.36 (Table 4). The insignificant impact could also be attributed to the burgeoning nature of ESG-linked compensation (Oyewo, 2023).

The analysis of the results by geographical regions shows that CEO duality is significantly and negatively associated with wastewater treatment in the America region and the Asia Pacific region, whilst the impact of CEO duality is significantly positive in the Western Europe region (Table 9). This could be explained by the prevalence of CEO duality in the America region (M = 0.64; Table 4) and the Asia Pacific region (M = 0.45; Table 4), whilst the practice of combining the office of the board Chairperson with the company CEO appears to be less prevalent in the Western Europe region (M = 0.14), as revealed by the results in Table 4. The result supports the argument that executive board members performing the dual role of Chairperson and CEO—as is the case for the America and Asia Pacific regions—may exploit their position to dodge their environmental responsibility of addressing the flow of microplastics into aquatic habitats through wastewater recycling investments (Nuskiya et al., 2021). On the other hand, the emplacement of a robust corporate governance structure such as recruiting independent directors to perform the oversight role on executive board members, as evident in the Western Europe region (board independence ratio of 83.63% in Table 4), could checkmate the tendencies of executive directors making suboptimal decisions that may not benefit stakeholders but which, conversely, maximise returns for owners (Correa-Garcia et al., 2020). Stakeholder theory, thus, underpins the corporate governance practice of CEO/Chairperson duty segregation (Freeman, 1984). The lower popularity of CEO duality in the Western Europe region (M = 0.14) may be traceable to corporate governance codes and regulations in the region, which checkmate the abuse of power by board members and promote best practice in corporate governance (Lepore et al., 2018; Poletti-Hughes and Dimungu-Hewage, 2022). This explains the significant positive impact of board independence on wastewater management in the Western Europe region (Table 9). The result buttresses the argument that robust corporate governance practices have the tendency to promote wastewater recycling as a strategy for curbing the flow of microplastics and other toxic substances into waterways.

6.2. *Governance mechanisms affecting wastewater management based on industry environmental pollution intensity*

The result shows that, whereas board gender diversity is positively associated with wastewater recycling in both high-polluting and low-polluting industries (Table 7), the impact is greater in the low-polluting industries in comparison to the high-polluting industries. The greater impact in the low-polluting industries could be linked to the higher board gender diversity rate in MNEs operating in those industries (M = 20.05%), which contrasts sharply to the board gender diversity rate in the high-polluting industries (M = 14.36%), and the difference is statistically significant (F ratio = 17.59, $p < 0.01$; Table 2). The result upholds the inference that board gender diversity enhances wastewater management (Nuber and Velte, 2021; Nicolò et al., 2022). Although the quantity of wastewater recycled in the high-polluting industries (M = 485, 950, 569.50 cubic metres) is generally higher than that of the low-polluting industries (M = 1,231,941.47 cubic metres), the board gender diversity rate in high-polluting industries is not so high as to appreciably influence wastewater recycling performance. This makes it compelling to strengthen board effectiveness by injecting more female directors into the board as a strategy to improve wastewater recycling and corporate environmental performance (Gull et al., 2023).

Whereas CEO duality has no impact on wastewater management in low-polluting industries, its impact is negative and significant in MNEs operating in high-polluting industries (Table 7), even though CEO duality is more popular in low-polluting industries (M = 0.63) in

comparison to high-polluting industries (M = 0.40) in Table 2. The result implies that executives performing the dual role of board Chairperson and CEO have a high propensity to use their power and position to downplay addressing wastewater recycle issues in high-polluting industries (Harun et al., 2020; Lu and Wang, 2021), possibly because of the intention of maximising shareholders returns, whilst also dodging investment in capital-intensive wastewater management projects. On the other hand, CEO duality may be unable to exert a negative influence on wastewater management in low-polluting industries perhaps because MNEs operating in those industries are under less pressure to address wastewater problems because of their low wastewater emissions rate (Table 2). This should motivate high-polluting firms to implement more robust governance measures to address environmental pollution issues if they are to preserve their corporate legitimacy in line with the legitimacy theory. Relatedly, to protect the interest of stakeholders, corporate entities should promote Chairperson/CEO separation to checkmate the tendency of executive directors seeking rent (Nuskiya et al., 2021). Such executive decisions may jeopardise corporate environmental performance in a bid to maximise returns for shareholders by avoiding investments in environmental sustainability projects.

Notwithstanding that board independence rate is generally high among MNEs operating in both low-polluting (M = 78.22%) and high-polluting industries (M = 73.75%) in Table 4, board independence is unable to exert a significant positive influence on wastewater management (Table 7). The result reinforces the inference that wastewater management ranks low among board agenda items, wastewater recycling is not prioritised, and/or board members generally lack sufficient knowledge and skills on wastewater management issues. Similarly, ESG-linked compensation has no significant impact on wastewater management in high-polluting and low-polluting industries, possibly because of the generally low popularity of such a reward scheme among MNEs in both industries, as well as the nascent nature of linking executive compensation to environmental performance as a corporate governance mechanism (Spierings, 2022; Oyewo, 2023).

6.3. Governance mechanisms affecting wastewater management in the MDGs and SDGs eras

The result shows that, whilst board gender diversity has a significant positive impact on wastewater management in both the MDGs and SDGs eras, the impact is greater in the MDGs era in comparison to the SDGs era (Table 8). Whereas board gender diversity rate was higher in the SDGs era (M = 18%) in comparison to the MDGs era (M = 11%) as shown in Table 3, board gender diversity rate is not noticeably high in the SDGs era as to appreciably influence wastewater management. This supports the contention that female board directors may have to reach a sizable number to either (a) facilitate one another's performance, and/or (b) form a critical mass before they can influence corporate environmental policies on the board of directors, including wastewater management practices (Konadu et al., 2021; Nuber and Velte, 2021). The result in Table 15 validates this argument. Whilst it would have been expected that board gender diversity will have greater impact on wastewater recycling in the SDGs era given the promotion of gender diversity agenda/the clamour for more female representation in top management team of public and private sector organisations (United Nations, 2016), the inability of board gender diversity to notably affect wastewater recycling implies that more female representation is required on corporate boards as a strategy to achieve Agenda 2030.

Although ESG-linked compensation has no significant impact on wastewater management in both the MDGs and SDGs eras (Table 8), the shift in the direction of relationship from negative in the MDGs era (b = −0.004) to positive in the SDGs era (b = 0.022) reveals that linking executive compensation to environmental performance has the potential to improve commitment to wastewater management. Meanwhile, the popularity of ESG-linked compensation waned between the MDGs (M = 0.42) and SDGs (M = 0.29) era (Table 3). Assuming that ESG-linked compensation was prominent in the SDGs era, it may have positively impacted wastewater management. This analysis upholds the argument that the appropriate tying of executive compensation to reasonable and achievable environmental performance targets can improve the commitment of company executive to taking eco-friendly decisions—such as wastewater recycling (Okafor and Ujah, 2020; Lu and Wang, 2021).

7. Conclusion

This study investigates the association between corporate governance mechanisms and wastewater recycling as a strategy for managing the flow of microplastics into the aquatic environment. The study focuses on four corporate governance mechanisms—notably, board independence, board gender diversity, CEO duality, and ESG-linked compensation. The result shows that, at the aggregate level, board gender diversity is positively and significantly associated with wastewater recycling (b = 0.378, $p < 0.05$), whilst CEO duality has a significant negative impact (b = −0.086, $p < 0.05$). The impact of board independence (b = −0.014, $p > 0.10$) and ESG-linked compensation (b = −0.009, $p > 0.10$) is not statistically significant. When disaggregated into industries based on intensity of environmental pollution, board gender diversity is positively associated with wastewater recycling in both high-polluting (b = 0.176, $p < 0.10$) and low-polluting (b = 0.441, $p < 0.10$) industries. However, the impact of board gender diversity on wastewater management is greater in low-polluting industries. Whereas CEO duality has a significant negative impact on wastewater recycling in high-polluting industries (b = −0.118, $p < 0.05$), board independence and ESG-linked compensation have no significant impact in both industries. In relation to the MDGs/SDGs eras, board gender diversity has a significant positive impact on wastewater recycling in both the MDGs and SDGs eras, whilst the influence of board independence, CEO duality, and ESG-linked compensation is not significant. However, the impact of gender diversity is greater in the MDGs era (b = 0.777, $p < 0.01$) in comparison to the SDGs era (b = 0.636, $p < 0.05$). At the geographical region level, CEO duality has a significant negative impact on wastewater management in the America region and the Asia Pacific region, whilst the impact of CEO duality is significantly positive in the Western Europe region. Whereas board independence has no significant impact on wastewater management in the America and Asia Pacific regions, the impact is positive in the Western Europe region. The significant positive association between board independence and wastewater management in the Western Europe region on one hand, and the lower popularity of CEO duality on the other hand supports the conclusion that instituting a robust corporate governance structure such as recruiting independent directors to perform an oversight role on executive board members could checkmate the tendencies of executive directors to make suboptimal decisions on environmental management. In all the three regions, board gender diversity evinces a positive but statistically insignificant impact on wastewater management, and this is attributable to the relatively low level of board gender diversity. The results (Table 15) reveal that models with 'at least 2 females' have the highest coefficients of determination ($\mathbf{R^2}$) for the full sample (Model 2; $R^2 = 13.40\%$), high-polluting industries (Model 5; $R^2 = 13.10\%$), and low-polluting industries (Model 8; $R^2 = 27.45\%$), thus corroborating the conclusion that a minimum of two female directors is required to improve the wastewater management practice of MNEs. Board gender diversity level should be reasonable to exert a significant influence on corporate environmental practice. Overall, the study concludes that whilst board gender diversity is a notable driver of wastewater management, CEO duality diminishes the commitment of MNEs to addressing wastewater management issues. Our results are robust to (i) alternative measures of wastewater management, (ii) alternate sample composition, (iii) alternate method of data analysis, and (iv) endogeneity checks.

The result, on one hand, that the number of companies disclosing wastewater recycling is low (115 companies from 336 non-financial

companies on the Forbes list, representing 34.22%), and, on the other hand, that the number of firm-year observations on wastewater recycling is low (878 observations on wastewater management from 4550 observations on environmental performance disclosure, representing 19.30%) establishes that the commitment of MNEs to wastewater recycling is generally low. The low coefficients of determination in the regression results buttresses the argument that the governance mechanisms emplaced by MNEs to promote wastewater recycling are weak. Drawing from the result that it is only a few companies that are addressing wastewater management issues, the study recommends that MNEs as key partners in Agenda 2030 should do more towards achieving SDG 6 and SDG 14 targets by strengthening their corporate governance structure. This can help to address the flow of microplastics and other wastes into water bodies. MNEs have an ethical burden as key partners for Agenda 2030 to be at the forefront in championing wastewater management issues. They should, therefore, actively tackle the discharge of microplastics and other toxic substances by addressing pollution in the aquatic eco-system to preserve corporate legitimacy.

The result shows that board independence has no significant impact on wastewater management, implying that either wastewater recycling is less popular among board members, or that wastewater recycling issues are not accorded the requisite level of attention as an environmental sustainability strategy in the board agenda. Therefore, the study recommends that organisations should promote more wastewater recycle initiatives through the appointment of board members that are knowledgeable about environmental issues to ensure that the board is not deficient in skills and experience in this regard. To strengthen board effectiveness on wastewater recycling, board members should also have access to professional services/expert advice and consultation with environmental specialists to improve the quality of board decisions on environmental management issues. Board members may consider working with water treatment specialists to leverage on their competence to identify potential areas of improvement in effluent management. MNEs may also benefit from wastewater audit to monitor wastewater discharge levels for the purpose of assessing compliance with regulatory requirements and usage trends to suggest more opportunities for more efficient wastewater treatment and water reuse/recycle. MNEs should be intentional about addressing water environmental pollution and microplastics by deliberately investing in wastewater treatment plants/facilities.

ESG-linked compensation may not have significantly impacted wastewater management, possibly because of the nascent nature of linking executive compensation to environmental performance as a corporate governance strategy. Linking wastewater management to executive compensation could promote long-termism and encourage executives to focus on metrics that matter. Against this backdrop, it is recommended that corporate entities should promote more initiatives that link executive compensation to environmental performance to incentivise executive board members. However, the ESG-linked compensation should be connected to appropriate and achievable targets to avoid rewarding undesired results and further creating unintended consequences which diminish environmental performance instead of promoting it. The result that the impact of other corporate governance variables on wastewater management is weak adds noise to the call on MNEs as critical stakeholders in the SDGs discourse to strengthen their governance structures to deliberately address wastewater management issues. The result that the SDGs have not considerably affected the commitment of MNEs to address wastewater management makes it important for MNEs to emplace more robust waste management strategies.

Drawing from the result that MNEs operating in low-polluting industries are taking more steps to address wastewater management ($R^2 = 64.95\%$) than companies in high-polluting industries ($R^2 = 10.93\%$), the study implores high environmental polluters to be proactive about investing in wastewater innovations to control microplastics environmental pollution as a strategy to preserve corporate legitimacy. Meanwhile, high polluters have a higher moral burden and heavier environmental responsibility to confront microplastics in wastewaters going by the nature of their business but their low commitment to wastewater recycling. The result that commitment to addressing water pollution was more in the MDGs era in comparison to the SDGs era, makes it compelling for MNEs to take active steps in addressing wastewater management to achieve the SDG targets relating to clean water (SDG 6) and preserving aquatic life/life below water (SDG 14). Whilst the statistical insignificance of the MDGs/SDGs eras dichotomy on wastewater recycling connotes that the UN agenda for sustainable development has not appreciably affected the commitment of MNEs to addressing wastewater management (Table 6), the negative coefficient suggests that MNEs were generally more committed to wastewater management initiatives in the MDGs era compared to the SDGs era. This corroborates the argument that MNEs need to do more in the way of addressing plastics in wastewaters. Ignoring calls for action on the dangers of microplastics in aquatic bodies would be tantamount to breaching the social contract between organisations and society, and this may put their corporate reputation in jeopardy in line with the stakeholder theory and legitimacy theory.

The study contributes to knowledge in five ways. First, it contributes to the limited literature on waste management and the circular economy, and particularly the role of governance mechanisms in wastewater management. Second, the study reveals the governance structures affecting wastewater management in an international context, thus closing some of the gap in knowledge on the impact of corporate governance on wastewater management rather than general environmental performance or carbon emissions performance that have received more research attention. Third, the study makes contributions to the stakeholder theory and the legitimacy theory by providing empirical evidence that wastewater management could be an effective strategy for gaining stakeholders' acceptance and entrenching corporate legitimacy. Fourth, the study provides empirical evidence on the progress that MNEs are making towards actualising their agendas for sustainable development in terms of mechanisms that they are putting in place to address environmental pollution from wastewater release. Finally, the study makes a methodological contribution to literature by using innovative statistical techniques to analyse data such as 2SLS/IV regression and PSM. As argued in the literature, limited studies on the governance–environmental sustainability nexus have applied sophisticated techniques to provide a more nuanced analysis of such association or addressed endogeneity concerns. The current study deploys sophisticated statistical techniques to ensure a well validated conclusion on the influence of corporate governance on wastewater recycling.

CRediT authorship contribution statement

Babajide Oyewo: Conceptualization, Methodology, Data curation, Writing – original draft. **Venancio Tauringana:** Supervision, Project administration, Writing - review & editing. **Ishmael Tingbani:** Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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