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RESEARCH ARTICLE

Effects of board gender diversity and sustainability committees on environmental performance: a quantile regression approach

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Abstract
This study examines the effect of board gender diversity (BGD) and sustainability committees on environmental performance. Using a quantile regression approach and a sample of publicly listed firms in Italy, we find that BGD and sustainability committees have different effects on firms' environmental performance over different points of conditional distribution. This shows that BGD and sustainability committees have greater quantitative impact in firms performing better environmentally and are positively related to environmental performance. We further discover that large Italian firms that reach a critical mass of three female directors maintain a stronger attitude towards environmental sustainability. Overall, the results confirm that BGD and sustainability committees enhance board effectiveness and help promote sustainable environmental initiatives. This study provides empirical evidence from a context that has not yet been investigated. It further augments the literature by employing a quantile regression approach, mostly unexamined by previous studies.

Key words: Board gender diversity; critical mass of female directors; environmental performance; quantile regression analysis; sustainability committees

Introduction

In recent years, there has been a global shift towards increased gender diversity in the workplace. The merits of board gender diversity (BGD) for improving corporate governance (Adams & Ferreira, 2009) and enhancing environmental performance have been largely emphasised (e.g., Kassinis, Panayiotou, Dimou, & Katsifaraki, 2016; Orazalin & Baydauletov, 2020). Research suggests that BGD is a significant predictor of a firm's environmental performance. For instance, firms with increased gender diversity unveil delicate strategic skills for environmental performance (Walls, Berrone, & Phan, 2012), offer advanced quality reporting (Rao, Tilt, & Lester, 2012), and appreciate a higher status for environmental performance (Kassinis et al., 2016).

In this study, we examine the impact of BGD and sustainability committees on the environmental performance of Italian publicly listed firms. Previous studies mostly examined the relationship between BGD, sustainability committee, and environmental performance in Anglo-American publicly listed firms (e.g., Cordeiro, Profumo, & Tutore, 2020; Deschênes, Rojas, Boubacar, Prud'homme, & Ouedraogo, 2015; Kassinis et al., 2016), Australian firms (e.g., Biswas, Mansi, & Pandey, 2018; Galbreath, 2011), emerging and developing markets (e.g., Alazzani, Hassanein, & Aljanadi, 2017; Elmagrhi, Ntim, Elamer, & Zhang, 2019; Sundarasen, Je-Yen, & Rajangam, 2016), and some European countries, such as France, Germany, and Spain (e.g., Baalouch, Ayadi, & Hussainey, 2019; García Martín & Herrero, 2020; Orazalin & Baydauletov, 2020).

Nevertheless, little attention was paid to Italy, despite its place as a significant European economy with corporate governance mechanisms that present some common features with the two archetypes in the existing literature (i.e., Anglo-Saxon and German-Japanese mechanisms). Moreover, these studies provided inconsistent results regarding the impact of BGD and sustainability committees on environmental performance. For instance, some studies revealed a positive relationship (e.g., Biswas, Mansi, & Pandey, 2018; Kassinis et al., 2016; McGuinness, Vieito, & Wang, 2017; Orazalin & Baydauletov, 2020), while others showed a negative relationship (e.g., Alazzani, Hassanein, & Aljanadi, 2017; Deschênes et al., 2015; Rodrigue, Magnan, & Cho, 2013); some studies report no relationship (e.g., Boulouta, 2013; Galbreath, 2011). These inconsistent results might be due to differences in corporate governance structure, empirical specifications and methodologies, statistical models, time horizons, omitted variables, and so on. Hence, more empirical research is required to better understand this phenomenon.

Another possible reason for such empirical inconsistency might also be the dominant estimation method applied. Prior studies mostly used the classic linear regression (i.e., *ordinary least square [OLS] or fixed-effect*) that was unsuitable for thoroughly examining how BGD and sustainability committees affected environmental performance. The problem of endogeneity was pervasive in almost all governance studies (Wintoki, Linck, & Netter, 2012), as well as BGD and performance studies (Adams & Ferreira, 2009). Hence, *OLS* regression could provide biased results due to unobserved heterogeneity and endogeneity issues. Nevertheless, in most prior studies, such matters were typically not addressed. Therefore, it is essential to consider and reconcile the potential explanations for such contradictory results. Thus, we employed a quantile regression method to address the issues in prior studies. Research suggests that quantile regression benefits in several ways: it is not sensitive to outliers, suitably fits data with skewed distributions, and captures non-monotonous and non-uniform effects of the explanatory variables on outcome variables (Li, 2015).

Our study makes significant contributions to both academic research and policy-making. From an academic perspective, we contribute to the literature on BGD, sustainability committees, and environmental performance. We show that the best governance practices, such as the existence of a sustainability committee and having more women on board, are effective mechanisms to achieve better environmental performance. The majority of previous studies were primarily conducted in the context of American and Anglo-Saxon markets; we advance the current knowledge by providing new evidence on BGD, sustainability committees, and environmental performance in Italy, a country characterised by changes in the ownership structure, investor protection environment, and corporate governance structures. Based on a 'theory mix' approach (such as resource dependence theory, stakeholder theory, and critical mass theory), we also make theoretical contributions to the existing literature. We show that the presence of women on board and a sustainability committee are crucial factors in creating a good governance mechanism that aligns the firm's interests with shareholders, managers, stakeholders, and society in general. We confirm that the presence of women on board and a sustainability committee enhance a firm's attitude towards adopting environmentally responsible behaviours and sustainability practices, stimulating, in turn, a higher level of accountability and environmental performance.

We further support the existing literature on the validity of female directors through critical mass theory for their boardroom representation. We find that most Italian firms reach the critical mass of three female directors, confirming the implication of female directors for supporting boards to improve environmental performance and the notion that female directors can provide a real commitment that goes beyond tokenism. Thus, improvement in environmental performance is reinforced when three women are on board, establishing the critical mass anticipated to raise environment-related issues. Unlike previous studies that mainly relied on linear regression, we expand the literature by employing a novel research method, the quantile regression approach, to re-examine the above-stated relationships at varied levels of environmental performance. We show that the impact of BGD and sustainability committees is quantitatively larger in

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magnitude for firms with high environmental performance scores relative to low environmental performance scores. Specifically, we reveal that higher environmental scores displayed by firms with more women on board and a sustainability committee are likely to reflect greater concerns regarding the risk presented by global climate change that numerous surveys have highlighted (Schwirplies, 2018).

Our findings offer new insights to policymakers for BGD and sustainability committees from both the business and environmental perspective. Our study is primarily interested in the European market (specifically Italy) because European Union (EU) regulators have implemented several reforms aimed at pressurising firms to meet stakeholder expectations on environmental sustainability, including the EU Emission Trading Scheme (ETS) in 2005, the Non-financial Reporting Directive (NFRD), and more recently, the 'European Green Deal'. Our findings can help legislators enhance firms' environmental sustainability by passing laws on aspects of board composition, such as the inclusion of women on corporate boards, and sustainability committees. Hence, our results are relevant for firms aiming to implement strong board compositions to track corporate social responsibility (CSR) activities and for policymakers interested in enhancing environmental sustainability.

The remainder of this paper proceeds as follows. Section 'Theoretical framework and hypotheses development' provides the theoretical framework and hypotheses development. Section 'Research method' presents the data, variables, and methods used. Here, we discuss the quantile regression approach and its key merits. Section 'Empirical results and discussions' presents the main results and discussions. Moreover, it carries out a battery of robustness checks and further analysis. Finally, section 'Conclusions' presents the conclusions, implications, and limitations of this study.

Theoretical framework and hypotheses development

This study explores the complex relationship between BGD, sustainability committees, and environmental performance. We believe that a single theory cannot examine this complex relationship. We argue that a multi-theoretical framework needs to be harnessed to explain the relationship. To this end, we employ several theories, such as resource dependence theory, stakeholder theory, and critical mass theory.

Resource dependence theory posits that a corporate board's diverse and unique human capital is viewed as a key resource to the firm, and board linkages are expected to provide counsel, information, and legitimacy to the firm (Pfeffer & Salancik, 1978). Therefore, more diverse boards have an advantage in obtaining and maintaining essential resources (Hillman, Withers, & Collins, 2009), which can lead to better decisions and ultimately improve firm environmental performance (Kassinis et al., 2016). The presence of women on corporate boards promotes high-quality decisions with divergent perspectives, ideas, skills, and orientations, leading to sustainable development (Shaukat, Qiu, & Trojanowski, 2016). Research suggests that female directors are concerned with environmental problems and are motivated to support corporate reforms that aim to advance environmental quality (e.g., Glass, Cook, & Ingersoll, 2016; Post, Rahman, & McQuillen, 2015). Likewise, Hillman, Cannella, and Paetzold (2000) argued that female directors could augment decision-making processes by providing a wider variety of perceptions, resulting in better social and environmental accountability. Post, Rahman, and McQuillen (2015) indicated that higher boardroom representations of women increased the likelihood of firms developing sustainability alliances and contributing positively to environmental performance. Kassinis et al. (2016) revealed that BGD could be a significant indicator of a firm's perception of environmental sustainability.

Concerning environmental sustainability, firms' attention to multiple stakeholders has recently received considerable attention. Thus, we include stakeholder theory to consider stakeholders' views on environmental performance. Traditionally, corporate governance protects shareholder

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interests and increases shareholder wealth by monitoring internal management, acquiring necessary resources, and strategic policy-making (Lan & Heracleous, 2010). However, stakeholder theory addresses environmental and CSR issues, and focuses on firms and their stakeholders who are affected by these issues. Stakeholder theory is defined as 'any group or individual who can affect or is affected by the achievement of firm objectives' (Freeman, 1984: 46). Thus, the main aim of stakeholder theory is to focus on firm stakeholders and their competing priorities. In recent years, external stakeholders have pressurised firms to minimise their negative impact on environmental practices and provide a better explanation for improving sustainability practices. Hence, a board with solid governance mechanisms can improve the firm–stakeholder relationship by fostering better CSR practices (Michelon & Parbonetti, 2012). Within the board of directors, BGD and sustainability committee recently received substantial attention to handle environmental issues. The interaction of stakeholder theory and resource dependence theory suggests that the presence of women on corporate boards and sustainability committees is more likely to represent diverse stakeholders (Freeman, 1984), providing access to information beneficial for corporate decisions (Pfeffer & Salancik, 1978) and leading to better environmental performance.

Critical mass theory is well established in legislative and political research (Sarah & Mona, 2008). However, it has rarely been tested in business research, and little attention has been paid to establishing a critical mass. This explains why group interactions vary across sizes and below a certain threshold, or why corporate boards with fewer than three women are less likely to be successful or efficient in influencing board decisions (Kanter, 1977). The classical cut-off point for critical mass theory is that of three women on the corporate board (Konrad, Kramer, & Erkut, 2008). The critical mass of female directors is essential because when only one woman is on the board, she has limited opportunities and less power, and is merely considered a token. However, when a corporate board has a critical mass of at least three women, their influence becomes more meaningful. Konrad, Kramer, and Erkut (2008) also posited that the critical mass of women on corporate boards is achieved when at least three women are on board, which impacts decision-making and, ultimately, environmental performance. Joecks, Pull, and Vetter (2013) argued that a critical mass of about 30% of female boardroom representation significantly influenced firms' overall performance. Erkut, Kramer, and Konrad (2008) showed that female directors could make a positive contribution and that corporations with three or more women on boards tended to benefit most from women's contributions. Torchia, Calabrò, and Huse (2011) argued that having at least two female directors was sufficient, depending on the qualifications and experience of managers, as well as the nature and size of the business. Resultantly, women's critical mass on corporate boards must be significant in order to improve strategic decision-making before it is accepted by all members.

BGD and environmental performance

Gender diversity is defined as the presence of female directors on corporate boards (Carter, Simkins, & Simpson, 2003). Resource dependence theory postulates that gender diversity on corporate boards increases board effectiveness by bringing new insights, expertise, innovation, and strategic decision-making (Pfeffer & Salancik, 1978), leading to improved overall performance (Apesteguia, Azmat, & Iriberri, 2012). Hillman, Cannella, and Paetzold (2000) argued that women's presence on corporate boards provided many benefits and helped firms understand diverse perspectives, thus accessing better resources. Ben Barka and Dardour (2015) postulated that female directors were more likely to serve on several boards, implying that they had a larger social network through board interlocks which increased awareness and distribution of actions. Prior literature showed that women were more rigorous and involved in board effectiveness and monitoring activities (Adams & Ferreira, 2009), more cautious in decision-making, and more sensitive to social and environmental issues (Liao, Luo, & Tang, 2015). Research on gender diversity also indicated that boards with female members had higher levels of environmental

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concerns (Kassinis et al., 2016), were actively involved in pro-environment behaviours (Li, Zhao, Chen, Jiang, Liu, & Shi, 2017), and had an excellent perception of environmental risks (Davidson & Freudenburg, 1996).

However, evidence on the relationship between BGD and environmental performance is mixed. For instance, research suggested that BGD was positively associated with environmental performance (Kassinis et al., 2016), and that the presence of women on corporate boards brought in different opinions and enhanced discussion quality to assess environmental-related decisions (Post, Rahman, & McQuillen, 2015). Sampling 94 Fortune 500 firms, Ciocirlan and Pettersson (2012) showed that firms with more female boardroom representations were more concerned about climate change and environmental performance. Walls, Berrone, and Phan (2012) supported their findings, discovering that one of the main reasons for less environmental efficiency was boards becoming more independent, bigger, and less diverse. McGuinness, Vieito, and Wang (2017) sampled Chinese joint-stock firms, revealing that firms with more female directors were associated with higher corporate environmental performance. Glass, Cook, and Ingersoll (2016) examined a sample of US firms, showing that firms with more female directors were more effective in implementing sustainability strategies. Shoham, Almor, Lee, and Ahammad (2017) sampled cross-country firms, revealing that only one woman on the corporate board positively encouraged firms towards environmental sustainability, regardless of the local culture. Birindelli, Iannuzzi, and Savioli (2019) examined 96 listed banks and found that gender diversity on corporate boards exerted a positive influence on firms' environmental performance, and that women leaders were essential drivers of environmental sustainability and were increasingly involved in environmental issues. Lu and Herremans (2019) analysed the industry effect, showing that BGD in more environmentally impacting industries was associated with higher scores in environmental performance; however, such impact was insignificant in less environment-impacting sectors, including retail and services. Orazalin and Baydauletov (2020) sampled firms from 10 European countries, revealing that BGD was positively related to environmental performance, reinforcing the notion that gender diversity fostered sustainable development. Sampling US firms, Cordeiro, Profumo, and Tutore (2020) showed similar findings: the higher the proportion of women on a corporate board, the better the firm's environmental performance. Nadeem, Bahadar, Gull, and Iqbal (2020a) sampled a large data set of publicly listed firms in the US and revealed a positive relationship between BGD and environmental innovation. Furthermore, the authors found that this association was more prominent in firms that were less profitable and environmentally sensitive. Using a sample of publicly listed firms in the UK from 2007 to 2017, Nadeem, Gyapong, and Ahmed (2020b) showed that in addition to economic returns, BGD significantly boosted firms' social and environmental value creation. More recently, Nuber and Velte (2021) analysed a cross-country sample of European firms from 2009 to 2018, showing a robust, linear, and positive relationship between BGD and environmental performance.

Inconsistent with these results, other studies showed that the presence of women on corporate boards negatively impacted environmental performance. Deschênes et al. (2015), for instance, reported that the presence of women on corporate boards was negatively related to environmental performance. Alazzani, Hassanein, and Aljanadi (2017) found that Malaysian female board members were more concerned with social issues than environmental ones. More recently, Nadeem (2021) sampled environmental violations and supplemental data on environmental projects and found that BGD might not nurture environmental initiatives, particularly in firms that had been found guilty of environmental violations. Another group of studies, however, failed to find any meaningful impact of BGD on environmental performance. For instance, Galbreath (2011) and Boulouta (2013) revealed that the presence of women on corporate boards was not directly associated with a firm's environmental quality. These contradictory results warrant further empirical investigation into how female directors contribute to environmental efficiency. In 2011, Italy enacted BGD quotas, mandating that firms have one-third of female directors on the

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board by 2015. Therefore, we believe that more women in the boardroom would positively affect environmental performance. Hence, we propose the following hypothesis:

Hypothesis 1: A positive and significant relationship exists between BGD and a firm's environmental performance.

Critical mass of female directors and environmental performance

The extant literature widely uses critical mass theory to explain how BGD affects board effectiveness (Schwartz-Ziv, 2017), firm performance (Joecks, Pull, & Vetter, 2013), innovation (Torchia, Calabrò, & Huse, 2011), and investment in research and development (Saggese, Sarto, & Viganò, 2021). However, little research has been conducted on the critical mass of female directors and environmental performance. Torchia, Calabrò, and Huse (2011) argued that the critical mass theory offered possible explanations for the influence of female directors on corporate issues. For example, in the boardroom, most male directors often dismissed or devalued the input of a minority of female directors. Nevertheless, when more female directors served on corporate boards, their influence increased. Accordingly, Konrad, Kramer, and Erkut (2008) contended that a firm's approach towards environmental sustainability and disclosure seemed to be affected by the presence of a critical mass of female directors. Based on the critical mass theory, Nadeem (2020) revealed that firms with at least two female directors communicated better with investors through voluntary intellectual capital disclosure in initial public offering prospectuses than those with a single female director. As a result, the critical mass theory recommends that having an unbalanced board of directors hinders innovative decision-making (Konrad, Kramer, & Erkut, 2008) because social pressures inspire minority board members to embrace or adapt to the majority's opinions (Torchia, Calabrò, & Huse, 2011). Nevertheless, when a minority of female directors form a critical mass or reach a recommended threshold, interpersonal interactions improved, and information overload and environmental risks were mitigated (Nuber & Velte, 2021).

Consistent with the critical mass theory, several studies have established a positive association between the critical mass of female directors and higher levels of environmental performance. For instance, Post, Rahman, and Rubow (2011) examined Fortune 1000 firms, showing that a critical mass of three female directors enhanced the environmental performance. Fernandez-Feijoo, Romero, and Ruiz-Blanco (2014) posited that boards with at least three women favoured and enhanced CSR performance. Cook and Glass (2018) sampled Fortune 500 firms from 2001 to 2010 and found that the critical mass of female directors led to a greater commitment to CSR activities. Nuber and Velte (2021) examined a sample of European non-financial firms from 2009 to 2018 and found that a critical mass of at least two female directors was to be reached to improve environmental performance. De Masi, Słomka-Gołębiowska, Becagli, and Paci (2021) sampled Italian FTSE-MIB firms from 2005 to 2017 and revealed that female directors positively impacted ESG disclosure only if the critical mass was reached. The authors showed that the contribution of female directors was insignificant when the board consisted of only one or two women. Other recent studies also indicated that firms with a higher proportion of women on board were likely to demonstrate higher ability in promoting sustainability and environment-related strategies and practices (e.g., Birindelli, Iannuzzi, & Savioli, 2019; Orazalin & Baydauletov, 2020). In line with the existing literature, we believe that female directors' critical mass would allow them to wield sufficient influence to alter firm decisions and improve environmental performance. Thus, we propose the following hypothesis:

Hypothesis 2: A positive and significant relationship exists between the critical mass of female directors and environmental performance.

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Sustainability committee and environmental performance

The board of directors is primarily committed to implementing long-term value creation strategies. The board's effectiveness depends not only on the board's composition but also its governance structure. In this regard, a sustainability committee's existence is one of the board attributes that influences sustainable efficiency (Ortiz-de-Mandojana & Aragon-Correa, 2015). Its aim is to systematically plan, implement, and review sustainability policies and activities (Liao, Luo, & Tang, 2015). Carter, D'Souza, Simkins, & Simpson (2010) posited that the relevant specialised committees allow the board to reflect on interests and issues more carefully. Michaels (2009) showed that establishing a sustainability committee signalled a firm's stakeholders about all relevant issues. Liao, Luo, and Tang (2015) documented that a sustainability committee improved employees' awareness of the environmental aspects of their jobs and responsibilities to reduce negative impacts. A sustainability committee assists corporate boards with the formulation and implementation of policies, principles, and practices to manage social and environmental risks, and achieve sustainable development goals (Biswas, Mansi, & Pandey, 2018). Eccles, Ioannou, and Serafeim (2014) argued that highly sustainable firms were more likely to establish separate board committees to achieve sustainable development. A sustainability committee makes social and environmental recommendations to the board of directors and helps board members in their tasks related to environmental concerns (Biswas, Mansi, & Pandey, 2018). Thus, having a well-structured sustainability committee responsible for sustainability-related strategy and performance would facilitate a competitive advantage for the business.

Addressing environmental problems is considered a crucial challenge for a firm's success (Post, Rahman, & McQuillen, 2015). Therefore, a responsible investor or stakeholder could also pressurise firms to establish a sustainability committee or promote initiatives to improve environmental performance (Liao, Luo, & Tang, 2015). Stakeholder theory also suggests that to better accommodate stakeholders' needs, the board of directors should establish a sustainability committee that presumably focuses on promoting and implementing firm sustainability initiatives (Rodrigue, Magnan, & Cho, 2013), and ensure the quality of the stakeholder engagement process (Michelon & Parbonetti, 2012). Research shows that a board-level sustainability committee helps address CSR concerns (Biswas, Mansi, & Pandey, 2018), efficiently tracks CSR strategies and policies (Liao, Luo, & Tang, 2015), improves the efficacy of CSR strategies (Orazalin, 2020), manages CSR-related risks and opportunities (Peters & Romi, 2014), and expands the scope of sustainability disclosures accessible to stakeholders (Michelon & Parbonetti, 2012).

Regarding empirical evidence, there is an ongoing debate on the relationship between sustainability committees and environmental performance. For instance, Berrone and Gomez-Mejia (2009) examined longitudinal data from US firms and found no significant association between the existence of sustainability committees and environmental performance. Rupley, Brown, and Marshall (2012) sampled 127 US firms from 2000 to 2005 and found an insignificant relationship between sustainability committees and sustainability performance. Similarly, Rodrigue, Magnan, and Cho (2013) analysed environmentally sensitive firms, revealing that a sustainability committee could be established under a symbolic approach to manage stakeholder concerns, thus having less impact on environmental performance. More recently, Nadeem (2021) used environmental violations and supplemental data on environmental projects and showed that the existence of a sustainability committee might not foster environmental initiatives, particularly in firms that have been found guilty of environmental violations.

Other studies showed that the existence of a sustainability committee had a positive impact on a firm's environmental performance. For instance, Liao, Luo, and Tang (2015) reported that UK firms with environmental committees were more environmentally transparent than firms with no such committees. Elmaghrabi (2021) used a sample of 100 non-financial firms from the Financial Times Stock Exchange (FTSE) from 2015 to 2017, demonstrating that firms with board-level sustainability committees had better CSR performance, better CSR strategy, and fewer controversies

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than firms without a sustainability committee. The author further showed that sustainability committees chaired by female directors exhibited better CSR performance and had lower CSR-related controversies. Kuzey, Uyar, Nizaeva, and Karaman (2021) analysed three sectors (tourism, healthcare, and financial sectors) from the Thomson Reuters Eikon database from 2011 to 2018 and showed that it was imperative to establish CSR committees for tourism firms to enhance environmental performance. Similarly, Martínez-Ferrero, Lozano, and Vivas (2021) sampled a group of firms located in Argentina, Brazil, Chile, and Mexico between 2012 and 2018 and found that the existence of a sustainability committee positively impacted a firm's sustainability performance. Other recent studies also showed that the presence of a sustainability committee heightened corporate transparency, especially concerning environmental information and above all, regarding the firm's environmental performance (e.g., Glass, Cook, & Ingersoll, 2020; Orazalin & Baydauletov, 2020). Given the documented positive relationship between sustainability committees and environmental performance, we expect the sustainability committee to positively influence environmental performance. Hence, we propose the following hypothesis:

Hypothesis 3: A positive and significant relationship exists between sustainability committees and environmental performance.

Research method

Sample

This study used a data set of large firms listed on the Italian Stock Exchange from 2014 to 2018. Starting with a sample composed of all Italian publicly listed firms, we excluded firms that were not consistently listed during the sample period, firms with missing and duplicate data, and firms with missing environmental data. We also excluded financial firms, including banks and insurance companies, because of their specific governance and regulatory rules. Our final sample comprised 82 Italian listed firms covering 13 different industries, including energy and natural resources, health care, information technology, telecommunications, utilities, textile, retail, pharmaceutical, beverage and tobacco, fashion, tourism, manufacturing and construction, and automotive industries. The environmental data were retrieved from the Thomson Reuters Eikon ASSET4 database. This comprehensive platform provided applicable, consistent, and auditable data on the environmental, social, and governance dimensions of firms' performance. This database has increasingly been validated in the literature and has been widely used in recent studies (e.g., Kassinis et al., 2016; Orazalin & Baydauletov, 2020). We also used the Bureau van Dijk Aida database to extract data related to the control variables in this study.

Variable's measurement

Dependent variable

This study used environmental performance as the dependent variable. Biswas, Mansi, and Pandey (2018) argued that environmental performance scores indicated a firm's influence on living and non-living natural systems such as air, water, land, and whole ecosystems. There are three main dimensions used to measure environmental performance scores: 'emission reduction', 'resource reduction', and 'product innovation'. These scores indicate how well a firm uses its management practices to avoid environmental risks and benefit from environmental opportunities to create long-term shareholder value. Birindelli, Iannuzzi, and Savioli (2019) postulated that environmental performance scores measured a firm's capability to reduce environmental emissions, implement effective practices regarding natural resource use in the production units, and encourage the research and development of eco-friendly products and services. The environmental performance scores were obtained from the Thomson Reuters Eikon, ASSET4 database.

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Independent variables

This study used BGD and sustainability committee as independent variables. In line with the existing literature, we employed different measures of female directors to capture gender diversity within corporate boards. First, we took the percentage of female directors on board (Glass, Cook, & Ingersoll, 2016). Second, we used the BLAU Index of heterogeneity, defined as;

$$BLAU = 1 - \sum_{i=1}^{n} P_i^2,$$

where 'P_i' is the percentage of board members in each gender and 'n' is the total number of gender groups (Biswas, Mansi, & Pandey, 2018).[1] Regarding the critical mass of women directors, we created three dummy variables: Critical Mass_1 (CM_1) equals '1' if a firm has only one woman on the corporate board and '0' otherwise; Critical Mass_2 (CM_2) equals '1' if a firm has two women on corporate board and '0' otherwise; Critical Mass_3 (CM_3) equals '1' if a firm has more than two women on corporate board and '0' otherwise.

Following prior studies such as Liao, Luo, and Tang (2015) and Biswas, Mansi, and Pandey (2018), we measured sustainability committee as a dummy variable equal to '1' if a firm has a sustainability committee and '0' otherwise. A sustainability committee on corporate boards indicates that firms are more engaged in environmental sustainability (Biswas, Mansi, & Pandey, 2018).

Control variables

In line with previous studies, we controlled several variables that impact environmental performance (e.g., Alazzani, Hassanein, and Aljanadi, 2017). These variables were firm size, firm performance, financial leverage, board size, board independence, and CEO duality. We measured firm size as the natural logarithm of total assets. Yu (2001) argued that small firms could adapt to environmental issues more effectively, with a higher level of flexibility than large firms. Nevertheless, Pfeffer and Salancik (1978) postulated that large firms paid more attention to environmental challenges due to regulatory pressure and were more likely to embrace environmental concerns than small firms. Firm performance was measured as net income divided by total assets, while financial leverage was measured as total debt over total assets. Corporate governance variables could affect a firm's environmental performance. Thus, we controlled for board size and measured the total number of directors on board. Board independence was measured as the percentage of independent directors on the board. CEO duality was taken as a dummy variable equal to '1' if a firm had the same person as CEO and Chairman, and '0' otherwise.

Quantile regression and model specifications

Quantile regression is a technique used to evaluate the conditional quantiles of a dependent variable in a linear model (Koenker & Bassett, 1978). The traditional classical regression (*OLS*) assumes the average (i.e., conditional mean) relationship between the dependent and independent variables. Unlike *OLS*, quantile regression offers a more comprehensive picture of the potential relationship between the dependent and independent variables at different levels of conditional distribution (Koenker & Hallock, 2001). Certainly, it can be used to predict the 25th or 75th percentile of the dependent variable or any percentile that the researcher is interested in. Quantile regression, according to Johnston and Di Nardo (2007), does not require any strict assumptions, unlike traditional linear regression of normality, homoscedasticity, and outliers. In addition,

[1]Blau index is used to measure gender diversity, taking into account both the number of gender categories (i.e., $n = 2$ for the case of gender) and the distribution of board members among them.

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quantile regression is less prone to the impact of extreme data points. Thus, an essential rationale for employing quantile regression is to quantify a complete picture of the relationship between the dependent and independent variables.

Prior studies mostly used linear regression, relying on 'mean' as a measure of central tendency, and could not provide a complete picture of the relationship between BGD, sustainability committees, and environmental performance. Assuming that the impact of BGD and sustainability committees is different across the conditional distribution of firms' environmental performance, the mean effect might be zero. However, this can hide differences between firms with different levels of environmental performance scores. Hence, previous studies showed the positive, negative, or insignificant findings did not imply that the impact of BGD and sustainability committees on environmental performance was positive, negative, or insignificant for all levels of environmental performance. We believe that these relationships may vary as the dependent variable may differ in scale. Thus, we proposed a quantile regression method to re-examine this relationship. This method produced several coefficients, examining the impact of BGD and sustainability committees on environmental performance at different points of the conditional distribution.

We followed Buchinsky (1998) and summarised the linear quantile regression model. Suppose (y_i, x_i), where x_i is a vector of independent variables that explains the dependent variable y_i and i denotes a sample of observations from the population. Assuming that the θ^{th}quantile of the conditional effect y_i is linear in x_i, we proposed the following model for conditional quantile regression.

$$y_i = x_i'\beta_\theta + u_{\theta i}, \tag{1}$$

where y_i is the dependent variable, x_i is a $k \times 1$ vector of the explanatory variables, β_θ is an unknown $k \times 1$ vector of regression parameters related to the θ^{th}quantile, and $u_{\theta i}$ is the unknown error term.

The θ^{th} conditional quantile regression of y_i assumed x_i would be as follows:

$$Quant_\theta\,(y_i/x_i) \equiv \inf\{y_i = F_i(y/x) \geq 0\} = x_i'\beta_\theta \tag{2}$$

and

$$Quant_\theta(u_{\theta i}/x_i) = 0. \tag{3}$$

The θ^{th} quantile regression $(0 < \theta < 1)$ of y_i is the clarification of the minimisation of the sum of the absolute deviation residuals.

$$\min_{\beta\theta}\left\{\sum_{i:y\geq x_i'\beta}\theta|y_i - x_i'\beta_\theta| + \sum_{i:y<x_i'\beta}(1-\theta)|y_i - x_i'\beta_\theta|\right\} = \min_{\beta\theta}\sum\nolimits_\theta^\rho(u_{\theta i}). \tag{4}$$

The quantile regression model for our proposed research models generally took the following form:

$$Quant_\theta(y_{it}/x_{it}) = \alpha + \beta_\theta^{'}BGD_{it} + \beta_\theta^{'}SC_{it} + \beta_\theta^{'}x_{it} + \mu_{it}, \tag{5}$$

where y_{it} is the outcome variable at quantileθ. BGD_{it}, shows BGD variables, SC_{it} represents the sustainability committee, x_{it} vector includes board and firm characteristics, and μ_{it} is the error term. Specifically, we regressed environmental performance for BGD, sustainability committees, and their interaction effect on environmental performance. Hence, we showed all the models in the following ways. First, we examined the impact of BGD on environmental performance, as shown in Equation (6). Second, we investigated the effect of the critical mass of female directors on environmental performance, as shown in Equation (7). Third, we examined the impact of

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sustainability committees on environmental performance, as indicated in Equation (8). Finally, we explored the interaction effect of BGD and sustainability committee on environmental performance, as reported in Equation (9).

$$Quant_{\theta}(EP_{it}/x_{it}) = \alpha + \beta_1 BGD_{it} + \beta_2 BLAU_{it} + \beta_3 \sum ControlVariables_{it} + \varepsilon_{it}, \quad (6)$$

$$Quant_{\theta}(EP_{it}/x_{it}) = \alpha + \beta_1 CM\_1_{it} + \beta_2 CM\_2_{it} + \beta_2 CM\_3_{it} + \beta_3 \sum ControlVariables_{it} + \varepsilon_{it}, \quad (7)$$

$$Quant_{\theta}(EP_{it}/x_{it}) = \alpha + \beta_1 SC_{it} + \beta_2 \sum ControlVariables_{it} + \varepsilon_{it}, \quad (8)$$

$$\begin{aligned} Quant_{\theta}(EP_{it}/x_{it}) = {} & \alpha + \beta_1 BGD_{it} + \beta_2 CM_{it} + \beta_3 BLAU_{it} + \beta_4 SC_{it} + \beta_5 BGD \times SC_{it} \\ & + \beta_6 BGD \times SC_{it} + + \beta_7 CM \times SC_{it} + \beta_8 BLAU \times SC_{it} \\ & + \beta_9 \sum ControlVariables_{it} + \varepsilon_{it}, \end{aligned} \quad (9)$$

where EP is the firm's environmental performance, BGD refers to board gender diversity, CM_1 denotes one woman on board, CM_2 denotes two women on board, CM_3 denotes more than two women on board, BLAU denotes the gender diversity BLAU Index; as for subscripts, (i) refers to the individual firms, (t) refers to the time period, and (ϵ) is the error term (residual). The definitions of all variables are reported in Table 1.

Empirical results and discussions

Correlation matrix and summary statistics

Table 2 shows the descriptive statistics for all variables. The mean (SD) value of the environmental performance score was 72.90% (26.75%), with a minimum of 5.261% and a maximum of 98.58%. This was consistent with the European Commission's recent report on Italy's environmental performance score.[2] Nevertheless, Birindelli, Iannuzzi, and Savioli (2019) reported an environmental performance score of 67.9% for firms from Europe, Middle East, and Africa (EMEA) from 2011 to 2016. Biswas, Mansi, and Pandey (2018), Baalouch, Ayadi, and Hussainey (2019), and Cordeiro, Profumo, and Tutore (2020) reported 34.60%, 83.16%, and 50.68% for Australian, French, and US firms, respectively. The mean (SD) of BGD was 32.05 (14.25), indicating 32.05% female boardroom representations. This result reflected the impact of Italian Law 120 of 2011, which stipulates that one-third of corporate board directors must comprise women. The mean (SD) of the critical mass of women directors was 19.52 (23.21), 31.16 (24.33), and 50.01 (27.60), indicating that 19.52% of firms had only one woman on board, 31.16% of firms had two women on board, and 50.01% of firms had more than two women on board. The mean (SD) of sustainability committees was .63 (.311), showing that 63% of sample firms designated a sustainability committee on board. The mean (SD) of board size (BS) was 09.33 (4.631), with a minimum of six and a maximum of 22 board members, in line with Lipton and Lorsch (1992), who argued that a board with nine members was ideal for monitoring purposes, and followed the best practices of corporate governance, wherein the 'ideal board size should not be less than seven' (Yermack, 1996). Of the total firms, 32.25% of

[2]Yale Center for Environmental Law & Policy (2018) reported Italy's environmental performance score as 76.96% and its rank as 16 out of 180. https://epi.envirocenter.yale.edu/downloads/epi2018policymakerssummaryv01.pdf

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Table 1. Definition of variables

Variables	Notations	Definitions
Board Gender Diversity	BGD	Percentage of women directors on board
BLAU Index	BLAU	'BLAU $= 1 - \sum_{i=1}^{n} P_i^2$' where P_i is the percentage of members in each gender and 'n' is the total number of genders
Critical Mass_1	CM_1	Coded '1' if board has only one woman, '0' otherwise
Critical Mass_2	CM_2	Coded '1' if board has two women, '0' otherwise
Critical Mass_3	CM_3	Coded '1' if board has more than two women, '0' otherwise
Sustainability Committee	SC	Coded '1' if a firm has a sustainability committee, '0' otherwise
Board Size	BS	Total number of directors on board
Board Independence	BI	Percentage of independent directors on board
CEO Duality	CEO_D	Same person CEO and Chairman = '1', otherwise = '0'
Firm Size	FS	Natural logarithm of total assets
Firm Performance	FP	Net income divided by total assets
Financial Leverage	FL	Total debt over total assets

Table 2. Descriptive statistics

Variables	Mean	Median	SD	Min	Max
EP	72.90	65.23	26.75	5.261	98.58
BGD	32.05	31.26	14.25	.00	65.55
BLAU	.431	.331	.173	.00	.557
CM_1	19.52	.00	23.21	.00	1.00
CM_2	31.16	.00	24.33	.00	1.00
CM_3	50.01	1.00	27.60	.00	1.00
SC	.630	1.00	.311	.00	1.00
BS	09.33	11.00	4.631	6.00	22.00
BI	32.25	42.66	15.65	.00	82.21
CEO_D	.438	.00	.492	.00	1.00
FP	1.827	2.71	11.47	−08.31	17.29
FS	7.765	7.68	2.82	.00	09.15
FL	.531	.501	.363	.00	69.37

Note: This table reports descriptive statistics of all the variables used in this study. SD denotes standard deviation. Min denotes minimum. Max denotes maximum. All variables are defined in Table 1.

firms represented independent directors on board, while 43.8% of CEOs also served as the chairman of the board of directors.

Table 3 presents the correlation matrix for all variables used in this study. We employed the Pearson correlation matrix to measure the direction of the linear relationship between the variables. The correlation results revealed a significant relationship between the main variables.

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Table 3. Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	VIF
1	EP	1													–
2	BGD	.169***	1												2.11
3	BLAU	.014*	.080**	1											1.62
4	CM_1	.042	.114*	.002	1										1.59
5	CM_2	.091*	.152**	.017*	.111*	1									2.08
6	CM_3	.182***	.538***	.077**	.254**	.223**	1								2.22
7	SC	.035***	.097**	−.107***	.018	.091*	.107**	1							1.27
8	BS	.289***	.501***	−.054**	.007	.441***	.668***	−.045	1						2.01
9	BI	−.079*	.227***	.009*	.003	.222**	.299***	.0311	.222***	1					1.82
10	CEO_D	.057*	.262***	.058**	.005	.117*	.321***	.067*	−.414***	−.157***	1				1.50
11	FP	−.013*	.023	.028	−.036*	.094*	.039*	.013	.043	.004	−.029	1			1.57
12	FS	.075**	.319***	−.021	.012	.228**	.335***	.025	.326***	.113***	−.133**	.063*	1		1.28
13	FL	−.027*	−.070*	−.002	−.021*	−.127**	−.147***	−.065*	−.107**	.066*	.057	−.199**	−.094**	1	1.09

Note: This table reports Pearson's correlation of the variables used in the regression of this study. All variables are defined in Table 1. VIF denotes the variance inflation factor. Significance level: ***$p < .01$, **$p < .05$, *$p < .1$.

Specifically, the results provided a preliminary indication that environmental performance was positively and significantly associated with BGD and sustainability committees. To rule out the presence of multicollinearity, we ran the variance inflation factor (VIF) for each estimated model. As a rule of thumb, multicollinearity was considered when the VIF of the explanatory variables exceeded 10 (Field, 2013). As shown in Table 3, the problem of multicollinearity was not a significant concern as it fell below the recommended threshold.

Quantile regression results

Table 4 examines the impact of BGD on environmental performance and presents the quantile regression results. We conducted an empirical investigation by using Equation (6) for different values of quantiles of θ (i.e., the 25th, 50th, and 75th quantiles). In doing so, we explored the influence of explanatory variables at different levels of conditional distribution. We examined the differential effect of BGD on environmental performance, depending on the portion of firm distribution. We found that BGD indicators (i.e., BGD% and BLAU Index) were positively and significantly associated with environmental performance at different percentile levels. This confirmed that BGD affected not only the conditional mean but also the dispersion of environmental performance. Specifically, we showed that the coefficients for BGD at low quantiles (i.e., 25th) were lower than the median and upper quantiles (50th and 75th). This indicated that in each case, BGD variables (BGD and BLAU Index) had a larger quantitative impact in firms performing better environmentally. Overall, the results were consistent with the extant literature (e.g., Kassinis et al., 2016; McGuinness, Vieito, & Wang, 2017; Orazalin & Baydauletov, 2020) and supported Hypothesis 1, which states that the presence of women on boards tended to pay more attention to the firm's environmental performance. However, the results contradicted the findings of Deschênes et al. (2015) and Alazzani, Hassanein, and Aljanadi (2017), who found that female directors were more concerned with social issues than environmental issues. In addition, the results were in line with resource dependence theory and stakeholder theory, suggesting that a gender-diverse board was likely to represent diverse stakeholders (Rao, Tilt, & Lester, 2012), allowing firms to draw from a variety of experiences and education (Shaukat, Qiu, & Trojanowski, 2016), and eventually providing a more accurate environmental performance disclosure (Hillman, Cannella, & Paetzold, 2000).

Table 4 further shows that board size positively and significantly impacted environmental performance in all quantile estimations. This indicated that boards with enhanced workload environments and broader collective backgrounds and skills were better at improving the firm's environmental performance (Jizi, 2017). We found that firm performance had a negative and significant impact on environmental performance in the first percentile (25th) and a positive impact in the median and upper percentiles (50th and 75th). This indicated that firms with lesser profitability were discouraged from external forces, while firms with more profitability utilised the external resources to improve environmental performance. We revealed that firm size had a positive and significant impact on environmental performance in all quantile regressions. This postulated that large firms performed better than small firms in terms of environmental performance. This might also be because large firms could have more resources than small firms to handle environmental hazards (Li et al., 2017). We, however, failed to find any significant impact of board independence, CEO duality, and financial leverage on environmental performance.

Table 5 examines the relationship between the critical mass of female directors and environmental performance by using Equation (7) for different quantile values (i.e., 25th, 50th, and 75th). We employed three indicators to gauge the critical mass of female directors (i.e., CM_1, CM_2, and CM_3). We found that the relationship between firms with only one woman on their board (CM_1) and environmental performance was insignificant for all quantiles. However, it improved for firms with two women on their board (CM_2) and was even more

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Table 4. BGD and environmental performance

Dependent variable → EP	(1)	(2)	(3)
Explanatory variables ↓	Q (25)	Q (50)	Q (75)
Constant	2.1254*** (.2043)	3.0514*** (.2066)	5.1471*** (.2477)
BGD-related variables			
BGD%	.3512*** (.1021)	.4731** (.2021)	.5548*** (.2022)
BLAU Index	2.0161** (1.0121)	2.3078** (.9745)	2.4756** (1.2641)
Governance-related variables			
BS	1.2488*** (.3044)	1.1321*** (.2354)	.7781*** (.1778)
BI	−.0421 (.0335)	−.0061 (.0333)	−.0621* (.0356)
CEO_D	1.6061* (.9652)	2.0873* (1.0909)	1.8551* (1.0397)
Firm-related variables			
FP	−.0914** (.0414)	.0314*** (.0093)	−.0254** (.0129)
FS	1.1654** (.5900)	1.5418*** (.5485)	1.7618*** (.5011)
FL	−1.1341** (.4854)	−2.7168*** (.9679)	−.9794** (.3533)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Pseudo R^2	.2421	.2101	.1765

Note: This table reports the quantile regression results of environmental performance (EP) on BGD and a set of control variables. All variables are defined in Table 1. Standard errors are in parentheses. Significance level: ***$p < .01$, **$p < .05$, *$p < .1$.

Table 5. Critical mass of female directors and environmental performance

Dependent variable → EP	(1)	(2)	(3)
Explanatory variables ↓	Q (25)	Q (50)	Q (75)
Constant	1.8994*** (.1854)	2.4133*** (.2261)	4.3222*** (.3374)
Critical mass-related variables			
CM_1	.1231 (.0771)	.1324 (.0829)	.1584 (.0994)
CM_2	.4169* (.2201)	.5185** (.2446)	.7958*** (.2904)
CM_3	1.0797** (.4514)	1.2165*** (.4121)	1.5433*** (.4186)
Governance-related variables			
BS	1.3091*** (.3441)	1.1501*** (.3196)	.7488** (.3771)
BI	−.4512* (.2465)	−.4612* (.2383)	−.4621 (.3356)
CEO_D	.9159* (.5366)	.9973* (.5909)	1.0951 (.7397)
Firm-related variables			
FP	.1024** (.0471)	.1313** (.0577)	.1854* (.0989)
FS	.8745** (.4311)	1.0183** (.4485)	1.3618*** (.5113)
FL	−.7821* (.4041)	−.7168** (.3086)	−.9794 (.714)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Pseudo R^2	.2614	.2217	.1942

Note: This table reports the quantile regression results of environmental performance (EP) on critical mass (CM) of women directors and a set of control variables. All variables are defined in Table 1. Standard errors are in parentheses. Significance level: ***$p < .01$, **$p < .05$, *$p < .1$.

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significant for firms with more than two women (CM_3). The results showed that a board with a single female director was not enough to eliminate the evidence of tokenism. Therefore, it is difficult to prevent women from being categorised, stereotyped, and ignored by the majority of men, making them unable to make any contributions to the board. On the contrary, two or more women on corporate boards enabled their interaction and potential impact on corporate decisions, ultimately improving the environmental performance. These findings were consistent with those of previous studies (e.g., Cook & Glass, 2018; Orazalin & Baydauletov, 2020; Post, Rahman, & Rubow, 2011) and supported the critical mass prediction of Hypothesis 2. The results showed that unless boards have a critical mass of two or more female directors, the influence of BGD on the corporate decision-making process was limited. Nevertheless, when this critical mass was reached, BGD had a positive effect on corporate response to stakeholders' demands to enhance the firm's environmental performance. Similarly, the critical mass theory suggested that one woman was a 'token', two women were a 'presence', and three or more women were a 'voice'. It further stated that a higher proportion of female directors would be more willing to support each other, thus collectively having a more significant impact on corporate decisions (Torchia, Calabrò, & Huse, 2011). In addition, minorities on boards were usually considered merely a token; however, as their numbers increased to a majority, they influenced the firm's strategic decisions, including environmental performance.

Table 6 shows the influence of sustainability committees on environmental performance by using Equation (8) for different values of θ (i.e., the 25th, 50th, and 75th quantiles). We found a positive and significant effect of sustainability committees on environmental performance at different percentiles (i.e., 25th, 50th, and 75th percentiles), obtaining different coefficient values. In particular, we found that the 25th and 75th percentile coefficients were lower in magnitude than the median (i.e., 50th percentile). The median percentile (50th percentile) showed a significant and strong effect. This indicated that a sustainability committee had a substantial and quantifiable influence on firms with a median environmental performance. These results were consistent with prior studies (e.g., Biswas, Mansi, & Pandey, 2018; Liao, Luo, & Tang, 2015), which asserted that a sustainability committee led to better environmental performance. Nevertheless, these findings contradicted those of Chams and García-Blandón (2019), who did not find any significant relationship between the sustainability committee and environmental performance. Michelon and Parbonetti (2012) posited that board committees were strategic dynamics for auditing, monitoring, and assessing governance performance, agendas, and policy-making. Likewise, a sustainability committee provided specialised counsel, involving the firm with strategic environmental constituencies and monitoring decision-making about environmental issues, and thus positively influencing environmental performance (Biswas, Mansi, & Pandey, 2018). Walls, Berrone, and Phan (2012) argued that a board-level sustainability committee played a significant role in the firm's overall performance by giving directors specialised responsibilities and facilitating boards more effectively towards better environmental awareness. Moreover, the results were in line with the stakeholder theory and argued that the existence of a sustainability committee showed the firm's commitment to its stakeholders in terms of corporate social responsibility (Michelon & Parbonetti, 2012). Firms were more likely to form a dedicated board committee on sustainability issues to better manage their stakeholder relationships, adequately address stakeholders' concerns, and demonstrate their commitment to responsible corporate practices. Hence, Hypothesis 3 was supported.

To inspect the interaction effect of BGD and sustainability committees on environmental performance, we used environmental performance as a dependent variable and sequentially introduced the independent variables of BGD, sustainability committees, the control variables, and the interaction terms between BGD variables and sustainability committees into the regression model, as indicated in Equation (9). The results presented in Table 7 revealed that when the interaction term between BGD variables and sustainability committees were included, the main influence of BGD variables on environmental performance remained significant, but notably, at a

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Table 6. Sustainability committee and environmental performance

Dependent variable → EP	(1)	(2)	(3)
Explanatory variables ↓	Q (25)	Q (50)	Q (75)
Constant	2.3485*** (.5301)	3.6943*** (.5558)	3.9969*** (.5937)
SC-related variable			
SC	1.1894** (.5801)	1.7522*** (.5937)	1.1884** (.5748)
Governance-related variables			
BS	1.3468*** (.1522)	1.1405*** (.1055)	.7535*** (.0676)
BI	−.0482* (.0286)	−.0031 (.0316)	−.0562 (.0398)
CEO_D	1.1301** (.5621)	2.1311** (1.0787)	1.6328** (.8284)
Firm-related variables			
FP	−.0288** (.0124)	−.0241** (.0109)	−.0223** (.0101)
FS	1.6430*** (.5226)	1.7541** (.7154)	2.1322*** (.5034)
FL	−2.2547* (1.3524)	−2.1843** (1.0358)	−1.5029** (.6941)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Pseudo R^2	.17548	.1529	.1501

Note: This table reports the quantile regression results of environmental performance (EP) on sustainability committee (SC) and a set of control variables. All variables are defined in Table 1. Standard errors are in parentheses. Significance level: ***$p < .01$, **$p < .05$, *$p < .1$.

higher magnitude than in Tables 4 and 5. We found a significant and positive interaction effect of BGD and sustainability committees on environmental performance. In particular, the interaction term between the percentage of female directors and sustainability committees (BGD% × SC) showed a positive and significant effect in all quantile regressions. This revealed that, on average, if the presence of female directors and sustainability committees in firms increased by one point, the firm's environmental performance would increase by 1.243 points. This indicated that BDG accentuated the positive effect of sustainability committees on environmental performance. The interaction term between the critical mass and sustainability committees (CM_3 × SC) had a positive and significant effect on all quantile estimations. This showed that, on average, if the critical mass and sustainability committees in firms increased by one point, the level of environmental performance would increase by 7.647 points. This showed that the critical mass of female directors reinforced the sustainability committee's positive effect on environmental performance. Furthermore, the interaction term between the gender diversity BLAU Index and sustainability committees (BLAU Index × SC) indicated a positive and significant effect on environmental performance in all quantile regressions. We further witnessed that an increase in female directors on boards and the presence sustainability committees increased environmental performance.

Consistent with the resource dependence theory, we found that female directors provided unique resources to firms by holding many key positions to monitor both formal and informal environmental activities, being actively involved in many environmental campaigns, and could transfer these related competencies to the board to boost the firm's overall performance. At the same time, we supported both the stakeholder theory and critical mass theory and revealed that more women on corporate boards led to environmental sensitivity and better policy-making because of their specific characteristics, ultimately improving environmental performance. These characteristics of women directors included a superior propensity to be 'green', more effective monitoring agents, more rigorous enforcement of ethical conduct, and a better likelihood to

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Table 7. BGD, sustainability committee, and environmental performance

Dependent variable → EP	(1)	(2)	(3)
Explanatory variables ↓	Q (25)	Q (50)	Q (75)
Constant	3.7562*** (.6196)	4.9565*** (.5999)	6.6896*** (.7812)
BGD related variables			
BGD%	.3585*** (.0575)	.3704*** (.0776)	.3919*** (.0519)
BLAU Index	2.1693** (.8997)	2.0754** (1.0371)	1.3402* (.7288)
CM_3	2.9228** (1.4470)	3.1417** (1.3811)	3.3460*** (1.2637)
SC-related variables			
SC	2.7798*** (.8855)	6.8320** (2.9847)	8.3319** (4.0949)
Governance and firm-related variables			
BS	1.3419*** (.2084)	1.2283*** (.1184)	.7556*** (.0898)
BI	−.0591 (.0865)	−.0234 (.0310)	−.0747 (.1290)
CEO_D	2.3023** (1.0550)	2.4689** (1.0519)	1.5933 (1.1097)
ROA	−.0322*** (.0118)	−.0312*** (.0101)	−.0260 (.0337)
FS	1.0331** (.4124)	1.4332** (.6078)	1.4630*** (.5130)
FL	−2.1373* (1.2538)	−2.1784** (.9928)	−.1414 (.8230)
Interaction effects			
SC × BGD%	1.2893*** (.4114)	1.2046*** (.4372)	1.2338*** (.4414)
SC × BLAU Index	4.7190** (2.0058)	6.3748** (3.0973)	6.9410** (3.3514)
SC × CM_3	5.9219** (2.5301)	8.2271** (3.4774)	8.7942** (3.9803)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Pseudo R^2	.2356	.2014	.1702

Note: This table reports the quantile regression results of environmental performance (EP) on BGD, SC, and a set of interaction variables. All variables are defined in Table 1. Standard errors are in parentheses. Significance level: ***$p < .01$, **$p < .05$, *$p < .1$.

participate with multiple stakeholders and respond to their necessities – all of which result in greater environmental awareness.

Overall, we found that BGD and sustainability committees led to higher environmental performance. We showed that female directors enhanced board effectiveness and environmental performance by bringing diverse perspectives, knowledge, experience, and ideas to the boardroom (Schwartz-Ziv, 2017). Firms with a higher number of women on board were more persuaded to embrace advanced sustainability agendas and select long-term rewarding social and environmental activities (Jizi, 2017). We also provided empirical evidence that sustainability committees with a higher proportion of female directors were more effective for firms' environmental performance. Hence, firms with sustainability committees and more women on board tended to tackle a broader spectrum of financial and non-financial issues, facilitating sustainable practices to improve firms' environmental performance.

Robustness check

We conducted several additional tests to check the robustness of the results. The problem of endogeneity is pervasive in almost all governance studies (Wintoki, Linck, & Netter, 2012), as

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well as BGD and performance studies (Adams & Ferreira, 2009). To reduce the influence of endogeneity, this study considered the issue of self-selection bias, reverse causality and simultaneity, as well as dynamic endogeneity, which are considered the main sources of endogeneity (Muhammad, Migliori, & Mohsni, 2021). To this end, we used a series of estimation checks that included alternative measures, the Heckman two-stage model, instrumentation techniques, lagging structures, and dynamic panel data methods. Following Lara, Osma, Mora, and Scapin (2017), we first implemented the Heckman two-stage model to mitigate potential self-selection problems and other forms of endogeneity. As shown in columns (1) and (3) of Table 8, in the first-stage regressions, we employed all those variables that potentially influenced a sustainability committee and a firm's decision to hire female directors. Specifically, we used a probit regression with a BGD and a sustainability committee dummy as outcome variables and all control variables from the main model as explanatory variables. We then computed the inverse mills ratio (IMR) from probit regressions and included it in stage-two *OLS* estimations (i.e., columns [2] and [4] of Table 8) to determine the association between BGD, sustainability committees, and environmental performance. We found that the coefficient for IMR in both regressions was statistically insignificant, confirming that the main results were not biased towards self-selection problems.

Second, we employed an instrumental variable regression (i.e., two-stage least squares [*2SLS*]) to account for possible endogeneity concerns. Wintoki, Linck, and Netter (2012) argued that endogeneity was pervasive in all corporate governance studies, and that the selection of board members was not an exogenous process. Rather, board attributes were endogenously chosen by firms to make their tasks and information uniform. The appointment of female directors on boards was also a choice made by firms and was, therefore, an endogenous decision (Sila, Gonzalez, & Hagendorff, 2016). To execute the *2SLS* method, we needed an exogenous instrument, a variable that was closely correlated to the explanatory variables but did not influence the outcome variable. Hence, we followed Adams and Ferreira (2009) and used the industry average of BGD (BGD^) as an exogenous instrument to deal with possible endogeneity issues. We justified using the BGD industry average as an instrument because BGD in a firm's industry could influence the firm's BGD but might not influence the firm's environmental performance.[3] The present governance variables might then be affected by past performance. Thus, we lagged all variables by one year to mitigate any possible simultaneity issues. The *2SLS* results, reported in column (5) of Table 8, confirmed the consistent results.

Finally, we used a dynamic panel data approach with a two-step system generalised method of moments (*GMM*) and a one-year lag to instrument the lagged dependent variable (Arellano & Bond, 1991; Roodman, 2009).[4] The *GMM* estimator dealt with dynamic endogeneity by drawing instrumental variables from the data set itself. It accounted for time-invariant firm characteristics using first differences to transform regressors and remove any fixed firm-specific effect, and thus adjusted for any unobserved shock in the firm's fixed effect, which might distort the results. Roodman (2009) posited that *GMM* could improve *OLS* or *fixed-effect* regression in three ways: first, by containing firm-fixed effects to account for unobservable heterogeneity; second, by allowing current corporate governance variables to be influenced by past performance; and third, by allowing the firm's past characteristics to be valid instruments to account for simultaneity. Hence, the *GMM* method was more robust in dealing with endogeneity issues (Wintoki, Linck, & Netter, 2012). We re-estimated model (9), and the results are reported in column (6) of Table 8. Overall, the robustness checks offered consistent results and reaffirmed the findings of this study.

[3]The un-tabulated results indicate that the correlation measure between BGD and BGD industry average is 0.671, while the correlation between BGD industry average and environmental performance is −0.0006.

[4]For *GMM* estimation, we execute the '*xtabond2*' command (for more details, please see Roodman, 2009). We run the '*robust*' command to check for heteroscedasticity. We also perform several post-estimation tests (Hansen and Arellano-Bond test) to look for possible autocorrelation and over-identification issues.

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Table 8. Robustness check

	Heckman two-stage self-selection bias					
	Probit	OSL	Probit	OLS	2SLS	GMM
Dependent variables →	BGD_D	EP	SC	EP	EP	EP
Explanatory variables ↓	(1)	(2)	(3)	(4)	(5)	(6)
Constant	2.320*** (.254)	2.231*** (.314)	3.030*** (.552)	2.889*** (.552)	1.159*** (.132)	
$EP_{(t-1)}$						.697*** (.058)
BGD_D		1.021*** (.335)	1.091** (.442)			
BGD%						.983*** (.326)
BGD%^					1.618*** (.554)	
BLAU Index		1.225* (.647)			.918** (.427)	.352** (.165)
CM_3		1.091*** (.373)	2.015** (.936)		1.032** (.464)	.556*** (.208)
SC				1.669*** (.574)	1.949** (.792)	.833** (.334)
BS	.521*** (.204)	2.928** (1.223)	2.221*** (.741)	1.093*** (.421)	.838*** (.262)	.340*** (.093)
BI	.321** (.136)	−.692** (.333)	.787** (.362)	−.471 (.323)	.016 (.037)	−.004 (.016)
CEO_D	−.302 (.235)	1.489* (.851)	2.112*** (.812)	1.666** (.731)	.692 (.817)	.681 (.534)
FP	.138** (.062)	−1.032** (.510)	.662** (.289)	−1.112* (.661)	−.041** (.019)	−.027* (.016)
FS	.033*** (.012)	2.432** (1.207)	1.099** (.459)	1.874** (.882)	1.011 (1.641)	.349 (.341)
FL	−.134** (.064)	−3.168*** (.972)	−1.771** (1.099)	−.899** (.443)	−2.633*** (1.026)	.297* (.154)
IMR		2.224 (1.447)		1.333 (.912)		

SC × BGD%					.854*** (.246)	.341*** (.097)
SC × Blau Index					−.657** (.291)	−.138** (.063)
SC × CM_3					.819*** (.228)	.238*** (.083)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
(Pseudo) R^2	.183	.321	.235	.339	.238	
Wald χ^2						229.03***
AR (2) (*p*-value)						1.57 (.221)
Hansen test (*p*-value)						22.54 (.418)

Note: This table reports the Heckman two-stage model, two-stage least-squares (*2SLS*), and system *GMM* estimations of environmental performance (EP) on BGD, SC and a set of interaction variables. BGD%^ is the percentage of women instrumented with industry average gender diversity. All variables are defined in Table 1. Standard errors are in parentheses. Significance level: ***$p < .01$, **$p < .05$, *$p < .1$.

Conclusions

This study employed quantile regression methods to capture the non-monotonic relationship of BGD, sustainability committees, and environmental performance. Sampling Italian publicly listed firms from 2014 to 2018, we found that BGD and sustainability committees had a positive and significant impact on the firm's environmental performance. We revealed that firms with a critical mass of two or more female directors had a stronger concern towards firms' environmental sustainability. In addition, we showed the positive interaction effect of BGD and sustainability committees on environmental performance. These results were consistent with prior studies (Biswas, Mansi, & Pandey, 2018; Liao, Luo, & Tang, 2015; Orazalin & Baydauletov, 2020), suggesting that BGD enhanced the board's decision-making and implemented better environmental practices; and that the existence of a sustainability committee signalled the effort to invest in better management practices and reflected a firm's commitment to sustainable development. Overall, the results confirmed that BGD and sustainability committees enhanced board effectiveness and helped promote sustainable initiatives.

Theoretical implications

This study provides valuable insights into the effect of BGD and sustainability committees on environmental performance. It shows a positive response to the presence of women on corporate boards and a sustainability committee, signifying that female directors may bring positive change to the board and enhance the firm's environmental performance, and that a sustainability committee enhances environmental performance through effective sustainability strategies. Moreover, our findings reveal the positive interaction effect of BGD and sustainability committees on environmental performance, suggesting that firms should ameliorate the functioning of their sustainability committee by including women directors, thus improving the committee's ability to implement proactive environmental strategies and better manage environmental risks.

From a theoretical perspective, this study supports the validity of entrenched arguments under the adopted 'resource dependence theory and stakeholder theory', suggesting that gender diversity and sustainability committees provide resources and skills that facilitate optimal decisions and thereby guarantee the felicitous implementation of environmental strategies, which ultimately enhances the firm's overall performance. Our findings also have implications for the critical mass theory. We show that a token representation of women on corporate boards does not significantly impact environmental performance. Nonetheless, having two or more female directors on a board helps it improve its monitoring activities and reap the benefits of the diverse expertise that women bring to decision-making. Overall, the results suggest that a firm with solid governance mechanisms, improved representation of women (two or more), and a sustainability committee shows a stronger commitment to environmental issues and aligns the board's aims with those of society, signalling to investors a potential improvement in the firm's reputation and performance.

Practical implications

According to the findings of this study, as stakeholders demand in various ways that firms address environmental issues, firms should take the initiative to improve board effectiveness by appointing more women to the board of directors. It also postulates that regulators should consider setting quotas or providing incentives for higher boardroom representation of women to reduce carbon emissions. Policies that enforce gender quotas for corporate boards and provide more equal opportunities for women could lead to improvements in environmental performance. Hence, firms can use greater gender diversity as a double-edged sword for the effective care of powerful stakeholders. In addition, the study provides insights into the balanced composition of sustainability committees that can foster better environmental performance and strategy

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formulation, reducing sustainability-related controversies. Our findings suggest that the existence of a sustainability committee helps meet the needs of all stakeholders and enhances transparency actions. Overall, our results imply that firms should designate a sustainability committee to monitor management decisions regarding environmental issues and implement education policies to improve the training of female directors regarding the identification of environmental problems.

Limitations and suggestions for future research

This study acknowledges some limitations that could provide opportunities for future research. First, the findings were based on Italian firms, so generalisability is limited to the said country and may not be applicable to other countries. Thus, future research should expand to non-Italian firms characterised by different corporate governance settings. Second, this study considered large Italian firms. Hence, the findings may not apply to family businesses and small and medium-sized firms. Finally, we used archival data; future research could offer new insights by conducting surveys, face-to-face interviews, quasi-experiments, or case studies to further assess the impact of BGD and sustainability committees on environmental performance.

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