Journal of Administrative and Economic Sciences • Vol 18, Issue 1 (2025) • p 757-778

Chief Sustainability Officers and Green Innovation: The Moderating Role of Sustainability Committee and Industrial Concentration

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Abstract:

Firms across the globe are increasingly appointing Chief Sustainability Officers (CSOs) to lead their environmental agendas, yet we know little about how these officers influence innovation outcomes. This study examines the role of CSOs in driving green innovation and investigates the conditions under which their impact is augmented. Drawing on upper echelon and institutional theories, it is argued that CSOs positively influence green innovation, and the sustainability committee amplifies whereas high industry concentration inhibits their effect. Using the firm and board-level data from 816 multinationals from G7 countries and applying system GMM estimation technique, the empirical results show a positive and statistically significant effect of CSOs on a firm's green innovation. This effect is found to be stronger when the sustainability committee has more power and industry is less concentrated. These findings highlight the effectiveness of CSOs in driving green innovation and show how this influence is shaped by governance structures and industry competitiveness.

Keywords: CSO, Corporate environmental innovation, Sustainability committee power, Multinationals, Industrial concentration.

JEL Classification codes: Q55, M14, G34, L16

1. Introduction

Over the last few years, companies have been under increasing pressure to respond to the dual demands of competitive performance and environmental responsibility (Kwilinski et al., 2025). Environmental innovation, the creation and the use of new processes, products, or practices that cause less harm to the environment, has moved out of the periphery to the center of strategic focus across all industries (Dwekat et al., 2025). Such change is not only the result of regulatory pressure or societal scrutiny but is also a manifestation of an emerging awareness that long-term business sustainability is becoming increasingly dependent on the extent to which firms are aligned with the global sustainability agenda (Wang et al., 2024).

With this increased environmental consciousness, many firms have sought to enhance their internal capacities by appointing dedicated leadership positions that address sustainability. Among the more notable trends is the rise of the Chief Sustainability Officer (CSO) as an important member of the top management team (Kachouri and Riguen, 2025). The hiring of a CSO is an indication that the company is moving toward making sustainability an integral part of corporate strategy and innovation (Wang et al., 2024). The CSO is ranked at the highest level of the corporate structure at the C-suite level, and the CSO is answerable to the CEO or the board of directors. The role of these leaders is not only to make sure that the environmental goals are achieved but also to ingrain sustainability principles into the decision-making process, stakeholder management, and long-term value creation (Fu et al., 2020). This change is an indication of recognition that the environmental issues must be handled by specialised knowledge, as well as a good representation at the top of corporate governance.

The increasing presence of CSO at the corporate helm also garnered scholarly attention. The existing literature on CSO widely acknowledged the direct link between the CSO and a firm's environmental performance (Kanashiro and Rivera, 2019). Studies have found a positive effect of CSO on environmental performance (Peters et al., 2019), sustainability (Kachouri and Riguen, 2025; Peters et al., 2019), sustainability disclosures (Thun and Zülch, 2023), and social activities (Velte and Stawinoga, 2020). While previous studies have looked into the role of CSOs in enhancing overall sustainability or environmental performance, the role CSOs play in green innovation has received very limited attention. This limited attention is somewhat surprising as the environmental performance tends to reflect adherence to the current regulations or gradual enhancement of operational practices, but green innovation encompasses the proactive participation of a firm in innovation of new products, processes, or technology in tackling environmental issues (Wei et al. 2025; Oduro et al., 2022). This distinction is important because green innovation not only enhances the long-term competitiveness of a firm but also demonstrates the true intentions of a firm in sustainability, besides mere tokenism (Arici and Uysal, 2022). Additionally, prior studies consider the impact of CSOs as uniform across organizations and markets, while overlooking the conditional effects of organizations and markets under which impact of CSOs attenuates or amplifies on sustainability-related outputs (Fu et al., 2020; Nath and Mahajan, 2008; Zhang, 2006). Specifically, we lack empirical evidence on how internal governance structure such as the role of sustainability committee, and industry environment such as industry competition influence the CSOs' ability to translate sustainability mandates into green innovation. Based on this, this study aims to answer the following research questions: what is the effect of CSO on green innovation and under what conditions (organizational and industry) the effect of CSO become more or less effective on green innovation?

In this study, drawing on echelon and institutional theories, the effect of the presence of CSO on green innovation is examined. The study uses the cross-country sample of G7 countries. The focus on G7 countries is due to the fact that these countries represent most advanced and institutionally sophisticated countries where sustainability orientations are particularly salient. Firm operating in the countries are under immense pressure to adopt sustainability-related strategies. Additionally, G7 economies also have sufficient variation in market conditions and governance structure which allows us to capture how internal governance and market structure shape the effectiveness of CSO in driving sustainability initiatives. These features of G7 countries make this context more appropriate setting to examine the relationship between CSO and green innovation. Using the firm and board-level data from G7 multinationals, it is found that CSOs exert a positive effect on a firm's green innovation. This effect is found to be stronger when the sustainability committee has more power and industry is less concentrated.

This research makes important contributions to the current CSO literature. First, this study contributes to the existing literature on CSOs that are conducted mostly in terms of their contribution to the realisation of broad sustainability results or an overall increase in environmental performance (Kachouri and Riguen, 2025; Kanashiro and Rivera, 2019). This work shifts the attention to a more specific and innovation-related outcome, green innovation. Such attention is important because green innovation is not only a demonstration of the firm's commitment to environmental goals but also an indication of its capacity to convert sustainability goals into practical technological changes, new products, and process enhancements (Oduro et al., 2022). In that way, a prospective aspect of corporate sustainability can be grasped that is firmly connected to long-term competence and regulatory adjustment that is not necessarily disclosed by broader measures of environmental performance (Arici and Uysal, 2022).

Second, this study uncovers the factors that condition the impact of a CSO on green innovation is enhanced or diminished. In particular, CSR committee power and industry concentration are identified as boundary conditions under which a CSO can exert a more favourable impact on the green innovation of a firm. The moderating results illustrate that how internal sustainability committee's authority and external industry pressure can drive CSOs to translate sustainability priorities into corporate innovation. By studying these moderating factors, this study transcends beyond existing studies focusing on the direct-effect and providing a more nuanced understanding of how and when CSO can effectively impact green innovation. Third, this work offers an integrated view of the nexus between internal governance and market structure in shaping sustainability outcomes. Instead of examining the effect of internal governance and market structure on leaders in silos, this study offers a more integrated view of when and how CSOs drive green innovation. Lastly, the empirical context of a cross-country sample increases the generalizability of these findings and provide insights that go beyond single county studies.

2. Literature Review and Hypothesis Development

2.1. Theoretical Framework

An integrated theoretical framework is developed, using the upper echelons theory (Hambrick and Mason, 1984) and institutional theory (North, 1990; DiMaggio and Powell, 1983) to explain the relationship between the appointment of a CSO and green innovation. This is a well-suited framework to examine both the micro-level processes by which executive attributes

influence strategic outcomes and the macro-level institutional environments in which these leadership influences become possible or impossible.

Upper Echelons Theory (Hambrick and Mason, 1984) holds that organisational outcomes are strongly influenced by the values, experiences, and cognitive frames of the top executives of a firm. The role of CSO is inherently influenced by the way they understand and interpret the complex environmental issues, prioritise green initiatives and how they mobilise resources towards innovation. Since sustainability projects are cross-functional, the vision and leadership pattern of the CSO can directly affect the extent to which the firm develops and implements new environmental solutions. Nevertheless, the upper echelons theory also acknowledges the fact that executive power is not exercised in isolation (Fu et al., 2020). The ability of a CSO to lead green initiatives is based on both the formal and informal levers of power available within the firm (Dwekat et al., 2025). A sustainability committee with significant power can increase the capacity of CSO to mobilise resources, align departmental agendas and drive the big environmental initiatives. The interplay of leadership characteristics and governance frameworks gives a nuanced insight into why CSO appointments can achieve significant sustainability gains in one firm but remain ceremonial in another.

Institutional theory (North, 1990; DiMaggio and Powell, 1983) provides a complementary perspective by focusing on the role of the institutional environment on the firm's behaviour. It emphasises that firms are not shaped solely by efficiency and profitability reasons, but the pressure to meet the expectations of the wider society (North, 1990). To maintain legitimacy and secure continued access to resources, firms often adopt practices that align with these expectations, when such practices are not necessarily associated with immediate financial benefits (Saeed et al., 2023).

Firms often align their decisions with these shared expectations to avoid appearing as outliers and to secure legitimacy in the eyes of stakeholders (DiMaggio and Powell, 1983). From an institutional perspective, the industry concentration intensity further shapes these dynamics (North, 1990). In industries where a small number of firms dominate the entire sector, these dominant firms set the tone for accepted practices (Hou and Robinson, 2006). Firms in such contexts are more likely to mirror the actions of dominant firms, implying that strategic decisions (e.g., investments in green innovation) are heavily influenced by the standards established by these firms within the industry (Soares et al., 2021). This dynamic amplifies the coercive and mimetic pressures to conform, as deviating from the standards set by dominant firms can undermine a firm's legitimacy in the eyes of stakeholders (DiMaggio and Powell, 1983). Furthermore, concentrated industries magnify the reputational consequences of nonconformity (Hou and Robinson, 2006). Because a few key players attract disproportionate stakeholders' attention, the diffusion of their practices often cascades across the industry, creating a strong expectation of compliance. In this way, industry concentration reinforces the institutional environment by narrowing the range of acceptable firms' behaviour and reducing firms' latitude to disregard sustainability-focused norms.

2.2. Review of Related Literature

The appointment of a CSO is a relatively recent development among firms, with most firms adopting the role of CSO only in the last two decades (Fu et al., 2020). Not surprisingly, scholarly attention to the influence of CSOs has also emerged only recently. The existing literature on CSO has mainly evolved into three directions. First stream of studies highlights

the role of CSO in shaping policies, practices and resource allocation in such a way that is conducive to improved environmental performance. For example, Zhang (2006) found that CSOs influence organisational culture by promoting values and behaviours that support sustainability. This cultural shift makes the employees inclined to participate in green innovation activities, thus improving the overall environmental performance of the firm. Nath and Mahajan (2008) show that CSOs are instrumental in securing resources for sustainability projects due to their innate values and knowledge of environmental performance and sustainability. The better alignment of sustainability goals and business objectives allows CSOs to promote the required funds so that green innovation projects are well-funded and reinforced.

The second strand of studies takes an external stakeholders' perspective and examines how CSOs play a role in ensuring that firms comply with environmental regulations and meet the demands of other stakeholders. Following this line of inquiry, Mazutis (2013) found that CSOs are instrumental in aligning corporate strategies with regulatory requirements, ensuring that firms not only comply with existing regulations but also foresee and plan for future environmental regulations. The proactive method assists companies in becoming more competitive and sustainable over time. Kang (2015) focused on the role of CSOs in stakeholder relationships. He highlights that by effectively communicating sustainability efforts and outcomes, CSOs help build trust and enhance the firm's reputation among stakeholders, which may result in greater support of green innovation initiatives.

The third stream of literature on CSO, which is growing in momentum, has examined the effects of CSOs on corporate environmental performance. For example, Nath and Mahajan (2008) found that the existence of a CSO in highly polluting industries was linked with better environmental performance, implying that CSOs are very instrumental in promoting environmental activities in these firms. Kachouri and Riguen (2025) show that individual characteristics of CSO positively impact the firm's sustainability performance. Within this literature, a very few studies consider the impact of CSOs on green innovation. For instance, Wei et al. (2025) find the moderating role of CSO on the relationship between government subsidies and green innovation among Chinese firms. Hashmi et al. (2023) observe that top management team diversity and CSO collectively exert a positive effect on green innovation in Pakistani hotels.

Although these studies provide valuable insights on the subject, they largely confined itself to the direct or interaction effects and pay limited attention to the underlying reasons that drive CSOs to influence green innovation. Moreover, existing studies generally overlook the role of internal governance structures and external market structure in shaping the effectiveness of CSOs. Specifically, the extent to which sustainability committee improves or dampens the effect of CSOs on sustainability initiatives has not been examined. Sustainability committee and industry structure can influence the ability of CSOs to drive innovation, thereby playing a moderating role in the relationship between CSOs and sustainability initiatives. Another important limitation in the existing scholarship is its focus on single-country environment, such as China or Pakistan, which limits the generalizability of findings. In sum, these gaps suggest that the understanding of how and under what conditions CSOs drive green innovation remains incomplete particularly in developed markets where sustainability pressures and institutional contexts are especially pronounced. Addressing this gap is important for clarifying the strategic role of CSOs in driving innovation that aligns both with environmental imperatives and competitive advantage.

2.3. CSO and Green innovation

According to the upper echelons' theory, the strategic orientation of a company is a direct reflection of the cognitive frames, values, and priorities of its top management (Hambrick and Mason, 1984). The CSO brings a unique sustainability-focused mindset within the top management group and influences the way the organisation perceives the environmental challenges and opportunities (Fu et al., 2020). The CSO can reframe sustainability as a source of competitive advantage by communicating a clear sustainability vision and integrating environmental priorities into the strategic roadmap of the firm so that sustainability becomes a proactive competitive differentiation rather than a compliance-driven duty (Dwekat et al., 2025). This influence extends beyond symbolic commitments since it influences the projects that make it into the innovation pipeline, investment decision criteria, and performance measures. When environmental considerations are integrated into the logic of value creation, the company is more likely to channel its innovation efforts toward solutions that may simultaneously promote environmental and economic goals. In such cases, green innovation is not seen as an add-on initiative but as a part of the core strategy of the firm, which will enhance both its market resilience and its long-term growth trajectory.

The unique values, knowledge, and frames of interpretation help the firm to connect with its external environment. Being the main interface between the firm and regulators, socially responsible investors, NGO, and industry alliances, the CSO filters and interprets external signals in a manner that is consistent with their own vision and priorities of sustainability (Wang et al., 2024). This selective involvement may help firms to obtain an early access to important information on upcoming regulations, technological changes and shifting societal demands (Dwekat et al., 2025). Meanwhile, the capacity of the CSO to cultivate trust and credibility among the influential stakeholders enhances the external legitimacy of the firm, which makes it a desirable partner in joint innovation projects. By aligning these external relationships to the strategic plan of the firm, the CSO facilitates the development of a favourable ecosystem where green innovation projects are more likely to receive external funding and shareholder support. Based on this discussion, it is hypothesised that:

Hypothesis 1. The presence of CSO has a positive effect on corporate green innovation.

2.4. Moderating Role of Sustainability Committee Power

From an upper echelon perspective, the strategic influence of a top executive is not only determined by his or her expertise and values, but also by the organisational structures that channel their voice into the decision-making process (Burke et al., 2019). The capacity of a highly capable CSO to steer innovation agendas can be limited if sustainability considerations are not regularly presented in the top-level discussions (Velte and Stawinoga, 2020). A powerful sustainability committee that bestows formal authority, agenda-setting power, and direct access to the board (Orazalin, 2020), which can increase the voice of the CSO in strategic meetings. This kind of influence will help to make sure that environmental priorities will not be pushed aside when dealing with competing demands, but rather be systematically incorporated in resource allocation. Consequently, projects that have large environmental value tend to have better chances of surviving internal budget decisions, moving beyond the conceptual phase, and eventually determining the green innovation outcomes.

Furthermore, a strong sustainability committee can serve as this critical conduit for CSO that ensures that the sustainability priorities are not just aspirational statements but formalised goals that are part of the governance and operating procedures of the firm (Burke et al., 2019). By incorporating environmental goals in the performance measures, monitoring progress, and the coordination of the CSO with the innovation-oriented activities (including R&D), a strong committee can fill in the gap between the strategic intent and the implementation. This structural alignment raises the likelihood of the sustainability vision of the CSO being systematically translated into the innovation portfolio, enabling the firm to create environmental solutions that are both strategically and operationally viable.

From the institutional theoretical perspective, the legitimacy of an organisation is a key lever in gaining access to the external resources and stakeholders that are required to achieve success in strategic initiatives (Saeed et al., 2023). The presence of a strong sustainability committee signals to investors, regulators, and advocacy groups a sign of credibility and responsible behaviour of a firm (Orazalin, 2020) because an influential sustainability committee is a tangible and prominent governing tool that indicates the firm is serious in achieving environmental objectives (Burke et al., 2019). This signal not only develops trust but also ensures stakeholders that commitments to sustainability are anchored in formal decision-making processes rather than being symbolic gestures. This legitimacy can be converted into higher levels of investor confidence, a smooth regulatory relationship, and increased reputational capital, which altogether produce a conducive environment in which a CSO can mobilise the resources and institutional support necessary to drive green innovation. This discussion leads to the following hypothesis:

Hypothesis 2. The sustainability committee's power strengthens the relationship between CSO and green innovation.

2.5. Moderating Role of Industry Concentration

Executive decisions are not made in a vacuum; rather, these are contingent on the larger environment within which the firm is operating (Hou and Robinson, 2006). Of these contextual forces, the industry competitiveness is particularly relevant, which may either enhance or limit the degree to which the initiatives of a top executive may be translated into meaningful desired outcomes. In less concentrated industries, firms have more reasons to distinguish themselves to be able to survive (Soares et al., 2021). The CSOs' values, expertise, and sustainability orientation are more likely to be translated into concrete actions when the companies cannot afford complacency (Wang et al., 2024). Green innovation provides a means of differentiation by signalling forward-looking environmental leadership, improving efficiency, and developing distinctive capabilities. Accordingly, the role of the CSO in strategic decisions is strengthened in competitive environments because firms pay more attention to sustainability-based innovation as a competitiveness tool.

Industry concentration not only determines the level of rivalry amongst the firms but also increases the external visibility and scrutiny (Bowers et al., 2014). In a competitive environment, sustainability practices and green innovation are used as criteria in measuring legitimacy by the stakeholders, such as regulators, customers, investors, and civil society (Chan et al., 2024). Firms with non-credible commitments are likely to be seen as laggards, and this will undermine their legitimacy and market position (Saeed et al., 2022). A CSO becomes instrumental in ensuring that the firm is responsive to these legitimacy requirements

proactively through green innovation as a visible and tangible indicator. Consequently, the institutional pressures and competitive pressures interact to intensify the effect of the CSO on green innovation.

Allocation of resources is another critical factor in competitive industries that may influence the CSO's impact on green innovation. In less concentrated industries, resource allocation decisions are subject to increased scrutiny and only initiatives with a high level of strategic justification gain traction (Chan et al., 2024). Due to expertise and relevant knowledge, CSO is in a better position to promote green innovation as an institutional requirement and strategic advantage (Hou and Robinson, 2006). The level of concentration (competition) also makes organisational actors more receptive to sustainability arguments framed in terms of innovation, efficiency, and differentiation. Such openness helps the CSO to secure resources, form cross-departmental coalitions, and make innovation practices institutionalised more effectively. Therefore, low concentration enhances the internal focus required to convert the vision of the CSO into tangible green innovations. Hence:

Hypothesis 3. The higher industry concentration weakens the relationship between CSO and green innovation.

3. Data and Methodology

To achieve the objectives of this research, this study employs a sample of 816 non-financial publicly listed multinationals from the G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) for the period of 2014 to 2023. The selection of G7 countries is particularly relevant, as these economies have pledged to achieve net-zero carbon emissions by 2050 through investments in environmentally friendly products, promotion of green innovation, and reduction of greenhouse gas emissions, which they generate at comparatively higher levels than other developed economies (Borgi et al., 2024; Doğan et al., 2022). Moreover, the G7 collectively contributes around 25% of global GDP while accounting for nearly 30% of global emissions, underscoring their pivotal role in shaping international environmental policies (Qin et al., 2021). Given their economic weight and environmental impact, examining this research question within the G7 context is both timely and significant. These multinationals are selected based on three criteria: (i) the presence of a Chief Sustainability Officer (CSO) during the sample period, (ii) market capitalization, and (iii) the availability of data for key variables. Applying these criteria results in a final sample of 816 firms across the G7 countries. Table 1, Panel A provides the distribution of firms across these economies while Panel B contains the definitions of included variables.

Table 1: Sample Distribution and Variables Description

Panel A	**Sample Distribution across countries**
Countries	**Number of Firms**
Canada	94
France	98
Germany	108
Italy	81

Japan	129
United Kingdom	148
United States	158
Total	**816**

Panel B **Variable Measurements**

Name	Acronyms	Definitions
Green Innovation	*Gre_Inn*	Measure as environmental R&D, a score normalized on a scale of 0-100 reflecting firm R&D investment in eco-friendly products/services that reduce emissions and resource use.
Chief Sustainability Officer	*CSO*	Taking the value 1 if the firm has an executive dedicated solely to manage environmental performance, else 0.
Sustainability Committee Power index	*SCPI*	An index based on four indicators, value ranges from 0 to 4.
Industrial Concentration	*Ind_Conc*	Measured as "Herfindahl Index (HHI)", value ranges from 0 (perfect market competition) to 1 (perfect market concentration).
Performance	*Perf*	Measured as return on assets.
Leverage	*Lever*	Total debt to total assets ratio.
Firm Size	*Size*	Nature log of total sales.
Strategic Flexibility	*Str_Flex*	Measured as current ratio
Board Size	*Board_Size*	Total number of board members
Regulatory Quality	*Reg_Qua*	Measured as World Governance Indicator' Regulatory Quality Index
GDP Per Capita	*GDP_Cap*	Natural log of country's GDP per capita

To collect the required data, this study draws on multiple sources. Firm-level information is obtained from the Asset4 ESG (Refinitiv-DataStream) database, proxy statements, sustainability reports, annual reports, and company websites. Country-level data is sourced from the World Bank's World Development Indicators (WDI) and the World Governance Indicators (WGI) databases. To mitigate the influence of potential outliers, all financial variables are winsorized at the 1% and 99% levels.

3.1. Variables and Empirical Strategy

The dependent variable in this study is green innovation (*Gre_Inn*). Consistent with de Villiers et al. (2022) and Liang & Renneboog (2017), it is measured as environmental research and development (R&D), expressed as a score normalized on a scale from 0 to 100. This score captures the extent of a firm's investment in R&D activities aimed at developing environmentally friendly products or services that reduce emissions and minimize environmental impact. A score closer to 100 indicates a higher level of engagement in green innovation initiatives, whereas a score near 0 reflects little to no involvement.

The key independent variable is the presence of a Chief Sustainability Officer (*CSO*). Following Kanashiro & Rivera (2019), it is measured as a binary variable, coded 1 if the firm has an executive exclusively responsible for managing environmental performance, including CSR, sustainability, environmental, or health-related responsibilities, and 0 otherwise. The *CSO* is responsible for overseeing critical sustainability-related issues and advising the firm on strategies to effectively address them. Furthermore, the study introduces two moderating variables, the sustainability committee power index (*SCPI*) and the industrial concentration (*Ind_Conc*).

The Sustainability Committee Power Index (*SCPI*) is constructed following Saeed et al. (2022) by summing four dummy variables, each taking the value 1 when: (i) a dedicated sustainability/ESG committee exists; (ii) an independent executive is present; (iii) more than two meetings are held in a year; and (iv) the committee has a broad mandate, including strategic influence over sustainability goals, climate strategy, risk management, and linkage to executive pay. The index ranges from 0 (no power) to 4 (high power), capturing the extent of the committee's influence on corporate sustainability initiatives. To calculate the industrial concentration (*Ind_Conc*), this study follows Liao & Liu (2024) and uses the "Hirschman–Herfindahl Index (HHI)" as the "sum of each firm's squared market share in each industry as a firm's sales to total industrial sales ratio". Its value ranges from 0 (perfect market competition) to 1 (perfect market concentration).

To ensure the robustness of the empirical model, this study incorporates several control variables based on prior literature (Saeed et al., 2025; Borgi et al., 2024; Doğan et al., 2022; Kanashiro & Rivera, 2019; Baloch et al., 2018). At the firm level, the controls include: performance (*Perf*), measured as return on assets; leverage (*Lever*), calculated as the total debt-to-assets ratio; firm size (*Size*), proxied by the natural log of total sales; strategic flexibility (*Str_Flex*), measured as the current ratio; and board size (*Board_Size*), representing the number of board members. At the country level, the controls include regulatory quality (*Reg_Qua*), measured using the WGI regulatory quality index, and GDP per capita (*GDP_Cap*), proxied

by the natural log of GDP per capita. All explanatory variables are 1-period lagged. Below I am providing the full empirical model based on the variables discussed above:

$$Gre\_Inn_{it} = \alpha + \beta_1 Gre\_Inn_{it-1} + \beta_2 CSO_{it-1} + \beta_3 SCPI_{it-1} + \beta_4 Ind\_Conc_{it-1} + \beta_5 SCPI_{it-1} * CSO_{it-1} + \beta_6 Ind\_Conc_{it-1} * CSO_{it-1} + \beta_7 Perf_{it-1} + \beta_8 Lever_{it-1} + \beta_9 Size_{it-1} + \beta_{10} Str\_Flex_{it-1} + \beta_{11} Board\_Size_{it-1} + \beta_{12} Reg\_Qua_{ct-1} + \beta_{13} GDP\_Cap_{ct-1} + \varepsilon_{it}$$

To empirically estimate the model, this study uses the twostep system GMM by following the existing literature (Saeed et al., 2025; Kanashiro & Rivera, 2019), suggesting the use of twostep system Generalized Method of Moments in case of dynamic panel model, which yields asymptotically efficient standard errors. It also effectively tackles the potential issues such as firm heterogeneity, serial correlation, and the presence of an autoregressive process. Further, twostep system GMM utilizes internal instruments by considering various levels of lagged values and lagged differences of explanatory variables (Saeed et al., 2025). Additionally, inclusion of AR(2) and Hansen tests suggest that these instruments are valid and reliable. All explanatory variables are 1 period lagged that help mitigating potential reverse causality and simultaneity concerns. This approach is consistent with the existing literature dealing with panel data (Saeed et al., 2025; Baloch et al., 2026). Compared to fixed effects estimation, system GMM is more appropriate as it accounts for simultaneity bias and dynamic relationships by using internal instruments. In addition, relative to difference GMM, system GMM improves efficiency by combining equations in levels and first differences, particularly when variables are persistent over time (Saeed et al., 2025).

4. Results and Discussion

4.1. Descriptives and Correlations

Table 2 reports the descriptives of key variables of interest. The mean value of *Gre_Inn* is 62, suggesting a higher level of engagement in green innovation activities by these sample firms. The mean value of *CSO* is 0.76. The average value of *SCPI* is 2.24, suggesting a moderate to high sustainability committee power. Similarly, the mean value of *Ind_Conc* is 0.22, indicating a moderate to high industrial concentration in sample countries. Finally, the financial variables have mean values close to their standard deviations, confirming their standardization.

Table 2: Descriptive statistics of variables

Variable	Observation	Mean	Std. dev.	Min	Max
Gre_Inn	8,160	62.3654	16.1731	5.3000	94.9000
CSO	8,160	0.7620	0.4259	0.0000	1.0000
SCPI	8,160	2.2407	1.4450	0.0000	4.0000

Ind_Conc	8,160	0.2262	0.1517	0.0922	0.6100
Perf	8,160	4.2474	3.4292	-0.8337	12.9900
Lever	8,160	0.5460	0.2183	0.0317	1.9039
Size	8,160	19.2740	3.5910	11.0634	27.0773
Str_Flex	8,160	1.5681	1.2226	0.1100	12.8300
Board_Size	8,160	9.6352	2.7860	6.0000	28.0000
Reg_Qua	8,160	1.4071	0.3265	0.4877	1.8797
GDP_Cap	8,160	10.7299	0.2197	10.3218	11.3238

Table 3 presents the correlation values among the key variables of interest. Importantly, the correlation between *Gre_Inn* and *CSO* is positive. Among the moderating variables, *SCPI* is positively correlated with *Gre_Inn*, while *Ind_Conc* exhibits a negative correlation. Notably, all correlation values are comparatively lower, suggesting there is no issue of multicollinearity. Further, this study employs the VIF test to determine the multicollinearity issue. Table 4 reports this result, again indicating that there exists no multicollinearity problem, as all values are lower.

Table 3: Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	**Gre_Inn**	1.00												
2	**CSO**	0.11	1.00											
3	**SCPI**	0.02	0.04	1.00										
4	**Ind_Conc**	-0.05	-0.04	0.03	1.00									
5	**SCPI × CSO**	0.05	0.41	0.31	0.01	1.00								
6	**Ind_Conc × CSO**	-0.03	0.39	0.06	0.27	0.39	1.00							
7	**Perf**	0.01	0.01	0.02	0.00	0.01	0.00	1.00						
8	**Lever**	0.17	-0.02	-0.02	-0.03	-0.01	-0.03	-0.09	1.00					
9	**Size**	0.21	0.04	-0.01	-0.03	0.02	0.01	0.01	0.11	1.00				
10	**Str_Flex**	-0.20	-0.01	0.01	0.01	-0.01	0.01	-0.01	-0.26	-0.14	1.00			
11	**Board_Size**	0.04	-0.01	-0.02	-0.02	-0.02	0.00	0.00	0.13	-0.22	0.07	1.00		
12	**Reg_Qua**	0.07	-0.19	-0.21	-0.09	-0.29	-0.21	0.00	0.05	0.06	-0.01	0.06	1.00	
13	**GDP_Cap**	0.04	-0.25	-0.07	-0.09	-0.22	-0.22	-0.02	0.08	0.02	0.01	0.00	0.19	1.00

Table 4: Variance Inflation Factor (VIF)

Variable	VIF	1/VIF
Str_Flex	1.68	0.595136
Lever	1.57	0.636171
Size	1.4	0.715742
Board_Size	1.28	0.783638
Reg_Qua	1.25	0.79754
GDP_Cap	1.24	0.806057
CSO	1.09	0.918237
SCPI	1.05	0.954947
Ind_Conc	1.02	0.981733
Perf	1.02	0.984268
Mean VIF	**1.26**	

4.2. Regression Estimates

To determine the cause and effect, this study employs the twostep system GMM to estimate the model. Table 5 reports the regression estimates obtained through employing system GMM in a hierarchical linear processing way. The insignificant probability values of AR (2) and Hansen tests suggest that the used instruments are valid and there is no issue of over-identification and serial correlation. Therefore, the reported estimates are robust.

Table 5: Regression Estimates of Twostep System GMM Method

VARIABLES	1	2	3	4	5
Lag Gre_Inn	0.582***	0.638***	0.554***	0.544***	0.567***
	(0.0314)	(0.0554)	(0.0592)	(0.0645)	(0.0763)
CSO	1.010**	2.632*	1.026**	1.040**	1.399*
	(0.4487)	(1.567)	(0.4312)	(0.4472)	(0.7835)
SCPI		1.321*	4.080***		4.555**
		(0.724)	(1.545)		(1.909)
Ind_Conc		-1.534**		-3.785**	-1.256*
		(0.6983)		(1.531)	(0.611)
SCPI × CSO			4.276**		4.121*
			(1.783)		(2.184)
Ind_Conc × CSO				-3.955*	-1.401***
				(1.870)	(0.3299)
Perf	0.221*	0.0351	0.594*	0.6239*	1.0579*
	(0.134)	(0.324)	(0.331)	(0.343)	(0.446)
Lever	-3.502*	-0.947	-2.278*	-0.5303*	-3.879**
	(1.605)	(5.323)	(1.169)	(0.248)	(1.542)
Size	1.963***	0.599**	0.993***	0.728***	1.285***
	(0.312)	(0.237)	(0.227)	(0.217)	(0.416)
Str_Flex	0.253	0.586	1.695**	0.865	3.297**
	(1.102)	(0.751)	(0.831)	(0.805)	(1.272)
Board_Size	2.031***	0.842*	1.712***	1.248***	1.496***
	(0.669)	(0.469)	(0.391)	(0.392)	(0.575)
Reg_Qua	2.747*	4.452***	4.009**	2.317	4.998***
	(1.568)	(1.457)	(1.642)	(1.515)	(1.806)
GDP_Cap	4.334**	1.793	2.490	2.067*	3.364
	(2.007)	(1.707)	(1.891)	(1.123)	(2.219)
Constant	-79.37***	-11.08	-33.72	-4.703	-54.23*
	(29.20)	(21.99)	(23.56)	(22.65)	(30.62)

Observations	7,344	7,344	7,344	7,344	7,344
Number of id	816	816	816	816	816
AR(2)	0.954	0.686	0.738	0.949	0.611
Hansen	0.183	0.526	0.901	0.356	0.846

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Column 1 of Table 5 contains the result of independent, i.e., the presence of the Chief Sustainability Officer and control variables. The coefficient of *CSO* is positive and statistically significant at the level of 5%, indicating that the presence of *CSO* has a positive influence on corporate green innovation. This finding is consistent with Miller & Serafeim (2014) and supports the first hypothesis. In the context of G7 countries, where strict environmental regulations are enforced, the presence of a *CSO* enhances firms' engagement in green innovation and plays a critical role in shaping corporate sustainability initiatives. For the moderation effects, first, this study introduces individual moderating variables, i.e., sustainability committee power index and industrial concentration in column 2 and then introduces interactive terms, i.e., *SCPI* × *CSO* and *Ind_Conc* × *CSO* in columns 3 and 4, respectively. Column 2 presents the positive and significant coefficient of *SCPI*, while a negative and significant coefficient of *Ind_Conc*.

Column 3 reports the positive and significant coefficient of the interactive term, i.e., *SCPI* × *CSO*, at the level of 5%, indicating a positive moderating effect of the sustainability committee power index on the relationship between the presence of *CSO* and the firm's green innovation. This finding is consistent with Li, Jia, & Chapple (2023) and supports the second hypothesis, suggesting that stronger sustainability committee power amplifies the positive impact of CSOs on firms' green innovation. Regarding the moderating effect of industrial concentration intensity, column 4 reports the negative and significant coefficient of the interactive term, i.e., *Ind_Conc* × *CSO*, at the level of 10%, suggesting a negative moderating effect of industrial concentration intensity on the relationship between the presence of *CSO* and a firm's green innovation. This finding is consistent with Hartmann & Vachon (2018) and supports the third hypothesis, stating that the high industrial concentration intensity weakens the relationship between the presence of CSO and green innovation. It supports the notion that high industrial competition facilitates environmental performance and therefore amplifies the positive impact of CSOs on firms' green innovation. Column 5 demonstrates the consistency of these key findings.

Regarding the control variables, the findings remain consistent with the earlier studies (Doğan et al., 2022; Kanashiro & Rivera, 2019; Miller & Serafeim, 2014). The increase in performance (*Perf*), firm size (*Size*), strategic flexibility (*Str_Flex*), and board size (*Board_Size*) leads to an increase in green innovation, while an increase in leverage (*Lever*) reduces it. To further validate the findings and determine the robustness of these findings, this study runs a robustness test by using an alternative estimation technique, i.e., the robust fixed effect method. The empirical model is re-estimated by using a robust fixed effect panel model, and the regression results are reported in Table 6. The findings remain consistent with the earlier result reported in Table 5, suggesting the rigour of these results and confirming that they are not influenced by the estimation bias.

Table 6: Regression Estimates of Fixed Effect Method

VARIABLES	1	2	3	4	5
Lag Gre_Inn	0.409***	0.420***	0.415***	0.402***	0.428***
	(0.0111)	(0.0183)	(0.0170)	(0.0155)	(0.0132)
CSO	0.646*	0.640**	0.565**	0.420*	0.335*
	(0.330)	(0.240)	(0.224)	(0.190)	(0.188)
SCPI		0.2315**	0.0563**		0.0578**
		(0.0983)	(0.0204)		(0.0204)
Ind_Conc		-2.627*		-2.417*	-2.423*
		(1.194)		(1.177)	(1.181)
SCPI × CSO			0.0440*		0.0452*
			(0.0228)		(0.0229)
Ind_Conc × CSO				-1.183*	-1.389*
				(0.672)	(0.675)
Perf	0.0109*	0.0105	0.0109*	0.0107***	0.0121*
	(0.0063)	(0.0726)	(0.0056)	(0.0030)	(0.0062)
Lever	-3.746***	-3.730**	-3.742**	-3.739**	-3.736**
	(1.061)	(1.871)	(1.879)	(1.843)	(1.877)
Size	0.526***	0.510***	0.578***	0.624***	0.542***
	(0.0539)	(0.0943)	(0.0921)	(0.0922)	(0.0899)
Str_Flex	0.0832	0.0817	0.0825	0.0731*	0.0624*
	(0.1732)	(0.2690)	(0.1222)	(0.0369)	(0.0299)
Board_Size	0.381***	0.374***	0.312***	0.389***	0.334***
	(0.0659)	(0.110)	(0.103)	(0.119)	(0.099)
Reg_Qua	3.255***	3.251***	3.249***	3.361***	3.242***
	(1.063)	(1.159)	(1.160)	(1.157)	(1.043)
GDP_Cap	0.962	1.000	0.999	1.289	1.997
	(1.382)	(1.436)	(1.422)	(1.411)	(1.435)
Constant	35.42**	36.33**	35.59**	36.77**	36.53**
	(15.44)	(15.88)	(15.34)	(15.65)	(15.90)
Number of id	816	816	816	816	816
R-squared	0.207	0.234	0.222	0.211	0.242
F Test	88.5***	74.01***	72.08***	74.08***	62.78***

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Taken together, the findings support all three hypotheses. Firms in G7 countries with the CSO are more engaged in green innovation activities and thus are keener on reducing the environmental impact of their operations. Similarly, the high sustainability committee power further strengthens this positive effect of the presence of CSO on green innovation, while

industrial concentration weakens this effect. Alternatively, the high industrial competition facilitates and amplifies the positive effect of the existence of CSO on corporate green innovation.

5. Discussion and Conclusion

The first contribution of this study lies in extending the CSO literature, which has been more focused on environmental performance or overall sustainability outcomes (e.g., Kachouri and Riguen, 2025; Peters et al., 2019; Thun and Zülch, 2023), to green innovation. Although the previous literature emphasises the role of CSOs in altering the environmental policies and compliance (Wei et al. 2025; Oduro et al., 2022), it does not pay much attention to the dynamic and forward-looking nature of green innovation as a unique strategic outcome. Drawing on the upper echelons' theory, it is argued that the existence of CSO can influence the cognitive frames and strategic attention of an organisation to environmentally oriented technological advancements that are more complex, uncertain and resource demanding as compared to incremental environmental improvements. Such a distinction is essential since green innovation, in contrast to overall environmental performance, is a proactive, competitive advantage and is capable of creating ecological and economic value (Oduro et al., 2022). Through this connection, this study enhances the knowledge of how the values and knowledge of top executives translate into radical, future-focused sustainability outcomes.

The second contribution is based on the identification of the boundary conditions which affect the CSO green innovation relationship, namely, the moderating effect of sustainability committee power and industry concentration. Hence, the process of transforming the influence of CSOs into innovative environmental strategies is not only a matter of individual executive traits but is also a matter of sustainability committees and industry settings that support and endorse the long-term, sustainable-focused decision-making.

The contribution of this work also lies in extending the emerging literature on the determinants of green innovation by introducing the role of the CSO as a strategic enabler of green innovation. Although past literature has found that several organisational and institutional factors affect green innovation, including investments in R&D, environmental regulations, and pressures by stakeholders (e.g., Costa-Campi et al., 2017; Cuerva et al., 2014), relatively little is known about the impact of a specific sustainability leadership position at the executive level. CSOs, owing to their expertise, vision, and authority, influence the strategic orientation of firms towards long-term environmental objectives, thus spurring the introduction and realisation of green innovations. CSO can also be a channel through which the external institutional pressures, like the expectations of society, investor requests, and changes in regulations, can be interpreted and translated into actionable innovation strategies. By empirically demonstrating the positive influence of CSO presence on green innovation, the findings show sustainability leadership a key but hitherto unexploited driver of environmentally-oriented technological advancement. This broadens the scope of earlier studies by noting that not merely resources or external pressures can play a decisive role in improving corporate sustainablity initiatives.

This study also adds to the upper echelons theory and institutional theory to show how sustainability leadership roles at the leadership level interact with institutional forces to shape

green innovation outcomes. Although it has been acknowledged in previous studies that corporate environmental actions are influenced by the values, experiences, and strategic orientations of its executives (Hambrick & Mason, 1984; Fu et al., 2020), there has been little exploration of how personal-level factors interact with the industry pressure to drive innovation. In this respect, by highlighting the role of the CSO, it is argued that the appointment of a sustainability leader is not just an indicator of the commitment of the top management to its environmental stewardship but also an indicator of the ability of the firm to be responsive to industry influences towards greener technological solutions (DiMaggio & Powell, 1983). This two-theoretical approach demonstrates that the CSO is not only an internal champion of sustainability but also a strategic boundary-spanner who reconciles internal capacity with external demands.

5.1. Practical Implications

This study also offers valuable practical implications. To managers, the findings send a loud message: sustainability leadership can no longer be a marginal activity or even a marketing gimmick; it must be integrated into the core of strategic decision-making. Appointing a CSO who will actually have power is not just a symbolic move, but a long-term investment in the competitiveness of the firm. In situations where a CSO is a member of the top leadership team, sustainability goals become more aligned with corporate goals, resources are allocated more effectively, and environmental innovation is pursued with a strategic vision instead of being an isolated and ad-hoc activity.

Managers also need to recognise the fact that the existence of a powerful CSO can enable communications across various departments to make sure innovative projects are not just technically competent but also in line with the market expectations and the regulatory provisions. In a competitive business market, those which take the initiative to develop sustainability abilities in the leadership structure are expected to gain the rewards of reputation and financial advantages as well. Findings suggest that appointing a CSO alone is not sufficient to improve sustainability, rather firms have to ensure that CSO is supported through empowering sustainability committee that can help in decision-making process, resource allocation, and strategic implementation of sustainability initiatives. Managers must also know that the effectiveness of CSOs differs across industries. In highly competitive industries the competitive pressure from the peers amplifies the positive effect of CSOs in driving green innovation. Therefore, managers should align sustainability leadership strategies with their industry conditions.

This study also offer valuable practical implications. To the policymakers, the results accentuate the need to move beyond broad environmental targets and concentrate on the mechanisms that drive green innovation. One possible such mechanism would be to encourage or even mandate companies to incorporate sustainability expertise in their executive ranks. Governments are able to develop policy instruments that reward companies that have committed to sustainability leadership, e.g., by allowing preferential access to green financing programs, offering tax breaks on investment in environmental innovation, or otherwise publicly recognising companies that have taken a leadership role on sustainability governance. The policymakers in G7 economies have a unique opportunity to enhance the efficacy of such leadership by making sure that the regulatory frameworks facilitate transparency, accountability, and the free flow of information on sustainability. In this way, they not only

contribute to the success of individual firms but also reinforce the national innovation ecosystem, bringing the economy to its environmental and climate ambitions without losing global competitiveness. Policymakers targeting to promote green innovation as a way forward to improve corporate sustainability should not only encourage firms to appoint CSO but also strengthen internal governance and provide competitive incentives for such sustainability initiatives. This combination of internal governance support and external pressure can significantly improve environmental innovation outcomes at the firm level.

5.2. Limitations and Future Research Directions

Like any empirical study, this work also has some limitations which offer valuable future research directions. First, the analysis is based on the data of G7 countries, which are characterised by developed economies, developed institutional frameworks, and high levels of awareness of the environment, comparatively. Though this setting is a perfect environment to examine the hypothesized relationships as firm-level data on green innovation is difficult to obtain in other settings, it might limit the generalizability of the findings to other institutional contexts such as emerging or developing economies where regulatory pressures, the maturity of the market, and cultural attitude towards sustainability may vary significantly (Saeed et al., 2022). Future research could extend this framework by considering different institutional settings to investigate whether the impact of CSOs on green innovation also holds in settings with different regulatory pressures and cultural values.

Second, the research is based on secondary data, which, on the one hand, provides breadth and objectivity, but on the other hand, inevitably limits the possibility of capturing the specifics of leadership styles or informal sustainability initiatives that are not publicly reported (Delmas & Toffel, 2008). Future studies may integrate qualitative research methods, such as in-depth interviews or case studies, to explore more about the mechanisms through which CSOs can convert sustainability objectives into something new and innovative. These mixed-method strategies might reveal how CSOs can overcome internal opposition, win cross-functional support and institutionalise green thinking into product innovation. Third, in this study, one source of external pressure, industry concentration, is considered as a contingency factor. Future studies may consider other sources of institutional pressures, such as consumer green consciousness and institutional protection, that may influence the CSOs' decisions on green innovation.

Finally, the research is relatively static since it examines the relationship at a particular time interval. Green innovation is, however, a dynamic process that depends on changing regulatory environments, technological advancements and evolving stakeholder demands (Oduro et al., 2022). Longitudinal designs may yield more information about the temporal impacts of CSO leadership on green innovation in times of environmental policy change or economic transition.

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