



## Full Length Article

## ESG reporting, corporate green innovation and interaction role of board diversity: A new insight from US

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## ABSTRACT

The Corporates' operations play a crucial role in environmental, social, and governance (ESG) practices to improve green innovation; thus, how to promote green practices through effective ESG reporting has attracted the attention of researchers. Through this lens, the current study seeks to explore the impact of ESG reporting on the direct and interaction impact of board diversity on green innovation in the context of a developed economy like the U.S. A total of 334 non-financial companies listed in the S&P 1500 Index were sampled for the period 2010 to 2021. Results of the study revealed that ESG rating has a significant and positive impact on the environmental pillar (EPS) and innovation scores (EIS). In addition, the CSR strategy score also has a positive relationship with EPS. Furthermore, board diversity positively impacts the relationship between ESG score, EPS, and EIS. Findings indicate that ESG reporting in U.S. firms improves green revenues, product innovation, and R&D activities aimed at promoting green innovation practices. Secondly, the CSR score also positively contributes to green innovation. Larger social and environmental practices (CSR) in US companies indicate higher eco-efficiency and implementation of clean technologies. In addition, board diversity in the US firms fosters green innovation through investments in green technologies and manufacturing eco-designed products. Based on our research findings, this study supports the stakeholder theory, a resource-based view, and the Upper-echelon theory.

## 1. Introduction

Investment in CSR has recently been enriched and expanded to include environmental, social, and governance (ESG) theory which is now widely considered to be an important social responsibility measure (Gerard, 2019; Halbritter & Dorfleitner, 2015). ESG reporting plays a vital role in revealing social, environmental, and governance practices (Arvidsson & Dumay, 2022; Sharma et al., 2020; Wasiuzzaman & Subramaniam, 2023). Through transparent disclosure, companies demonstrate credibility and accountability to their potential stakeholders, including investors, employees, and local communities (Liu et al., 2022). ESG performance information enables stakeholders to assess the contribution of companies to environmental sustainability and green practices (Zhou et al., 2022). The ESG score presents the performance of companies by considering environmental, social, and governance issues (Maji & Lohia, 2023). The increase in ESG requirements shows society's attention to business operations and their environmental impacts on local communities. A stakeholder accesses companies' environmental performance through sustainability reports (Orazalin & Mahmood, 2020). Sustainability reports disclose information on environmental emissions,

community rights, and governance practices that cannot be captured in the financial reports (Aggarwal & Singh, 2019). With the emergence of the green concept in environmental and financial practices, companies are now accepting the ESG evaluation obtained by rating agencies. The ESG rating significantly improves environmentally sound practices by attracting socially responsible investors (Tan & Zhu, 2022; Zheng, Khurram, & Chen, 2022). Existing studies have indicated little evidence of how the ESG score contributes to green innovation practices (Li, Ba, et al., 2023; Liu et al., 2022; Tan et al., 2022; Zhang et al., 2020). For example, Li, Lian, and Xu (2023) work on contribution of ESG ratings to corporate innovation in developing economies. Their findings indicate that ESG rating with high financial investment enhance corporate innovation. Tan and Zhu (2022) founded that managers environmental awareness strengthen the association between ESG rating and green innovation in developing countries. Moreover, Liu and Lyu (2022) stated that institutional environment highly influence on the contribution of firm level ESG to green innovation in the Chinese A listed firms. However, addressing the stakeholders' interests is still missing. The ethical and moral responsibility of multinational corporations (MNCs) is to safeguard stakeholder interests through investment in Corporate Social

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Responsibility (CSR) projects (Kamal, 2021; Yim et al., 2019). The company's CSR strategy has a major impact on the green environment. In addition, achieving a green environment and innovation requires effective governance that is again rated by the ESG rating (Zheng, Khurram, & Chen, 2022). Corporate directors' decisions on social and environmental practices are indicative of their contribution to ecological performance (He et al., 2022; Xue et al., 2023). Independent directors with diverse backgrounds, skills, and training are highly capable of understanding the interests of individual stakeholders (Khatib et al., 2023; Yousaf et al., 2022). As a result, board diversity within the senior management team contributes to green innovation through their transparent ESG reporting.

In response to the growing demand for green finance initiatives, multinational corporations now accept ratings from ESG assessment agencies (Veenstra & Ellemers, 2020). Existing research on the validity of ESG evaluations has resulted in controversial conclusions. Scholars who support ESG assessments argue that they provide an objective measure of business performance by assessing their social reputation, competitive advantage, and financial growth that may ultimately engage stakeholders (Feng et al., 2022; Shin et al., 2022; Yoon et al., 2018). Conversely, other studies have argued that ESG assessments of corporations are tied to external requirements to obtain various benefits that may not substantially improve corporate performance, but also indicate corporate degradation and misleading stakeholder interests (Billio et al., 2021; Schumacher, 2022). These conflicting arguments underscore the need to further examine the efficacy of ESG assessment. As a result, more research in this area is still needed to understand the impact of ESG reporting on green practices. ESG ratings include environmental, social, and corporate governance performance. Social performance is primarily determined by CSR activities and governance performance is measured by board characteristics. As a result, to evaluate and verify the contribution of environmental, social, and governance reporting to green innovation, current research incorporates the CSR score, board diversity, and ESG rating. Therefore, the current study counter-verifies the contribution of environmental, social, and governance reporting on green innovation. For the very first time, current research considers the CSR score, board diversity, and ESG to predict green innovation.

For environmental sustainability, ESG becomes now a challenge for Biden's Administration to mitigate greenhouse emissions by fifty percent by 2030 (Wang et al., 2023). At the beginning of 2020, global investment in ESG raised 35.3 trillion US dollars and is considered on third of the global assets under management (Meira et al., 2023). A study postulated ESG rating enhances the green innovation outputs of the corporates by 3.9 percent (Wang et al., 2023). A study conducted on the US and real-world European data found that ESG investment positively contributes to financial and economic stability (Bax et al., 2023). In addition, sustainable investment has become a major force in the U.S. capital market, representing more than 33 percent of the \$51.4 trillion included in corporate asset management. This represents a remarkable growth of over 42 percent compared to 2017, according to the US FIS ("Sustainable, Responsible, and Impact Investing Trends") (Peng et al., 2023). This increase in investment has fueled the Ministry of Labour's 2015 guidance that has allowed regulators to include ESG factors in corporate investment strategies (Eccles et al., 2017). While the number of green patent and environmental technology applications in the United States increased in 2011, it has since been slowly declining (Urbaniec et al., 2021). In conclusion, sustainable investment has become an important factor in the US financial market, in part because of the Ministry of Labor's guidance on ESG investment. While environmental innovation, enhances the growth of sustainable investing suggests that investors are now aware of the significance of ESG factors in their investment decisions (Inderst & Stewart, 2018; Maiti, 2021; Sood et al., 2023).

The United States' economic development poses serious environmental stability problems (Alola, 2019). In this respect, protecting the environment is becoming a key driver of green innovation and development (Huang et al., 2020; Liu et al., 2021). Green innovation is a major factor in technological innovation linked to eco-economic development

and environmental protection (Schiederig et al., 2012; Zhang, Sun, et al., 2020). The green innovation process requires risky investments and lengthy payback periods (Xu et al., 2021). Multinationals in developed countries have a large share of the resources needed to achieve green innovation targets through multi-organizational support and coordination measures (Khanra et al., 2022). As the largest developed economy, the United States is very familiar with the problems of environmental and social practices during the economic transition (Marshall et al., 2010). Board influence on ESG reporting (Bamahros et al., 2022; Ismail & Latiff, 2019); therefore, the diversity mechanism is becoming a priority for academics in the United States. To the best of our knowledge, the current study analyzes very first time the effectiveness of ESG reporting in the context of the developed country specifically, whether the corporate sector in the US improves green innovation. Moreover, the mechanism by which board diversity interacts with the association between ESG reporting and green innovation (GI) continues to require further investigation and conclusions are not irrefutable.

This study examines the impact of ESG reporting on green innovation with the direct effect and interaction effect of board diversity in U.S. listed companies from 2010 to 2021. The study includes the panel regression model and Hierarchical regression to investigate hypotheses. Empirical findings indicate that ESG rating has a significant and positive impact on green innovation. In addition, the CSR strategy also has a positive relationship with environmental innovation scores. Furthermore, board diversity positively impacts the relationship between ESG reporting and green innovation. ESG reporting in U.S. firms improves green revenues, product innovation, and R&D activities aimed at promoting green innovation practices. Larger social and green practices in US companies indicate higher eco-efficiency and implementation of cleaner technologies. The study explores the impact of ESG ratings on green innovation, under the lens of stakeholders' view (Freeman, 2004), resource-based theory (Barney, 2001), and the upper echelons 'point of view' (Hambrick & Mason, 1984). Research findings suggested that ESG reporting in US companies enhances green revenues, product innovation, and R&D activities to achieve green innovation practices. Secondly, social and environmental practices (CSRS) in US companies indicate the eco-efficiency and implementation of clean technologies to foster green practices. In addition, board diversity-based decision-making in U.S. companies encourages green innovation through investments in green technologies and the production of eco-designed products. To the best of our knowledge, it provides fresh insights into emerging literature by addressing the interaction impact of board diversity on the relationship between corporate ESG reporting and green innovation, specifically in developed markets. It extends the moderating aspects of green innovation beyond environmental regulation, by highlighting corporate governance contributions to green innovation. Furthermore, the study enlarges green innovation determinants, incorporating the environment pillar and innovation score to measure the green innovation.

## 2. Literature review and hypotheses development

### 2.1. Theoretical framework

ESG reporting looks at corporate performance in social, environmental, and governance practices. All stakeholders are equally important to an organization (Freeman, 2004; Stieb, 2009). The social performance of a business comes under the lens of stakeholder theory. In social practices, corporations develop local societies and communities (Freeman et al., 2021; Valentinov & Hajdu, 2021). In this vein, the theory of legitimacy has argued that firms seek to operate continuously under social norms. The resource base view supports green innovation aimed at reducing pollution from manufacturing processes (Hill & Jones, 1992; Waheed & Zhang, 2022). Investments in R&D and green projects improve the environment through the deployment of clean and environmentally friendly technologies. However, agency theory (Jensen & Meckling, 2019) addresses the barriers and conflicts that arise between

environmental, social, and governance practices because of Principal-Agency issues. ESG reports strongly indicate decisions made by boards of directors concerning green initiatives. Board diversity minimizes agency conflicts through diverse knowledge, skills, and problem-solving abilities (Amin et al., 2022), which simultaneously confirms the resource-based view (Yang & Konrad, 2011) and upper echelon theory (Kanadli et al., 2018). With increasing volatility in global markets, gaining a competitive advantage is a key factor and reputation challenge for the business (Liu & Yang, 2019). The most important means of developing a competitive advantage is the efficient use of resources and the ability to innovate in commercial operations while minimizing environmental distortions (Hassan, 2000). According to Raghunandan and Rajgopal (2022), the business sector can overcome these challenges through strategic decisions in green practices. The business sector must take the initiative of green practices in strategic decisions to obtain long-term economic and competitive benefits (Baah et al., 2021). Addressing CSR practices reduces inter-agency conflict and safeguards stakeholder interests (Ciliberti et al., 2011).

## 2.2. ESG reporting and corporate green innovation

Demand for corporate social responsibility has now grown due to sustainability initiatives (Fallah et al., 2022; Nurunnabi et al., 2020). ESG performance is now reported based on environmental, social, and governance, with transitional investments in green environmental practices (Linnenluecke, 2022). ESG performance of companies improved through investment in CSR projects (Parikh et al., 2023). The ESG rating defines the valuable resources and capabilities established by companies concerning social responsibility, green technology, and environmental performance (Billio et al., 2021; Escrig-Olmedo et al., 2019). ESG is distinct from traditional economic and social development because it protects the interests of all stakeholders, such as consumers, providers, and local communities (Henisz et al., 2019). As a result, ESG reporting fosters green innovation practices by developing a competitive advantage over the industry in various aspects (Zhang & Jin, 2022). ESG practices drive corporate growth by modernizing technologies and manufacturing processes, introducing green activities, and establishing long-term relationships with suppliers, employees, and other stakeholders (Chouaibi & Chouaibi, 2021; Xu et al., 2021). Moreover, ESG practices highlight the development of intangible assets and improve organizational value in the marketplace, which discloses information on the social and environmental accountability of potential stakeholders (Liu et al., 2022; Raghunandan & Rajgopal, 2022). For instance, equity provided by creditors and investors can encourage greener practices (Ikram et al., 2021). One study suggested that business sectors with better social performance have a cutting-edge advantage over industry. In particular, those with strong ESG performance can meet stakeholder demands, which may gain higher market share with minimum funding costs (Paolone et al., 2022; Zhou et al., 2022).

ESG practices may reinforce the legitimacy of ecological innovation activities (Zhai et al., 2022; Zheng, Khurram, & Chen, 2022). Environmental performance, which protects the rights and interests of stakeholders, is the corporate social obligation and the primary requirement of regulators (Elmagrhi et al., 2019). ESG practices are viewed as driving economic growth and social development that impact green innovation (Lyu et al., 2022; Zhang, Sun, et al., 2020). In contrast, the fact that the organization violates ESG practices leads to a rapid spread of potential stakeholder concerns, affecting the image and reputation of businesses (Asante-Appiah & Lambert, 2022). Corporate social performance and responsibility strengthen the concept of ESG practices by embedding a value system into corporate activities that mitigate institutional isomorphism (Sorri, 2022). ESG-related activities highlight the legal issues associated with the green environment and facilitate flexible green innovation strategies (Wang & Sun, 2022). To meet long-term objectives, ESG performance also minimizes the cost of implementing green innovation and provides a mechanism for transferring green production

(Tang, 2022). Green innovation is huge challenge due to an internal shortage of knowledge management, technology, and capital, including the external barriers in terms of corporate governance policy-making, and competitive advantage (Abdullah et al., 2016; Bar, 2015; Chien et al., 2021). However, ESG practice involves strengthening organizational capacity and learning for green enterprise innovation. ESG not only provides corporate commitments for green innovation, protection of the environment, and motivation to enhance awareness about environmental issues (Tan & Zhu, 2022), but also enhance front ability in the value creation taking activities in times of uncertainty (Ctapobepoba, 2022). Ronalter et al. (2022) stated that the corporate sector could voluntarily adopt environmental protection to improve their market recognition and ESG performance to create external financing and legitimacy. Regulators and legislators develop requirements regarding ESG reporting to build the interest of stakeholders in corporate social responsibility practices, which enhances the capital flow in organizational sustainability (Amel-Zadeh & Serafeim, 2018; Park & Jang, 2021). ESG reporting enhances significantly corporate image and reputation as most studies have found a positive and significant relationship between corporate financial performance and ESG reporting (Li, Ba, et al., 2023; Naimy et al., 2021; Xie et al., 2019; Zhao et al., 2018). In the opinion of Mukhtar et al. (2022), companies can provide technology tools to stimulate innovation using ESG practices. Therefore, companies must improve the effectiveness of GI activities in their strategic decision-making. A study led by Zhai and al. (2022) on Social Responsibility revealed that ESG practices enhance green business innovation through organizational learning. Corporations must communicate knowledge about the green initiative to employees, investors, and external suppliers as well as to strategic partners who have a strong stake in the business (Shahzad et al., 2020). Moreover, ESG factors can create innovative ideas and knowledge absorption capacity for businesses (Yuan & Cao, 2022).

Companies can use successful governance strategies to generate innovative green ideas and address organizational conflicts (Ren et al., 2020; McGlinch & Henisz, 2021). Furthermore, corporates fulfill their ESG responsibilities for acquiring sustainable development, they must adopt innovative technology through interactive relationships with stakeholders including investors, the local community, and regulatory authorities (Zhang & Jin, 2022). These insights can be integrated into ecological innovation practices (Li et al., 2022). The discussion and literature, conclude that:

**H1:** ESG reporting has a positive and significant relationship with corporate green innovation.

## 2.3. The moderating role of board diversity

Upper Echelon view suggests that the nationality and background of directors, significantly influence strategic decisions and choices about the long-term goals of the company (Azam et al., 2019; Hambrick & Mason, 1984). As well, the training, skills, and experience of directors were primarily related to their nationality, which has an impact on strategic outcomes. The board structure is largely influenced by the diversity of boards based on their nationality, skills, knowledge, and experience (Ciasullo et al., 2022). The diverse knowledge and skills of boards rooms contribute to the optimization of CSR practices (Brinette et al., 2023; Manita et al., 2018; Romano et al., 2020). Corporate directors with diverse backgrounds and experience enable businesses to adopt green practices in environmental and social activities, indirectly stimulating green innovation (Abreu et al., 2022; Mohy-ud-Din, 2023). On the board, diversity is the key indicator of corporate performance (Aggarwal et al., 2019; Mohsni et al., 2021; Song et al., 2020). Earlier research has highlighted the importance of diversity concerning foreign affiliations (Coffey & Wang, 1998; Ferreira, 2010; Shehata, 2013). Board diversity is linked to effective decision makings, which may improve the corporation's performance (Bin Khidmat et al., 2020; Song et al., 2020). In terms of governance characteristics, board diversity, and independence are seen as more robust in monitoring

managers and preventing poor performance (Puni & Anlesinya, 2020). Ahn et al. (2020) stated that external directors are very socially responsive and meet the needs of all stakeholders. According to human capital theory, international directors provide features that significantly and positively influence environmental performance (Iwamoto & Suzuki, 2019). Moreover, international and foreign board rooms assist the corporate sector to be more environmentally friendly. Corporate boards belonging to foreign nationals significantly support green innovation (Usman et al., 2020). Furthermore, the theory of resource dependence argues that foreign and external administrators play a significant role in green innovation (Yousaf et al., 2022). According to research carried out by Quan et al. (2021), international experiences help businesses to become more environmentally friendly. A study conducted on Chinese listed firms for the periods of 2003–2020. Findings revealed that foreign directors with diverse knowledge and skills help the corporate function in the best possible way and create a competitive advantage in the business world (Fei et al., 2022).

From a resource dependency perspective, foreign boards provide core competencies and experience in eco-friendly practices (Schmid & Roedder, 2021). However, Xia et al. (2022) found a non-linear relationship between age diversity, gender diversity, and corporate green innovation in the Chinese manufacturing industry. Another study highlighted a quadratic relationship between gender diversity and eco-innovation practices in the logistics and transportation sector (Kuzzy et al., 2022). Birindelli et al. (2019), stated a non-linear association between gender diversity and the environmental performance of the banking industry. Cast diversity positively contributes to the social performance of corporates (Mohy ud din et al., 2022). Moreover, educational diversity has a U-shaped non-linear association with social responsibility practices (Chang & Cochran-Smith, 2022). However, the presence of independent directors in the boardroom has a linear association with climate change and environmental innovation (García-Sánchez et al., 2023). In addition, upper echelons scholars postulated the characteristics of directors that affect firms' outcomes, and boards with the appropriate traits can influence a firm's inclination toward Green innovation (Ren et al., 2021). Similarly, the resource-based perspective considers the skills of foreign directors to build an innovative and competitive edge in the acquisition of green practices (Yahya et al., 2021). Board diversity, in particular nationality, is a crucial aspect of achieving organizational goals and likely influences company-level results. Yang et al. (2022) assert that foreign diversity is a relevant dimension global business paradigm. In addition, the literature indicates that board diversity is related to the reputation, governance, and performance of the corporation (Larkin et al., 2012). Based on the literature above, it is concluded that.

**H2:** Board diversity positively moderates the relationship between ESG reporting and corporate green innovation.

#### 2.4. Conceptual framework

In this study, we take three variables into account. Green business innovation is considered a dependent variable, whereas environment, society, and governance are independent variables within the

framework. Moreover, board diversity is employed as the moderating variable in the model. To measure corporate green innovation this study includes two proxies environment pillar score and environmental innovation score. However, ESG reporting is determined by the ESG score and the CSR score (See Fig. 1).

### 3. Data and methodology

#### 3.1. Data collection and sample selection

To test our proposed framework, the current study used a sample of 334 companies listed in the S&P 1500 Index that comprise a diverse segment of small, medium, and large companies. An unbalance panel data for sampled firms were gathered from professional portal Eikon data stream. Green business innovation is the dependent variable, whereas environmental, social, and governance (ESG) reporting is an independent variable. In addition, the diversity of boards is used as the moderating variable in the model. Moreover, corporate revenues, returns on assets, and debt ratio are included as control variables in the framework. Funds allocated to green practices are associated with revenues earned by a particular business (Lin et al., 2014). Higher revenues suggest higher expenditures for green innovation practices. The firm performance also linked to revenues, shows a higher visibility of green performance (Quan et al., 2021), and is considered an effective tool in stakeholders' interest. US firms with higher asset yields are more committed to green innovation (Hoang et al., 2020). However, a higher debt ratio is not able to promote environmentally sustainable practices (Xu et al., 2022). In addition, a company's equity does not indicate a potential contribution to green innovation practices (Tang et al., 2020). Green innovation can be defined as the development of new production processes and technologies aimed at mitigating environmental risks such as pollution and the adverse impacts of resource depletion (Takalo & Tooranloo, 2021). EIS is the weighted average of green revenues, product innovation and R&D. EPS also weighted average of innovations, emissions and resources usage (Senadheera et al., 2021). Hence, Environmental innovation (EIS) and pillar (EPS) scores are employed as proxies of green innovation. Moreover, Aastvedt et al. (2021) also determined green innovation through EPS and EIS. To address the possible multi-collinearity problem among focused variables and interaction terms, predictors were standardized after estimating the bivariate correlation (Aiken & West, 1994; Bauer & Curran, 2005). For investigating hypotheses, the current study gathered a sample from the professional Eikon data stream for the period of 2010–2021. A total of 334 non-financial firms listed in the S&P 1500 index were included in the proposed sample. In the first step, panel regression with fixed and random effects was used for the investigation of direct effect while hierarchical regression determines the moderating effect of board diversity. In addition, quantile regression evaluates the robustness of the results. According to Greene (2007), Pooled OLS excludes the heterogeneity present in the sample data. However, the fixed-effect model takes into account constant time with unequal intercepts because of the historical difference in business data. While random effect captures errors between and within the cross sections because of time variation.

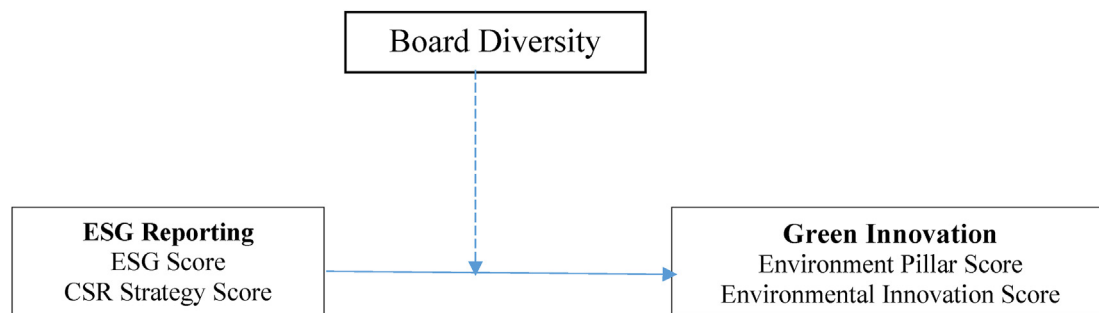


Fig. 1. Conceptual framework.



### 3.2. Description of variables

Table 1 explains the measurement of variables incorporated in the proposed model. Green business innovation is employed as the dependent variable, while environmental, social, and governance (ESG) reporting is an independent variable. Moreover, the interaction effect is examined by board diversity. Furthermore, corporate revenues, returns on assets, and debt ratio were included as control variables in the framework.

### 3.3. Model specification

To estimate our proposed hypotheses a total of seven variables are incorporated. Log of sales, return on assets, and debt ratio are included as control variables. Environmental pillar score and environmental innovation score were employed as proxies on environmental innovation (dependent variable) while ESG reporting (focused variable) was determined by corporate social responsibility strategy score and environmental social governance score. Furthermore, board diversity is incorporated as a moderating variable. Equations i and ii estimate H<sub>1</sub> that examine the direct impact of ESG reporting and CSR score on the environmental pillar score and environmental innovation score. While the interaction impact of board diversity on the environmental pillar score and environmental innovation score is estimated in equations iii and iv to confirm H<sub>2</sub>.

$$EPS_{it} = \beta_0 + \beta_1 SL_{it} + \beta_2 ROA_{it} + \beta_3 DR_{it} + \beta_4 ESGS_{it} + \beta_5 CSRS_{it} + \varepsilon_{it} \quad (i)$$

$$EIS_{it} = \beta_0 + \beta_1 SL_{it} + \beta_2 ROA_{it} + \beta_3 DR_{it} + \beta_4 ESGS_{it} + \beta_5 CSRS_{it} + \varepsilon_{it} \quad (ii)$$

$$EPS_{it} = \beta_0 + \beta_1 SL_{it} + \beta_2 ROA_{it} + \beta_3 DR_{it} + \beta_4 ESGS_{it} + \beta_4 CSRS_{it} + \beta_5 BD_{it} + \beta_6 BD \times ESGS_{it} + \beta_7 BD \times CSRS_{it} + \varepsilon_{it} \quad (iii)$$

$$EIS_{it} = \beta_0 + \beta_1 SL_{it} + \beta_2 ROA_{it} + \beta_3 DR_{it} + \beta_4 ESGS_{it} + \beta_4 CSRS_{it} + \beta_5 BD_{it} + \beta_6 BD \times ESGS_{it} + \beta_7 BD \times CSRS_{it} + \varepsilon_{it} \quad (iv)$$

Here EPS is the environmental pillar score, EIS is the environmental innovation score, SL is the log of sale, ROA is the return on assets, DR is the debt ratio CSRS is the corporate social responsibility strategy score and ESGS is the environmental social governance score.

## 4. Results and findings

Table 2 elaborates on the mean and standard deviation of focused, control, moderating, and dependent variables. To test our proposed hypotheses, results were analyzed for 334 cross-sections followed by 12 years. A bivariate relationship using the Pearson method showed a positive and significant relationship between the CSR strategy score and the environmental innovation score ( $r = 0.474$ ,  $p\text{-value} < 0.05$ ). The same results are repeated for the ESG score with environment innovation ( $r = 0.539$ ,  $p\text{-value} < 0.05$ ). Furthermore, the environmental pillar score is also significantly and positively associated with CSR strategy ( $r = 0.804$ ,  $p\text{-value} < 0.05$ ) and the ESG score ( $r = 0.863$ ,  $p\text{-value} < 0.05$ ). Hence, the initial idea of our study confirmed that ESG reporting has an important link to environmental innovation through the ESG rating and the environmental pillar score. In addition, board diversity also has a positive and significant association with both environmental innovation ( $r = 0.345$ ,  $p\text{-value} < 0.05$ ) and pillar ( $r = 0.196$ ,  $p\text{-value} < 0.05$ ) scores. Initial results of the research revealed that a diverse board of directors in the U.S. business sector significantly enhances environmental innovation. Directors belonging to foreign nationality in the US corporate board significantly improve environmental innovation. The initial results of the research support stakeholder theory.

To examine the direct relationship between environmental innovation and ESG reporting, a panel regression was utilized, and hierarchical regression was employed to estimate the moderating role of board diversity. In the panel regression model, the portion of the change in environmental innovation is attributed to a change in ESG reporting. Before estimating the results, the normality and linearity of the data were analyzed within the estimated sample. Table 3 presents fixed and Random effect model (Hausman test) for both direct and moderating relationship among. H<sub>1</sub> predicts a positive and significant relationship between ESG reporting and green innovation. The results of the pooled regression model demonstrated the positive impact of the ESG score on the environmental pillar score ( $\beta = 0.726$ ,  $p\text{-value} < 0.05$ ) and the environmental innovation rating ( $\beta = 0.852$ ,  $p\text{-value} < 0.05$ ). In the fixed-effect model, the ESG rating also has a significant and positive impact on the environmental pillar score ( $\beta = 0.486$ ,  $p\text{-value} < 0.05$ ) and the environmental innovation score ( $\beta = 0.748$ ,  $p\text{-value} < 0.05$ ). The same

**Table 1**  
Measurement of variables.

Variable Type	Variable Name	Proxy	Measurement	References
Dependent variables	Green Innovation (GI)	Environment Pillar Score (EPS)	Firms' initiatives for product innovation, R&D, and earning green revenues	Aastvedt et al., 2021; Bossle et al., 2016
		Environmental Innovation Score (EIS)	Show the firm's ability to minimize environmental costs and customers' burden by creating new markets through new technology and eco-products.	
Independent variables	ESG Reporting (ESGR)	ESG score (ESGS)	Firms' performance concerning Environmental, Social, and Governance (ESG) issues.	Tarmuji et al., 2016; Rajesh, R. (2020)
		CSR Strategy Score (CSRS)	Company's reflection into financial, social, and environmental dimensions in decisions making.	
Moderating variable	Board Diversity (BD)	Foreign Board (FB)	Total number of foreign directors present on the board	Masulis et al., 2012; Miletkov et al., 2017
Control variables	Sales (SAL)		Annual sales revenue	Ullah et al., 2020
	Return on Assets (ROA)		Earning after tax/Total Assets	Radu, C., & Francoeur, C. (2017)
	Debt Ratio (DR)		Total debt/Total assets	

**Table 2**  
Bivariate analysis.

Variables	Mean	Std. Dev.	LNSL	DR	ROA	BD	CSRS	ESGS	EPS	EIS
LNSL	16.02	1.535	1							
DR	0.631	0.243	0.215 <sup>a</sup>	1						
ROA	-10.58	11.055	0.200 <sup>a</sup>	-0.071 <sup>a</sup>	1					
BD	19.81	10.004	0.281 <sup>a</sup>	0.144 <sup>a</sup>	0.019	1				
CSRS	47.59	35.403	0.482 <sup>a</sup>	0.109 <sup>a</sup>	0.032	0.346 <sup>a</sup>	1			
ESGS	55.96	19.719	0.510 <sup>a</sup>	0.125 <sup>a</sup>	0.077 <sup>a</sup>	0.435 <sup>a</sup>	0.794 <sup>a</sup>	1		
EPS	49.72	29.019	0.535 <sup>a</sup>	0.109 <sup>a</sup>	0.052 <sup>a</sup>	0.345 <sup>a</sup>	0.804 <sup>a</sup>	0.863 <sup>a</sup>	1	
EIS	33.61	33.372	0.334 <sup>a</sup>	-0.002	0.012	0.196 <sup>a</sup>	0.474 <sup>a</sup>	0.539 <sup>a</sup>	0.684 <sup>a</sup>	1

EPS-environmental pillar score, EIS-environmental innovation score, LNSL-log of sale, ROA -return on assets, DR-debt ratio, CSRS-corporate social responsibility strategy score, ESGS- environmental social governance score.

<sup>a</sup> \*\*\*Correlation is significant at the 0.01 level (2-tailed), \*\*Correlation is significant at the 0.05 level (2-tailed).

results are repeated for a random effect model ( $\beta = 0$ ,  $w$ -value  $< 0.05$ ). Higher ESG reporting in the S&P listed firms enhances product innovation, R&D, and green revenues (environmental pillar score). Zhu and Lee (2022) also found a significant relation between ESG rating and product innovation. In addition, similar findings also examined by Li, Lian, and Xu (2023). Moreover, a higher EGS score also improves eco-product design by deploying clean technologies (Environmental Innovation Score). Therefore, the ultimate outcomes will lead to green innovation. These results matched with a previous studies (Tan & Zhu, 2022; Xu et al., 2021). Results also indicate that the CSR strategy score has a positive and significant relationship with EPS ( $\beta = 0.092$ ,  $p$ -value  $< 0.05$ ) and EIS ( $\beta = 0.241$ ,  $p$ -value  $< 0.05$ ) in the pooled effect model. The same results are repeated in fixed and random effect ( $p$ -value  $< 0.05$ ) both in Models I and II. The results of the fixed and random effects model are chosen according to the Huasman test ( $p$ -value  $< 0.05$ ) (Bartels, 2009). The social and environmental dimensions (CSRS) practices of US companies indicate the eco-efficiency and implementation of clean technologies to achieve green practices. Lagasio et al. (2023) also examined similar results in his investigation. Hence, H1 proved to be significant. Higher ESG and CSR strategy scores in US corporations support environmental green innovation, meaning that Higher funds allocated to EGS issues (ESG Score) enhance the firms' capacity to develop eco-designed products (Environmental innovation score) and environment protection. Furthermore, CSR practices also cultivate a green-oriented environment. In addition, ESG and CSR ratings also enhance green efficiency by minimizing energy use.

H2 looks at how board diversity impacts the relationship between ESG reporting and companies' green innovation. To eliminate the multicollinearity between the predictors and the interaction terms, variables are normalized before regression analysis (Aiken & West, 1994). The results of the pooled regression model show that board diversity positively moderates the relationship between ESG score and environmental pillar score ( $\beta = 2.850$ ,  $p$ -value  $< 0.05$ ) and environmental innovation score ( $\beta = 2.504$ ,  $p$ -value  $< 0.05$ ). A more diverse board in the U.S. corporate sector produces better ESG reporting, which optimizes companies' green revenue, product innovation, and R&D initiatives. The results are aligned with earlier literature (Javeed et al., 2022; Konadu et al., 2022). In addition, board diversity strengthens the relationship between EGS, clean technology, and green product manufacturing. As a result, decisions made by U.S. corporate boards foster green innovation through good ESG reporting. A study examined similar relationship between board of directors and eco-innovation (Albitar et al., 2023). However, results are insignificant for fixed and random effects models ( $p$ -value  $> 0.05$ ). Moreover, board diversity moderates the relationship between CSR strategy score and environmental pillar score ( $\beta = 2.631$ ,  $p$ -value  $< 0.05$ ) and environmental innovation score ( $\beta = 1.976$ ,  $p$ -value  $< 0.05$ ). Similar results are repeated in fixed effect model III and model IV ( $p$ -value  $< 0.05$ ). In contrast, the random effect model is insignificant. The social and environmental decision-making (CSRS) adopted by foreign directors significantly impacts eco-efficient operations and the implementation of clean technologies. Asad et al. (2023) reported board

diversity significantly contribute in R&D activities. Again, the results of the fixed and random effect model are preferred by the Hausman test ( $p$ -value  $< 0.05$ ). Hence, H2 proved to be significant. Higher the foreign board members in US firms stronger the ESG and CSR associated with green innovation. In the United States, foreign directors allocate higher funds to EGS (ESG rating), which improves the ability of businesses to protect the environment and develop eco-oriented products (EIS). In addition, they also promote CSR practices to develop a green-oriented environment. Furthermore, the ESG and CSR strategy developed by a diverse board room also enhances eco-efficient resources (See Table 3).

To study the moderating impact of board diversity, the hierarchical regression model was estimated. Variables are firstly standardized to eliminate the multicollinearity between predictors and interaction terms. Then Interaction terms are estimated by multiplication of moderating and independent variables. In the main effect, the direct relation between ESG reporting and corporate green innovation was captured while the interaction effect determined the moderating impact of board diversity by observing the change in R square. Model I & III determines H1 however, H2 is investigated by models II and IV. ESG and CSR strategy scores were again found to be significant in Models I & III ( $p$ -value  $< 0.05$ ). H2 shows the moderating role of board diversity on the relationship between ESG reporting and eco-innovation. The interacting effect of board diversity and ESG rating had a significant impact on EPS ( $\beta = 0.383$ ,  $p$ -value  $< 0.05$ ) and EIA ( $\beta = 0.745$ ,  $p$ -value  $< 0.05$ ) in models II and IV. The same results were reported for BD  $\times$  CSRS and EPS scores. On the other hand, the relationship of BD  $\times$  CSRS with EIN score is insignificant (See Table 4).

#### 4.1. Robustness of results

For more confirmation and a clear presentation of the results, the interaction role of board diversity was estimated by the two-way moderating effect. A graph was plotted on the high and low parameters of ESG reporting (ESG score and CSR strategy score) on the X-axis, while green innovation was plotted on the vertical axis. Analysis of the plot shows a positive and significant relationship between board diversity on the Environmental pillar and innovation scores See Fig. (2–5). Furthermore, the quantile regression model is also employed for the cross-verification and robustness of the results. The quantile model estimates a separate model on each quantile rather than presenting a single regression line. In the quantile regression, green innovation is predicted at various quantiles based on the given regressors. Moreover, a potential difference of predictors on various quantiles of the dependent variables also determines it. The phenomena are more robust when the theory considers a non-linear relationship in the proposed model. By allowing multiple quantiles, coefficient estimates are more valid for the outliers' sensitive data. Table 5 presents the results at QR 0.25, 0.50, and 0.75. The model I and II indicate a positive and significant relationship between ESG reporting, Environment Pillar Score (EPS), and Environmental Innovation Score (EIS) in all of the Quantiles. The relationship between variables is stronger at upper quantiles as compared to lower levels of

**Table 3**  
Panel regression models.

Variables	Dependent Variables			
	Environment Pillar Score (EIS) Model I		Environment Pillar Score (EIS) Model II	
	PE	RE	PE	RE
BD × ESG				
BD × CSRS				
BD	-12.860*** (0.000)	-7.185*** (0.000)	-2.095*** (0.000)	-2.852** (0.023)
ESG	0.726*** (0.000)	0.486** (0.037)	0.510*** (0.008)	0.748** (0.000)
CSRS	0.092*** (0.000)	0.040** (0.037)	0.241*** (0.000)	0.175*** (0.000)
ROA	-0.176*** (0.004)	-0.011** (0.012)	-0.029 (0.570)	0.010 (0.721)
LNSL	2.100*** (0.000)	1.982 (0.833)	2.126*** (0.000)	3.348*** (0.000)
Constant	-35.69*** (0.000)	-23.244* (0.077)	-42.060*** (0.000)	-54.0780*** (0.000)
R-sq.	0.302	0.195	0.7875	0.655
Adj. R-sq.	0.3021	0.1582	0.7871	0.654
Prob.(F)	280.710*** (0.000)	41.331*** (0.000)	2389.000*** (0.000)	1223.170*** (0.000)
Hausman test (χ <sup>2</sup> )	56.891*** (0.000)		25.450*** (0.000)	
Environmental Innovation Score (EIS) Model III				
	PE	RE	PE	RE
BD × ESG				
BD × CSRS				
BD	2.850*** (0.000)	2.631*** (0.000)	0.220 (0.478)	0.364 (0.237)
ESG	-1.468*** (0.005)	-1.750** (0.076)	0.548** (0.047)	0.291 (0.345)
CSRS	0.706*** (0.000)	0.211*** (0.000)	0.015 (0.306)	0.102 (0.723)
ROA	0.035*** (0.000)	-0.013 (0.641)	0.299*** (0.000)	-1.365 (0.106)
LNSL	1.130*** (0.000)	1.476*** (0.000)	0.035*** (0.000)	0.375*** (0.000)
Constant	-24.430*** (0.000)	-54.0780*** (0.000)	0.004*** (0.843)	0.015 (0.413)
R-sq.	0.8245	0.8241	1.476*** (0.000)	1.143*** (0.000)
Adj. R-sq.	0.8241	0.8229	-22.560*** (0.000)	-17.565*** (0.000)
Prob.(F)	1899.700*** (0.000)	295.100*** (0.000)	0.9733	0.8234
Hausman test (χ <sup>2</sup> )	25.450*** (0.000)	132.03*** (0.000)	0.9700	0.8229
Environmental Innovation Score (EIS) Model IV				
	PE	RE	PE	RE
BD × ESG				
BD × CSRS				
BD	2.504*** (0.006)	2.504*** (0.006)	0.220 (0.478)	0.364 (0.237)
ESG	1.976*** (0.030)	1.976*** (0.030)	0.548** (0.047)	0.291 (0.345)
CSRS	-11.470*** (0.000)	-11.470*** (0.000)	0.015 (0.306)	0.102 (0.723)
ROA	0.592*** (0.000)	0.592*** (0.000)	0.299*** (0.000)	-1.365 (0.106)
LNSL	0.054*** (0.000)	0.054*** (0.000)	0.035*** (0.000)	0.375*** (0.000)
Constant	-0.071 (0.685)	-0.071 (0.685)	0.004*** (0.843)	0.015 (0.413)
R-sq.	1.334*** (0.034)	1.334*** (0.034)	1.476*** (0.000)	1.143*** (0.000)
Adj. R-sq.	-10.690*** (0.000)	-10.690*** (0.000)	-22.560*** (0.000)	-17.565*** (0.000)
Prob.(F)	0.4919	0.4919	0.9733	0.8234
Hausman test (χ <sup>2</sup> )	628.9*** (0.000)	628.9*** (0.000)	0.9700	0.8229

Notes: P-values significant at \*p < 0.10; \*\*p < 0.05; \*\*\*p < 0.01, PE-Pooled effect, RE-Fixed effect, RE-Random effect, LNSL-log of sales, ROA-Return On Assets, DR-Debt Ratio, EPS- Environment Pillar Score, EIS- Environmental Innovation Score, BD-Board Diversity.

quantiles. Moreover, CSRS also has a significant impact on EPS and EIS however, the results indicate opposite findings at various Quantiles. In addition, Board diversity strongly interacts with ESG and CSRS at upper counties of the Environment Pillar Score and Environmental Innovation Score. In contrast, moderation is weaker at lower quantiles (See Table 5). For a more precise estimation, study conducted a variance inflation factor (VIF) to examine the presence of multicollinearity problems. As illustrated in Table 4, all VIF values for the all predictors are less than 5, demonstrating the absence of multicollinearity that could possibly diminish the predictive accuracy of estimation (Kock, 2015). A VIF value below 10 suggests that the model may not be influenced by common method bias, suggesting minimal collinearity concerns. Hence, if all VIF ≤ 10, it can be concluded that the model is free from common method bias (Pallant, 2010).

## 5. Conclusions and policy implications

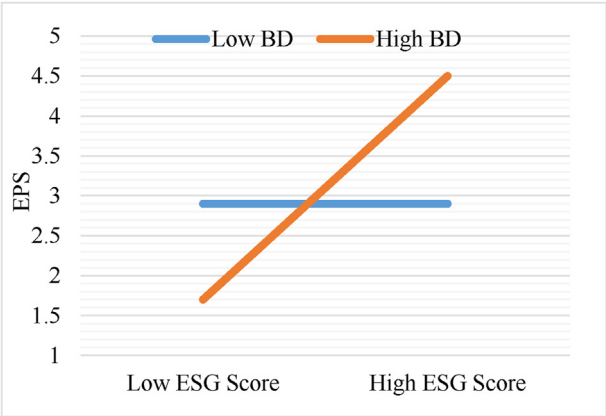
To address the role of ESG reporting on green innovation and improving sustainability, this study used a combination of stakeholder theory, upper-echelon theory, and resource-based approaches. The study highlighted the importance of ESG reporting on GI practices and developed an internal relation mechanism to address stakeholder theory. In addition, we are exploring the moderating role of board diversity on the relationship between ESG reporting and green innovation to support upper-echelon theory and the resource-based vision. The sample used for the analysis included 334 companies listed in the S&P 1500. Research findings make a significant contribution to the emerging literature on ESG factors and green innovation practices.

First, the results of the study revealed that quality ESG reporting in U.S. companies enhances green revenues, product innovation, and R&D activities to promote green innovation practices. Tan and Zhu (2022) also found a significant relation between ESG rating and product innovation. Li, Lian, and Xu (2023) posited similar findings on ESG and corporate innovation in their research. In addition, the EGS score also contributes to enhancing eco-product design in the U.S. non-financial sector by deploying clean technology in manufacturing plants. Findings are consistent with a previous study (Tan & Zhu, 2022; Xu et al., 2021). Secondly, the CSR Policy has a positive and significant impact on the Environmental Pillar and innovation scores. Larger social and environmental practices (CSRS) in US firms indicate the higher eco-efficiency and implementation of clean technology that leads to green innovation practices. Lagasio et al. (2023) also examined similar findings during his investigation. A higher ESG rating and corporate social responsibility strategy in the US indicate that ESG funding is higher, improving companies' ability to protect the environment and develop eco-friendly products. A study on CSR and the eco-environment came to the same conclusion (Oo et al., 2020).

Thirdly, board diversity has served as a moderator between ESG, EPS, and EIS. Foreign directors allocate higher funds to ESG issues to develop product innovation, and R&D activities and generate green revenues. These findings are synchronized with earlier literature (Javeed et al., 2022; Konadu et al., 2022). In addition, a diverse board also moderates the relationship between EGS score and EIS. Therefore, board diversity-based decision-making in U.S. companies fosters green innovation through investments in green technologies and the production of eco-designed products. These results are consistent with the study of (Lin et al., 2022; Naveed et al., 2023). A study conducted on the board of directors and eco-innovation also yielded similar results (Albitar et al., 2023). Finally, board diversity moderates the relationship between CSRS, EPS, and EIS. Greater involvement of foreign directors in environmental and social practices improves R&D activities and also enhances product innovation and green revenues. These results are confirmed in previous studies (Javeed et al., 2022; Konadu et al., 2022). Asad et al. (2023) found a significant relation between board diversity and R&D activities. Furthermore, a diverse board also moderates the relationship between CSRS scores and EIS. As a result, the foreign board members also

**Table 4**  
Hierarchical regression models.

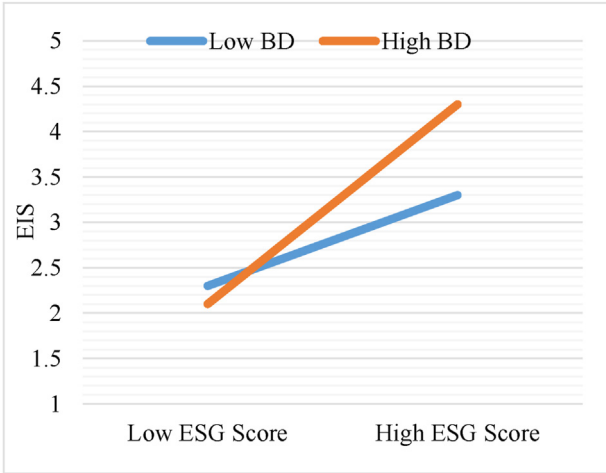
Variables	Environment Pillar Score (EPS)		Environmental Innovation Score (EIS)		VIF
	Model I	Model II	Model III	Model IV	
<i>Step II</i>					
BD × ESGS		0.383*** (0.000)		0.785** (0.043)	1.365
BD × CSRS		1.141*** (0.002)		0.642 (0.411)	1.355
<i>Step I</i>					
BD			3.193*** (0.000)	3.023*** (0.016)	1.416
ESGS	0.869*** (0.000)	0.867*** (0.000)	0.746*** (0.000)	0.753*** (0.000)	1.075
CSRS	0.242*** (0.000)	0.241*** (0.000)	0.094*** (0.000)	0.094*** (0.000)	3.401
LNSL	2.144*** (0.000)	2.120 (0.379)	1.822*** (0.000)	1.807*** (0.000)	1.487
ROA	−0.025 (0.381)	−0.025*** (0.000)	−0.128** (0.035)	−0.131** (0.032)	1.041
Constant	−43.269*** (0.000)	−42.152*** (0.000)	−38.799*** (0.000)	−39.084*** (0.000)	
	R square	Change in R square	F-test	Sig.	
Model I	0.786	0.788	2398.48***	(0.000)	
Model II	0.789	0.003	6.923***	(0.000)	
Model III	0.291	0.297	272.858***	(0.000)	
Model IV	0.297	0.001	5.508**	(0.000)	



**Fig. 2.** Interaction effect of board diversity with ESG score.

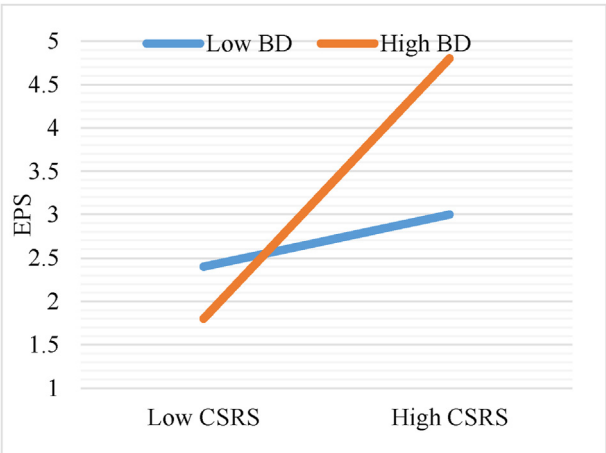
encourage green innovation through investments in green technologies and green product manufacturing. A study on board of directors and eco-innovation yielded similar results (Albitar et al., 2023).

The above findings show that companies that perform better on CSR and ESG could better promote product innovation and R&D activities and be able to generate green revenues. Effects of ESG and CSR strategies on green innovation varied slightly across the sectors. By demonstrating that better ESG can alleviate through corporate board diversity, which induces better green innovation. This study highlights the role of boards’

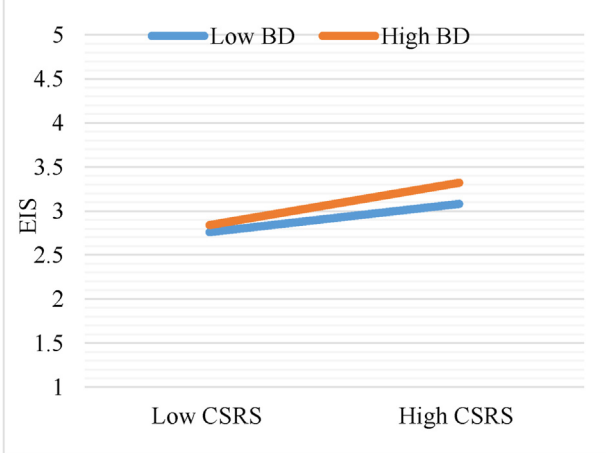


**Fig. 4.** Interaction effect of board diversity with ESG score.

decision-making in promoting sustainable development. Specifically, our results suggest that corporate boards with foreign nationality can better perform on green innovation. These findings bring a new dimension to understanding how businesses can leverage ESG for green innovation.



**Fig. 3.** Interaction effect of board diversity with CSR score.



**Fig. 5.** Interaction effect of board diversity with CSR score.



**Table 5**  
Quantile regression model.

Variables	Dependent Variables											
	Environment Pillar Score (EPS)			Environment Innovation Score (EIS) Model II			Environment Pillar Score (EPS) Model III			Environment Innovation Score (EIS) Model IV		
	QR 25	QR 50	QR 75	QR 25	QR 50	QR 75	QR 25	QR 50	QR 75	QR 25	QR 50	QR 75
BD × ESGS												
BD × CSR												
BD												
DR	-4.573*** (0.001)	-1.389*** (0.000)	-19.750*** (0.000)	-3.285** (0.018)	-1.008 (0.597)	-0.438 (0.690)	0.557 (0.308)	0.896 (0.272)	3.217** (0.020)	0.193*** (0.000)	1.703 (0.168)	4.541*** (0.000)
ESGS	0.263*** (0.000)	0.561*** (0.000)	0.983*** (0.000)	0.788*** (0.000)	0.908** (0.000)	0.931*** (0.000)	0.425 (0.436)	1.648*** (0.041)	3.625*** (0.009)	1.193*** (0.000)	1.317 (0.292)	4.408*** (0.000)
CSR	0.152*** (0.000)	0.276** (0.000)	0.139** (0.000)	0.315*** (0.000)	0.217*** (0.000)	0.179*** (0.000)	-0.004 (0.990)	-0.954 (0.124)	-3.552** (0.036)	7.031 (0.973)	-1.174** (0.044)	-1.826*** (0.014)
ROA	-0.027 (0.449)	-0.141** (0.021)	-0.174 (0.141)	-0.001 (0.996)	-0.055 (0.128)	0.050 (0.295)	-0.681 (0.243)	0.273*** (0.000)	-16.862*** (0.000)	-1.501 (0.980)	-1.143 (0.300)	1.462 (0.140)
LNSL	0.141 (0.681)	1.563*** (0.000)	2.455*** (0.000)	1.651*** (0.000)	1.798*** (0.000)	1.976*** (0.000)	0.021 (0.127)	0.082*** (0.000)	0.826*** (0.000)	4.381 (0.745)	0.556 (0.000)	0.826*** (0.000)
Constant	-10.078** (0.049)	-30.781*** (0.000)	-33.973*** (0.000)	-42.289*** (0.000)	-38.980*** (0.000)	-33.266*** (0.000)	0.005	0.082*** (0.000)	0.063 (0.101)	1.661 (0.970)	0.164 (0.000)	0.176*** (0.000)
							0.433	-0.003 (0.868)	-0.071*** (0.000)	-3.761 (0.970)	0.002 (0.923)	-0.053 (0.146)
							0.104 (0.423)	1.230*** (0.000)	3.367*** (0.383)	6.391 (0.942)	0.795*** (0.000)	1.366*** (0.000)
							-1.757 (0.369)	-18.22*** (0.000)	-48.456*** (0.000)	-1.701 (0.883)	-18.06*** (0.000)	-21.615*** (0.000)

Notes: P-values significant at \*p < 0.10; \*\*p < 0.05; \*\*\*p < 0.01. PE-Pooled effect, FE-Fixed effect, RE-Random effect, LNSL-log of sales, ROA-Return On Assets, DR-Debt Ratio, EPS- Environment Pillar Score, EIS- Environmental Innovation Score, BD-Board Diversity.

### 5.1. Theoretical implications

The present study has various theoretical support in the emerging literate of environmental, social, and governance practices. The findings of the research indicate that ESG reporting has a significant influence on environmental and green innovation, supporting the concept of stakeholder theory (Freeman, 2004). Higher CSR and ESG practices result in eco-efficiency and environmental protection that improve stakeholder interest. Board diversity has the most prominent influence on ecological innovation and environmental protection, supporting the concept of upper-echelon theory and the resource-based vision. Board of directors with diverse nations involved in innovation and environmental protection. Corporate boards with diverse nationals have a range of skills, knowledge, and problem-solving abilities in environmental protection that confirms the view resource-based view. The current study combined the stakeholder Freeman (2004) view with the upper echelon (Hambrick & Mason, 1984) and the resource-based view (Barney, 2001).

### 5.2. Policy implications

ESG reporting plays a crucial role in inducing corporate green innovation and protecting environmental issues. In addition, corporate boards from diverse national levels are improving the relationship between ESG reporting and green innovation in the context of the S&P 1500 Index. The study addresses the importance of ESG in GI practices. The findings have significant practical implications for businesses, investment institutions, ESG rating agencies, and the U.S. government. Policymakers in US companies need to focus on their ESG and CSR strategies to develop green business innovation in terms of environmental protection and eco-friendly product development. To promote the green innovation in United States, S&P listed firms must enhance the product innovation, green revenues and R&D activities. Moreover, US firms must deploy the clean technology for optimal green innovation practices.

Firstly, Policymakers need to better understand CSR strategies and ESG concepts in their day-to-day decisions to improve eco-efficiency. To achieve sustainability and green innovation, they need to rethink CSR and ESG strategies. Furthermore, corporate governance must emphasize board diversity to optimize green innovation.

Secondly, to achieve eco-efficiency in US corporates, security and exchange commission of US must monitor social and environmental practices (CSRS) take by US firms. Moreover, for environmental protection and develop eco-friendly products, US firms must enhance their ESG and CSR ratings.

Thirdly, board of directors are mainly responsible for green innovation in the United States. In order to develop product innovation, R&D activities and generating green revenues, US firms must introduce reforms on the listing requirement of foreign board members.

### 5.3. Limitations and further research

Apart from several theoretical contributions and managerial implications, the study also has certain limitations. It emphasizes companies listed in the S&P 1500 Index. Future research can expand the analysis to the financial sector such as banks, insurance companies, private companies, and family businesses. The current study was conducted in the context of a developed economy while further studies will be investigated in developing and merging economies. Additionally, studies may incorporate other features of the board, such as the audit committee and ownership structure. Future studies can be carried out on other board indicators to predict green innovation, financial performance, sustainable development, and CSR practices.

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## CRediT authorship contribution statement

**Kamran Mohy-ud-Din:** Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

## Declaration of competing interest

Author has no conflict of interest.

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