Article:
Morrison, E.A., Adu, D.A. and Kimani, D. orcid.org/0000-0002-8267-4150 (2025) Propelling the transition to circular economy: Exploring the role of corporate circular economy performance-based incentive policy. Business Strategy and the Environment. ISSN 0964-4733

https://doi.org/10.1002/bse.4285

Business Strategy and the Environment

WILEY

Business Strategy and the Environment

RESEARCH ARTICLE OPEN ACCESS

Propelling the Transition to Circular Economy: Exploring the Role of Corporate Circular Economy Performance-Based Incentive Policy

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Received: 28 June 2024 | **Revised:** 28 February 2025 | **Accepted:** 26 March 2025

Keywords: circular economy | circular economy performance–based incentive policy | climate resilience | sustainable resource utilisation

ABSTRACT

This study examines the impact of executive compensation (EC) and corporate circular economy performance incentives (CCEPI) on corporate circular economy initiatives (CCEI) and corporate circular economy performance (CCEP) by integrating legitimacy theory and the resource-based view. Despite increasing attention to sustainability, there is limited understanding of how governance mechanisms, such as EC and CCEPI, drive circular economy practices. Addressing this gap, we analyse 41,370 firm-year observations from 50 countries over the period 2002–2022. The findings reveal four key insights: (1) higher EC significantly enhances CCEI, demonstrating greater corporate commitment to circular economy practices; (2) CCEPI positively influences the effectiveness of CE efforts; (3) CCEPI does not directly improve CCEP but strengthens CCEI as a long-term strategic investment; (4) these relationships vary by country, sector and over time. The study offers crucial implications for policymakers and practitioners, emphasising the role of targeted incentives in promoting sustainable business practices and recognising the contextual factors that affect their effectiveness.

1 | Introduction

As the world grapples with an escalating environmental crisis that is linked to climate change, the concept of the circular economy (CE) has received attention across various sectors, including academia, governments, businesses and the wider society. Currently, the global economy operates at a mere 7.2% circularity and is heavily dependent on new materials, hence resulting in increased waste and emissions (CGR 2023). Consequently, over 90% of materials end up wasted, misplaced or inaccessible for immediate reuse, often tied up in long-lasting assets like buildings and machinery. Thus, the CE represents a paradigm shift from traditional linear production systems of take, make and dispose to a regenerative approach emphasising reuse and recycling of materials (Zameer et al. 2021; Geissdoerfer et al. 2017; Zucchella and Previtali 2019). In this case, CE primarily aims to reduce resource use and waste production, thereby lessening environmental impacts and fostering economic and societal prosperity (Geissdoerfer et al. 2018; Kiefer et al. 2019; Manninen et al. 2018). The CE's

Abbreviations: 2SLS, two-stage least squares; CCE, corporate circular economy; CCEI, corporate circular economy initiatives; CCEP, corporate circular economy performance; CCEPI, corporate circular economy performance incentives; CCER, circular collaborations/external relations; CDSE, circular design and service enhancement; CE, circular economy; CEMM, circular economy market mechanisms; CEO, chief executive officer; CERC, circular emission reduction commitments; CERE, circular energy and resource efficiency; CETM, circular environmental team management; CG, corporate governance; COP, circular organisational practices; CPSE, circular process and supply chain management; CSR, corporate social responsibility; CTA, circular technological advancement; EC, executive compensation; EU, European Union; EU-CEAP, European Union circular economy action plan; GDP, gross domestic product; GHG, greenhouse gas; GMM, generalised method of moments; RBV, resource-based view; SDGs, sustainable development goals.

growing prominence is driven by an imperative to address climate change and its capacity to deliver wide-ranging environmental, economic and social advantages (Adu et al. 2023; Ghisellini et al. 2016).

Despite this increasing focus on CE, there remains a significant research gap concerning how corporate governance (CG) mechanisms, particularly executive compensation (EC) and corporate CE performance incentives (CCEPI), can drive the adoption and success of CE initiatives (CCEI).

Existing literature emphasises the importance of innovative organisational–environmental interactions, highlighting the significance of closed-loop systems in sustainable production (Ghisellini et al. 2016; Zucchella and Previtali 2019). Other studies also suggest the need for strategic insights into CE implementation, including factors enabling or hindering the transition to circular business models and the significance of strategic supply chain collaborations (Ferasso et al. 2020; Geissdoerfer et al. 2018; Lewandowski 2016). However, there is a recognised gap in understanding the specific management skills and capabilities required for CE models (Hopkinson et al. 2018). In responding to this gap, scholars such as Orazalin et al. (2024) call for policymakers to design effective policies for achieving the long-term goal of carbon neutrality. However, CG mechanisms specifically incentives have received limited attention in this area. As a result, managers and policymakers looking to accelerate the transition to more sustainable business practices must understand which CG mechanisms can boost enterprises' commitment to creating and executing CE initiatives.

This study fills this gap by examining a global sample of non-financial listed firms in 50 countries from 2002 until 2022. The present study provides novel insights concerning the impact of EC on both CE emission initiatives and CE performance, particularly in reducing greenhouse gas (GHG) emissions. It also distinctively explores whether CE incentives moderate these relationships and the effect of CE emission initiatives on CE performance. By focusing on EC and incentives, this study addresses an emergent strand of management literature, offering fresh insights into how organisational leadership can be effectively motivated to implement and sustain CE initiatives.

This study contributes to existing literature in several ways. First, prior studies (Adu et al. 2022; Haque and Ntim 2020; Orazalin et al. 2024) have focused on the aggregate indexes related to environmental sustainability measures. Thus, the present study is one of the first to explore the effects of EC and CCEPI on various facets of corporate CE initiatives (CCEI) as well as the aggregate index.

Second, while prior studies (e.g., Berrone and Gomez-Mejia 2009; Deckop et al. 2006) have documented the positive relationship between EC and general environmental performance, they have often overlooked the specific impacts of integrating CE targets into compensation structures. Our findings show that CCEPI significantly influences the relationship between EC and CCEI, suggesting that integrating CE goals into compensation strengthens a firm's commitment to CCEI and enhances its CE capabilities. However, our research also reveals that CCEPI primarily incentivises executives to adopt measures that enhance firm legitimacy or image rather than leading to substantive improvements in CE performance (CCEP). This highlights the potential limitations of incentive-based CG mechanisms, making a unique contribution to the literature by distinguishing between symbolic adoption and substantive outcomes. This issue remains understudied in extant research.

Third, unlike previous studies that often focus on the immediate impact of sustainability practices (Adu et al. 2022; Haque and Ntim 2020), our findings provide new evidence concerningn the long-term effects of corporate CE initiatives. Despite the limited short-term impact of CCEPI on improving CCEP, the findings advocate for a persistent commitment to CCEI. In line with the resource-based view (RBV) and the concept of long-term resource utilisation, our results support the notion of a 'CE rebound'. This concept suggests that the strategic value of resources such as CCEI may not yield immediate returns but gradually builds over time, ultimately leading to sustained improvements in CCEP. This long-term perspective adds a critical new dimension to the literature, emphasising the cumulative benefits of consistent investments in CE initiatives, which has been underexplored in prior studies.

The rest of the paper is structured as follows: Section 2 outlines the theoretical framework and develops the research hypotheses. Section 3 presents a detailed review of the literature, followed by the research methodology in Section 4. Section 5 discusses the empirical results and key findings. Section 6 concludes with the study's contributions, limitations and suggestions for future research.

2 | Theoretical Framework

In examining the interrelationships among EC, CCEPI, CCEI and CCEP, we utilise a multi-theoretical framework including the RBV and legitimacy theories. The CE requires specialised capabilities, such as developing products for recycling and reuse or developing new business models aimed at reducing waste. The RBV posits that firms can achieve competitive edge through strategic management of their resources and distinct capabilities in that these resources are valuable and unique (Barney 1991). Resources such as innovative technologies, specialised knowledge and efficient supply chain management are critical in CE business model (Adu et al. 2023). The RBV predicts that when these capabilities are aligned with firm-specific resources, it can lead to both environmentally and economically valuable sustainable business practices (Wernerfelt 1984).

Firms that successfully incorporate CE principles into their business practices can then gain a competitive advantage and enhance the likelihood of achieving the Paris Agreement and SDGs. Transitioning to a CE model can be costly in terms of resources and may necessitate considerable changes in corporate procedures and capabilities. RBV presents a framework for understanding these difficulties, with an emphasis on strategic resource allocation to maximise efficiency and innovation (Barney 1991). From the standpoint of RBV, EC and CCEPI can be considered as strategic resources that aid in the creation and execution of CCEI. When integrated with CCEI objectives, EC becomes a unique resource that can propel CE practices

forward. The effective implementation of EC schemes and CCEPI can also increase a company's ability to adopt CCEI, contributing to improving CCEP. This is consistent with the RBV, which emphasises the development of distinct internal capabilities for long-term competitive advantage. Internal governance structures such as EC and CCEPI can be crucial in designing and implementing effective CCEI, hence improving CCEP (Barney 1991; Hart 1995).

Building on this foundation, Suchman (1995) highlights the pursuit of organisational legitimacy, emphasising the importance of aligning internal capabilities with external expectations and norms. Organisational legitimacy is a generalised perception that an organisation's actions are desirable, legitimate or appropriate within some socially formed system of norms, values, beliefs and definitions. The theory posits that firms constantly strive to function within the boundaries and norms of their respective societies. In the context of CE, this relates to how firms match their operations with the growing societal and environmental demands of sustainable practices. Firms are required to engage in environmentally responsible activities not only for ethical reasons but also to retain societal legitimacy (Deegan 2002; Suchman 1995). Firms undertake CE projects to achieve and retain credibility in the eyes of their stakeholders, which include consumers, investors, regulators and the general public. Firms that implement CE initiatives signify their commitment to international agreements and standards (like the Paris Agreement), which is rapidly becoming a criterion for legitimacy (Bansal and Clelland 2004). According to DiMaggio and Powell (1983), institutional forces such as coercive, symbolic and normative pressures may induce organisations to embrace sustainable practices, particularly those related with the CE, in order to gain legitimacy.

The CE can be viewed as a response to social calls for more environmentally friendly economic systems. Environmental disclosures, a crucial component of CE activities, are utilised by corporations to manage perceptions of legitimacy, according to Deegan (2002). This is particularly pertinent as stakeholders become more conscious of and concerned about environmental challenges. Thus, adoption of CE activities can be viewed as a legitimacy-seeking behaviour. Firms embrace reuse, recycle and reduce procedures to position themselves as environmentally responsible and innovative organisations in line with changing societal expectations (Murray et al. 2017). Additionally, companies employ CE concepts for ethical as well as strategic reasons in response to environmental concerns. In a world where resource depletion and climate change risk are major problems, this approach is considered as a way to legitimise their operations (Hart 1995). Empirical studies (Girschik 2020; Murray et al. 2017) have revealed that organisations that engage in CE strategies have an enhanced recognition and legitimacy. They are frequently viewed in a favourable light by stakeholders, which could result in a competitive edge (Lacy and Rutqvist 2015). In this study, we maintain that firms proactively pursue legitimacy by engaging in relational efforts. This involves dedicating resources to cultivate relationships with various stakeholders, thereby adjusting and redefining roles and responsibilities in the process. The study focuses on how firms employ narrative approaches to legitimise their social sustainability initiatives, such as CE practices and investments. The study further stresses the significance of aligning organisational practices with social norms in order to preserve legitimacy.

3 | Literature Review and Hypotheses Development

Given the variability in CG practices across countries, including EC and CCEPI, it is crucial to adopt an international data sample. Differences in regulatory frameworks, cultural values and business environments across nations can significantly affect how CG mechanisms influence CE strategies. By examining firms from multiple countries, this study captures the diversity in governance mechanisms and how they drive CE initiatives differently across varying contexts (Aguilera and Jackson 2010). Moreover, an international sample allows for cross-country comparability, revealing how national regulations and economic conditions shape the effectiveness of CG practices in promoting CE adoption. For example, countries with stricter environmental policies may see a stronger impact of EC and CCEPI on CE strategies, while firms in less regulated environments might show weaker engagement (Cahan et al. 2015). This approach enhances the generalisability of the findings and provides valuable insights for global firms and policymakers, making the study relevant across different markets (Ioannou and Serafeim 2012). Additionally, the influence of global supply chains, where multinational corporations must adhere to both local regulations and global stakeholder pressures, is captured effectively in an international context (Grewatsch and Kleindienst 2017).

3.1 | EC on Corporate CE (CCE)

According to legitimacy theory, high EC can be viewed as an organisation's commitment to supporting practices, such as CCEI, that enhance its societal legitimacy. The RBV further supports this perspective by suggesting that EC is a key resource that can be instrumental in engaging in CCEI (Berrone and Gomez-Mejia 2009). However, conflicting evidence exists in the literature regarding the effectiveness of EC in driving long-term CE efforts. For instance, Haque (2017) argues that executives often hesitate to initiate long-term projects aimed at reducing carbon emissions (i.e., improving CE performance, CCEP), primarily due to the significant capital investments required and the uncertainty of financial returns, especially in the short term.

In contrast, Melis et al. (2015) contend that firms with highly paid executives face heightened public and media scrutiny. Due to societal pressure, these firms may symbolically engage in environmental initiatives (CCEI) without necessarily achieving substantial improvements in environmental performance (Morrison et al. 2024). This symbolic engagement serves as a strategy to mitigate potential adverse media attention, thereby enhancing the firm's corporate reputation and legitimacy. This suggests that although EC may be associated with environmental initiatives, the motivation might often be limited to legitimization rather than substantive change.

Prior empirical studies have predominantly established a positive relationship between EC and environmental performance

(Adu et al. 2022; Haque and Ntim 2020; Ritz 2022). For example, Adu et al. (2022) find that both EC and CEO pay have a positive influence on sustainable business practices (CCEI) among UK firms. Similarly, Berrone and Gomez-Mejia (2009) report that CEO pay in US firms is positively associated with effective pollution prevention strategies (CCEI). However, it is important to recognise that these positive relationships are not universal. Haque (2017) and Melis et al. (2015) present contrasting viewpoints, indicating that while executives may be financially incentivised to engage in environmental practices, their actions may be primarily driven by image management rather than genuine improvements in corporate CE performance (CCEP).

Building on the aforementioned arguments, we propose that a higher degree of EC positively influences CE (CCE) capabilities, with a more pronounced effect on CCEI compared with CCEP. The premise is that higher EC levels reflect a greater commitment and resource allocation towards CCEI, which should translate into more effective and comprehensive CCEI implementation. However, we also acknowledge the possibility that this relationship may be influenced by the firm's intention to maintain societal legitimacy, rather than generating substantive improvements in CCEP. Therefore, we hypothesise as follows:

Hypothesis 1a. *EC has a positive impact on CCE, and this relationship is stronger for CCEI than CCEP.*

3.2 | Corporate Circular Economy Performance Incentives (CCEPI), Executive Compensation (EC) and Corporate Circular Economy (CCE)

The implementation of CCEPI has the potential to significantly influence corporate executives to engage in CCEI and carbon reduction activities, thereby enhancing organisational legitimacy (Adu et al. 2022). For instance, the Corporate Knights Global 100 ranking shows that some companies associate a substantial percentage of CEO incentive-based pay with ESG targets. Specifically, Iberdrola, a Spanish multinational electric utility, links 50% of its CEO's variable pay to ESG targets, in an effort to contribute to the net zero agenda (Corporate Knights 2023).

Previous studies have demonstrated that CCEPI play a crucial role in influencing the relationship between EC and environmental sustainability performance (Al-Shaer et al. 2023; Campbell et al. 2007; Radu and Smaili 2022). For instance, Bose et al. (2023) report that climate-linked compensation positively affects the adoption of climate strategies; however, its effect on actual carbon emissions is insignificant. This aligns with Haque and Ntim (2020), who argue that organisational leadership may use EC as a form of symbolic image management to gain legitimacy, rather than as a substantive strategy for enhancing efficiency. This suggests that while CCEPI can influence the adoption of environmental initiatives, they may not always lead to significant improvements in measurable environmental performance.

In contrast, other studies have provided evidence that CCEPI can drive substantive improvements in performance outcomes. For example, Al-Shaer et al. (2023) found that linking executive incentives directly to sustainability metrics can lead to significant gains in reducing emissions and resource efficiency, suggesting that EC can play an instrumental role beyond mere symbolism. However, these mixed findings indicate that the effectiveness of CCEPI may be highly context-dependent, influenced by factors such as firm culture, regulatory environment and the specific design of the incentive structure.

According to legitimacy theory, including CE objectives in compensation (CCEPI) boosts societal legitimacy, suggesting that firms aim to enhance their reputation through these incentives. On the other hand, the RBV suggests that CCEPI, as a strategic resource, can support EC to promote CCEI more effectively (Deckop et al. 2006). Overall, we posit that the moderating effect of CCEPI is more pronounced on the EC and CCEI nexus than on the relationship between EC and CCEP. This assumption is based on the notion that CCEPI, which are specifically designed to incentivise CE initiatives, are more likely to influence actions and decisions related to CCEI rather than delivering substantive performance outcomes (CCEP).

Accordingly, we hypothesise as follows:

Hypothesis 1b. *CCEPI has a positive moderating effect on CCE, and this effect is greater on the EC-CCEI relationship than on the EC-CCEP relationship.*

3.3 | Corporate Circular Economy Performance Incentives (CCEPI) on Corporate Circular Economy (CCE)

Prior empirical studies have demonstrated that CCEPI can moderate the relationship between EC and sustainability outcomes, suggesting that the inclusion of sustainability metrics in EC contracts is associated with improvements in these outcomes (Haque and Ntim 2020). Such compensation policies can incentivise executives to engage more actively in initiatives that promote CE practices, thus enhancing organisational legitimacy and potentially improving CCEP.

However, there are contrasting perspectives in the literature regarding the effectiveness of CCEPI. Some scholars argue that corporate boards might use CCEPI more as a symbolic tool for image management rather than as a substantive strategy for efficiency and actual performance improvement (Cordeiro and Sarkis 2008). This view posits that while CCEPI linked to sustainability targets might enhance process-based sustainability outcomes, they may not always lead to significant improvements in measurable performance metrics such as CCEP. For example, Bose et al. (2023) found that while climate-linked compensation improved executives' engagement in climate strategies, it did not lead to a meaningful reduction in carbon emissions, suggesting that the impact may be largely limited to symbolic initiatives.

In contrast, Al-Shaer et al. (2023) presented evidence suggesting that when CCEPI are effectively designed and embedded within long-term strategic objectives, they can lead to substantive gains in environmental performance, including reductions in emissions and enhancements in resource efficiency. This suggests that the context in which CCEPI are

implemented, such as the specificity of sustainability goals and the alignment of incentives with firm values, can significantly influence whether these incentives yield symbolic or substantive outcomes.

Furthermore, Haque and Ntim (2020) also noted that CCEPI can be implemented more effectively when supported by broader regulatory frameworks and stakeholder pressures that hold executives accountable for meeting sustainability targets. This reinforces the notion that while CCEPI have potential, their effectiveness can be limited without a supportive external environment that demands tangible results.

Given these contrasting perspectives and the empirical evidence available, we propose the following hypothesis:

Hypothesis 2. *CCEPI has a positive impact on CCE, and this relationship is greater for CCEI than CCEP.*

3.4 | Corporate Circular Economy Initiatives (CCEI) on Circular Economy Performance (CCEP)

There have been some suggestions that firms react to demands for carbon efficiency by initiating climate change and environmental initiatives that genuinely benefit the environment, or they might succumb to public pressure and engage in symbolic measures to protect their legitimacy (Adu et al. 2023). For instance, Haque and Ntim (2022) provide evidence supporting the efficiency view of legitimacy theory, which argues that firms address climate-related challenges through substantive involvement in sustainability initiatives. Such substantive involvement helps in reducing GHG emissions and enhancing overall carbon performance, suggesting that CE initiatives (CCEI) can effectively drive improvements in CCEP.

Conversely, conflicting evidence is also present in the literature. Orazalin et al. (2024) find a positive association between process-oriented climate change efforts and increased GHG emissions. This supports the symbolic legitimacy perspective, which suggests that firms might adopt process-oriented climate strategies primarily to create a favourable image among stakeholders and safeguard their legitimacy, rather than achieving real environmental benefits. This implies that while CCEI can be designed with the intent to improve sustainability performance, in practice, these efforts may sometimes be more about image management than genuine performance enhancement.

Further, Bose et al. (2023) reported that while many firms actively engage in sustainability initiatives, these efforts often lack the necessary strategic alignment to achieve substantive environmental gains. This suggests that the impact of CCEI on CCEP may depend heavily on how deeply these initiatives are integrated into a firm's core strategy. Firms that implement CCEI as a means to gain short-term legitimacy may not achieve significant reductions in emissions, contrasting with firms that embed sustainability into their operational practices for long-term resource efficiency.

According to the RBV, CCEI can have a positive impact on CCEP by enhancing the firm's sustainable practices and operational efficiency, thereby improving overall performance (Hart 1995; Lieder and Rashid 2016). However, the RBV also implies that the impact of CCEI on CCEP will be contingent upon the firm's ability to effectively leverage these initiatives as a valuable resource, rather than merely as a symbolic gesture.

Taken together, the theoretical arguments and conflicting empirical evidence suggest that while CE initiatives have the potential to drive substantive improvements in corporate performance, the actual impact may vary based on the firm's motivation and implementation approach. Firms that strategically integrate CCEI as part of their core operations are more likely to realise significant environmental performance benefits.

Hence, we hypothesise as follows:

Hypothesis 3a. *CCEI have a positive impact on CCEP.*

3.5 | Corporate Circular Economy Performance Incentives (CCEPI), Corporate Circular Economy Initiatives (CCEI) and Corporate Circular Economy Performance (CCEP)

Legitimacy theory suggests that CCEPI serve as tools to reflect a firm's commitment to prevailing social and environmental sustainability standards. This alignment can enhance the firm's perceived legitimacy in its CE practices (Haque and Ntim 2020; Suchman 1995). Integrating CCEPI with CCEI can lead to a more effective sustainability strategy, potentially improving overall CCEP. Furthermore, promoting CE practices enables firms to move beyond mere symbolic gestures to achieve substantial CE performance (Berrone and Gomez-Mejia 2009).

The RBV reinforces this perspective by suggesting that CCEPI can be an invaluable resource in bolstering the impact of CCEI on CCEP (Berrone and Gomez-Mejia 2009). In the context of CE practices, CCEI represents a strategic resource through which firms can enhance their sustainability efforts. In this case, the presence of CCEPI as a sustainability-based incentive aligns with the RBV's premise by providing a framework for integrating CE practices into the firm's broader strategic objectives.

However, conflicting evidence exists regarding the actual impact of CCEPI on performance outcomes. Some researchers argue that CCEPI may be implemented as symbolic measures aimed more at enhancing legitimacy rather than achieving genuine performance gains. For example, Cordeiro and Sarkis (2008) highlight that sustainability-based incentives are often used to appease external stakeholders without necessarily translating into meaningful improvements in firm performance metrics. This view suggests that while CCEPI might be strategically aligned with CCEI, their implementation may remain largely symbolic, limiting their effectiveness in delivering substantive CCEP gains.

Further evidence of delayed effects of sustainability-based incentives can be seen in the study by Derchi et al. (2021), who found that linking EC to corporate social responsibility (CSR) targets yields positive outcomes only in the third year, indicating

a significant, albeit delayed, impact on CSR performance. This delayed effect suggests that the interaction between CCEPI and CCEI may not lead to immediate improvements in CCEP but could have a gradual and cumulative impact over time. Such findings indicate that while the RBV suggests CCEPI can enhance CCEI's impact, the timeline and actual efficacy of these improvements may vary significantly.

On the other hand, empirical evidence from Al-Shaer et al. (2023) shows that under certain conditions, where incentives are effectively designed and closely aligned with strategic sustainability goals, CCEPI can indeed lead to substantial improvements in CCEP. This suggests that the success of these incentives may depend significantly on their design, implementation context and the degree of alignment with firm-level strategic priorities.

Taken together, these perspectives highlight that while CCEPI and CCEI have the potential to create synergies that improve CCEP, the actual realisation of these benefits may depend on whether the incentives are implemented substantively or merely symbolically. The interaction between CCEPI and CCEI, as posited by the RBV, indicates that when incentives are strategically aligned with CE initiatives, they can lead to more effective implementation and tangible sustainability outcomes.

Thus, based on both RBV and legitimacy theoretical perspectives and supported by prior empirical evidence, we propose the following hypothesis:

Hypothesis 3b. *CCEPI moderates the association between CCEI and CCEP.*

Figure 1 presents the conceptual framework and hypotheses outlined in this study.

4 | Methodology

4.1 | Data and Sample Selection

We concentrate on all firms in the world with the required data available from 2002 to 2022.[1] Based on available data in the Refinitiv Workspace database, the initial sample consisted of 63 industrialised countries. Further, the sample was then sorted as follows: (1) due to varied regulatory systems, accounting requirements and governance structures of financial organisations, the sample was limited to only non-financial organisations (Haque and Ntim 2020; Orazalin et al. 2024); (2) only firms with data on each of EC, CCEI, CCEP and CCEPI for at least five consecutive years were then retained[2] to obtain 1970 firms; (3) firm-level control variables such as firm size, board size, CEO-chair duality and leverage were then obtained from the Refinitiv Workspace database; (4) The Worldwide Governance Indicators by Kaufmann et al. (2011) were employed to gather data on country governance metrics, and The World Bank database was used to procure information on GDP growth rates and inflation, representing macroeconomic factors (World Bank 2020), serving as country-level

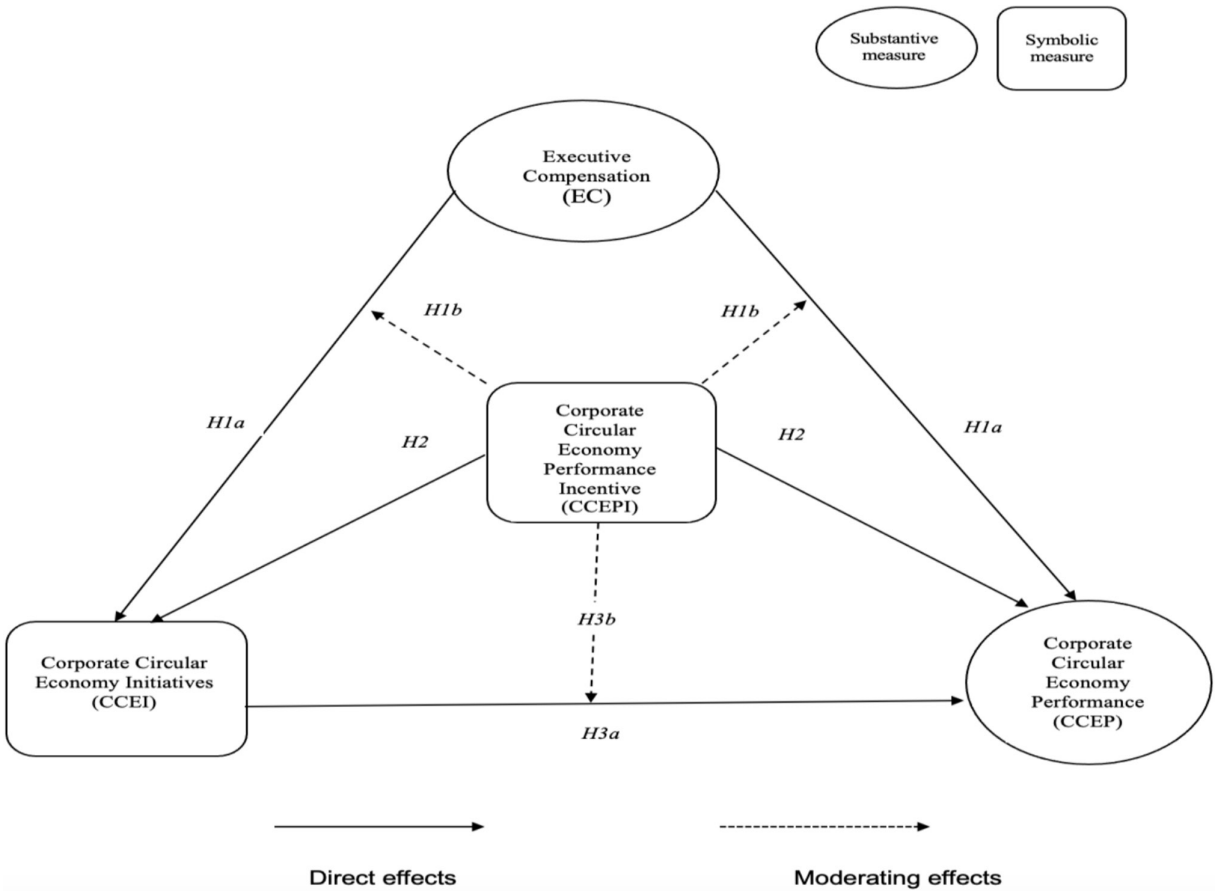

FIGURE 1 | Conceptual framework.

control variables. The final dataset includes 1970 firms across 67 sectors, amounting to 41,370 firm-year observations. Table S1 (Supporting information) illustrates the distribution of the sample across countries. As expected, carbon-intensive industries like mining and oil, metals and consumable fuels are predominant in the sample, representing 7.26% and 6.55%, respectively, whereas healthcare technology has the lowest presence at 0.05%.

When conducting research using international data, several potential limitations must be addressed to ensure the validity and generalisability of the findings. One key limitation is the inconsistency in data availability across countries, particularly between developed and developing nations, which may result in incomplete reporting. To address this, multiple imputation techniques were employed to handle missing data, and robustness checks were conducted to ensure consistency across different datasets (Rubin 1987; Schafer and Graham 2002). Another limitation is the reliance on GHG emissions as a measure of CCEP, which may not fully capture all aspects of CE practices. This was mitigated by incorporating an index of CCEI to provide a more comprehensive view (Lieder and Rashid 2016). Furthermore, concerns regarding endogeneity, such as reverse causality between EC and CE performance, were addressed using two-stage least squares (2SLS) regression models with instrumental variables (Wooldridge 2010). Cross-country comparability poses another challenge, given differences in governance structures and regulatory environments; this was handled by including country-level control variables (e.g., GDP growth, inflation) and employing fixed-effects models to account for unobservable heterogeneity (Ioannou and Serafeim 2012). Lastly, the time-lag between implementing CE initiatives and seeing measurable performance outcomes was accounted for by using a longitudinal dataset covering multiple years, although future research should consider longer-term studies to fully capture these effects (Porter and Van der Linde 1995). These strategies ensure that the limitations of the dataset are addressed, providing robust and reliable results.

4.2 | Model Specifications

The following models are employed to examine the effects of among EC, CCEPI, CCEP and the moderating effects of CCEPI. Model (1) examines the effects of EC and CCEPI on CCEI[3] and the moderating effect of CCEPI on the EC-CCEI relationship.

$$\begin{aligned}\mathrm{CCEI}_{it} = {} & \alpha_0 + \beta_1 * \mathrm{EC}_{it} + \beta_2 * \mathrm{CCEPI}_{it} + \beta_3 * \left(\mathrm{EC}_{it} * \mathrm{CCEPI}_{it}\right) \\ & + \beta_4 * \mathrm{NBMEET}_{it} + \beta_5 * \mathrm{BSIZE}_{it} + \beta_6 * \mathrm{BINDE}_{it} + \beta_7 * \mathrm{BGEND}_{it} \\ & + \beta_8 * \mathrm{CEOCD}_{it} + \beta_9 * \mathrm{CSIZE}_{it} + \beta_{10} * \mathrm{PROFT}_{it} + \beta_{11} * \mathrm{LEVE}_{it} \\ & + \beta_{12} * \mathrm{CASHR}_{it} + \beta_{13} * \mathrm{CAPIN}_{it} + \beta_{14} * \mathrm{GDPG}_{kt} \\ & + \beta_{15} * \mathrm{INFR}_{kt} + \beta_{16} * \mathrm{QCG}_{kt} + \gamma_i + \mu_t + \varepsilon_{it} \end{aligned} \quad (1)$$

Model (2) examines the effects of EC and CCEPI on CCEP and the moderating effect of CCEPI on the EC-CCEP relationship. Model (3) then examines the effects of CCEI and CCEPI on CCEP and the moderating effect of CCEPI on the CCEI-CCEP relationship.

$$\begin{aligned}\mathrm{CCEP}_{it} = {} & \alpha_0 + \beta_1 * \mathrm{EC}_{it} + \beta_2 * \mathrm{CCEPI}_{it} + \beta_3 * \left(\mathrm{EC}_{it} * \mathrm{CCEPI}_{it}\right) \\ & + \beta_4 * \mathrm{NBMEET}_{it} + \beta_5 * \mathrm{BSIZE}_{it} + \beta_6 * \mathrm{BINDE}_{it} + \beta_7 * \mathrm{BGEND}_{it} \\ & + \beta_8 * \mathrm{CEOCD}_{it} + \beta_9 * \mathrm{CSIZE}_{it} + \beta_{10} * \mathrm{PROFT}_{it} + \beta_{11} * \mathrm{LEVE}_{it} \\ & + \beta_{12} * \mathrm{CASHR}_{it} + \beta_{13} * \mathrm{CAPIN}_{it} + \beta_{14} * \mathrm{GDPG}_{kt} + \beta_{15} * \mathrm{INFR}_{kt} \\ & + \beta_{16} * \mathrm{QCG}_{kt} + \gamma_i + \mu_t + \varepsilon_{it} \end{aligned} \quad (2)$$

where CCEIs represents both the aggregate index (CCEI) and the sub-indexes (CERC, CERE, CDSE, CPSE, CETM, COP, CTA, CEMM and CCER), respectively.

i and t represent company and year, respectively.β represents the estimate of each independent variable on the dependent variable.

$$\begin{aligned}\mathrm{CCEP}_{it} = {} & \alpha_0 + \beta_1 * \mathrm{CCEIs}_{it} + \beta_2 * \mathrm{CCEPI}_{it} + \beta_3 * \left(\mathrm{CCEIs}_{it} * \mathrm{CCEPI}_{it}\right) \\ & + \beta_4\, \mathrm{NBMEET}_{it} + \beta_5 * \mathrm{BSIZE}_{it} + \beta_6 * \mathrm{BINDE}_{it} + \beta_7 * \mathrm{BGEND}_{it} \\ & + \beta_8 * \mathrm{CEOCD}_{it} + \beta_9 * \mathrm{CSIZE}_{it} + \beta_{10} * \mathrm{PROFT}_{it} + \beta_{11} * \mathrm{LEVE}_{it} \\ & + \beta_{12} * \mathrm{CASHR}_{it} + \beta_{13} * \mathrm{CAPIN}_{it} + \beta_{14} * \mathrm{GDPG}_{kt} + \beta_{15} * \mathrm{INFR}_{kt} \\ & + \beta_{16} * \mathrm{QCG}_{kt} + \gamma_i + \mu_t + \varepsilon_{it} \end{aligned} \quad (3)$$

γ_i and μ_t represent the company fixed effects and year fixed effects, respectively.

EC*CCEPI and CCEI*CCEPI represent the interaction terms between EC and CCEPI, and CCEI and CCEPI, respectively. All the variables are defined in Table 1.

4.3 | Main Variables

Adoption of CE practices involves engagement in a variety of initiatives that companies engage in to adjust and enhance their production methods, material consumption, waste handling and additional practices to adhere to the reduction, reuse and recycle principles (Nechifor et al. 2020). In line with CE processes defined in the EU CE Plan 2020, we develop an aggregate index adjusted for sector specifics and weighted based on 40 unique CCEI, where higher CCEI values indicate increased advocacy for CCE (Orazalin et al. 2024; Giannarakis et al. 2017). However, this study conducts further analyses in the different facets of the CCEI for a more thorough analysis which are fully detailed in Table 1. This CE model is characterised by its production features: low consumption, low emissions and high efficiency (Howard et al. 2019). In addition, in May 2023, the EU revised the CE monitoring framework which also includes GHG emissions from production activities (EU Commission 2023). Therefore, we utilise the natural logarithm of total GHG emissions, including Scope 1 and Scope 2 emissions in tonnes to measure CCEP (Adu et al. 2022; Orazalin et al. 2024). Consistent with prior studies (Adu et al. 2022; Haque and Ntim 2020), this study utilises the natural logarithm of the total fixed and variable compensation awarded to senior executives, as disclosed by the firms, as a measure of EC. Further, CCEPI is measured as a binary variable, with 1 indicating that a firm has integrated CE-related performance targets into EC and 0 otherwise. This measure is important because it captures whether firms are aligning executive incentives with sustainability goals

TABLE 1 | Variable definitions.

Variable	Symbols	Details (see Supporting Information for further details on the derivation of the various indices)	Source
Corporate circular economy initiatives	CCEI	This aggregate index represents a sector-adjusted weighted average, derived from 40 specific corporate-level elements pertinent to circular economy initiatives and practices. Its scale extends from 0 (*indicating an absence of CCEI*) to 40 (*signifying fully implemented CCEI*).	Refinitiv Workspace
Circular emission reduction commitments	CERC	The index represents a sector-adjusted weighted average, derived from nine specific corporate-level elements (refer to Supporting Information) pertinent to circular economy emission reduction commitments. Its scale extends from 0 (*indicating an absence of CERC*) to 9 (*signifying fully implemented CERC*).	Refinitiv Workspace
Circular energy and resource efficiency	CERE	The index represents a sector-adjusted weighted average, derived from eight specific corporate-level elements (refer to Supporting Information) pertinent to circular energy and resource efficiency. Its scale extends from 0 (*indicating an absence of CERE*) to 8 (*signifying fully implemented CERE*).	Refinitiv Workspace
Circular design and service enhancement	CDSE	The index represents a sector-adjusted weighted average, derived from nine specific corporate-level elements (refer to Supporting Information) pertinent to circular design and service enhancement. Its scale extends from 0 (*indicating an absence of CDSE*) to 9 (*signifying fully implemented CDSE*).	Refinitiv Workspace
Circular process and supply chain management	CPSE	The index represents a sector-adjusted weighted average, derived from three specific corporate-level elements (refer to Supporting Information) pertinent to circular process and supply chain management. Its scale extends from 0 (*indicating an absence of CPSE*) to 3 (*signifying fully implemented CPSE*).	Refinitiv Workspace
Circular environmental team management	CETM	The index represents a sector-adjusted weighted average, derived from two specific corporate-level elements (refer to Supporting Information) pertinent to circular environmental team management. Its scale extends from 0 (*indicating an absence of CETM*) to 2 (*signifying fully implemented CETM*).	Refinitiv Workspace
Circular organisational practices	COP	The index represents a sector-adjusted weighted average, derived from three specific corporate-level elements (refer to Supporting Information) pertinent to circular organisational practices. Its scale extends from 0 (*indicating an absence of COP*) to 3 (*signifying fully implemented COP*).	Refinitiv Workspace
Circular technological advancement	CTA	The index represents a sector-adjusted weighted average, derived from three specific corporate-level elements (refer to Supporting Information) pertinent to circular technological advancement. Its scale extends from 0 (*indicating an absence of CTA*) to 3 (*signifying fully implemented CTA*).	Refinitiv Workspace

(Continues)

TABLE 1 | (Continued)

Variable	Symbols	Details (see Supporting Information for further details on the derivation of the various indices)	Source
Circular economy market mechanisms	CEMM	The index represents a sector-adjusted weighted average, derived from two specific corporate-level elements (refer to Supporting Information) pertinent to circular economy market mechanisms. Its scale extends from 0 (*indicating an absence of CEMM*) to 2 (*signifying fully implemented CEMM*).	Refinitiv Workspace
Circular collaborations/external relations	CCER	The index represents a sector-adjusted weighted average, derived from one specific corporate-level elements (refer to Supporting Information) pertinent to circular collaborations/external relations. Its scale consists of 0 (*indicating an absence of CCER*) or 1 (*signifying fully implemented CCER*).	Refinitiv Workspace
Corporate circular economy performance	CCEP	The natural logarithm of total GHG emissions, encompassing both Scope 1 (direct emissions from sources that are owned or controlled by the company) and Scope 2 consists of indirect emissions stemming from the use of purchased electricity, cooling, heat, steam and similar sources in tonnes. Higher positive values of CCEP higher levels of GHG emissions, implying a weaker CCEP, while lower values suggest the otherwise.	Refinitiv Workspace
Corporate circular economy performance incentive	CCEPI	A binary variable is used, set to 1 if the firm incorporates corporate circular economy performance incentives, and 0 in the absence of such incentives.	Refinitiv Workspace
Executive compensation	EC	The natural logarithm of the aggregate fixed and variable remuneration disbursed to all senior executives, reported in USD. The fixed component encompasses the base salary and additional non-monetary benefits, including housing, healthcare and transportation. The variable component encompasses bonuses and other long-term incentive schemes, such as equity ownership and extended share options.	Refinitiv Workspace
Corporate governance variables			
Number of board meetings	NBMEET	The natural logarithm of the number of board meetings during the year	Refinitiv Workspace
Board size	BSIZE	The natural logarithm of the total number of board directors at the end of the fiscal year	Refinitiv Workspace
Board independence	BINDE	The percentage of independent directors on the board	Refinitiv Workspace
Board gender diversity	BGEND	The percentage of female directors on the board	Refinitiv Workspace
CEO chairman duality	CEOCD	A binary variable is applied, where it is assigned a value of 1 when the CEO and the board chair are distinct individuals, and 0 in cases where they are the same person.	Refinitiv Workspace
Company-level control variables			
Company size	CSIZE	The natural logarithm of total assets	Refinitiv Workspace

(Continues)

TABLE 1 | (Continued)

Variable	Symbols	Details (see Supporting Information for further details on the derivation of the various indices)	Source
Profitability	PROFT	Net income divided by total assets	Refinitiv Workspace
Leverage	LEVE	Total debt divided by total assets	Refinitiv Workspace
Cash rate	CASHR	Cash and cash equivalents divided by total assets	Refinitiv Workspace
Capital intensity	CAPIN	Property, plant and equipment divided by total assets	Refinitiv Workspace
Country-level variables			
Quality of country governance	QCG	A composite index constructed to represent country governance quality. Computed based on CG factors including regulatory quality, rule of law, government effectiveness and political stability. This metric ranges between 0 (*poor governance quality*) and 1 (*highest possible level of governance excellence*).	Worldwide Governance Indicators
GDP growth rate	GDP	The total value of production, which includes gross value added by resident producers, product taxes and subtracts subsidies not counted in product values.	World Bank
Inflation rates	INF	The yearly percentage shift in the prices of goods and services, which can either remain constant or fluctuate within the year.	World Bank

(Cordeiro and Sarkis 2008). The rationale for selecting these variables is rooted in prior literature that identifies EC and performance incentives as key mechanisms for influencing strategic environmental decisions (Berrone and Gomez-Mejia 2009). Additionally, using firm-level CE initiatives and GHG emissions as measures of CE performance allows for a concrete assessment of both process-based and outcome-based aspects of sustainability, providing a holistic view of corporate CE efforts (Haque and Ntim 2020).

4.4 | Control Variables

To address the potential influence of different country- and firm-specific attributes on CCEP, this study employs a range of control variables. In keeping with similar research (e.g., Orazalin et al. 2024), we include various CG characteristics such as board size, board independence and CEO-chairman duality. Furthermore, following previous research (Adu et al. 2022; Siddique et al. 2021), we employ firm-level control variables such as firm size, leverage, capital intensity and profitability. Finally, country governance metrics and macroeconomic factors, like GDP growth and inflation rate, are employed as control variables, as applied by prior studies (Marin and Vona 2021).

4.5 | Descriptive Statistics

Table 2 presents an overview of the statistics for all variables. CCEI ranges from 0 to 37, with an average value of 10. CCEP varies between 2.71 and 21.79, with an average of 15.49 and a standard deviation of 2.43. In addition, about 20% of firms have a portion of their senior executives' compensation tied to CE goals. In line with other studies, the pairwise correlation coefficients in Table 3 show a positive correlation between CCEP, CCEI and EC (Adu et al. 2022; Haque and Ntim 2020). The correlation coefficients among the independent variables do not exceed 0.80, implying minimal multicollinearity concerns (Shrestha 2020).[4]

Moving on, Figures 2 and 3 display the annual distribution of GHG emissions and CCEI from 2002 to 2022, respectively. The average annual GHG emissions in Figure 2 demonstrates a rising trend from 2002 until 2018, followed by a period of stabilisation from 2018 to 2020, then a marked increase in 2021 and a return to previous levels in 2022.

In addition, Figure 3 reveals a steady and consistent rise in CCEI throughout the entire period from 2002 to 2022, aligning with findings from similar research (Haque 2017; Orazalin et al. 2024).

5 | Empirical Results and Discussion

5.1 | Excutive Compensation (EC) and Corporate Circular Economy Performance Incentives (CCEPI) on Corporate Circular Economy Initiatives (CCEI)

Table 4 presents the results of Equation (1). The findings show that EC has a positively significant effect on CCEI indicating an increase in EC is associated with high level of CCEI

TABLE 2 | Descriptive statistics.

Variables	Observations	Mean	Standard dev.	Minimum	Maximum
CCEP (ln)	41,370	12.86	2.43	2.71	21.79
EC (ln)	41,370	15.49	1.32	4.18	24.41
CCEI	41,370	10.68	9.74	0.00	37.00
CCEPI	29,741	0.20	0.40	0.00	1.00
BMEET (ln)	23,821	2.17	0.47	0.00	5.04
BSIZE (ln)	29,620	2.31	0.35	0.00	3.66
BIND (%)	27,123	48.87	25.83	0.00	100.00
BGEN (%)	27,123	48.87	25.83	0.00	100.00
CEOCD	29,741	0.29	0.45	0.00	1.00
FSIZE (ln)	38,975	22.27	1.58	6.06	28.04
PROFT (%)	38,975	0.05	0.30	−34.45	17.42
LEVE (%)	38,975	0.11	7.25	0.00	1109.76
CASHR (ratio)	38,975	0.10	0.10	−0.15	1.03
CAPIN (ratio)	38,975	0.39	6.27	−379.65	681.69
QCG (%)	41,730	0.67	0.20	0.00	0.89
GDP (%)	38,846	426.02	258.57	1.00	958.00
INF (%)	39,400	8.31	11.83	−4.48	49.00

($p < 0.01$). This evidence supports Hypothesis 1a, confirming that incentivising top management through high compensation can positively influence corporate executives' commitment to CE practices (Mahoney and Thorne 2005; Deckop et al. 2006). The results also reveal a positive relationship between CCEPI and CCEI ($p < 0.01$). This suggests that implementing incentives geared towards CE leads to more effective CE practices, supporting H3a. This evidence corroborates the findings of prior studies, which report that such incentives are effective channels for advancing corporate environmental engagements (Adu et al. 2022; Berrone and Gomez-Mejia 2009). Moreover, the moderator CCEPI has a significant influence on the EC-CCEI relationship ($p < 0.01$), implying an increased commitment to undertake CE practices when CE targets are integrated into compensation schemes (Berrone and Gomez-Mejia 2009; Deckop et al. 2006). Thus, Hypothesis 1b is accepted.

Tables 5–7 then presents the results of EC, CCEPI and EC*CCEPI on the nine various facets of the CCEI. The results show that an increase in EC is associated with an increase in the levels of the individual components of the CCEI, including, circular emission reduction commitments (CERC), circular energy and resource efficiency (CERE), circular design and service enhancement (CDSE), circular process and supply chain management (CPSE) ($p < 0.01$). In addition, the estimated results reveal that EC has positive effect on circular environmental team management (CETM), circular organisational practices (COP), circular technological advancement (CTA) and circular collaborations/external relations (CCER) ($p < 0.01$). This implies that well compensated executives are more inclined to invest in long-term circular practices (Edmans 2011), supporting Hypothesis 1a. By contrast, the results show that EC has no influence on CE market mechanisms (CEMM). This evidence implies that the CEMM is distinct in that it might be influenced more by market and regulatory factors than by internal EC structures. This is consistent with Margolis and Walsh (2003) who suggested that the impact of CSR efforts may not necessarily be directly influenced by internal corporate policies.

The results in Table 6 also indicate that an increase in CCEPI is linked to positive changes in all the various facets of CCEI ($p < 0.01$ for CERC, CERE, CDSE, CPSE, CETM, COP, CTA and CCER; $p < 0.05$ for CEMM). Further, the results in Table 8 also show that CCEPI moderates the relationship between EC and the various facets of CCEI ($p < 0.01$ for CERC, CERE, CDSE, CPSE, CETM, COP, CTA and CCER; $p < 0.05$ for CEMM). In supporting Hypothesis 1a, this evidence suggests that performance-related incentives can encourage corporate practices such as CCEI (Zhou et al. 2022; Dow and Raposo 2005). This is consistent with literature, which demonstrates the effectiveness of integrating sustainability incentives into EC structures to enhance corporate performance and the attainment of the SDGs (Abdelmotaal and Abdel-Kader 2016). This lends credence to the notion that well-designed incentive policy can effectively drive environmental programmes including the achievement of the Paris Agreement and SDGs (Adu et al. 2022; Indjejikian 1999).

TABLE 3 | Correlation matrix.

Variables	CCEP	EC	CCEP	CCEPI	BMEET	BSIZE	BIND	BGEN	CEOCD	CASHR	LEVE	PROFT	CAPIN	GDPG	INF	QCG
CCEP	1.00															
EC	0.13**	1.00														
CCEP	0.32**	0.22**	1.00													
CCEPI	0.03**	0.19**	0.18**	1.00												
BMEET	0.06**	−0.01	0.13**	0.04**	1.00											
BSIZE	0.29**	0.18**	0.23**	−0.02**	−0.06**	1.00										
BIND	−0.03**	0.19**	0.05**	0.30**	−0.03**	−0.22**	1.00									
BGEN	−0.13**	0.16**	0.21**	0.32**	0.02**	−0.03**	0.38**	1.00								
CEOCD	0.03**	0.03**	0.04**	−0.08**	−0.04**	0.09**	−0.12**	−0.11**	1.00							
CAHR	−0.19**	−0.04**	−0.04**	−0.09**	0.01	−0.07**	−0.15**	−0.10**	0.08**	1.00						
LEVE	0.01*	−0.004	0.01	−0.003	0.004	−0.01	0.012*	0.01	−0.01	0.001	1.00					
PROFT	−0.05**	−0.01	−0.01	0.001	−0.05**	−0.004	0.01	−0.02**	0.01	0.05**	0.13**	1.00				
CAPIN	0.42**	−0.01	−0.01*	0.01	−0.001	−0.01	0.01	−0.0002	−0.001	−0.02**	−0.0003	0.0002	1.00			
GDPG	0.04**	−0.13**	−0.19**	−0.05**	−0.12**	−0.05**	−0.03**	−0.05**	−0.02**	0.01	0.001	0.03**	0.01**	1.00		
INF	0.03**	−0.01	−0.36**	0.03**	−0.04**	−0.03**	0.11**	0.50**	−0.10**	−0.04**	−0.01	0.02**	0.02**	0.33**	1.00	
QCG	−0.05**	0.10**	−0.14**	−0.08**	−0.03**	−0.05**	0.001	−0.11**	0.02**	0.02**	−0.001	−0.002	0.0001	−0.24**	−0.26**	1.00

Note: Statistically significant at the ** 0.01 level; * 0.05 level (2-tailed).

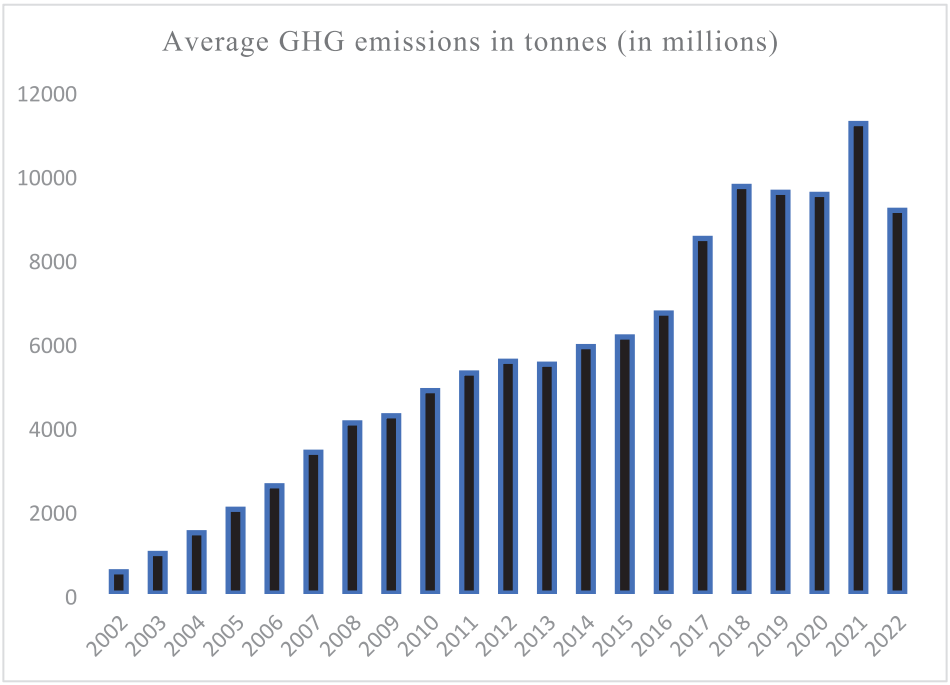

FIGURE 2 | Average GHG emissions in tonnes (millions) by year. *Source:* Authors' construct based on data obtained from Refintiv Eikon.

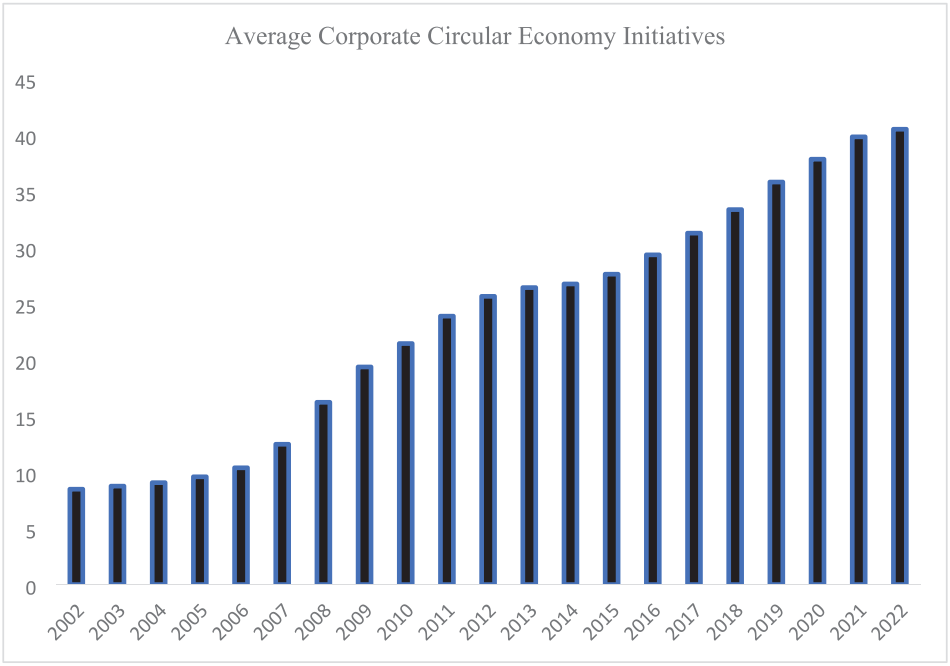

FIGURE 3 | Average corporate circular economy incentives by year. *Source:* Authors' construct based on data obtained from Refintiv Eikon.

5.2 | Impact of Executive Compensation (EC) and Corporate Circular Economy Performance Incentive (CCEPI) on Corporate Circular Economy Performance (CCEP)

In contrast to the results in Tables 4–7, those in Table 8 show that EC, CCEPI and their interaction (EC*CCEPI) have an insignificant impact on CCEP. These findings indicate that firms tend to implement process-oriented CE initiatives (CCEI) primarily to enhance their public image (Adu et al. 2022; Haque and Ntim 2020; Orazalin et al. 2024). This is consistent with the legitimization view, suggesting that incentive-based CG tools such as EC and CCEPI are more likely to promote symbolic rather than substantive improvements in CE performance. Consequently, Hypothesis 1a, which posited that EC would have a positive impact on both CCEI and CCEP with a stronger effect on CCEI, is only partially supported. Furthermore, Hypothesis 2, which proposed that CCEPI would have a greater positive impact on CCEI than on CCEP, is also partially supported, as the results show significant effects for CCEI but not for CCEP.

TABLE 4 | Impact of executive compensation and corporate circular economy performance incentive on corporate circular economy initiatives.

Models	(1) CCEI	(2) CCEI	(3) CCEI
EC	0.406***		
	(6.33)		
CCEPI		1.247***	
		(8.61)	
EC*CCEPI			0.074***
			(7.75)
NBMEET	0.810***	0.741***	0.773***
	(3.95)	(3.87)	(3.77)
BSIZE	−0.802**	−0.657**	−0.763**
	(−2.07)	(−1.99)	(−1.97)
BINDE	0.021***	0.028***	0.020***
	(4.25)	(6.35)	(4.06)
BGEND	0.127***	0.129***	0.122***
	(4.79)	(5.36)	(4.90)
CEOCD	0.657***	0.375**	0.661***
	(3.06)	(2.03)	(3.08)
CSIZE	2.277***	2.615***	2.310***
	(5.52)	(7.28)	(5.86)
PROFT	−0.269	−0.401*	−0.263
	(−0.89)	(−1.84)	(−0.87)
LEVE	0.006	0.009	0.006
	(0.90)	(1.36)	(0.94)
CASHR	1.740	1.813*	1.497
	(1.61)	(1.82)	(1.39)
CAPIN	0.014	0.018	0.013
	(0.72)	(0.63)	(0.69)
GDPG	−0.001***	−0.001***	−0.001***
	(−3.60)	(−4.75)	(−3.61)
INFR	−0.038***	−0.052***	−0.040***
	(−4.70)	(−7.04)	(−4.91)
QCG	−2.371	7.383***	−1.420
	(−0.79)	(3.74)	(−0.47)
Constant	−44.374***	−53.174***	−39.607***
	(−6.07)	(−4.64)	(−5.91)
Country effects	Fixed	Fixed	Fixed
Industry effects	Fixed	Fixed	Fixed
Year effects	Fixed	Fixed	Fixed
Observations	41,370	41,370	41,370
R-squared	0.410	0.415	0.411

Note: This table presents the estimation results for the fixed effect regression of executive compensation, corporate circular economy performance incentives on the corporate circular economy initiatives. All variables are defined and measured in Table 1. *t*-statistics estimated using robust standard errors are reported in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

5.3 | Impact of Corporate Circular Economy Initiatives (CCEI) on Corporate Circular Economy Performance (CCEP)

The results in Table 9 reveal that the individual dimensions of CCEI have significant negative coefficients, which indicates a positive impact on CCEP (low GHG emissions). This finding is consistent with the literature highlighting the positive effects of CE practices, such as increased resource efficiency, cost savings and enhanced sustainability profiles. Thus, Hypothesis 3a which posits that CCEI has a positive impact on CCEP, is accepted.

The results in Table 9 also show that CCEPI has a positive moderating impact on the relationships between CERC, CERE, CDSE, CETM, CEMM, CER and CCEP. By contrast, CCEPI does not moderate the relationship between CPSE, COP, CTA and CCEP. This finding suggests that the effectiveness of CCEPI in encouraging participation in CPSE, COP and CTA is limited by the complexity of CE practices, the influence of external institutional pressures, the need for broader business model and supply chain innovations and the moderating role of technological factors such as big data. For instance, companies may be motivated to engage in CTA by the need for innovation in response to environmental challenges and economic growth (Jia et al. 2020). The adoption of Industry 4.0 technologies can also enable CPSE, resulting in increased efficiency and traceability, which can indirectly support CTA (Mastos et al. 2021). Further, the impact of institutional pressures on supply chain relationship management and CE capability implies that external factors such as regulatory and normative pressures may have a greater influence on the adoption of CPSE than internal incentives such as CCEPI (Zeng et al. 2017). Hypothesis 3b, which posits that CCEPI moderates the association between CCEI and CCEP, is partially accepted based on these findings.

Notwithstanding the positive impacts of the individual facets of CCEI on CCEP, the results in Table 8 show that the aggregate CCEI has a positive coefficient, indicating a negative impact on CCEP ($p < 0.01$); however, $CCEI_{t-7}$ has a negative coefficient. The initial negative impact of CCEI on CCEP could be due to short-term barriers such as the capital required for implementing CE practices, operational delays or the duration required for personnel and

TABLE 5 | Impact of executive compensation on the various facets of corporate circular economy initiatives.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Models	**CERC**	**CERE**	**CDSE**	**CPSE**	**CETM**	**COP**	**CTA**	**CEMM**	**CCER**
EC	0.331***	0.292***	0.239***	0.108***	0.057***	0.061***	0.054***	0.005	0.029***
	(7.08)	(3.01)	(4.61)	(3.65)	(9.07)	(7.45)	(7.26)	(1.12)	(8.03)
NBMEET	0.317**	0.131*	0.063	0.048*	0.009	0.052**	0.044*	0.023	0.028**
	(2.12)	(1.83)	(1.04)	(1.76)	(0.46)	(1.99)	(1.87)	(1.58)	(2.44)
BSIZE	0.983***	0.781***	0.823***	0.320***	0.202***	0.091*	0.200***	0.050*	0.049**
	(3.48)	(5.76)	(7.19)	(6.21)	(5.34)	(1.85)	(4.48)	(1.79)	(2.23)
BINDE	−0.013***	−0.010***	−0.011***	−0.006***	−0.003***	−0.003***	−0.002***	0.0003	−0.001***
	(−3.61)	(−5.87)	(−7.74)	(−8.65)	(−6.11)	(−5.08)	(−3.00)	(0.74)	(−4.37)
BGEND	−0.093***	−0.081***	−0.076***	−0.033***	−0.015***	−0.021***	−0.022***	−0.007***	−0.011***
	(−20.84)	(−38.11)	(−42.34)	(−40.86)	(−25.32)	(−26.93)	(−30.70)	(−15.21)	(−32.20)
CEOCD	−0.029*	−0.049	0.040	0.008	−0.013	0.091***	−0.004	−0.004	0.020
	(−1.82)	(−0.66)	(0.63)	(0.28)	(−0.63)	(3.34)	(−0.15)	(−0.29)	(1.63)
CSIZE	−1.240***	−0.611***	−0.545***	−0.167***	−0.143***	−0.087***	−0.116***	−0.038***	−0.043***
	(−11.56)	(−11.94)	(−12.58)	(−8.54)	(−9.97)	(−4.67)	(−6.87)	(−3.57)	(−5.23)
PROFT	−0.203	−0.135	−0.120	−0.074*	−0.017	−0.008	−0.082**	−0.019	−0.015
	(−0.93)	(−1.28)	(−1.35)	(−1.84)	(−0.56)	(−0.21)	(−2.35)	(−0.87)	(−0.90)
LEVE	−0.006	−0.003	−0.003	−0.001	−0.001	−0.001	−0.0002	−0.0001	−0.002
	(−1.08)	(0.202)	(−1.32)	(−0.81)	(−1.09)	(−0.79)	(−0.22)	(−0.18)	(−0.53)
CASHR	0.728	0.324	0.551	−0.093	0.185*	0.033	0.031	−0.098	0.021
	(0.93)	(0.86)	(0.08)	(−0.64)	(1.75)	(0.24)	(0.25)	(−1.25)	(0.34)
CAPIN	−0.006	0.007	−0.008	−0.002	−0.003*	0.002	0.001	0.0001	0.001
	(−0.42)	(1.09)	(−1.59)	(−0.63)	(−1.70)	(0.86)	(0.35)	(0.09)	(1.07)
GDPG	0.001***	0.001***	0.0007***	0.002***	0.0002***	0.0004***	0.0002***	0.00004*	0.0001***
	(5.89)	(8.96)	(7.74)	(5.81)	(5.76)	(9.93)	(6.52)	(1.86)	(6.02)
INFR	0.020***	0.008***	0.016***	−0.004***	0.003***	−0.002	0.004***	0.003***	0.003***
	(3.41)	(2.82)	(6.52)	(−3.41)	(3.69)	(−1.50)	(4.48)	(5.06)	(7.66)

(Continues)

TABLE 5 | (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Models	**CERC**	**CERE**	**CDSE**	**CPSE**	**CETM**	**COP**	**CTA**	**CEMM**	**CCER**
QCG	−11.017***	−0.494	−0.448	1.186***	−1.580***	−1.844***	−1.367***	−0.212	−0.307*
	(−5.01)	(−0.47)	(−0.50)	(2.96)	(−5.36)	(−4.80)	(−3.94)	(−0.97)	(−1.81)
Constant	35.650***	13.086***	11.897***	3.038***	5.010***	4.060***	4.187***	2.063***	2.095***
	(6.21)	(9.35)	(7.05)	(5.70)	(5.80)	(7.96)	(9.08)	(7.08)	(9.28)
Country effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Industry effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Year effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Observations	17,006	17,006	17,006	17,006	17,006	17,006	17,006	17,006	17,006
R-squared	0.301	0.381	0.311	0.305	0.404	0.320	0.220	0.221	0.592

Note: This table presents the estimation results for the fixed effect regression of executive compensation on the various facets of the corporate circular economy performance initiatives. All variables are defined and measured in Table 1. *t*-statistics estimated using robust standard errors are reported in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

TABLE 6 | Impact of corporate circular economy performance incentives on the various facets of corporate circular economy initiatives.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Models	**CERC**	**CERE**	**CDSE**	**CPSE**	**CETM**	**COP**	**CTA**	**CEMM**	**CCER**
CCEPI	1.072***	0.928***	0.763***	0.317***	0.157***	0.215***	0.185***	0.023**	0.086***
	(5.12)	(7.92)	(7.17)	(6.43)	(5.01)	(6.19)	(5.72)	(2.17)	(6.37)
NBMEET	0.336**	0.122*	0.074	0.054**	0.008	0.057**	0.040	0.024*	0.022**
	(2.40)	(1.78)	(1.27)	(2.13)	(0.40)	(2.22)	(1.73)	(1.70)	(2.03)
BSIZE	0.533**	0.662***	0.728***	0.277***	0.155***	0.126***	0.144***	0.093***	0.0454**
	(2.21)	(5.62)	(7.20)	(6.30)	(4.79)	(2.88)	(3.65)	(3.84)	(2.41)
BINDE	−0.011***	−0.013***	−0.014***	−0.007***	−0.003***	−0.004***	−0.002***	0.0001	−0.001***
	(−3.34)	(−8.21)	(−5.38)	(−6.80)	(−6.30)	(−7.41)	(−4.26)	(0.16)	(−5.54)
BGEND	−0.094***	−0.085***	−0.0796***	−0.034***	−0.015***	−0.022***	−0.022***	−0.007***	−0.011***
	(−3.41)	(−4.86)	(−4.86)	(−4.23)	(−7.21)	(−9.27)	(−4.26)	(−6.37)	(−4.75)

(Continues)

TABLE 6 | (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Models	**CERC**	**CERE**	**CDSE**	**CPSE**	**CETM**	**COP**	**CTA**	**CEMM**	**CCER**
CEOCD	−0.035	0.281***	0.368***	0.128***	0.017	0.208***	0.078***	0.009	0.051***
	(−0.26)	(4.26)	(6.51)	(5.20)	(0.95)	(8.50)	(3.55)	(0.67)	(4.88)
CSIZE	−1.065***	−0.569***	−0.543***	−0.157***	−0.123***	−0.099***	−0.118***	−0.046***	−0.044***
	(−5.74)	(−4.74)	(−6.05)	(−8.66)	(−9.22)	(−5.48)	(−7.31)	(−4.56)	(−5.74)
PROFT	−0.009	−0.019	−0.003	−0.029	0.009	0.006	−0.040	−0.008	−0.002
	(−0.06)	(−0.24)	(−1.62)	(−1.00)	(0.40)	(0.22)	(−1.53)	(−0.52)	(−0.19)
LEVE	−0.006	−0.004	−0.016	−0.001	−0.001	−0.001	−0.0005	−0.0002	−0.003
	(−1.22)	(−1.56)	(−1.62)	(−1.18)	(−1.25)	(−0.97)	(−0.64)	(−0.43)	(−0.81)
CASHR	0.767	0.021	−0.016	−0.171	0.145	−0.167	−0.064	−0.105	−0.048
	(1.05)	(0.06)	(−0.05)	(−1.29)	(1.47)	(−1.26)	(−0.54)	(−1.43)	(−0.84)
CAPIN	−0.006	0.007	−0.009	−0.002	−0.003*	0.002	0.001	0.0001	0.001
	(−0.44)	(1.02)	(−1.60)	(−0.71)	(−1.72)	(0.80)	(0.30)	(0.08)	(1.06)
GDPG	0.001***	0.001***	0.001***	0.0003***	0.0002***	0.0005***	0.0003***	0.0001***	0.0001***
	(7.44)	(8.03)	(7.89)	(9.01)	(7.32)	(6.14)	(9.04)	(2.86)	(7.91)
INFR	0.006	−0.003	0.005**	−0.007***	0.001	−0.004***	0.002*	0.002***	0.003***
	(1.07)	(−1.28)	(2.27)	(−6.98)	(1.34)	(−3.81)	(1.74)	(4.37)	(6.26)
QCG	−15.540***	−7.118***	−7.170***	−0.743**	−2.389***	−4.247***	−2.815***	−0.634***	−0.889***
	(−7.90)	(−7.40)	(−8.69)	(−2.07)	(−9.03)	(−11.90)	(−8.77)	(−3.20)	(−5.78)
Constant	40.511***	21.511***	20.44***	5.864***	6.061***	6.907***	6.219***	2.510***	2.598***
	(5.26)	(6.57)	(8.35)	(4.11)	(6.98)	(4.33)	(4.35)	(9.39)	(4.38)
Country effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Industry effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Year effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Observations	20,086	20,086	20,086	20,086	20,086	20,086	20,086	20,086	20,086
R-squared	0.520	0.337	0.463	0.351	0.470	0.382	0.481	0.232	0.393

Note: This table presents the estimation results for the fixed effect regression of corporate circular economy performance incentives on the various facets of the corporate circular economy performance initiatives. All variables are defined and measured in Table 1. *t*-statistics estimated using robust standard errors are reported in parentheses.

***$p < 0.01$.

**$p < 0.05$.

*$p < 0.1$.

TABLE 7 | Impact of executive compensation and corporate circular economy performance incentives on the various facets of corporate circular economy initiatives.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Models	**CERC**	**CERE**	**CDSE**	**CPSE**	**CETM**	**COP**	**CTA**	**CEMM**	**CCER**
EC*CCEPI	0.067***	0.058***	0.047***	0.020***	0.010***	0.013***	0.011***	0.001**	0.006***
	(9.67)	(7.40)	(6.70)	(5.74)	(6.94)	(8.70)	(9.17)	(1.99)	(7.68)
NBMEET	0.282*	0.101	0.039	0.038	0.004	0.045*	0.038	0.023	0.025**
	(1.89)	(1.42)	(0.65)	(1.40)	(0.21)	(1.73)	(1.63)	(1.52)	(2.19)
BSIZE	1.006***	0.802***	0.842***	0.330***	0.208***	0.095*	0.203***	0.050*	0.051**
	(3.57)	(5.95)	(7.38)	(6.43)	(5.50)	(1.92)	(4.56)	(1.79)	(2.34)
BINDE	−0.014***	−0.011***	−0.012***	−0.006***	−0.003***	−0.003***	−0.002***	0.0002	−0.001***
	(−3.85)	(−6.32)	(−8.17)	(−9.05)	(−6.38)	(−5.35)	(−3.25)	(0.69)	(−4.64)
BGEND	−0.097***	−0.085***	−0.079***	−0.034***	−0.016***	−0.022***	−0.022***	−0.007***	−0.011***
	(−4.74)	(−3.85)	(−4.98)	(−4.37)	(6.33)	(−7.93)	(−4.63)	(−5.33)	(−3.17)
CEOCD	−0.281*	−0.046	0.043	0.009	−0.013	0.092**	−0.003	−0.004	0.020*
	(−1.80)	(−0.62)	(0.68)	(0.32)	(−0.60)	(3.39)	(−0.12)	(−0.28)	1.67
CSIZE	−1.223***	−0.598***	−0.533***	−0.159***	−0.138***	−0.086***	−0.114***	−0.038***	−0.042***
	(−4.55)	(−6.82)	(−7.45)	(−8.25)	(−9.75)	(−4.64)	(−6.84)	(−3.63)	(−5.11)
PROFT	−0.199	−0.131	−0.117	−0.073*	−0.016	−0.007	−0.081**	−0.019	−0.015
	(−0.90)	(−1.25)	(−1.32)	(−1.81)	(−0.54)	(−0.19)	(−2.33)	(−0.87)	(−0.87)
LEVE	−0.005	−0.003	−0.002	−0.001	−0.001	−0.001	−0.0001	−0.0001	−0.0002
	(−1.04)	(−1.20)	(−1.24)	(−0.73)	(−1.03)	(−0.74)	(−0.17)	(−0.17)	(−0.48)
CASHR	0.512	0.137	0.399	−0.158	0.151	−0.009	−0.005	−0.103	0.002
	(0.65)	(0.37)	(1.26)	(−1.10)	(1.43)	(−0.06)	(−0.04)	(1.31)	(0.03)
CAPIN	−0.006	0.007	−0.009*	−0.002	−0.003*	0.002	0.001	0.0001	0.001
	(−0.45)	(1.03)	(−1.66)	(−0.70)	(−1.74)	(0.83)	(0.32)	(0.08)	(1.03)
GDPG	0.001***	0.001***	0.001***	0.0002***	0.0002***	0.0004***	0.0002***	0.00004**	0.0001***
	(5.89)	(8.97)	(7.75)	(5.80)	(5.75)	(9.94)	(6.51)	(1.86)	(6.02)
INFR	0.019***	0.007**	0.015***	−0.004***	0.003***	−0.002*	0.004***	0.003***	0.003***
	(3.18)	(2.39)	(6.13)	(−3.83)	(3.40)	(−1.76)	(4.24)	(5.02)	(7.41)

(Continues)

TABLE 7 | (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Models	**CERC**	**CERE**	**CDSE**	**CPSE**	**CETM**	**COP**	**CTA**	**CEMM**	**CCER**
QCG	−10.155***	0.249	0.156	1.443***	−1.449***	−1.677***	−1.224***	−0.195	−0.233
	(−4.62)	(0.24)	(0.18)	(3.60)	(−4.92)	(−4.37)	(−3.53)	(−0.89)	(−1.37)
Constant	39.745***	16.654***	14.809***	4.314***	5.673***	4.833***	4.859***	2.138***	2.450***
	(3.66)	(5.98)	(4.58)	(8.14)	(4.55)	(9.51)	(3.58)	(7.36)	(5.89)
Country effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Industry effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Year effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Observations	17,006	17,006	17,006	17,006	17,006	17,006	17,006	17,006	17,006
R-squared	0.590	0.490	0.576	0.361	0.477	0.473	0.588	0.422	0.300

Note: This table presents the estimation results for the fixed effect regression of executive compensation and corporate circular economy performance incentives on the various facets of the corporate circular economy performance initiatives. All variables are defined and measured in Table 1. *t*-statistics estimated using robust standard errors are reported in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

TABLE 8 | Impact of executive compensation and corporate circular economy performance incentive on corporate circular economy performance.

	(1)	(2)	(3)	(4)	(5)
Models	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**
EC	0.004				
	(0.72)				
CCEPI		−0.014			
		(−1.14)			
EC*CCEPI			−0.001		
			(−0.85)		
CCEI				0.005***	
				(4.25)	
CCEI*CCEPI					−0.001
					(0.283)
NBMEET	−0.070***	−0.071***	−0.069***	−0.074***	−0.071***
	(−3.53)	(−3.91)	(−3.50)	(−4.08)	(−3.91)
BSIZE	0.181***	0.111***	0.183***	0.109***	0.111***
	(4.74)	(3.57)	(4.80)	(3.50)	(3.57)
BINDE	−0.001	−0.001	−0.001	−0.001	−0.001
	(−1.00)	(−0.90)	(−0.99)	(−1.25)	(−0.91)
BGEND	−0.003***	−0.003***	−0.003***	−0.004***	−0.003
	(−5.38)	(−5.84)	(−5.30)	(−6.86)	(−5.80)
CEOCD	0.044**	0.032**	0.044**	0.033	0.032*
	(2.10)	(1.86)	(2.08)	(1.87)	(1.86)
CSIZE	0.534***	0.543***	0.538***	0.524***	0.543***
	(31.14)	(35.10)	(31.43)	(32.91)	(35.05)
PROFT	−0.060*	−0.079***	−0.061*	−0.075***	−0.079***
	(−1.87)	(−4.06)	(−1.88)	(−3.84)	(−4.06)
LEVE	−0.023	−0.006	−0.025	−0.010	−0.005
	(−0.63)	(0.868)	(−0.67)	(0.774)	(−0.15)
CASHR	−0.496***	−0.404***	−0.494***	−0.415***	−0.403***
	(−4.49)	(−4.08)	(−4.48)	(−4.18)	(−4.07)
CAPIN	0.181***	0.207***	0.180***	0.212***	0.207***
	(3.59)	(4.50)	(3.57)	(4.61)	(4.50)
GDPG	−0.0004	−0.00006***	−0.00004***	−0.0001**	−0.0001***
	(−1.53)	(−2.65)	(−1.55)	(−2.30)	(−2.56)
INFR	−0.003***	−0.002***	−0.003***	−0.002***	−0.002***
	(−4.12)	(−3.42)	(−4.07)	(−3.46)	(−3.42)
QCG	1.710***	1.618***	1.704***	1.675***	1.617***
	(5.87)	(6.40)	(5.85)	(6.63)	(6.39)

(Continues)

TABLE 8 | (Continued)

Models	(1) CCEP	(2) CCEP	(3) CCEP	(4) CCEP	(5) CCEP
Constant	−0.894**	−0.767**	−0.900**	−0.045**	−0.771**
	(−2.00)	(−1.98)	(−2.01)	(−2.12)	(−1.96)
Country effects	Fixed	Fixed	Fixed	Fixed	Fixed
Industry effects	Fixed	Fixed	Fixed	Fixed	Fixed
Year effects	Fixed	Fixed	Fixed	Fixed	Fixed
Observations	13,428	15,838	13,428	15,838	15,838
R-squared	0.317	0.317	0.318	0.321	0.317

Note: This table presents the estimation results for the fixed effect regression of executive compensation and corporate circular economy performance incentives on the various facets of the corporate circular economy performance initiatives. All variables are defined and measured in Table 1. *t*-statistics estimated using robust standard errors are reported in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

systems to adjust to the changes. However, the positive impact of $CCEI_{t-7}$ on CCEP is consistent with studies demonstrating that the benefits of sustainable practices, such as greater efficiency and market positioning, compound gradually, resulting to improved performance in the long run (Lacy and Rutqvist 2015; Ritzén and Sandström 2017). For example, Derchi et al. (2021) report that linking named executive officers' compensation to CSR targets produces positive effects in the third year of adoption, suggesting a delayed yet significant effect on CSR performance. Zink and Geyer (2017) define this phenomenon as 'CE rebound', highlighting that the impacts of CE implementation (CCEI) are long-term. This understanding urges companies to persist with CCEI even in periods when immediate benefits are not apparent.

5.4 | Additional Analysis

In order to explore the effects of global policy interventions in reforming internal CG to engage in CE practices, Equation (2) is estimated for two year-groups, namely, PRE EU-CEAP[5] (2002–2015) to POST EU-CEAP (2016–2022), to assess the impact of the first EU-CEAP. The results in Table 10 show that EC, CCEPI and EC*CCEPI are not statistically significant on CCEP for the PRE EU-CEAP era. In contrast, CCEPI and EC*CCEPI show a positively significant impact on CCEP ($p < 0.01$ and $p < 0.05$, respectively) for the POST EU-CEAP period. The findings indicate that before the implementation of the CE plan, traditional compensation structures were not effectively aligned with CE goals. The introduction of the CE plan appears to have played a significant role in this shift, suggesting that policy measures can effectively influence corporate behaviour and performance in relation to CE (Pinkse and Kolk 2012). The findings also align with the RBV, as the significant impact of CCEPI and EC*CCEPI indicate that these incentives have become key strategic resources in driving corporate CE efforts (Hart 1995). Subsequently, the shift in the significance of these incentives post-implementation reflects a change in societal values towards a greater emphasis on CE, thereby influencing corporate practices to align with these new norms, thereby supporting the legitimacy view (Deegan 2002).

Further, Equation (1) is estimated for countries that have implemented national carbon tax policies and countries that have not. Table S2 shows that EC is positively significant on CCEI ($p < 0.01$) for countries with national tax policies and not significant for those without carbon tax policies. The findings suggest that in the absence of regulatory fiscal drivers like carbon taxes, traditional forms of EC may not be sufficiently aligned with or incentivised towards CE goals. Thus, highlighting the critical role of environmental policies, such as carbon taxes, in shaping CCE strategies and enhancing the efficacy of internal incentive mechanisms. In line with RBV, the findings indicate that external factors like carbon taxes can augment the value of internal resources (EC and CCEPI), making them more effective in driving sustainable performance (Hart 1995). The increased significance of these compensation mechanisms in countries with carbon tax policies also reflects a response to heightened societal and regulatory expectations for environmental responsibility, reinforcing the firm's legitimacy (Bansal and Clelland 2004).

Finally, Equation (1) is again estimated to for in industries with varying degrees of decarbonisation challenges. In difficult-to-decarbonise industries, the results in Table S3 show that EC, CCEPI and EC*CCEPI do not significantly influence CCEP. Conversely, in industries where decarbonisation is less challenging, the study observes that CCEPI and the interaction of EC and CCEPI significantly improve CCEP ($p < 0.01$). This could be due to complexity and high costs associated with decarbonisation which may render traditional compensation tools less effective in enhancing CCEP. The legitimacy theory also suggests that these industries might face more significant challenges in aligning their operations with societal expectations for sustainability, especially when the path to decarbonisation is technologically or financially intensive (Suchman 1995). The differing impacts in these two sets of industries highlight the need for tailored approaches in designing EC strategies. This suggests that a one-size-fits-all approach may not be effective, especially in sectors with high decarbonisation costs or technological barriers.

TABLE 9 | Impact of corporate circular economy performance incentives and the various facets of corporate circular economy initiatives on corporate circular economy performance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Models	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**
CERC*CCEPI	−0.004***								
	(−3.02)								
CERE*CCEPI		−0.006***							
		(−2.99)							
CDSE*CCEPI			−0.005*						
			(−1.95)						
CPSE*CCEPI				−0.004					
				(−0.82)					
CETM*CCEPI					−0.018***				
					(−3.03)				
COP*CCEPI						−0.007			
						(−1.20)			
CTA*CCEPI							0.002		
							(0.44)		
CEMM*CCEPI								−0.021***	
								(−3.97)	
CCER*CCEPI									−0.017**
									(−2.09)
NBMEET	−0.070***	−0.069***	−0.070***	−0.071***	−0.070***	−0.071***	−0.072***	−0.070***	−0.070***
	(−3.85)	(−3.83)	(−3.88)	(−3.92)	(−3.86)	(−3.90)	(−3.96)	(−3.85)	(−3.87)
BSIZE	0.112***	0.112***	0.112***	0.111***	0.113***	0.111***	0.110***	0.112***	0.112***
	(3.60)	(3.61)	(3.59)	(3.56)	(3.64)	(3.55)	(3.52)	(3.61)	(3.59)
BINDE	−0.0004	−0.0004	−0.0004	−0.0004	−0.0004	−0.0004	−0.0004	−0.0004	−0.0003
	(−0.97)	(0.91)	(−0.92)	(−0.92)	(−0.91)	(−0.91)	(−0.92)	(−0.85)	(−0.89)
BGEND	−0.003	−0.003***	−0.003***	−0.003***	−0.003***	−0.003***	−0.003***	−0.003***	−0.003***
	(−5.90)	(−5.99)	(−5.99)	(−5.97)	(−5.87)	(−5.93)	(−5.95)	(−5.83)	(−5.87)

(Continues)

TABLE 9 | (Continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Models	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**
CEOCD	0.032*	0.032*	0.032*	0.032*	0.032*	0.032*	0.032*	0.032*	0.032*
	(1.83)	(1.84)	(1.84)	(1.86)	(1.83)	(1.86)	(1.87)	(1.83)	(1.85)
CSIZE	0.544***	0.545***	0.544***	0.543***	0.546***	0.543***	0.541***	0.545***	0.545***
	(5.27)	(5.28)	(5.19)	(5.19)	(5.28)	(5.11)	(5.00)	(5.25)	(5.19)
PROFT	−0.079***	−0.079***	−0.079***	−0.079***	−0.080***	−0.079***	−0.079***	−0.079***	−0.079***
	(−4.06)	(−4.08)	(−4.07)	(−4.05)	(−4.08)	(−4.06)	(−4.04)	(−4.07)	(−4.07)
LEVE	−0.008	−0.011	−0.009	0.007	−0.009	−0.007	−0.004	−0.007	−0.007
	(−0.23)	(−0.32)	(−0.28)	(−0.20)	(−0.26)	(−0.19)	(−0.12)	(−0.22)	(−0.21)
CASHR	−0.399***	−0.403***	−0.403***	−0.406***	−0.398***	−0.405***	−0.407***	−0.402***	−0.403***
	(−4.03)	(−4.07)	(4.06)	(4.09)	(−4.01)	(−4.08)	(−4.11)	(−4.05)	(−4.06)
CAPIN	0.207***	0.204***	0.205***	0.207***	0.205***	0.207***	0.209***	0.206***	0.205***
	(4.51)	(4.43)	(4.46)	(4.50)	(4.45)	(4.49)	(4.54)	(4.47)	(4.46)
GDPG	−0.0001**	−0.0001**	−0.0006***	−0.0001***	−0.0001***	−0.0001***	−0.0001***	−0.0001***	−0.001***
	(−2.54)	(−2.55)	(−2.59)	(−2.63)	(−2.62)	(−2.61)	(−2.61)	(−2.63)	(−2.62)
INFR	−0.002***	−0.002***	−0.002***	−0.002***	−0.002***	−0.002***	−0.002***	−0.002***	−0.002***
	(−3.50)	(−3.46)	(−3.44)	(−3.47)	(3.41)	(−3.46)	(−3.47)	(−3.39)	(−3.41)
QCG	1.624***	1.635***	1.634***	1.632***	1.609***	1.624***	1.634***	1.610***	1.612***
	(6.43)	(6.48)	(6.47)	(6.46)	(6.37)	(6.43)	(6.47)	(6.37)	(6.40)
Constant	−0.797**	−0.826**	−0.795**	−0.762*	−0.824**	−0.770*	−0.727*	−0.797**	−0.798**
	(−2.01)	(−2.08)	(−2.00)	(−1.92)	(−2.07)	(−1.94)	(−1.83)	(−2.01)	(−2.01)
Country effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Industry effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Year effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Observations	15,838	15,838	15,838	15,838	15,838	15,838	15,838	15,838	15,838
R-squared	0.317	0.316	0.316	0.317	0.317	0.317	0.317	0.317	0.317

Note: This table presents the estimation results for the fixed effect regression of executive compensation and corporate circular economy performance incentives on the various facets of the corporate circular economy performance initiatives. All variables are defined and measured in Table 1. *t*-statistics estimated using robust standard errors are reported in parentheses.

***$p < 0.01$.

**$p < 0.05$.

*$p < 0.1$.

TABLE 10 | Impact of executive compensation and corporate circular economy performance incentive on corporate circular economy performance.

PRE EU-CEAP (2002–2015)				POST EU-CEAP (2016–2022)		
	(1)	(2)	(3)	(4)	(5)	(6)
Models	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**	**CCEP**
EC	0.006			0.001		
	(0.71)			(0.09)		
CCEPI		−0.0002			−0.042***	
		(−0.01)			(−2.60)	
EC*CCEPI			−0.0003			−0.002**
			(−0.26)			(−2.28)
NBMEET	0.054*	0.033	0.054*	−0.103***	−0.091***	−0.099***
	(1.82)	(1.26)	(1.85)	(−4.54)	(−4.31)	(−4.41)
BSIZE	0.201***	0.127***	0.204***	0.123**	0.053	0.121**
	(3.77)	(2.94)	(3.84)	(2.39)	(1.24)	(2.37)
BINDE	0.003	0.002***	0.003***	−0.001	−0.001	−0.001
	(4.45)	(3.93)	(4.46)	(−1.47)	(−0.94)	(−1.37)
BGEND	−0.003**	−0.002***	−0.003***	−0.002*	−0.001	−0.001
	(−2.57)	(−2.71)	(−2.59)	(−1.84)	(−1.38)	(−1.59)
CEOCD	0.049*	0.041*	0.049*	−0.014*	0.005	−0.014
	(1.75)	(1.88)	(1.74)	(−0.48)	(0.18)	(−0.48)
CSIZE	0.533***	0.519***	0.537***	0.338***	0.346***	0.344***
	(9.39)	(3.04)	(9.68)	(3.17)	(4.51)	(3.41)
PROFT	0.268	0.216	0.281	−0.005	−0.025	−0.01
	(1.49)	(1.33)	(1.57)	(−0.17)	(−1.41)	(−0.21)
CASHR	−0.528***	−0.356**	−0.528***	−0.794***	−0.073****	−0.786***
	(−3.38)	(−2.52)	(−3.38)	(−5.83)	(−5.84)	(−5.77)
CAPIN	0.153***	0.144***	0.151***	−0.217**	−0.187	−0.213**
	(2.97)	(3.07)	(2.94)	(2.06)	(−1.90)	(−2.02)
GDPG	0.00002	−0.00004	0.000002	−0.0001***	−0.0001***	−0.0001***
	(0.53)	(−1.24)	(0.51)	(−2.64)	(−3.13)	(−2.83)
INFR	−0.001	−0.001	−0.002	−0.003***	−0.002***	−0.002***
	(−0.99)	(−0.47)	(−1.13)	(−3.47)	(−3.20)	(−3.05)
QCG	−0.371	0.272	−0.357	0.682*	0.716**	0.644**
	(−0.73)	(0.64)	(−0.70)	(1.94)	(2.17)	(1.83)
Constant	0.232	0.486	0.239	4.64***	4.61***	4.551***
	(0.33)	(0.78)	(0.34)	(7.16)	(7.63)	(7.02)
Country effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Industry effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Year effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Observations	5710	6895	5710	7718	8943	7718
R-squared	0.413	0.390	0.413	0.252	0.250	0.255

Note: This table presents the estimation results for the fixed effect regression of executive compensation and corporate circular economy performance incentive on corporate circular economy performance. All variables are defined and measured in Table 1. *t*-statistics estimated using robust standard errors are reported in parentheses.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

TABLE 11 | 2SLS results.

	First stage (1) (CCEP)	Second stage (2) (CCEP)	First stage (3) (CCEI)	Second stage (4) (CCEI)
CCEP	8.11***	−0.040***	0.813***	0.130***
	(4.52)	(−3.12)	(4.46)	(5.90)
CCEP_Industry	3.50***		0.145***	
	(6.03)		(4.44)	
CCEI				0.130***
				(4.90)
CCEI_Industry				
CCEPI	0.087***	0.087***	0.171*	0.096***
	(2.69)	(2.69)	(1.93)	
NBMEET	0.002**	−0.008	0.406***	0.557***
	(2.14)	(−0.24)	(4.96)	(8.58)
BSIZE	0.314***	0.314***	0.706***	0.929***
	(5.74)	(5.74)	(5.13)	(18.43)
BIND	−0.135***	0.002**	−0.020***	−0.019***
	(−4.15)	(2.32)	(−5.80)	(−7.93)
BGEN	−0.013***	−0.013***	0.041***	0.033***
	(−3.18)	(−4.13)	(4.28)	(3.24)
CEOCD	−0.164***	−0.164***	0.624***	0.763***
	(−4.79)	(−4.79)	(7.20)	(4.02)
CSIZE	0.952***	0.952***	1.123***	1.215***
	(5.23)	(5.23)	(4.79)	(3.03)
PROFT	−0.378***	−0.378***	0.745***	0.639***
	(−6.1.6)	(−6.1.6)	(4.25)	(9.95)
LEVE	−0.408***	−0.408***	0.002	0.004***
	(−5.86)	(−5.86)	(0.59)	(2.71)
CASHR	0.398**	0.398**	2.693***	4.575***
	(2.16)	(2.16)	(5.94)	(7.65)
CAPIN	3.925***	3.925***	0.015	0.012***
	(6.32)	(6.32)	(1.21)	(3.71)
GDPG	0.0002***	0.0002***	−0.002***	−0.002***
	(3.86)	(4.52)	(−3.73)	(−4.50)
INF	−0.004*	−0.004*	−0.010**	−0.014***
	(−1.78)	(−1.78)	(−1.97)	(−7.46)
QCG	−1.822***	−1.822***	0.634**	0.519***
	(−4.75)	(−3.60)	(2.09)	(4.63)
Constant	−9.314***	−9.314***	−33.219***	−28.034***
	(−3.45)	(−3.98)	(−4.70)	(−4.32)

(Continues)

TABLE 11 | (Continued)

	First stage (1) (CCEP)	Second stage (2) (CCEP)	First stage (3) (CCEI)	Second stage (4) (CCEI)
Observations	13,428	17,011	17,011	17,011
Control variables	Fixed	Fixed	Fixed	Fixed
Country effects	Fixed	Fixed	Fixed	Fixed
Industry effects	Fixed	Fixed	Fixed	Fixed
Year effects	Fixed	Fixed	Fixed	Fixed
R^2	0.608	0.925	0.000	0.000
Wald chi^2	208.97	210.96	305.39	210.96
Prob > chi^2	0.000	0.000	0.000	0.000

Note: This table presents the estimation results for the two-stage least square (2SLS) regressions for the effects of executive compensation, corporate circular economy performance incentives on both corporate circular economy initiatives and corporate circular economy performance. The definitions for all variables are provided in Table 1. The *t*-statistics calculated with robust standard errors are shown in brackets.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

TABLE 12 | GMM results.

	(1) (CCEP)	(2) (CCEP)	(3) (CCEI)	(4) (CCEI)	(5) (CCEP)
L.CCEP	0.856***	0.921***			1.027***
	(6.75)	(8.36)			(7.64)
L.CCEI			0.916***	1.146***	
			(3.17)	(4.24)	
CCEI					0.215**
					(2.19)
EC	−0.079		1.712***		
	(−0.73)		(2.69)		
CCEPI	−0.346**	−0.085	−5.069***	−1.361**	
	(−2.54)	(−0.54)	(−4.71)	(−2.19)	
Control variables	Fixed	Fixed	Fixed	Fixed	Fixed
Country effects	Fixed	Fixed	Fixed	Fixed	Fixed
Industry effects	Fixed	Fixed	Fixed	Fixed	Fixed
Year effects	Fixed	Fixed	Fixed	Fixed	Fixed
Observations	13,175	15,537	17,011	20,091	15,537
Arellano-Bond (AR-1)	0.000	0.000	0.000	0.000	0.000
Arellano-Bond (AR-2)	0.602	0.463	0.207	0.408	0.463
Hansen test (*p*-value)	0.403	0.807	0.550	0.309	0.721

Note: This table presents the estimation results for the generalised method of moments (GMM) regressions for the effects of executive compensation, corporate circular economy performance incentives on both corporate circular economy initiatives and corporate circular economy performance. The definitions for all variables are provided in Table 1. The *t*-statistics calculated with robust standard errors are shown in brackets.
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.

5.5 | Robustness Checks

To validate the reliability of the results, we conduct several further analyses. First, a 2SLS approach is employed to address potential endogeneity concerns, ensuring the primary findings remain robust. Consistent with prior studies (García and Ansón 2022; Orazalin et al. 2024), the first lag and industry average values of the primary independent variables are used as instrumental variables. These are chosen based on their low likelihood of correlation with the error term and minimal direct impact on the dependent variables. The test statistics presented in Table 11 affirm the appropriateness of the selected instruments.

Second, Equations (1) and (2) are re-estimated using the dynamic two-step system generalised method of moments (GMM), as devised by Arellano and Bond (1991) and Blundell and Bond (1998). In this GMM framework, EC is treated as an endogenous variable within the regression models for CCE metrics. The specification for CCE also includes EC as an endogenous variable to ensure comprehensive and reliable analysis as shown in Table 12.

6 | Conclusion

This study was driven by the need to deepen the understanding of how EC influences the CE transformation capabilities of corporate executives. The existing literature on the role of EC in fostering CE initiatives has offered mixed insights, with some studies indicating positive impacts, while others suggest limited or varying effects. This study seeks to clarify these divergent perspectives and draws on the context of corporate sustainability to argue that EC, particularly when aligned with CE goals, significantly enhances the ability of corporate executives to effectively drive CE transformation within their organisations. This is crucial in understanding the dynamics of CG and strategy in the transition towards CE. The study then contributes to literature in several ways.

First, the positive impact of EC on CCEI supports the RBV, suggesting that financial incentives are crucial internal resources (CE capabilities) that can drive strategic CE and net zero agenda. This aligns with the RBV assertion that a firm's resources, including EC strategies, are instrumental in shaping its environmental and sustainability practices (Hart 1995). The study also finds that CCEPI enhances the effectiveness of EC in promoting CCEI, indicating that strategically designed incentive mechanisms are valuable resources that can significantly influence CE efforts. This supports the RBV notion that unique organisational resources, when effectively leveraged, can create a competitive advantage in CE. However, our supplementary analyses reveal that prior to the implementation of the EU-CEAP, these internal compensation mechanisms do not significantly impact CCEP. This aligns with the criticism in existing literature regarding the often too narrow focus of traditional compensation structures which fail to account for sustainability goals (Deckop et al. 2006; Mahoney and Thorne 2005). The positive impact of EC and CEPI post EU-CEAP implementation reinforces the RBV, suggesting a shift in corporate strategies, in that these incentives have evolved into strategic resources, enhancing corporate CE efforts (Hart 1995). The findings again extend the RBV by illustrating how regulatory factors such as carbon taxes augment the strategic value of internal resources (EC and CCEPI), making them more effective in driving CE (Hart 1995).

Second, the insignificance of EC and CCEPI in improving CCEP echoes the principles of legitimacy theory. This suggests that while companies may adopt CE measures for legitimacy and to enhance their public image, these actions might not always translate into substantive environmental performance improvements. The shift in the impact of incentives after the implementation of the EU-CEAP illustrates how changes in societal values and regulatory frameworks can compel firms to realign their strategies to maintain legitimacy (Deegan 2002). Additionally, this is also evidenced by the positive effect of EC in countries with carbon tax implementation. The findings therefore reflect corporate responsiveness to heightened societal and regulatory expectations for environmental responsibility (Bansal and Clelland 2004).

Third, the findings support the synergy of both RBV and legitimacy theories by highlighting how corporate strategies, driven by internal resources (as per the RBV), are increasingly being aligned with external societal and regulatory expectations (a key aspect of legitimacy theory). This alignment reflects a strategic response to the evolving landscape of CE, where maintaining legitimacy involves not just symbolic actions but also the integration of genuine CE into business models. The variation in the impact of EC and CCEPI pre- and post-EU-CEAP also emphasise the influence of policy interventions in reshaping CG and strategy. This suggests that external policy measures can effectively complement internal resources, enhancing their value in driving CE performance. This finding bridges the RBV and legitimacy theory, indicating that companies' resource allocation and strategy are influenced by the need to conform to societal norms and regulatory requirements.

Our findings provide useful insights for both policymakers and corporate leaders on how EC and CCEPI can be leveraged to drive meaningful engagement in CE practices.

For corporate leaders, our results emphasise the need to design compensation packages that integrate CE objectives alongside traditional business goals. By aligning executive rewards with sustainability targets, firms can ensure that CE initiatives move beyond symbolic compliance to generate substantive performance improvements (Berrone and Gomez-Mejia 2009; Mahoney and Thorne 2005). For instance, companies such as Iberdrola and Unilever, which link a substantial portion of their CEO compensation to ESG goals, exemplify how structured incentive mechanisms can reinforce CE transitions (Corporate Knights 2023). Given that well-compensated executives are more inclined to invest in long-term sustainability strategies (Edmans 2011), organisations should develop incentive structures that encourage resource efficiency, waste reduction and carbon neutrality as measurable CE performance indicators.

For policymakers, the findings emphasise the critical role of regulatory frameworks in reinforcing corporate commitment to CE practices. Policies such as carbon taxes, mandatory ESG

disclosure and sustainability-linked EC regulations can significantly enhance the effectiveness of CE incentives (Deegan 2002; Bansal and Clelland 2004). Governments and regulatory bodies should consider implementing legislation that incentivises or mandates the integration of CE performance indicators into executive pay structures to drive accountability and long-term sustainability efforts. Evidence from countries with stringent ESG disclosure laws suggests that such policies contribute to a stronger alignment between CG and CE objectives (Al-Shaer et al. 2023). Furthermore, industry-specific customisation of CE incentives is necessary. In resource-intensive sectors such as manufacturing and energy, CE-linked incentives should prioritise carbon reduction, energy efficiency and circular supply chains (Haque and Ntim 2020). In contrast, service-based industries may benefit more from incentives targeting sustainable procurement, product lifecycle management and waste minimization (Grewatsch and Kleindienst 2017). A tailored approach ensures that CE incentives align with sector-specific sustainability challenges, making them more effective in facilitating a transition towards a low-carbon, CE-oriented economy. By demonstrating a positive relationship between EC, CCEPI and CE initiatives, our study provides a blueprint for organisations seeking to integrate sustainability into their governance models. This insight is crucial for managing the transition to a net-zero economy, as it highlights how CG structures can be leveraged to drive large-scale adoption of CE practices.

While the immediate effects of CCEPI can be observed in short-term sustainability commitments, their long-term impact is more gradual and unfolds over extended periods. Empirical evidence suggests that linking EC to sustainability targets often produces cumulative effects, with measurable improvements in CE performance emerging after multiple years of strategic integration (Derchi et al. 2021). This aligns with the CE rebound effect (Zink and Geyer 2017), where initial CE investments face short-term barriers like capital costs, inefficiencies and workforce adaptation but ultimately yield cost savings, resource efficiency and competitive advantages.

From a regulatory and governance perspective, the effectiveness of CE incentives is likely to evolve alongside policy shifts and increasing corporate accountability measures. For instance, as carbon pricing mechanisms, extended producer responsibility (EPR) schemes and sustainability-linked compensation frameworks become more prevalent, firms will face mounting pressures to transition from symbolic CE initiatives to substantive, long-term sustainability commitments (Bansal and Clelland 2004). Additionally, investor-driven ESG disclosure requirements, such as those under the EU Taxonomy, ISSB and TCFD frameworks, will play a significant role in institutionalising CE-aligned governance mechanisms. This will likely reinforce sustainability-linked EC as a standard corporate practice rather than a voluntary initiative.

Despite these contributions, the study has certain limitations. The reliance on firm-level data from the Refinitiv Workspace database may lead to challenges in data consistency, particularly across different regions. Future studies could expand on this work by exploring additional data sources, focusing on specific regions and incorporating broader CE performance metrics beyond GHG emissions to provide a better understanding of corporate sustainability practices. Moreover, longitudinal studies are recommended to better capture the long-term impacts of EC and CCEPI on CE performance.

Endnotes

[1] The sample starts in 2002 as this was the earliest year with enough data available for the all the variables. The sample ends in 2022 as that was the latest year available and the time of data collection.

[2] This method aligns with previous research (Baboukardos et al. 2018; Orazalin et al. 2024) in effectively tracking the evolution of carbon performance and climate change initiatives over time.

[3] CCEI represents nine individual circular economy initiative components, which have also been combined into an aggregate index. The relationships involving CCEI therefore examines the nine components of the index, as well as the index itself (see full description in Table 1).

[4] In this analysis, the variance inflation factor (VIF) for each variable has been calculated. According to Vatcheva et al. (2016), a VIF exceeding 10 indicates multicollinearity. The findings, which are not published, reveal that the highest VIF is 2.29, with an average VIF of 1.34, confirming that multicollinearity does not pose a concern in this study.

[5] Adopted in 2015, the European Union initiated the first Circular Economy Action Plan (CEAP), which encompassed a wide array of legislative and non-legislative measures. Its primary objective was to shift the European economy from its traditional linear model to a more sustainable circular model.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.