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# Governing for the green: How European board attributes are driving environmental innovation

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## Abstract

This study examines the impact of corporate board attributes, namely, gender diversity, independence, size, tenure, and CEO duality, on environmental innovation (EI). The study utilised a large dataset of 13,278 firm-year observations belonging to companies from 24 European countries and covered the period 2010–2021. Drawing from the agency and stakeholder theories, we find that all attributes addressed in this study have a positive impact on EI. These findings enhance our understanding of how businesses manage EI in the real world. Strategic focus is essential for achieving environmental sustainability and fostering innovation in business processes. This study expands our understanding of the role of diverse, long-term, and independent board structures in fostering EI. We can use the insightful results it provides to plan future corporate strategies and policies.

**KEYWORDS**
board characteristics, corporate governance, environmental innovation, Europe

## 1 | INTRODUCTION

This study aims to explore the impact of board characteristics on Environmental Innovation (EI) in European companies from 2010 to 2021, examining how governance shapes firms' environmental strategies and practices. Concerns about environmental sustainability have recently increased with the massive growth in economic activity. In search of rapid growth rates, companies' increased production and consumption have had a detrimental impact on the climate and natural capital (Sandberg et al., 2019). Consumers, in turn, responded by gravitating toward goods that mitigate these unfavourable effects (Estapé-Dubreuil et al., 2016). Therefore, the focus on environmentalism has amplified, encouraging pertinent environmental regulations, suitable environmental management strategies, and market tools, as well as general organisational changes (Horbach, 2008; Ruiz-Castillo et al., 2024; Yin & Wang, 2018). New business models have been adopted where sustainability, social, and environmental governance mechanisms are of focal importance (García-Sánchez et al., 2019; Martínez-Azúa & Sama-Berrocal, 2022; Sandberg et al., 2019).

Environmental innovation (EI) implies adopting new business models that are manifested by innovation in methods, procedures, systems, and products to avoid or lessen adverse environmental effects (Brunnermeier & Cohen, 2003; Cai & Li, 2018; Horbach, 2008; Kesidou & Demirel, 2012; Kim et al., 2021; Riahi et al., 2023). EI is a long-term strategy that promotes sustainability by reducing resource consumption and associated adverse environmental effects (Nadeem et al., 2020) and aligning the business with the values of its stakeholders and customers (Zhu et al., 2022). It would help obtain legitimacy and a competitive advantage for business operations (Cecere et al., 2020). According to Nadeem et al. (2020) and Traversi et al. (2024), companies can improve their reputation, lessen environmental harm, and increase the effectiveness of their resources by incorporating sustainability values into their innovation activities. Although these mechanisms for innovation have many advantages, they also pose obstacles that businesses must overcome. Compared to other innovations, EI comes with higher costs, is riskier, more complicated, and uncertain (del Río et al., 2016). Adopting EI could potentially lead to several undesirable consequences for firms, such as the risk of failure, challenges with data accessibility, employee dissatisfaction, insufficient funding, high costs, and uncertainty about financial returns (Farza et al., 2022). Consequently, they hesitate to make significant systemic changes and continue using conventional business models (Confino, 2011).

  

Effective management of EI obstacles necessitates understanding and dedication to environmental stewardship (Farza et al., 2022). The strategic direction of the board's governance and mindfulness closely correlate with the effectiveness of EI (Githaiga & Kosgei, 2023; Nadeem et al., 2020). Boards have significant power in the strategic orientations of companies and are key players in integrating social and environmental issues (Keshminder & del Río, 2019). Ensuring sustainability, fostering innovation, and removing barriers to environmental progress all depend on efficient board oversight (Bower & Paine, 2017; Saman & Nelson, 2020). Committed board oversight guarantees the incorporation of life cycle considerations, environmental strategies, and sustainable production into core business models (Farza et al., 2022).

Most studies undervalue the contribution of corporate governance (CG) in promoting EI by concentrating on particular facets of board characteristics. Scholars have conducted a thorough investigation of board diversity. For example, Nadeem et al. (2020) examined comparable gender-related factors in American firms. Likewise, Moreno-Ureba et al. (2022) focused on the effects of female board participation in the FTSE-250. Furthermore, Gangi et al. (2023) examined the association between gender diversity, the board, and environmental responsibility using a sample of international banks. Farza et al. (2022) investigated how diversity in boards affects the EI of German firms. Simultaneously, Albitar et al. (2022) looked into the moderating effects of environmental governance on the EI and $CO_2$ relationship in UK enterprises, while Al-Maliki et al. (2023) considered the influence of the directors' attributes on innovation in the Middle Eastern business landscape. Konadu et al. (2022) investigated the effect of boards' diversity on carbon emissions within S&P 500 companies. The existing literature only covers a limited set of board characteristics and lacks thorough evidence based on a large dataset (Al-Maliki et al., 2023; Farza et al., 2022; Moreno-Ureba et al., 2022; Nadeem et al., 2020).

This study addresses the relationship between board characteristics and EI in Europe from 2010 to 2021. By utilising a substantial dataset consisting of 13,278 firm-year observations from a diverse sample of European countries, encompassing the majority of EU member states, we thoroughly examine how board attributes influence EI. Our findings demonstrate that several factors significantly promote alignment between firms' strategies and the increasing demand for environmental responsibility. Notably, the presence of female directors, independence of boards, longer tenure, larger board sizes, and the dual role of the board chair and the CEO in policy formulation emerge as significant in shaping sustainable practices.

This study offers several substantial contributions to the existing body of knowledge on corporate governance (CG) and EI. First, it broadens our understanding of the factors influencing EI by analysing a comprehensive range of board characteristics. While prior research has primarily focused on specific elements like board gender diversity (Albitar et al., 2022; Farza et al., 2022), our study goes further by considering board independence, duality, size, and tenure, thus filling a critical gap in the literature. This more extensive analysis provides a deeper understanding of the governance mechanisms that drive or hinder environmental efforts, offering significant theoretical and practical insights. Moreover, by incorporating *robustness tests*, such as controlling for the dynamic nature of EI using the system GMM estimator, our findings confirm the reliability and significance of these characteristics on EI.

Second, this study stands out for its European perspective, which allows it to offer insights beyond the limited geographical scope of much prior research. For instance, while studies such as Farza et al. (2022) and Albitar et al. (2022) have provided valuable insights, they are often regionally constrained. Our inclusion of data from small, intermediate, and large firms across Europe enhances the comprehensiveness of our analysis. Furthermore, by controlling for the EU Directive 2014/95, we capture how regulatory frameworks shape corporate sustainability strategies, adding relevance to the European context. This broader geographical lens allows us to contribute meaningfully to global discussions on EI and corporate governance, particularly as European firms are recognised as pioneers in environmental responsibility (Kolk, 2008; Simnett et al., 2009).

Third, this research provides robust evidence through additional tests that further enhance the validity of our findings. By controlling for the *endogeneity of board characteristics*, we ensure that the direction of causality between board traits and EI is accurately assessed. Moreover, by examining industries' sensitivity to CSR and *profitability*, we demonstrate how board characteristics exert differential impacts on EI across sectors and financial performance levels. For instance, board gender diversity and CSR committees have stronger positive effects on EI in CSR-sensitive industries and less profitable firms, which is crucial for crafting tailored governance strategies.

Fourth, by excluding UK firms from the analysis and controlling for *country-level cultural effects*, such as power distance and uncertainty avoidance, we further affirm the robustness of our results. These tests reveal the importance of considering broader contextual factors, as cultural and national dynamics significantly influence how board characteristics affect EI. This highlights the broader applicability of our findings to diverse cultural and regulatory settings, reinforcing the practical value of our research for both academics and practitioners.

Finally, this study underlines the growing importance of EI in response to increasing pressures from stakeholders and consumers. By highlighting actionable insights for firms seeking to align governance practices with sustainability goals, our research provides timely guidance in a rapidly evolving global business environment.

The study's format is as follows: The study's hypotheses are developed in Section 2 after the existing research and theoretical framework have been reviewed. The methodology, comprising the data, sample, variable measurement, and regression model, is delineated in Section 3. The empirical descriptive statistics, correlation, and regression analysis results are shown in Section 4. In Section 5, the conclusion is presented.

## 2 | THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

### 2.1 | Theoretical framework

The board of directors (BoD) is accountable for establishing the company's vision, mission, objectives, policies, and priorities, as well as the

regular approval and review of these elements. Additionally, they must guarantee that the strategies and capabilities necessary to accomplish these goals are available (Coulson-Thomas, 2023). Effective governance mechanisms enhance the board's oversight of the executives when it comes to managing potential risks, like those associated with social and environmental issues (Desender et al., 2013; Saman & Nelson, 2020), and the company's response, as demonstrated by EI. Increased levels of corporate governance have the potential to counteract managers' inadequate actions, advance the organisation's sustainable development, and aid in the formulation of an innovative long-term investment strategy (Dwekat, Seguí-Mas, et al., 2022).

Agency theory posits that managers put their interests ahead of those of shareholders in the event of a conflict (Alia & Mardawi, 2021; Landier et al., 2013). The preservation of shareholders' interests is guaranteed by adopting efficient governance mechanisms, particularly those related to the board (Korir & Tenai, 2020). In terms of the business's performance and continuity, its market share, competitive position, and environmental and social duties (Al-Shaer & Zaman, 2018; Ferrero-Ferrero et al., 2012), corporate governance ensures that the managers follow the established policies, strategic plan, and procedures (Armstrong et al., 2014; Zhu et al., 2022). The board effectiveness in carrying out its responsibilities and establishing sound governance is contingent upon the qualifications and characteristics of its members (Aguilera et al., 2011).

According to stakeholder theory, executives should prioritise stakeholders' needs in order to establish a relationship with them that will be beneficial to the organisation's long-term expansion (Edmans, 2013). Stakeholders pressure organisations to disclose their sustainability initiatives (Abdeljawad et al., 2022; Li, 2014; Neubaum et al., 2012; Phung et al., 2023; Sekarlangit & Wardhani, 2021). Environmentalists' significant pressure has compelled businesses to implement environmental initiatives overseen and monitored by the BoD (Radu & Smaili, 2022). This dedication relies on governance practices that are exceedingly effective (Voinea et al., 2022). Businesses demonstrate their societal and environmental commitment through their participation in social and environmental initiatives (Sen & Cowley, 2013). EI supports the company's reputation as intangible benefits, strengthens the company's relationship with stakeholders, and responds to stakeholders' environmental concerns, thereby enhancing the company's social role (Zheng & Iatridis, 2022).

Considering the legitimacy theory, firms should consider the society's values and interests and establish a mutually beneficial convention demonstrating both society's explicit and implicit expectations. To gain social legitimacy, firms need to adhere to legal regulations and exhibit socially responsible activities (O'Donovan, 2002; Vitolla & Rubino, 2017). As a firm's survival actually depends heavily on societal acceptance and stakeholders' understanding of its activities, loosing legitimacy endangers the firm's ability to continue and therefore, it should be eager to communicate its environmental and social commitment as a foundation for society's evaluation of its activities (Ogunode, 2022). In fact, creating a bond full of trust with society requires a positive board role in terms of governance to ensure social commitment and high transparency (Farza et al., 2022). The BoD must strengthen businesses' social contracts to ensure adherence to the norms, principles, and limitations of the local community. Implementing sustainable structures and procedures can achieve this (Dwekat, Seguí-Mas, & Tormo-Carbó, 2020).

Resource dependency theory suggests that BoDs with diverse resources can improve the firm's performance by reducing its reliance on external resources (Pfeffer & Salancik, 2015). When boards are well-composed and have skilled members and extensive networks, they can provide valuable perspectives, strategic orientation, and access to essential resources. Accordingly, the firm is better able to navigate and manage its external environment, thereby facilitating innovative activities (Hillman et al., 2009).

## 2.2 | Hypotheses development

The BoD is a vital governance mechanism that monitors executive behaviour, including social responsibility and sustainability-related budgets and activities, with the objective of protecting stockholders and other stakeholders' interests (Chang et al., 2017). Effective and competent boards are essential for ensuring that the business adheres to social responsibility laws and regulations and that the board fulfils its designated function (García-Sánchez et al., 2020; Konadu et al., 2022; Phung et al., 2023; Rossi et al., 2021). Li and He (2023) posited that a competent board facilitates member coordination and communication, which in turn effectively monitors the managers' cautious actions. Consequently, it reduces the management's opportunistic behaviour, increases risk-taking, and promotes innovation within the company. Furthermore, it reduces innovation uncertainty by providing the knowledge and resources required (Lu & Wang, 2018).

### 2.2.1 | Board gender diversity

Diversity in BoD is a critical governance tool that enhances firm performance, increases supervision, and reduces agency costs (Konadu et al., 2022). Increasing the representation of women on a corporation's BoD improves its environmental performance by addressing the diverse interests of stakeholders, shareholders, and communities. Gender-diverse BoDs are more capable of incorporating different viewpoints, as women bring qualities such as empathy and compassion to the table. These characteristics are critical for developing an ethical decision-making process that is essential for societal impact. This approach is consistent with stakeholder theory and enhances dedication to environmental sustainability, fostering long-term prosperity for all stakeholders (Dwekat, Meqbel, et al., 2022).

Participation of women in BoDs enhances decision-making processes by facilitating the development of innovative, environmentally sustainable strategies (Nadeem et al., 2020). Women's diverse perspectives frequently result in more comprehensive and creative approaches to addressing environmental issues. Their capacity to expand their knowledge and contribute complementary skills, in addition to their inherent abilities, stimulates their creativity and fosters various innovations (Horbach & Jacob, 2018).

A consensus on the environmental inclination of female directors exists as they boost boards performance in EI (Moreno-Ureba et al., 2022). Empirically, the overwhelming majority of existing studies suggest a strong and positive relationship between female involvement and EI despite the fact that some studies (e.g., Agustia, 2023; Traversi et al., 2024) demonstrated a negative correlation. However, it is crucial to acknowledge that women's tendency for risk-aversion may influence their approach to high-intensity R&D projects, such as those with an environmental focus (Cecere et al., 2020). Nevertheless, the diverse array of experiences and knowledge that female executive board members possess results from the numerous challenges they encounter. This diversity may serve to mitigate risk aversion and promote innovative solutions to environmental concerns. More female leaders are essential for advancing business environmental initiatives, as women's leadership styles prioritise teamwork and holistic thinking (Bazel-Shoham et al., 2024; Luís Firmino & Maciel Peixoto, 2023; Nadeem et al., 2020). Consequently, we suggest the following hypothesis:

**H1.** Environmental innovation is positively correlated with gender diversity on boards.

### 2.2.2 | Board size

The efficient execution of CG duties, particularly those related to EI, is the subject of ongoing debate on the impact of board size. In contrast to the widely held belief that larger board sizes decrease efficiency (Cheng, 2008; Horvath & Spirollari, 2012), an increasing body of research indicates the opposite. Larger boards are more effective at addressing stakeholder concerns, efficiently allocating control responsibilities, and positively influencing an organisation's social responsibility and employee engagement policies, as per stakeholder theory (Fuente et al., 2017; Rossi et al., 2021).

According to resource dependence theory, larger BoD with a wider variety of skills and expertise can substantially enhance a strategic initiative, particularly one emphasising EI. A board capable of successfully navigating the challenges of implementing clean technology and environmental management techniques is essential for EI, which integrates environmental protection into firm innovation practices (Karakaya et al., 2014; Mi et al., 2020). A larger board can more effectively prevent agency problems, leading to a higher quality of decision-making, as per agency theory. Consequently, the board is able to establish a positive environmental reputation and implement environmentally friendly technology (Adams et al., 2016).

The association between BoD size, EI, and corporate reputation is becoming more widely recognised (Zhao et al., 2022). However, large boards may negatively affect EI due to potential inefficiencies and higher transaction costs (Chindasombatcharoen et al., 2022). Studies have shown that the implementation of larger boards can enhance external engagement and emphasise the significance of sustaining a positive corporate image, thereby providing additional motivation for employee engagement initiatives (Orozco et al., 2018). So, we express our second hypothesis as follows:

**H2.** Board size and environmental innovation are positively related.

### 2.2.3 | Board duality

CEO duality is a form of governance that can potentially reduce the BoD's effectiveness and independence. In this scenario, the CEO serves as the chairman of the board (Ghardallou, 2022; Rossi et al., 2021). This duality may lead to administrative uncertainty, reduced responsibility distribution, and power concentration. The agency theory recommends separating the CEO and chair roles to prevent internal conflicts and ensure independence in governance and decision-making (Korir & Tenai, 2020). Following stakeholder theory, the BoD is more effectively able to address the stakeholders' diverse interests by separating the duties of the CEO and chairman, thereby enhancing the company's dedication to environmental issues (Frynas & Yamahaki, 2016).

Contradictory empirical evidence is present. Numerous studies indicate that stakeholders' interests are more effectively met when the CEO is not the board chairperson, particularly concerning EI (Voinea et al., 2022; Zhu et al., 2022). Research indicated that CEO dualism prioritises financial results over environmental and social responsibility (Godos-Díez et al., 2014; Rossi et al., 2021; Zhang, 2012). Other research specified that CEO duality may enhance efficiency (Brickley et al., 1997; Davies, 2000). Accordingly, we suggest the subsequent hypothesis:

**H3.** Board duality is associated with lower levels of environmental innovation.

### 2.2.4 | Board independence

The board's independence significantly influences a company's capacity to innovate environmentally friendly solutions and achieve long-term success. Zhu et al. (2022) and García-Sánchez et al. (2021) confirmed that independent directors enhance governance structures by offering an impartial and objective perspective, which guarantees that corporate decision-making considers environmental considerations. Because they are non-executives, they are able to offer an objective assessment of the firm's strategies, particularly in the areas of sustainability and innovation (Fuzi et al., 2016; Lu & Wang, 2018).

In order to prevent managers from making opportunistic decisions and to foster a commitment to long-term viability, agency theory posits that independent board members are vital (Moreno-Ureba et al., 2022). Social responsibility and sustainability in development significantly depend on the monitoring and defence of stakeholders' interests (García-Sánchez et al., 2020; Ntim & Soobaroyen, 2013). Al-Maliki et al. (2023) demonstrated the advantages of an independent board in the context of corporate innovation, particularly in environmental projects.

By broadening the company's perspective, ensuring adherence to environmental regulations, and enhancing transparency, independent

board members promote EI. Consequently, they promote the development of innovative strategies for environmental sustainability (Farza et al., 2022; Lu & Wang, 2018). Board independence fosters transparency and visibility, which are advantageous to EI. Consequently, stakeholders' confidence increases in accordance with the increasing demands of the environmentally-conscious market (Farza et al., 2022). Thus, we propose the subsequent hypothesis:

**H4.** Environmental innovation is positively affected by the independence of the board.

#### 2.2.5 | Board tenure

While the length of board tenure is one of the attributes affecting the company's environmental performance, the relationship is the subject of contradictory debate. Long-serving directors are inclined to be acquainted with managers, which diminishes the significance of their monitoring responsibilities and reduces their independence. This phenomenon aligns with agency theory, which posits that extended tenure may exacerbate agency issues by fostering closer relationships between directors and management, potentially resulting in decreased oversight and accountability (Jensen & Meckling, 1976). The counter-argument views the long tenure as a merit, as it positively influences the directors' knowledge and experience, as well as their commitment and adherence to oversight (Gallego-Álvarez & Rodriguez-Dominguez, 2023; Jia, 2017; Sun & Bhuiyan, 2020).

According to Li and Yang (2019) and Sierra-Morán et al. (2024), long tenure positively affects the company's innovation. According to stakeholder theory, directors with longer tenures may be more adept at incorporating sustainable practices into the organisation's strategy and more profoundly comprehending stakeholder expectations (Frynas & Yamahaki, 2016). Long-tenured members are more likely to be environmentally committed, as they are more likely to advocate for a wider variety of environmental initiatives, according to Gallego-Álvarez and Rodriguez-Dominguez (2023). Similarly, Cahyono, Harymawan, and Kamarudin (2023) asserted that board tenure diversity has a substantial role in reducing carbon emissions. However, Jia (2017) discovered that extending directors' tenures lowers the innovation rate. The following is our hypothesis:

**H5.** Board tenure positively impacts environmental innovation.

## 3 | METHODOLOGY

### 3.1 | Sample selection and data sources

This study uses a dataset of listed European-originated companies that spans 2010–2021, obtained from the Refinitiv Eikon database. The sample consists of a broad range of businesses from 24 European countries. The dataset initially contained 30,912 firm-year observations for 2576 corporations. To avoid a possible regulatory discrepancy, we exclude all firms incorporated outside of Europe. We also dropped all firms that had less than three consecutive years. This translates to 27,804 observations. Finally, we dropped firms with missing values on the required variables. In the final analysis, we used the remaining 13,278 firm-year observations. We also winsorised the variables that could have outlier values, particularly firm size, leverage, and profitability, at the 1 and 99% levels.

This sample is appropriate for EI analysis for several reasons. In large part, European businesses have gained recognition for their dedication to environmental impact due to the region's progressive environmental policies and the increasing emphasis on sustainable practices across various industries. In an effort to advance environmentally sound and commercially viable solutions, the European environmental research and innovation policy prioritises collaborative endeavours among diverse sectors (Mongo et al., 2021). Furthermore, the increasing demand for green products has motivated numerous organisations to implement innovative strategies that promote product excellence while concurrently complying with environmental regulations (Song et al., 2020).

The sample's extensive geographic coverage makes it an ideal choice to investigate the effect of BoD characteristics on EI in these 24 European countries due to the diverse regulatory frameworks, environmental policies, and market dynamics. Additionally, including diverse industries enhances the analysis (Albitar et al., 2022; Dwekat, Meqbel, et al., 2022). This enables a more thorough investigation of the relationship between EI and board characteristics in the European corporate sector.

### 3.2 | Variables measurement

#### 3.2.1 | Environmental innovation

Following prior studies (e.g., Albitar et al., 2022; Nadeem et al., 2020), we utilised the Environmental Innovation Score (EIS) from the Refinitiv Eikon database as the dependent variable to evaluate a company's environmentally focused initiatives. The score is a percentage that offers an in-depth understanding of an organisation's ability to capitalise on eco-friendly market opportunities, including technological advancements and sustainable product innovations, as well as to reduce environmental expenses. The greater the commitment to EI, the closer the score is to 100.

#### 3.2.2 | Board characteristics

The board attributes are independent variables. Our primary focus is on board duality, BoD gender diversity, tenure, independence, and size. The percentage of female directors on a BoD indicates the impact of gender diversity on decision-making and creativity (Moreno-Ureba et al., 2022). The size of the BoD, as determined by the number of its members, offers valuable insights into the diversity of perspectives that can enhance effective governance and oversight (Dwekat, Meqbel, et al., 2022). Board duality evaluates the influence

**TABLE 1** Variables of the study.

| Type of variable | Variable | Label | Measurement |
|---|---|---|---|
| Dependent | Environmental innovation | Environmental innovation | Environmental innovation score (EIS) obtained from the Refinitiv Eikon database degree takes values from 0%–100%. |
| Independent | Board gender diversity | Board gender | The percentage of female directors |
| | Board size | Board size | The number of board members |
| | CEO duality | Board duality | A dummy variable (takes one if the chairman is also the CEO, takes zero otherwise) |
| | Board independence | Board independence | Ratio of independent directors on the board |
| | Board tenure | Board tenure | The average number of years each board member has been on the board |
| Firm level control variables | Firm size | F-SIZE | The natural algorithm of total assets |
| | Return on assets | ROA | Net income to total assets |
| | Financial leverage | LEV | Total debt to total assets |
| | CSR committee | CSR committee | Dummy variable (1 if the firm has CSR Committee, zero otherwise) |
| Macro level control variables | GDP growth | GDP growth | Annual percentage growth rate of GDP (World Bank). |
| | Rule of law | Rule of law | Index from −2.5 to 2.5 reflecting confidence in societal rules (World Bank). |

of a single individual who serves as both CEO and chairman on a company's strategic direction and governance (Voinea et al., 2022). The proportion of independent directors on the BoD is a crucial indicator of fair governance, which is essential for using sustainable practices and making ethical decisions (Moreno-Ureba et al., 2022). Additionally, board tenure, the average number of years of each member service, offers insight into the board's stability and experience (Gallego-Álvarez & Rodriguez-Dominguez, 2023; Mardawi et al., 2023).

### 3.2.3 | Control variables

Our analysis is controlled by a variety of variables. Alia et al. (2024) define the size of the firm variable as the natural logarithm of total assets. Size represents the firm's resource capacity, a critical factor in innovation (Dwekat, Seguí-Mas, et al., 2022). We employ the ratio of total debt to total assets (financial leverage) to evaluate a company's financial strategy and influence on investments in sustainable and innovative projects (Dwekat, Meqbel, et al., 2022). Return on assets is used to evaluate our financial performance. Wagner (2007) posits that financially stable organisations are more inclined to participate in environmentally sustainable initiatives. The existence of a CSR committee, expressed as a binary variable, indicates an organisation's commitment to achieving the objectives related to sustainable development (Hussain et al., 2018; Rodrigue et al., 2013).

In addition, we include two macro-level variables: GDP growth and the rule of law. To consider the country's economic condition, we incorporate the gross domestic product (GDP) growth rate into our analysis. We calculate GDP growth using fixed prices (Kaufmann et al. 2011), utilising data from the World Bank (WB, 2023). To evaluate the influence of the current regulatory culture on firm supervision and monitor compliance with standards and regulations (Kaufmann et al. 2011), we include the rule of law as an indicator of the degree of confidence in society's rules, including the integrity of contract and rights enforcement, the strength of the judiciary, and the degree of compliance with them. The World Bank's governance indicators (WB, 2023) contain information regarding the rule of law. Table 1 summarises the study variables, their type, and their measurements.

## 3.3 | Regression model

The subsequent multiple regression model was implemented to evaluate the impact of board characteristics on EI:

$$\begin{aligned} EI_{it} = {} & \alpha_0 + \beta_1 \text{Board Gender}_{it} + \beta_2 \text{Board size}_{it} \\ & + \beta_3 \text{Board duality}_{it} + \beta_4 B \text{ Board Independence}_{it} \\ & + \beta_4 \text{Board tenure}_{it} + \beta_5 \text{FSIZE}_{it} + \beta_6 \text{ROA}_{it} \\ & + \beta_6 \text{CSR Committee}_{it} + \beta_6 \text{LEV}_{it} + \beta_6 \text{GDP Growth}_{it} \\ & + \beta_6 \text{Rule of Law}_{it} + \varepsilon_{it} \end{aligned} \quad (1)$$

While the main variables are identified in Table 1, $\beta_k$ represents the regression coefficients, and $\varepsilon_{it}$ is the error term or regression residual.

In our estimation process, we accounted for the variations in countries, firms, and times separately in different specifications to enhance the robustness of the findings. Additionally, we conduct various tests to ensure the reliability and stability of our primary estimates, which are discussed in Section 4.4.

# 4 | EMPIRICAL RESULTS

## 4.1 | Descriptive statistics

Table 2 presents the descriptive statistics for the study variables, offering a comprehensive overview of the factors influencing

Environmental Innovation (EI). The average EI score is reported at 33.1%, accompanied by a standard deviation of 33.3%, highlighting significant variability in the extent of companies' engagement in environmental activities and their commitment to sustainability.

Regarding board-related attributes, there is notable diversity. The average percentage of female board members is 25.2%, which reflects the degree of gender diversity within these governance bodies. Additionally, the average board size of 9.836 members illustrates a range of governance structures and levels of expertise present within the boards. Furthermore, with an average board independence of 55.2%, there is evidence of considerable independent decision-making capacity. The average board tenure, standing at 6.241 years, indicates both the experience and stability of board members. Finally, CEO duality is observed in 20.6% of the companies, indicating a prevalent centralised leadership model within these firms.

Firm-level attributes also show a significant deal of variation. The average firm size (Ln of assets) is 15.062, with a 2.053 standard deviation, suggesting a wide range of operational scales. The average return on assets (ROA) is 6%, signifying varying profitability and financial efficiency levels across the sample. CSR committees are present in approximately 64% of companies, highlighting the importance of CSR in governance frameworks. The 24.5% average leverage indicates that firms have different risk-taking and financial management approaches.

The variables that capture macroeconomic and institutional contexts are the GDP growth rate, which has a mean of 1.356%, and the Rule of Law, which has a mean of 1.518. These statistics indicate the broader economic and regulatory environments in which these firms operate.

## 4.2 | Correlation

Table 3 provides a bivariate perspective on the relationship between variables. It also offers a supportive viewpoint on the issue of multicollinearity between the independent variables in the estimation process. Correlations are generally negligible, which indicates that multicollinearity is not a concern in our dataset. The BoD size and the firm size exhibit the highest correlation, which is 58.8%. The value is

**TABLE 2** Descriptive statistics.

| Variable | Obs. | Mean | SD | Max | Min |
|---|---|---|---|---|---|
| Environmental innovation | 13,278 | 0.331 | 0.333 | 0.999 | 0.000 |
| Board gender | 13,278 | 0.252 | 0.147 | 1.000 | 0.000 |
| Board independence | 13,278 | 0.552 | 0.265 | 1.000 | 0.000 |
| Board size | 13,278 | 9.836 | 4.020 | 63.000 | 1.000 |
| Board tenure | 13,278 | 6.241 | 2.948 | 40.750 | 0.000 |
| Board duality | 13,278 | 0.206 | 0.405 | 1.000 | 0.000 |
| F-SIZE | 13,278 | 15.062 | 2.053 | 20.123 | 8.398 |
| ROA | 13,278 | 0.060 | 0.099 | 0.358 | −0.594 |
| CSR committee | 13,278 | 0.640 | 0.480 | 1.000 | 0.000 |
| LEV | 13,278 | 0.245 | 0.175 | 0.807 | 0.000 |
| GDP growth | 13,278 | 1.356 | 4.119 | 24.475 | −11.167 |
| Rule of law | 13,278 | 1.518 | 0.424 | 2.125 | 0.049 |

**TABLE 3** Correlation matrix.

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Environmental innovation | 1.000 | | | | | | | | | | | |
| (2) Board gender | 0.148 | 1.000 | | | | | | | | | | |
| (3) Board independence | 0.125 | 0.219 | 1.000 | | | | | | | | | |
| (4) Board size | 0.299 | 0.072 | −0.131 | 1.000 | | | | | | | | |
| (5) Board tenure | 0.019 | −0.077 | −0.107 | 0.020 | 1.000 | | | | | | | |
| (6) Board duality | 0.069 | 0.031 | −0.115 | 0.159 | 0.222 | 1.000 | | | | | | |
| (7) F-SIZE | 0.447 | 0.135 | 0.119 | 0.588 | −0.003 | 0.070 | 1.000 | | | | | |
| (8) ROA | −0.014 | 0.007 | 0.041 | −0.028 | 0.084 | 0.012 | 0.147 | 1.000 | | | | |
| (9) CSR committee | 0.336 | 0.165 | 0.121 | 0.303 | −0.034 | 0.077 | 0.394 | 0.079 | 1.000 | | | |
| (10) LEV | 0.044 | 0.041 | −0.029 | 0.088 | −0.087 | 0.036 | 0.196 | −0.057 | 0.112 | 1.000 | | |
| (11) GDP growth | 0.010 | −0.013 | 0.034 | −0.022 | −0.004 | −0.041 | −0.037 | 0.042 | 0.005 | −0.053 | 1.000 | |
| (12) Rule of law | −0.011 | −0.009 | 0.178 | −0.253 | 0.031 | −0.139 | −0.186 | 0.003 | 0.004 | −0.080 | 0.129 | 1.000 |

significantly below the 80% threshold (Asteriou & Hall, 2007), which is widely regarded as the standard for identifying multicollinearity issues.

## 4.3 | Regression analysis

Using data from 2010 to 2021, the regression analysis provides fundamental insights into how board characteristics affect European companies' EI. We first determine if a fixed- or random-effects model is fitting using the Hausman test. The fixed effect model was selected because the test's p-value was less than 5%. Table 4 provides five specifications for the estimation results, improving reliability and providing a comprehensive understanding of the nexus between BoD composition and EI in European corporate governance.

In models 2 and 3, we employed the dummy variable approach to account for the time and country fixed effects, respectively. However, in model 2, we removed the macro variables because of multicollinearity with the country dummies. We employed the within estimator for the firm fixed effect in models 4 and 5; for the time fixed effect in model 5, the dummy approach is used. Finally, for reference, Model 1 does not consider any fixed effects. All models used robust standard errors that were corrected to account for heteroskedasticity. The five models' R-squares vary from 8.5% to 26.5%.

All the board characteristics addressed in this study positively affect EI, according to Table 4's findings. Increased gender diversity on boards significantly boosts EI initiatives. Previous research (Konadu et al., 2022; Moreno-Ureba et al., 2022; Nadeem et al., 2020) supports this finding by highlighting female directors' critical role in guiding corporate strategies toward environmental concerns. BoDs with a

**TABLE 4** Regression analysis.

| Variables | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Board gender | 0.132*** | 0.0910*** | 0.0861*** | 0.149*** | 0.0343 |
| | (0.0145) | (0.0191) | (0.0195) | (0.0303) | (0.0318) |
| Board independence | 0.0733*** | 0.0559*** | 0.0730*** | 0.0427** | 0.0250 |
| | (0.0140) | (0.0120) | (0.0103) | (0.0195) | (0.0201) |
| Board size | 0.00565*** | 0.00315*** | 0.00647*** | −0.00167 | −0.000478 |
| | (0.00115) | (0.000954) | (0.000823) | (0.00151) | (0.00152) |
| Board tenure | 0.00339*** | 0.00108*** | 0.00317*** | 0.00559*** | 0.00459** |
| | (0.000393) | (0.000321) | (0.000892) | (0.00199) | (0.00197) |
| Board duality | 0.0199*** | 0.0186*** | 0.0212*** | 0.00276 | 0.00524 |
| | (0.00360) | (0.00378) | (0.00644) | (0.0114) | (0.0113) |
| F-SIZE | 0.0540*** | 0.0558*** | 0.0563*** | 0.0512*** | 0.0362*** |
| | (0.00171) | (0.00173) | (0.00159) | (0.00918) | (0.00948) |
| ROA | −0.117*** | −0.0425 | −0.0940*** | −0.0433 | −0.0159 |
| | (0.0317) | (0.0257) | (0.0221) | (0.0375) | (0.0374) |
| CSR committee | 0.113*** | 0.122*** | 0.113*** | 0.0589*** | 0.0509*** |
| | (0.0104) | (0.0108) | (0.00591) | (0.00964) | (0.00980) |
| LEV | −0.0349*** | −0.0639*** | −0.0400*** | 0.0133 | −0.00142 |
| | (0.00605) | (0.00746) | (0.0143) | (0.0324) | (0.0326) |
| GDP growth | −5.55e-05 | | −0.000543 | 0.000418 | 0.000617 |
| | (0.000528) | | (0.00116) | (0.000259) | (0.000740) |
| Rule of law | 0.0253*** | | 0.0332*** | −0.161*** | −0.0387 |
| | (0.00489) | | (0.00635) | (0.0280) | (0.0395) |
| Constant | −0.732*** | −0.719*** | −0.790*** | −0.314** | −0.288** |
| | (0.0220) | (0.0160) | (0.0262) | (0.142) | (0.146) |
| Observations | 13,278 | 13,278 | 13,278 | 13,278 | 13,278 |
| Firm fixed effect | No | No | No | Yes | Yes |
| Year dummy | No | No | Yes | No | Yes |
| Country dummy | No | Yes | No | No | No |
| R-squared | 0.241 | 0.265 | 0.244 | 0.085 | 0.099 |
| Number of id | | | | 2247 | 2247 |

*Note*: Robust standard errors in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

higher female presence are more proactive in incorporating environmental priorities into their corporate agendas.

These findings are consistent with the European Commission's emphasis on gender equality, as gender-diverse boards are recognised for enhancing collective decision-making. Compared to their male colleagues, female directors are more sensitive to environmental and social issues (Farza et al., 2022). Their empathetic and ethical decision-making enhances the firm's environmental and social performance and stakeholder relationships (Nuber & Velte, 2021). Riahi et al. (2023) found that BoD heterogeneity promotes EI more than homogeneity. Additionally, the environmental performance of corporations is significantly predicted by the presence of women on boards, particularly independent directors (Ciasullo et al., 2022). A cost-effective innovation is enhanced by gender diversity, which fosters a balanced risk attitude (Griffin et al., 2021). According to Nadeem et al. (2019), women, as directors, are more cautious in managing innovation risks due to their tendency to be risk-averse. Additionally, Mirza et al. (2012) contended that a diverse boardroom encourages innovative thinking, providing companies with a competitive advantage in industries that are driven by innovation.

Additionally, the effect of female directors on equal opportunity is enhanced by social responsibility committees (Konadu et al., 2022; Moreno-Ureba et al., 2022). Women's moral commitment and empathy render them valuable board members, fostering social and environmental progress and enhancing stakeholder relations (Nuber & Velte, 2021). This not only preserves the organisation's reputation but also mitigates legal and regulatory consequences.

Empirical evidence also indicates that the decision-making of female directors, which is risk-averse and regulatory-compliant, enhances employee engagement, creativity, innovation, and overall firm progress (Nadeem et al., 2019). Gender-diverse boards demonstrate superior performance in executing EI strategies (Alia & Mardawi, 2021; Dwekat, Seguí-Mas, Tormo-Carbó, & Carmona, 2020). In order to optimise their beneficial influence on EI, female directors should be granted an adequate level of authority and power on boards (García-Meca et al., 2023). Therefore, female directors and board diversity are essential for enhancing firm performance and EI in various aspects (Elad Fotoh et al., 2018; Konadu et al., 2022).

In models 1–3, BoD size and CEO duality have a positive effect on EI; however, they become insignificant in models 4 and 5. The positive effects suggest that larger boards and combined leadership roles have the potential to drive EI primarily through improved resources and strategic alignment. However, the insignificance of these variables conforms to the findings of Farza et al. (2022) and Romano et al. (2020).

Fuente et al. (2017) asserted that a larger board can foster EI by implementing policies that prioritise employee engagement, control responsibility distribution, social responsibility, and stakeholders' concerns at an entirely feasible level. Larger boards, by offering diverse skills and expertise, support strategic initiatives and more effectively address the complicated nature of the implementation of advanced environmental management practices and clean technologies, which are significant drivers of innovation (Karakaya et al., 2014). Additionally, agency theory contends that the quality of decisions is enhanced and agency costs are reduced when the board is sufficiently large, promoting the adoption of environmentally friendly technologies and establishing a more environmentally friendly image (Adams et al., 2016). Additionally, larger boards facilitate sustainable innovation, which is consistent with the firm's overall goals for society and the environment (Fuente et al., 2017; Moreno-Gómez et al., 2018).

In contrast to our initial assumptions, a positive correlation between board duality and EI has been established. This outcome supports the findings of Nadeem et al. (2020). Macaulay et al. (2018) demonstrated that the decision-making process and a shared strategic orientation are positively impacted by board duality. This leadership arrangement is designed to encourage and facilitate the implementation of a wide range of sustainable management solutions, ideas, and behaviours relevant to the environment. It also ensures that these initiatives are strategic, meaning they align with the organisation's operational objectives. Additional research has contended that strong CEOs leverage social and environmental sustainability to enhance their reputation, affecting their tenure and compensation (Bear et al., 2010; Jizi et al., 2014; Nekhili et al., 2017). Finally, Galia et al. (2015) suggested a positive correlation between the likelihood of introducing environmental benefits and CEO duality.

In accordance with prior research, a positive correlation between EI and BoD independence is observed. Farza et al. (2022) argued that an independent board is essential to enhance a company's transparency and compliance with environmental regulations. Resource mobilisation and administration are essential for EI development, as García-Sánchez et al. (2020) indicated. Independent directors play a significant role in such processes. Managers are encouraged to take risks by independent boards, which is essential for the promotion of innovation, as Lu and Wang (2018) highlighted. García-Sánchez et al. (2020) and Zhu et al. (2022) emphasised the significance of independent directors in integrating environmental factors into corporate decision-making. In addition, Al-Maliki et al. (2023) demonstrated that environmentally focused initiatives are prioritised by highly independent boards, thus significantly contributing to business innovation.

The central concepts of stakeholder theory and agency theory are in agreement with these findings. According to Moreno-Ureba et al. (2022), the company's long-term viability is encouraged, and initiatives to enhance corporate culture are promoted by the presence of actively supervising independent directors. Nadeem et al. (2020) found that independent directors' increased accountability and commitment to stakeholders, the community, and environmental issues have a substantial positive impact on their EI. In addition, Ruiz-Castillo et al. (2024) illustrated that independent directors exercise caution when confronted with potential dissatisfaction with the company's strategic direction to safeguard both the company's image and their professional reputation. The legitimacy and reputation of the company are also enhanced by board independence, as discovered by Farza et al. (2022).

The results show a positive correlation between BoD tenure and EI, which contributes to our comprehension of the ways in which board characteristics influence corporate sustainability practices. This

result matches the hypothesis that directors who have served for an extended period have a positive impact on environmental performance given their accumulated knowledge and experience, which enhances their commitment and effectiveness in their oversight roles (Gallego-Álvarez & Rodriguez-Dominguez, 2023; Sun & Bhuiyan, 2020).

Previous research has confirmed that BoD tenure has a beneficial impact on EI. According to research conducted by Li and Yang (2019) and Sierra-Morán and Cabeza-García, directors who have served for an extended period are more likely to foster innovation within their organisations. Directors are able to develop a more comprehensive understanding of the company's operations and strategic objectives as a result of their extended tenure, which in turn strengthens their dedication to environmental initiatives. Gallego-Álvarez and Rodriguez-Dominguez (2023) confirmed that long-tenured members are more likely to support a broader range of environmental initiatives, underscoring their significance in promoting sustainable practices.

Additionally, Cahyono, Harymawan, and Kamarudin (2023) discovered that diversity in board tenure significantly reduces carbon emissions. This suggests that combining long and short tenures may benefit environmental effects. This diversity ensures a balance of new perspectives and experienced oversight, enhancing the board's overall effectiveness in addressing environmental issues. On the other hand, Jia (2017) contended that the extension of directors' tenures may result in a loss of independence and complacency, which could impair innovation. Nevertheless, the vast majority of evidence indicates that the advantages of accumulated experience and more profound firm-specific knowledge outweigh these apprehensions, particularly in the context of EI.

The results provide insight into the substantial impact of controlling variables on EI. The existence of a CSR committee and the company's size have a positive and significant effect, while leverage and ROA have a negative impact. Specifically, the positive impact of firm size suggests that larger companies are more capable of funding and supporting EI projects, potentially due to their increased resources and capabilities. Research has demonstrated that larger organisations implement sustainable practices more effectively due to their extensive infrastructure and resources (Dwekat, Seguí-Mas, et al., 2022; Zhou et al., 2023). Additionally, the positive impact of a CSR committee on EI supports the theory that businesses with dedicated CSR committees have a higher chance to value and effectively manage environmental issues. The significance of these committees in strengthening an organisation's dedication to environmentally conscious practices and reconciling corporate strategy with environmental objectives is highlighted by their noteworthy influence (Dwekat, Meqbel, et al., 2022).

Conversely, the negative return on assets effect implies that more profitable firms may have a reduced incentive to pursue EI, instead prioritising the preservation of financial performance. This suggests that these organisations may prioritise immediate benefits over long-term sustainability plans, considering EI a cost rather than an investment. Similarly, the negative leverage effect suggests increased debt levels may compromise a company's ability to finance innovative environmental projects. Nadeem et al. (2020) argued that organisations with substantial leverage may prioritise immediate financial obligations over long-term investments in environmentally sustainable practices, thus hindering innovation in this field. This finding emphasises the necessity for companies to wisely manage their debt in order to prevent their environmental initiatives from being compromised, thereby highlighting the critical balance between financial management and the application of environmental strategies. The study results regarding the macro variables suggest that GDP growth has no significant impact on EI, while the rule of law effect produces mixed results.

## 4.4 | Robustness tests

### 4.4.1 | Controlling for the dynamic nature of EI

The current year's board characteristics and the previous year's EI activities can influence EI. We can capture the dynamic effect of previous periods of the dependent variable on the model by including the lagged value of EI as a regressor. Static panel data estimators are frequently inadequate for mitigating this regressor's endogeneity. Following previous research (Nadeem et al., 2017; Nadeem et al., 2020), we used the System Generalised Method of Moments (GMM) estimator. To account for the lagged regressor's endogeneity bias, we re-estimate the study regression with a two-step system GMM estimator (Blundell & Bond, 1998).

The empirical results from system GMM estimation, displayed in Table 5, are similar to the main results shown in Table 4, which show that the baseline models are reliable. By considering the dynamic effects and controlling for endogeneity, our findings confirm the significant impact of BoD characteristics on EI, supporting the results' robustness. However, we can see that the speed of adjustment is extremely slow (less than 10%), indicating the inertia of firms' EI practices from year to year. We conclude that EI is primarily a firm-specific characteristic that slowly shifts from year to year.

### 4.4.2 | Controlling for the endogeneity of board characteristics

Endogeneity concerns pose a significant challenge to accounting and finance research. The appointment of directors to boards, along with their various characteristics, can be an endogenous process influenced by the firm's operational and informational environments (Wintoki et al., 2012). Governance studies, like this one on board characteristics and EI, frequently encounter endogeneity issues. One way to overcome this possibility is to include independent variables that lag one period behind the dependent. This should confirm that the relationship goes from the independent variable to the dependent variable, not the other way around. Table 6 reproduces the results in Table 4 after accounting for this possibility. The results are qualitatively comparable to those presented in Table 4.

**TABLE 5** GMM-system.

| Variables | (1) | (2) |
|---|---|---|
| Board gender | 0.017* | −0.004 |
| | (0.010) | (0.011) |
| Board independence | 0.013** | 0.012** |
| | (0.006) | (0.006) |
| Board size | −0.000 | 0.000 |
| | (0.000) | (0.000) |
| Board tenure | 0.001** | 0.001** |
| | (0.001) | (0.001) |
| Board duality | 0.000 | 0.000 |
| | (0.003) | (0.003) |
| F-SIZE | 0.005*** | 0.005*** |
| | (0.001) | (0.001) |
| ROA | −0.013 | −0.006 |
| | (0.015) | (0.015) |
| CSR committee | 0.012*** | 0.011*** |
| | (0.004) | (0.004) |
| LEV | 0.003 | 0.001 |
| | (0.008) | (0.008) |
| GDP growth | 0.001** | 0.000 |
| | (0.000) | (0.001) |
| Rule of law | −0.005 | −0.003 |
| | (0.003) | (0.003) |
| L. Environmental innovation | 0.900*** | 0.914*** |
| | (0.020) | (0.019) |
| Constant | −0.050** | −0.043** |
| | (0.020) | (0.019) |
| Observations | 11,118 | 11,118 |
| Firm fixed effect | No | No |
| Year dummy | No | Yes |
| Country dummy | No | No |
| Number of id | 2085 | 2085 |
| ar1 p | 0.001 | 0.001 |
| ar2 p | 0.415 | 0.443 |
| Hansen *p* | 0.692 | 0.359 |

*Note*: Robust standard errors in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

### 4.4.3 | Controlling for sensitivity of industry to CSR

Table 7 illustrates the effect of industry sensitivity on the relationship between EI and BoD characteristics. Environmentally sensitive industries are more likely to prioritise environmental values due to their greater environmental impact. The stronger correlation between BoD characteristics and EI in these industries indicates this increased emphasis.

The impact of each type of industry was considered by dividing companies into CSR-sensitive and CSR-non-sensitive categories. Following Nadeem et al. (2020) and Dwekat, Meqbel, et al. (2022), we classified firms in the utilities, mining, and production industries as CSR-sensitive. These industries are believed to be more likely to convey a positive social image due to the substantial environmental impact of their operations (Al-Shaer & Zaman, 2018).

Table 7 demonstrates that the correlation between EI and BoD gender diversity is significantly more pronounced in environmentally sensitive industries. This implies that female directors are particularly effective in promoting EI in industries where environmental impact is a primary concern. In contrast, board gender diversity is still advantageous in non-sensitive industries; however, its influence is weakened. Additionally, the degree of influence exerted by board independence and CSR committees is contingent upon the industry's sensitivity. The significance of governance structures in sectors with high environmental stakes is underscored by the association between these characteristics and increased EI in sensitive industries. These results underscore the significance of considering the industry context when evaluating board characteristics' efficiency in fostering EI. The disparities in impacts observed across industries indicate that customised governance strategies are essential for enhancing environmental outcomes.

### 4.4.4 | Controlling for the level of profitability

Our results in Table 8 demonstrate that profitability is a significant factor in the relationship between EI and board characteristics. Profitable firms are able to allocate resources to costly and long-term environmental initiatives, while those that are less profitable may employ these strategies to attract eco-conscious customers, optimise resources, and reduce costs. In accordance with Nadeem et al. (2020), we employ ROA to categorise firms as either high or low profitability, as determined by the mean of the ROA variable. We find that the correlation between board gender diversity and EI is significantly stronger in less profitable firms, suggesting that female directors are particularly effective in these environments. In contrast, the influence of BoD gender diversity is less important in more profitable firms despite the fact that it remains positive.

The degree of influence of other BoD characteristics, such as independence and CSR committees, is contingent upon profitability, with less profitable firms experiencing the greatest impact. These results underscore the significance of profitability in evaluating a board's effectiveness in fostering EI. The disparities in impacts across profitability levels suggest that customised governance strategies are essential for enhancing environmental outcomes. Our results provide evidence that less profitable companies are more likely to benefit from diverse and independent boards that have strong CSR commitments. This suggests that firms with limited resources could leverage these factors to increase their EI.

### 4.4.5 | EU directive

Directive 2014/95/EU is the most significant directive of the European Union (EU) influencing corporate sustainability strategies

**TABLE 6** Reproducing the results of Table 4 using lagged independent variables.

| Variables | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| L. Board gender | 0.130*** | 0.0836*** | 0.0775*** | 0.139*** | 0.0235 |
| | (0.0154) | (0.0199) | (0.0224) | (0.0334) | (0.0358) |
| L. Board independence | 0.0839*** | 0.0634*** | 0.0833*** | 0.0480** | 0.0291 |
| | (0.0151) | (0.0131) | (0.0117) | (0.0208) | (0.0213) |
| L. Board size | 0.00598*** | 0.00344*** | 0.00682*** | −0.000913 | 0.000239 |
| | (0.00119) | (0.00103) | (0.000892) | (0.00169) | (0.00171) |
| L. Board tenure | 0.00365*** | 0.00128** | 0.00343*** | 0.00634*** | 0.00526** |
| | (0.000547) | (0.000474) | (0.00102) | (0.00222) | (0.00223) |
| L. Board duality | 0.0194*** | 0.0194*** | 0.0206*** | −0.00169 | 6.26e-05 |
| | (0.00337) | (0.00366) | (0.00713) | (0.0113) | (0.0112) |
| F-SIZE | 0.0544*** | 0.0558*** | 0.0566*** | 0.0505*** | 0.0375*** |
| | (0.00193) | (0.00206) | (0.00179) | (0.0103) | (0.0105) |
| ROA | −0.132*** | −0.0506 | −0.107*** | −0.0313 | −0.00955 |
| | (0.0362) | (0.0317) | (0.0274) | (0.0454) | (0.0448) |
| CSR committee | 0.112*** | 0.121*** | 0.112*** | 0.0553*** | 0.0502*** |
| | (0.0109) | (0.0115) | (0.00668) | (0.0109) | (0.0110) |
| LEV | −0.0386*** | −0.0683*** | −0.0430*** | −0.0130 | −0.0257 |
| | (0.00684) | (0.00706) | (0.0161) | (0.0363) | (0.0366) |
| GDP growth | −0.000195 | | −0.00233* | 0.000535* | 0.000604 |
| | (0.000572) | | (0.00131) | (0.000281) | (0.000843) |
| Rule of law | 0.0238*** | | 0.0333*** | −0.160*** | −0.0506 |
| | (0.00587) | | (0.00709) | (0.0305) | (0.0421) |
| Constant | −0.736*** | −0.719*** | −0.799*** | −0.297* | −0.279* |
| | (0.0287) | (0.0190) | (0.0288) | (0.164) | (0.166) |
| Firm fixed effect | No | No | No | Yes | Yes |
| Year dummy | No | No | Yes | No | Yes |
| Country dummy | No | Yes | No | No | No |
| Observations | 11,040 | 11,040 | 11,040 | 11,040 | 11,040 |
| *R*-squared | 0.225 | 0.251 | 0.228 | 0.080 | 0.092 |
| Number of id | | | | 2064 | 2064 |

*Note*: Robust standard errors in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

(Di Vaio et al., 2020). Businesses that employ more than 500 personnel are legally mandated to disclose sustainability-related data (Mardawi et al., 2023). Consequently, our research incorporates Directive 2014/95/EU, as it has the potential to influence the environmental practices of businesses (García-Sánchez et al., 2022; Meqbel et al., 2024). The results presented in Table 9 are consistent with those obtained from the main model.

### 4.4.6 | Excluding UK from the sample

The study's results may be influenced by the sample distribution, which suggests a substantial representation of UK firms. In line with Simoni et al. (2020) and Meqbel et al. (2024), we revised our study models by excluding these firms from our analysis in order to mitigate the effect of the predominance of UK companies in the sample. The results presented in Table 9 are consistent with those obtained from the primary model.

### 4.4.7 | Controlling for country-level culture

Previous research (e.g., De Beelde & Tuybens, 2015; Simnett et al., 2009) suggested that country-level characteristics like stakeholder orientation can influence a firm's decision to engage in environmental reporting. Building on these insights, we examined how cultural dimensions—such as power distance, individualism, masculinity, and uncertainty avoidance—affect EI. These dimensions are measured according to Hofstede's framework (Hofstede, 2011). Specifically, power distance (PDI), measured using Hofstede's power

**TABLE 7** CSR sensitive industries.

| Variables | CSR sensitive | CSR non-sensitive |
|---|---|---|
| Board gender | 0.232*** | 0.116*** |
| | (0.0605) | (0.0349) |
| Board independence | 0.0603* | 0.0375 |
| | (0.0352) | (0.0232) |
| Board size | 0.00193 | −0.00288* |
| | (0.00343) | (0.00163) |
| Board tenure | 0.00124 | 0.00745*** |
| | (0.00353) | (0.00234) |
| Board duality | 0.00209 | 0.00185 |
| | (0.0192) | (0.0137) |
| F-SIZE | 0.0362** | 0.0548*** |
| | (0.0178) | (0.0106) |
| ROA | −0.0958 | −0.0231 |
| | (0.0683) | (0.0440) |
| CSR committee | 0.0443*** | 0.0641*** |
| | (0.0140) | (0.0123) |
| LEV | 0.0624 | −0.00273 |
| | (0.0456) | (0.0406) |
| GDP growth | 0.000337 | 0.000493 |
| | (0.000503) | (0.000301) |
| Rule of law | −0.0720 | −0.196*** |
| | (0.0492) | (0.0334) |
| Constant | −0.201 | −0.331** |
| | (0.283) | (0.164) |
| Observations | 4083 | 9195 |
| *R*-squared | 0.071 | 0.096 |
| Number of id | 688 | 1559 |

*Note*: Robust standard errors in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

**TABLE 8** Controlling for the level of profitability.

| Variables | High-profitability | Low-profitability |
|---|---|---|
| Board gender | 0.0807* | 0.208*** |
| | (0.0419) | (0.0442) |
| Board independence | 0.0457 | 0.0233 |
| | (0.0281) | (0.0268) |
| Board size | −0.000776 | −0.00122 |
| | (0.00236) | (0.00188) |
| Board tenure | 0.00421* | 0.00796*** |
| | (0.00240) | (0.00293) |
| Board duality | −0.00128 | 0.00332 |
| | (0.0143) | (0.0169) |
| F-SIZE | 0.0782*** | 0.0491*** |
| | (0.0148) | (0.0131) |
| ROA | 0.0124 | −0.0748 |
| | (0.0724) | (0.0591) |
| CSR committee | 0.0458*** | 0.0686*** |
| | (0.0122) | (0.0162) |
| LEV | −0.0142 | 0.0346 |
| | (0.0433) | (0.0424) |
| GDP growth | 0.000557 | 0.000325 |
| | (0.000375) | (0.000419) |
| Rule of law | −0.101*** | −0.258*** |
| | (0.0346) | (0.0457) |
| Constant | −0.782*** | −0.176 |
| | (0.215) | (0.212) |
| Observations | 7284 | 5994 |
| *R*-squared | 0.074 | 0.109 |
| Number of id | 1481 | 1563 |

*Note*: Robust standard errors in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

distance scores ranging from 0 to 100, indicates the extent to which a society accepts unequal power distribution, where a higher score denotes a larger power distance between individuals. Individualism (INV), also scored from 0 to 100, reflects the degree of individualism in society, with higher scores representing more pronounced individualistic traits. The masculinity/femininity dimension (MAS) gauges whether a society is driven by competition, achievement, and success, characterised by higher scores, or whether it values caring for others and quality of life, indicated by lower scores. Finally, uncertainty avoidance (UAI) is captured by scores ranging from 0 to 100, where higher scores signify a greater level of uncertainty avoidance within a society.

Our analysis reveals that EI is shaped not only by firm-specific factors but also by broader cultural contexts. As shown in Table 10, these cultural factors play a significant role, and our main findings, detailed in Table 4, remain consistent even after controlling for country-level effects. For instance, power distance affects EI negatively. In societies where hierarchical structures dominate, transparency tends to be limited, reducing expectations for environmental progress. This finding aligns with previous studies (Dwekat, Meqbel, et al., 2022; Peng et al., 2014), which suggested that power inequalities discourage open environmental disclosure.

Similarly, masculinity negatively impacts EI. Environmental efforts often receive less attention in cultures that prioritise material success and competition. This result is consistent with earlier research (Husted, 2005; Orij, 2010), which also identified a negative relationship between masculinity and environmental practices. In contrast, uncertainty avoidance positively influences EI. In societies with high levels of uncertainty avoidance, firms are more likely to innovate to comply with stricter regulations and meet stakeholder expectations (Dwekat, Meqbel, et al., 2022). This suggests that risk-averse cultures push companies toward innovation to manage future uncertainties.

## 5 | CONCLUSION

This study investigates the effect of various BoD characteristics, such as gender, independence, and tenure, on environmental innovation

**TABLE 9** Controlling for EU Directive and Excluding UK from the sample.

| Variables | (1) EU directive | (2) Sample without UK |
|---|---|---|
| Board gender | 0.100*** | 0.186*** |
| | (0.0294) | (0.0354) |
| Board independence | 0.0333* | 0.0291 |
| | (0.0197) | (0.0210) |
| Board size | −0.00109 | −0.000711 |
| | (0.00151) | (0.00167) |
| Board tenure | 0.00533*** | 0.00695*** |
| | (0.00197) | (0.00224) |
| Board duality | 0.00380 | 0.00472 |
| | (0.0114) | (0.0130) |
| F-SIZE | 0.0462*** | 0.0415*** |
| | (0.00910) | (0.0111) |
| ROA | −0.0373 | −0.0545 |
| | (0.0373) | (0.0474) |
| CSR committee | 0.0581*** | 0.0571*** |
| | (0.00962) | (0.0112) |
| LEV | 0.0131 | 0.0863** |
| | (0.0323) | (0.0350) |
| EU directive | 0.0335*** | |
| | (0.00698) | |
| GDP growth | 0.000540** | 8.19e-05 |
| | (0.000259) | (0.000379) |
| Rule of law | −0.0977*** | −0.190*** |
| | (0.0283) | (0.0385) |
| Constant | −0.342** | −0.145 |
| | (0.141) | (0.179) |
| Firm fixed effect | Yes | Yes |
| Year dummy | Yes | Yes |
| Country dummy | Yes | Yes |
| Observations | 13,278 | 9641 |
| *R*-squared | 0.090 | 0.086 |

*Note*: Robust standard errors in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

(EI) in response to the pressing environmental sustainability issues. The analysis is based on a large dataset of 13,278 firm-year observations pertaining to European companies from the Refinitiv Eikon database between 2010 and 2021.

The results show that the enhancement of EI entails board gender, size, duality, independence, and tenure. These results support the stakeholder and agency theories, suggesting that diverse and independent board structures enhance an environment-conscious culture. In particular, female board members, independent directors, and board tenure positively correlate with a greater commitment to environmentally innovative practices. Additionally, our research indicates that board size and duality significantly affect EI.

The findings have important practical implications for environmental sustainability practices and corporate governance. The importance of having a greater number of women in leadership positions, particularly in the field of EI, is highlighted by the advantages of gender diversity on firm boards. This research posits that policymakers and business leaders should adopt proactive measures to augment the representation of women on company boards. Diversity not only fulfils the criteria of progressive governance, but it also introduces innovative approaches and novel perspectives to environmental initiatives. Businesses would implement gender diversity policies and practices to ensure moral management and strategically promote innovation, which is essential for the long-term sustainability of both the firm and the environment. In a sustainability-driven market, the organisation's standing and competitive advantage can be enhanced by the presence of female leadership, which has the potential to enhance the efficacy of environmental endeavours.

In terms of the positive connection between board size, board duality, and EI, larger boards with various skills and perspectives can improve strategic decision-making and address stakeholder concerns, thereby increasing EI. Companies would benefit from policies that encourage sustainable practices by advocating for a balanced increase in board size. Furthermore, board duality simplifies decision-making and guarantees a unified strategic vision, thereby enabling the rapid implementation of environmentally sustainable initiatives. This combined leadership structure improves the efficiency and effectiveness of the EI efforts. Companies and policymakers would acknowledge the advantages of optimising board size and advocating board duality in order to align organisational objectives with sustainability. Businesses can more effectively navigate the complicated nature of EI by developing an integrated and well-informed governance approach. Additionally, the company's dedication to environmental objectives can be further reinforced by the ability to respond more promptly and take more decisive action, which is facilitated by duality.

Additionally, the importance of a substantial number of independent directors on companies' boards is emphasised by the important role that board independence plays in supporting EI. Companies need to prioritise selecting independent board members with a high level of expertise in environmental and sustainability issues. The environmental initiatives and policies of the business are guaranteed to be managed and guided efficiently by this plan. Additionally, our findings emphasise the importance of laws and policies prioritising board independence as a critical element of effective corporate governance. Companies could significantly benefit from increased board independence requirements, enabling them to comply with environmental regulations and actively pursue EI as a strategic objective. Our research indicates that organisations would reevaluate and potentially restructure their boards to enhance their capacity to advance global sustainability objectives. Consequently, board independence is not merely a matter of compliance but a strategic advantage promoting long-term success and EI.

Similarly, the positive correlation between board tenure and EI highlights the critical role of seasoned board members in advancing sustainable initiatives. The strategic decision-making process can be

**TABLE 10** Controlling for country-level culture.

| Variables | (1) EnvInnov | (2) EnvInnov | (3) EnvInnov |
|---|---|---|---|
| Board gender | 0.00103*** | 0.00104*** | 0.000589*** |
| | (0.000165) | (0.000156) | (0.000208) |
| Board independence | 0.000734*** | 0.000736*** | 0.000741*** |
| | (0.000129) | (0.000132) | (0.000105) |
| Board size | 0.00446*** | 0.00449*** | 0.00522*** |
| | (0.00105) | (0.00111) | (0.000829) |
| Board tenure | 0.00248*** | 0.00246*** | 0.00223** |
| | (0.000407) | (0.000412) | (0.000887) |
| Board duality | 0.0180*** | 0.0178*** | 0.0170** |
| | (0.00399) | (0.00401) | (0.00669) |
| F-SIZE | 0.0535*** | 0.0534*** | 0.0553*** |
| | (0.00162) | (0.00167) | (0.00161) |
| ROA | −0.0704** | −0.0711** | −0.0500** |
| | (0.0283) | (0.0288) | (0.0221) |
| CSR committee | 0.121*** | 0.121*** | 0.120*** |
| | (0.0110) | (0.0109) | (0.00591) |
| LEV | −0.0562*** | −0.0558*** | −0.0606*** |
| | (0.00745) | (0.00757) | (0.0143) |
| GDP growth | | 8.41e-05 | −0.000240 |
| | | (0.00105) | (0.00118) |
| Rule of law | | 0.00367 | 0.0151* |
| | | (0.00892) | (0.00876) |
| PDI | −0.00317*** | −0.00310*** | −0.00283*** |
| | (0.000177) | (0.000237) | (0.000439) |
| INV | −0.000144 | −0.000170 | −7.78e-05 |
| | (0.000265) | (0.000239) | (0.000426) |
| MAS | −0.00118*** | −0.00116*** | −0.00118*** |
| | (9.94e-05) | (7.86e-05) | (0.000167) |
| UAI | 0.00210*** | 0.00209*** | 0.00211*** |
| | (0.000198) | (0.000186) | (0.000354) |
| Constant | −0.582*** | −0.588*** | −0.662*** |
| | (0.0368) | (0.0420) | (0.0445) |
| Year dummy | No | No | Yes |
| Country dummy | No | No | No |
| Observations | 13,268 | 13,268 | 13,268 |
| *R*-squared | 0.253 | 0.253 | 0.254 |
| Number of id | | | |

*Note*: Robust standard errors in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

enhanced, and a greater commitment to environmental objectives can be encouraged by the wealth of expertise and stability that long-serving members bring. This research implies that organisations would evaluate policies that encourage extended board tenures in order to capitalise on the continuity and expertise that tenured members offer. Business leaders and policymakers would acknowledge the advantages of retaining experienced members who can effectively enhance EI. Firms could guarantee a consistent and informed sustainability strategy by encouraging board tenure, leveraging the strategic expertise and historical insights of experienced board members. Ultimately, businesses would enrich an environment that prioritises long-term sustainability objectives by implementing practices that balance

the necessity for new perspectives with the benefits of stability and extensive institutional knowledge.

The robustness tests conducted in this study provide deeper insights into how EI is influenced by BoD characteristics across various contexts, shedding light on the differential impacts within CSR-sensitive industries and across different levels of firm profitability. Notably, industries with a greater environmental impact demonstrate a stronger correlation between board characteristics and EI, emphasising the crucial role of corporate governance in sectors where sustainability is dominant. This suggests that companies in such industries could not only comply with existing regulations but also proactively exceed them by adopting governance practices that drive EI. It is evident that the representation of women on boards is especially impactful in these settings, implying a need for policies that enhance gender diversity as a strategic approach to enhancing EI.

Moreover, the analysis of profitability levels reveals that less profitable firms exhibit a stronger relationship between board gender diversity and EI, suggesting that they could use EI as a strategic tool to improve their market position and attract eco-conscious stakeholders. This insight is critical for policymakers and business leaders, as it underlines the necessity of supporting governance reforms that encourage diversity and independence in less profitable firms, which could potentially lead to enhanced sustainability practices. Additionally, compliance with the EU Directive 2014/95/EU highlights the interplay between regulatory frameworks and corporate behaviour, illustrating how legislation could shape corporate strategies toward sustainability.

These findings call for a nuanced approach to governance and policy-making that considers industries and firms' specific needs and contexts. Policymakers could craft regulations and guidelines that not only mandate minimum standards but also encourage businesses to adopt governance structures that foster innovation and sustainability tailored to their operational contexts and financial capabilities. This approach aligns with the theoretical foundations of stakeholder and agency theories. It has a profound practical impact on how companies integrate environmental concerns into their strategic planning and execution, offering rich implications for enhancing corporate sustainability and the effectiveness of environmental initiatives.

In the end, this investigation is not without its constraints. Nevertheless, these constraints offer valuable potential for future research. One constraint is the reliance on data that ends in 2021. Using more recent data in future research could facilitate an improved understanding of the most recent corporate governance and EI developments. It would provide organisations with a comprehensive understanding of the business and environmental landscape, capturing the dynamic opportunities and challenges they encounter. Furthermore, the generalizability of our findings may be restricted by the limited geographic context of our study. The applicability and robustness of the conclusions could be improved by broadening the geographic scope of future research. Additionally, our investigation did not conduct a comprehensive examination of the qualifications and experience of board members, which is another area that warrants further investigation. The field could be significantly advanced by comprehending the ways in which these attributes affect corporate governance and EI.

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## REFERENCES

Abdeljawad, I., Alia, M. A., Yassin, S., Morrar, S., & Mubaslat, M. (2022). An initial assessment of sustainability reporting practices, motives and obstacles for Palestinian corporations. In *European, Asian, Middle Eastern, North African conference on management & information systems* (pp. 167–184). Springer International Publishing.

Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., & Overy, P. (2016). Sustainability-oriented innovation: A systematic review. *International Journal of Management Reviews*, *18*(2), 180–205.

Aguilera, R. V., Desender, K. A., & Kabbach de Castro, L. R. (2011). *A configurational approach to comparative corporate governance* (11-0103). University of Illinois at Urbana-Champaign, College of Business.

Agustia, D. (2023). Does green innovation play an important role in the effect board gender diversity has on firm performance? *Intangible Capital*, *19*(2), 146–164.

Albitar, K., Borgi, H., Khan, M., & Zahra, A. (2022). Business environmental innovation and $CO_2$ emissions: The moderating role of environmental governance. *Business Strategy and the Environment*, *32*, 1996–2007. https://doi.org/10.1002/bse.3232

Alia, M. A., Dwekat, A., Ismail, T., AL-Saber, D., & Salman, L. (2024). CSRD in the Arab world: The role of audit quality. In *Artificial intelligence and economic sustainability in the era of industrial revolution 5.0* (pp. 123–135). Springer Nature Switzerland.

Alia, M. A., & Mardawi, Z. (2021). The impact of ownership structure and board characteristics on corporate social responsibility disclosed by Palestinian companies. *Jordan Journal of Business Administration*, *17*(2), 254–277.

Al-Maliki, H., Salehi, M., & Kardan, B. (2023). The relationship between board characteristics and social responsibility with firm innovation. *European Journal of Management and Business Economics*, *32*(1), 113–129.

Al-Shaer, H., & Zaman, M. (2018). Credibility of sustainability reports: The contribution of audit committees. *Business Strategy and the Environment*, *27*(7), 973–986.

Armstrong, C. S., Core, J. E., & Guay, W. R. (2014). Do independent directors cause improvements in firm transparency? *Journal of Financial Economics*, *45*(1), 383–403.

Asteriou, D., & Hall, S. G. (2007). *Applied econometrics: A modern approach* (Revised ed.). Palgrave Macmillan.

Bazel-Shoham, O., Lee, S. M., Munjal, S., & Shoham, A. (2024). Board gender diversity, feminine culture, and innovation for environmental sustainability. *Journal of Product Innovation Management*, *41*(2), 293–322.

Bear, S., Rahman, N., & Post, C. (2010). The impact of board diversity and gender composition on corporate social responsibility and firm reputation. *Journal of Business Ethics*, *97*, 207–221.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, *87*(1), 115–143.

Bower, J. L., & Paine, L. S. (2017). The error at the heart of corporate leadership. *Harvard Business Review*. https://hbr.org/2017/05/the-error-at-the-heart-of-corporate-leadership

Brickley, J. A., Coles, J. L., & Jarrell, G. (1997). Leadership structure: Separating the CEO and chairman of the board. *Journal of Corporate Finance*, *3*(3), 189–220.

Brunnermeier, S. B., & Cohen, M. A. (2003). Determinants of environmental innovation in US manufacturing industries. *Journal of Environmental Economics and Management*, *45*(2), 278–293.

Cahyono, S., Harymawan, I., & Kamarudin, K. A. (2023). The impacts of tenure diversity on boardroom and corporate carbon emission performance: Exploring from the moderating role of corporate innovation. *Corporate Social Responsibility and Environmental Management*, *30*(5), 2507–2535.

Cai, W., & Li, G. (2018). The drivers of eco-innovation and its impact on performance: Evidence from China. *Journal of Cleaner Production*, *176*, 110–118.

Cecere, G., Corrocher, N., & Mancusi, M. L. (2020). Financial constraints and public funding of eco-innovation: Empirical evidence from European SMEs. *Small Business Economics*, *54*, 285–302.

Chang, Y. K., Oh, W.-Y., Park, J. H., & Jang, M. G. (2017). Exploring the relationship between board characteristics and CSR: Empirical evidence from Korea. *Journal of Business Ethics*, *140*, 225–242.

Cheng, S. (2008). Board size and the variability of corporate performance. *Journal of Financial Economics*, *87*(1), 157–176.

Chindasombatcharoen, P., Chatjuthamard, P., Jiraporn, P., & Treepongkaruna, S. (2022). Achieving sustainable development goals through board size and innovation. *Sustainable Development*, *30*(4), 664–677.

Ciasullo, M. V., Montera, R., & Douglas, A. (2022). Environmental sustainability orientation and ambidextrous green innovation: Do the roles of women on corporate boards matter? *Sinergie Italian Journal of Management*, *40*(2), 209–231.

Confino, J. (2011). Companies must push harder for sustainable growth. *The Guardian*. https://www.theguardian.com/sustainable-business/blog/businesses-social-environmental-impact-sustainable-growth

Coulson-Thomas, C. (2023). Values based and/or responsible leadership for addressing climate change. *Effective Executive*, *25*(4), 7–29.

Davies, P. (2000). *The Board of Directors: Composition, structure, duties and powers*. Organisation for Economic Co-operation and Development.

De Beelde, I., & Tuybens, S. (2015). Enhancing the credibility of reporting on corporate social responsibility in Europe. *Business Strategy and the Environment*, *24*(3), 190–216.

del Río, P., Peñasco, C., & Romero-Jordán, D. (2016). What drives eco-innovators? A critical review of the empirical literature based on econometric methods. *Journal of Cleaner Production*, *112*(4), 2158–2170.

Desender, K. A., Aguilera, R. V., Crespi, R., & GarcÍa-cestona, M. (2013). When does ownership matter? Board characteristics and behavior. *Strategic Management Journal*, *34*(7), 823–842.

Di Vaio, A., Palladino, R., Hassan, R., & Alvino, F. (2020). Human resources disclosure in the EU Directive 2014/95/EU perspective: A systematic literature review. *Journal of Cleaner Production*, *257*, 120509.

Dwekat, A., Meqbel, R., Seguí-Mas, E., & Tormo-Carbó, G. (2022). The role of the audit committee in enhancing the credibility of CSR disclosure: Evidence from STOXX Europe 600 members. *Business Ethics: A European Review*, *31*, 718–740. https://doi.org/10.1111/beer.12439

Dwekat, A., Seguí-Mas, E., & Tormo-Carbó, G. (2020). The effect of the board on corporate social responsibility: Bibliometric and social network analysis. *Economic Research-Ekonomska istraživanja*, *33*(1), 3580–3603.

Dwekat, A., Seguí-Mas, E., Tormo-Carbó, G., & Carmona, P. (2020). Corporate governance configurations and corporate social responsibility disclosure: Qualitative comparative analysis of audit committee and board characteristics. *Corporate Social Responsibility and Environmental Management*, *27*(6), 2879–2892.

Dwekat, A., Seguí-Mas, E., Zaid, M. A., & Tormo-Carbó, G. (2022). Corporate governance and corporate social responsibility: Mapping the most critical drivers in the board academic literature. *Meditari Accountancy Research*, *30*(6), 1705–1739.

Edmans, A. (2013). The link between job satisfaction and firm value, with implications for corporate social responsibility. *Academy of Management Perspectives*, *26*(4), 1–19.

Elad Fotoh, L., Ngan Wong, M., & Solange Bongbee, N. (2018). The role of board characteristics in effective corporate governance: The case of Airbus Group. *International Journal of Social Sciences Perspectives*, *2*(1), 87–95.

Estapé-Dubreuil, G., Ashta, A., & Hédou, J.-P. (2016). Micro-equity for sustainable development: Selection, monitoring and exit strategies of micro-angels. *Ecological Economics*, *130*, 117–129.

Farza, K., Ftiti, Z., Hlioui, Z., Louhichi, W., & Omri, A. (2022). The effect of corporate board characteristics on environmental innovation. *Environmental Modeling & Assessment*, *27*, 1021–1042.

Ferrero-Ferrero, I., Fernández-Izquierdo, M. Á., & Muñoz-Torres, M. J. (2012). The impact of the board of directors characteristics on corporate performance and risk-taking before and during the global financial crisis. *Review of Managerial Science*, *6*, 207–226.

Frynas, J. G., & Yamahaki, C. (2016). Corporate social responsibility: Review and roadmap of theoretical perspectives. *Business Ethics: A European Review*, *25*(3), 258–285.

Fuente, J. A., García-Sánchez, I. M., & Lozano, M. B. (2017). The role of the board of directors in the adoption of GRI guidelines for the disclosure of CSR information. *Journal of Cleaner Production*, *141*, 737–750.

Fuzi, S. F. S., Abdul Halim, S. A., & Julizaerma, M. K. (2016). Board independence and firm performance. *Procedia Economic and Finance*, *37*, 460–465.

Galia, F., Zenou, E., & Ingham, M. (2015). Board composition and environmental innovation: Does gender diversity matter? *International Journal of Entrepreneurship and Small Business*, *24*(1), 117–141.

Gallego-Álvarez, I., & Rodriguez-Dominguez, L. (2023). Board of directors and environmental practices: The effect of board experience, culture, and tenure. *Environment, Development and Sustainability*, 1–26.

Gangi, F., Daniele, L. M., D'Angelo, E., Varrone, N., & Coscia, M. (2023). The impact of board gender diversity on banks' environmental policy: The moderating role of gender inequality in national culture. *Corporate Social Responsibility and Environmental Management*, *30*(3), 1273–1291.

García-Meca, E., Ramón-Llorens, M. C., & Martínez-Ferrero, J. (2023). Feminine expertise on board and environmental innovation: The role of critical mass. *Review of Managerial Science*, 1–32.

García-Sánchez, I.-M., Aibar-Guzmán, C., & Aibar-Guzmán, B. (2020). The effect of institutional ownership and ownership dispersion on eco-innovation. *Technological Forecasting and Social Change*, *158*, 120–173.

García-Sánchez, I.-M., Gallego-Álvarez, I., & Zafra-Gómez, J.-L. (2021). Do independent, female and specialist directors promote eco-innovation and eco-design in agri-food firms? *Business Strategy and the Environment*, *30*(2), 1136–1152.

García-Sánchez, I. M., Sierra-García, L., & García-Benau, M. A. (2022). How does the EU non-financial directive affect the assurance market? *Business Ethics, the Environment & Responsibility*, *31*(3), 823–845.

García-Sánchez, I.-M. G.-S., Hussain, N., & Martínez-Ferrero, J. (2019). An empirical analysis of the complementarities and substitutions between effects of ceo ability and corporate governance on socially responsible performance. *Journal of Cleaner Production*, *215*, 1288–1300.

Ghardallou, W. (2022). Corporate sustainability and firm performance: The moderating role of CEO education and tenure. *Sustainability*, *14*(6), 3513.

Githaiga, P. N., & Kosgei, J. K. (2023). Board characteristics and sustainability reporting. A case of listed firms in East Africa. *Corporate Governance*, *23*(1), 3–17.

Godos-Díez, J.-L., Fernández-Gago, R., Cabeza-García, L., & Martínez-Campillo, A. (2014). Determinants of CSR practices: Analysis of the

influence of ownership and the management profile mediating effect. *Spanish Journal of Finance and Accounting*, *43*, 47–68.
Griffin, D., Li, K., & Xu, T. (2021). Board gender diversity and corporate innovation: International evidence. *Journal of Financial and Quantitative Analysis*, *56*(1), 123–154.
Hillman, A. J., Withers, M. C., & Collins, B. J. (2009). Resource dependence theory: A review. *Journal of Management*, *35*(6), 1404–1427.
Hofstede, G. (2011). Dimensionalizing cultures: The Hofstede model in context. *Online Readings in Psychology and Culture*, *2*(1), 8.
Horbach, J. (2008). Determinants of environmental innovation—New evidence from German panel data sources. *Research Policy*, *37*(1), 163–173.
Horbach, J., & Jacob, J. (2018). The relevance of personal characteristics and gender diversity for (eco-) innovation activities at the firm-level: Results from a linked employer–employee database in Germany. *Business Strategy and the Environment*, *27*(7), 924–934.
Horvath, R., & Spirollari, P. (2012). Do the Board of Directors' characteristics influence firm's performance? The US evidence. *Prague Economic Papers*, *21*(3), 470–486.
Hussain, N., Rigoni, U., & Orij, R. P. (2018). Corporate governance and sustainability performance: Analysis of triple bottom line performance. *Journal of Business Ethics*, *149*, 411–432.
Husted, B. W. (2005). Culture and ecology: A cross-national study of the determinants of environmental sustainability. *Management International Review*, *45*(3), 349–371.
Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, *3*(4), 305–360.
Jia, N. (2017). Should directors have term limits?–Evidence from corporate innovation. *European Accounting Review*, *26*(4), 755–785.
Jizi, M. I., Salama, A., Dixon, R., & Stratling, R. (2014). Corporate governance and corporate social responsibility disclosure: Evidence from the US banking sector. *Journal of Business Ethics*, *125*, 601–615.
Karakaya, E., Hidalgo, A., & Nuur, C. (2014). Diffusion of eco-innovations: A review. *Renewable and Sustainable Energy Reviews*, *33*, 392–399.
Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The worldwide governance indicators: Methodology and analytical issues. *Hague Journal on the Rule of Law*, *3*(2), 220–246.
Keshminder, J., & del Río, P. (2019). The missing links? The indirect impacts of drivers on eco-innovation. *Corporate Social Responsibility and Environmental Management*, *26*(5), 1100–1118.
Kesidou, E., & Demirel, P. (2012). On the drivers of eco-innovations: Empirical evidence from the UK. *Research Policy*, *41*(5), 862–870.
Kim, I., Zhang, Z., & Pantzalis, C. (2021). Multinationality and the value of green innovation. *Journal of Corporate Finance*, *69*(2), 101–996.
Kolk, A. (2008). Sustainability, accountability and corporate governance: Exploring multinationals' reporting practices. *Business Strategy and the Environment*, *17*(1), 1–15.
Konadu, R., Sam Ahinful, G., Jeff Boakye, D., & Elbardan, H. (2022). Board gender diversity, environmental innovation and corporate carbon emissions. *Technological Forecasting and Social Change*, *174*, 121–279.
Korir, F. J., & Tenai, J. K. (2020). Does structural power matter? Board attributes and firm performance: Moderated by CEO duality. *SEISENSE Journal of Management*, *3*(5), 54–64.
Landier, A., Sauvagnat, J., Sraer, D., & Thesmar, D. (2013). Bottom-up corporate governance. *Review of Finance*, *17*(1), 161–201.
Li, M., & Yang, J. (2019). Effects of CEO duality and tenure on innovation. *Journal of Strategy and Management*, *12*(4), 536–552.
Li, Y. (2014). Environmental innovation practices and performance: Moderating effect of resource commitment. *Journal of Cleaner Production*, *66*, 450–458.
Li, Y. X., & He, C. (2023). Board diversity and corporate innovation: Evidence from Chinese listed firms. *International Journal of Finance & Economics*, *28*(1), 1092–1115.
Lu, J., & Wang, W. (2018). Managerial conservatism, board independence and corporate innovation. *Journal of Corporate Finance*, *48*, 1–16.
Luís Firmino, A., & Maciel Peixoto, F. (2023). The relationship between board gender diversity in Brazilian companies and adhesion to the carbon efficient index. *Advances in Scientific & Applied Accounting*, *16*(2), 78–108.
Macaulay, C. D., Richard, O. C., Peng, M. W., & Hasenhuttl, M. (2018). Alliance network centrality, board composition, and corporate social performance. *Journal of Business Ethics*, *151*, 997–1008. https://doi.org/10.1007/s10551-017-3566-7
Mardawi, Z., Dwekat, A., Meqbel, R., & Ibáñez, P. C. (2023). *Configurational analysis of corporate governance and corporate social responsibility reporting assurance: Understanding the role of board and CSR committee*. Meditari Accountancy Research.
Martínez-Azúa, B. C., & Sama-Berrocal, C. (2022). Objectives of and barriers to innovation: How do they influence the decision to innovate? *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(3), 134.
Meqbel, R., Alta'any, M., Kayed, S., & Al-Omush, A. (2024). Earnings management and sustainability assurance: The moderating role of CSR committee. *Corporate Social Responsibility and Environmental Management*, *31*(3), 1769–1785.
Mi, L., Yue, X. G., Shao, X. F., Kang, Y., & Liu, Y. (2020). Strategic asset seeking and innovation performance: The role of innovation capabilities and host country institutions. *Journal of Risk and Financial Management*, *13*(3), 42.
Mirza, H. H., Andleeb, S., & Ramzan, F. (2012). Gender diversity and firm performance: Evidence from Pakistan. *Journal of Social and Development Sciences*, *3*(5), 161–166.
Mongo, M., Belaïd, F., & Ramdani, B. (2021). The effects of environmental innovations on $CO_2$ emissions: Empirical evidence from Europe. *Environmental Science & Policy*, *118*, 1–9.
Moreno-Gómez, J., Lafuente, E., & Vaillant, Y. (2018). Gender diversity in the board, women's leadership and business performance. *Gender in Management: An International Journal*, *33*(2), 104–122.
Moreno-Ureba, E., Bravo-Urquiza, F., & Reguera-Alvarado, N. (2022). An analysis of the influence of female directors on environmental innovation: When are women greener? *Journal of Cleaner Production*, *374*, 133871.
Nadeem, M., Bahadar, S., Gull, A. A., & Iqbal, U. (2020). Are women eco-friendly? Board gender diversity and environmental innovation. *Business Strategy and the Environment*, *29*(8), 3146–3161.
Nadeem, M., Suleman, T., & Ahmed, A. (2019). Women on boards, firm risk and the profitability nexus: Does gender diversity moderate the risk and return relationship? Author links open overlay panel. *International Review of Economics & Finance*, *64*, 427–442.
Nadeem, M., Zaman, R., & Saleem, I. (2017). Boardroom gender diversity and corporate sustainability practices: Evidence from Australian Securities Exchange listed firms. *Journal of Cleaner Production*, *149*, 874–885.
Nekhili, M., Nagati, H., Chtioui, T., & Rebolledo, C. (2017). Corporate social responsibility disclosure and market value: Family versus nonfamily firms. *Journal of Business Research*, *77*, 41–52.
Neubaum, D. O., Dibrell, C., & Craig, J. B. (2012). Balancing natural environmental concerns of internal and external stakeholders in family and non-family businesses. *Journal of Family Business Strategy*, *3*(1), 28–37.
Ntim, C., & Soobaroyen, T. (2013). Corporate governance and performance in socially responsible corporations: New empirical insights from a neo-institutional framework. *Corporate Governance: An International Review*, *21*(5), 468–494.
Nuber, C., & Velte, P. (2021). Board gender diversity and carbon emissions: European evidence on curvilinear relationships and critical mass. *Business Strategy and the Environment*, *30*(4), 1958–1992.
O'Donovan, G. (2002). Environmental disclosures in the annual report: Extending the applicability and predictive power of legitimacy theory. *Accounting, Auditing & Accountability Journal*, *15*(3), 344–371.

Ogunode, O. A. (2022). Legitimacy theory and environmental accounting reporting and practice: A review. *South Asian Journal of Social Studies and Economics*, *13*(1), 17–28.

Orij, R. (2010). Corporate social disclosures in the context of national cultures and stakeholder theory. *Accounting, Auditing & Accountability Journal*, *23*(7), 868–889.

Orozco, L. A., Vargas, J., & Galindo-Dorado, R. (2018). Trends on the relationship between board size and financial and reputational corporate performance: The Colombian case. *European Journal of Management and Business Economics*, *27*(2), 183–197.

Peng, Y.-S., Dashdeleg, A.-U., & Chih, H.-L. (2014). National culture and firm's CSR engagement: A cross-nation study. *Journal of Marketing and Management*, *5*(1), 38–49.

Pfeffer, J., & Salancik, G. (2015). External control of organizations—Resource dependence perspective. In *Organizational behavior 2* (pp. 355–370). Routledge.

Phung, G., Trinh, H. H., Nguyen, T. H., & Trinh, V. Q. (2023). Top-management compensation and environmental innovation strategy. *Business Strategy and the Environment*, *32*(4), 1634–1649.

Radu, C., & Smaili, N. (2022). Alignment versus monitoring: An examination of the effect of the CSR committee and CSR-linked executive compensation on CSR performance. *Journal of Business Ethics*, *180*, 145–163.

Riahi, R., Hamrouni, N., Chibani, F., & Jahmane, A. (2023). Gender Diversity on the Board of Directors and Green Innovations (Diversité de genre au conseil d'administration et innovations vertes). Available at SSRN 4532552.

Rodrigue, M., Magnan, M., & Boulianne, E. (2013). Stakeholders' influence on environmental strategy and performance indicators: A managerial perspective. *Management Accounting Research*, *24*(4), 301–316.

Romano, M., Cirillo, A., Favino, C., & Netti, A. (2020). ESG (environmental, social and governance) performance and board gender diversity: The moderating role of CEO duality. *Sustainability*, *12*(21), 92–98.

Rossi, M., Chouaibi, J., Chouaibi, S., Jilani, W., & Chouaibi, Y. (2021). Does a board characteristic moderate the relationship between CSR practices and financial performance? Evidence from European ESG firms. *Risk and Financial Management*, *14*(8), 354.

Ruiz-Castillo, M., Aragón-Correa, J. A., & Hurtado-Torres, N. E. (2024). Independent directors and environmental innovations: How the visibility of public and private shareholders' environmental activism moderates the influence of board independence. *Business Strategy and the Environment*, *33*, 424–440.

Saman, R., & Nelson, J. (2020). Integrated corporate governance: A practical guide to stakeholder capitalism for boards of directors. World Economic Forum. https://www3.weforum.org/docs/WEF_Integrated_Corporate_Governance_2020.pdf

Sandberg, M., Klockars, K., & Wilén, K. (2019). Green growth or degrowth? Assessing the normative justifications for environmental sustainability and economic growth through critical social theory. *Journal of Cleaner Production*, *206*, 133–141.

Sekarlangit, L. D., & Wardhani, R. (2021). The effect of the characteristics and activities of the board of directors on sustainable development goal (SDG) disclosures: Empirical evidence from Southeast Asia. *Sustainability*, *13*(14), 8007.

Sen, S., & Cowley, J. (2013). The relevance of stakeholder theory and social capital theory in the context of CSR in SMEs: An Australian perspective. *Journal of Business Ethics*, *118*, 413–427.

Sierra-Morán, J., Cabeza-Garcia, L., & Gonzalez-Alvarez, N. (2024). Independent directors and firm innovation: The moderating role of gender and nationality diversity. *European Journal of Innovation Management*, *27*(2), 373–402.

Simnett, R., Vanstraelen, A., & Chua, W. F. (2009). Assurance on sustainability reports: An international comparison. *The Accounting Review*, *84*(3), 937–967.

Simoni, L., Bini, L., & Bellucci, M. (2020). Effects of social, environmental, and institutional factors on sustainability report assurance: Evidence from European countries. *Meditari Accountancy Research*, *28*(6), 1059–1087.

Song, M., Yang, M. X., Zeng, K. J., & Feng, W. (2020). Green knowledge sharing, stakeholder pressure, absorptive capacity, and green innovation: Evidence from Chinese manufacturing firms. *Business Strategy and the Environment*, *29*(3), 1517–1531.

Sun, X. S., & Bhuiyan, M. B. U. (2020). Board tenure: A review. *Journal of Corporate Accounting & Finance*, *31*(4), 178–196.

The World Bank (2023). *World Development Indicators*, *DataBank*. https://databank.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG/1ff4a498/Popular-Indicators#

Traversi, M., Bannò, M., & Filippi, E. (2024). The role of the cultural context in moderating the effect between the presence of women directors and firm environmental innovation. *Corporate Social Responsibility and Environmental Management*, *31*, 3685–3702.

Vitolla, F., & Rubino, M. (2017). Legitimacy theory and sustainability reporting. Evidence from Italy. In *10th annual conference of the Euro-Med academy of business* (Vol. 1, 1st ed., pp. 1835–1848). EuroMed Press.

Voinea, C. L., Rauf, F., Naveed, K., & Fratostiteanu, C. (2022). The impact of CEO duality and financial performance on CSR disclosure: Empirical evidence from state-owned enterprises in China. *Journal of Risk and Financial Management*, *15*(1), 37.

Wagner, M. (2007). On the relationship between environmental management, environmental innovation and patenting: Evidence from German manufacturing firms. *Research Policy*, *36*(10), 1587–1602.

Wintoki, M. B., Linck, J. S., & Netter, J. M. (2012). Endogeneity and the dynamics of internal corporate governance. *Journal of Financial Economics*, *105*(3), 581–606.

Yin, J., & Wang, S. (2018). The effects of corporate environmental disclosure on environmental innovation from stakeholder perspectives. *Applied Economics*, *50*(8), 905–919.

Zhang, L. (2012). Board demographic diversity, independence, and corporate social performance. *Corporate Governance International Journal of Business in Society*, *12*(5), 686–700.

Zhao, J., Pongtornkulpanich, A., & Cheng, W. (2022). The impact of board size on green innovation in China's heavily polluting enterprises: The mediating role of innovation openness. *Sustainability*, *14*(14), 8632.

Zheng, L., & Iatridis, K. (2022). Friends or foes? A systematic literature review and meta-analysis of the relationship between eco-innovation and firm performance. *Business Strategy and the Environment*, *31*(4), 1838–1855.

Zhou, S., Rashid, M. H. U., Mohd. Zobair, S. A., Sobhani, F. A., & Siddik, A. B. (2023). Does ESG impact firms' sustainability performance? The mediating effect of innovation performance. *Sustainability*, *15*(6), 5586.

Zhu, C., Husnain, M., Ullah, S., Khan, M. T., & Ali, W. (2022). Gender diversity and firms' sustainable performance: Moderating role of CEO duality in emerging equity market. *Sustainability*, *14*(12), 7177.

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