Female board representation and carbon performance: Do gender quotas and governance codes matter?

Nurlan Orazalin (KIMEP University, Almaty, Kazakhstan; Southampton Business School, University of Southampton)

Collins G Ntim (Southampton Business School, University of Southampton; Azerbaijan State University of Economics, Baku, Azerbaijan; University for Development Studies, Tamale, Ghana; Taylor's Business School, Taylor's University, Selangor, Malaysia)

John Kalimilo Malagila (Essex Business School, University of Essex)

Accepted for publication in Review of Accounting and Finance.

Female board representation and carbon performance: Do gender quotas and governance codes matter?

Abstract

Purpose – This study explores the impact of board gender diversity (*BGEND*) on corporate carbon performance in countries with different gender-related reforms.

Design/methodology/approach – The study applies panel regression methods to test the hypotheses using an international dataset and addresses endogeneity issues using the two-stage least squares (2SLS), propensity score matching (PSM), and Heckman models.

Findings – The results show that higher *BGEND* significantly reduces carbon emissions in quota countries but not in governance code countries. The additional analysis shows that firms with higher *BGEND* exhibit better carbon performance following the introduction of quotas. The results also show the effectiveness of *BGEND* in improving carbon performance in countries with an Emissions Trading Scheme (ETS).

Practical implications – The findings suggest that higher *BGEND* leads to enhanced corporate sustainability through reduced carbon emissions, emphasizing the importance of adopting gender quota laws. Our findings also suggest that national governments should incorporate specific targets into gender diversity recommendations when developing corporate governance codes.

Originality/value – The study provides new evidence on the relationship between *BGEND* and carbon emissions in a multi-country context and suggests that higher *BGEND* reduces carbon emissions in countries with quotas, and most importantly, following the introduction of gender quotas, but has no impact on carbon performance in countries with governance codes.

Keywords: Female board directors, Carbon performance, Gender quotas, Corporate governance codes, Cross-country analysis

1. Introduction

Due to the rapidly increasing levels of greenhouse gas (GHG) emissions across all industries, climate change is worsening at an alarming pace, posing severe threats to society and causing sustainability-related risks for businesses (Bui *et al.*, 2020). As a result, global corporations are proactively undertaking climate mitigation initiatives that aim to manage carbon threats/risks and promote sustainable development (Orazalin *et al.*, 2024; Vejarano Swinkels, Laurens, 2024). Whilst the effective implementation of proactive climate-related initiatives depends on corporate governance structures (Choi and Luo, 2021; Haque, 2017; Luo and Tang, 2021), the role of board gender diversity (*BGEND*) can be particularly crucial in addressing climate issues (Kyaw *et al.*, 2022; Nuber and Velte, 2021; Toukabri and Jilani, 2023; Valls Martínez *et al.*, 2022). Nevertheless, empirical evidence on *BGEND*'s contribution to climate mitigation is mixed. Some scholars (Atif *et al.*, 2021; Nuber and Velte, 2021; Oyewo, 2023) suggest that female board directors are more committed to climate issues and play a critical role in mitigating corporate carbon risks. In contrast, other studies (Bui *et al.*, 2020; Liao *et al.*, 2015) have reported that female directors have no impact on carbon initiatives/strategies aimed at reducing GHG emissions, and therefore, their role in combating climate change is limited.

The mixed findings in past research can be attributed to differences in institutional environments that shape firms' practices and performance (Byron and Post, 2016; Ginglinger and Raskopf, 2023). An institutional environment refers to a country's regulatory frameworks and legal systems that can determine female board representation (Maxfield and Wang, 2024; Ye *et al.*, 2019). In this regard, gender-related reforms, such as gender quotas and corporate governance codes, play a key role in decreasing gender discrimination, increasing *BGEND*, and providing equal opportunities for female directors to serve on boards (Mateos de Cabo *et al.*, 2022; Terjesen *et al.*, 2015). Gender quotas are generally passed as national laws, whereas corporate governance codes serve as recommendations/guidelines for publicly traded entities (Barroso *et al.*, 2024; Deloitte, 2022). Nevertheless, prior studies (Barroso *et al.*, 2024; Ferrari *et al.*, 2021; Marchini *et al.*, 2022; Martínez-García *et al.*, 2022) investigating the effect of gender-related reforms on corporate outcomes have

provided mixed results. For instance, Ferrari et al. (2021) find that increased *BGEND* after the adoption of a mandatory gender quota has no impact on the financial outcomes of Italian firms. In contrast, Yang et al. (2019) document that the gender quota in Norway adversely affects firm financial performance. As for comply-or-explain reforms, Martínez-García et al. (2022) report that corporate governance codes in the form of general recommendations for *BGEND* do not affect firm performance. However, the above/prior studies have primarily focused on firm financial outcomes and ignored the impacts of gender quotas and governance codes on corporate carbon emissions.

Meanwhile, several countries, especially in Europe, have demonstrated increasing interest in promoting gender equality and improving female representation in corporate boardrooms by adopting gender quotas and corporate governance codes (Mateos de Cabo *et al.*, 2022). For example, in 2003, Norway introduced the world's first mandatory quota, requiring 40% of board members to be female directors. Other European countries, including France, Spain, Finland, Belgium, Italy, Austria, Portugal, Spain, and the Netherlands, have also introduced quota laws to increase gender diversity on corporate boards (Martínez-García *et al.*, 2022; Nguyen *et al.*, 2023; Su and Yin, 2024; Terjesen and Sealy, 2016). Some countries (e.g., the UK, Turkey, Sweden, and Switzerland) have adopted a non-binding approach and proposed broad policies, recommendations, and targets concerning *BGEND* in their corporate governance codes/principles (Deloitte, 2022). Although countries have opted for different approaches to balance gender diversity (Barroso *et al.*, 2024; Marchini *et al.*, 2022), empirical research analyzing how gender quotas and governance codes/principles are associated with corporate carbon performance through changes in female board representation in an international setting is scarce. Hence, motivated by the recent calls for cross-country research (Konadu *et al.*, 2022; Luo and Tang, 2021), this work aims to study the effects of gender quotas and governance codes implemented by different countries on the role of *BGEND* in reducing emissions.

Consequently, drawing on gender socialization, diversity, and institutional theories, we examine an international sample over the period 2002−2020 to assess whether the relationship

between *BGEND* and carbon emissions differs between countries with gender quotas and countries with governance codes. Our results show that female board representation is associated with better carbon performance in quota countries but not in governance code countries. We also provide new evidence that firms with higher *BGEND* exhibit better carbon performance following the enactment of gender quota laws. The introduction of governance codes, however, does not lead to significant emissions reductions for firms with higher *BGEND*. Our additional analysis also reveals that the impact of female board representation on carbon emissions is negative for countries with an Emissions Trading Scheme (ETS) but positive for non–ETS markets, thus emphasizing the role of female board directors in mitigating climate issues in countries with strict environmental regulations. Our findings are robust to alternative measures and various robustness checks for different forms of endogeneity.

Our work contributes to the *BGEND* and carbon performance literature in several ways. First, our study extends prior research (Garcia-Blandon *et al.*, 2023; Marchini *et al.*, 2022; Mateos de Cabo *et al.*, 2022) on gender quota laws and governance codes/principles by examining the effects of *BGEND* on carbon emissions in countries with different gender-related reforms. While past studies (Ferrari *et al.*, 2021; Terjesen *et al.*, 2015) have focused on the effects of gender-related reforms on *BGEND*, our paper is among the first to study the impact of *BGEND* on carbon emissions between countries with gender quotas and countries with governance codes. We provide new evidence that higher representation of female board directors improves carbon performance in countries with quotas but has no impact in countries with governance codes. Second, our work extends available research (Ginglinger and Raskopf, 2023; Martínez-García *et al.*, 2022; Muktadir-Al-Mukit and Bhaiyat, 2024; Toukabri and Jilani, 2023) by investigating whether *BGEND* leads to reduced emissions after the introduction of gender quotas and governance codes. Our results reveal that firms with higher *BGEND* exhibit better carbon performance following the introduction of gender quotas and emphasize the roles of quotas in reinforcing female board directors' influence on climate change and sustainability, thus confirming the findings by Barroso et al. (2024). Finally, our study contributes

to the existing literature (Barroso *et al.*, 2024; Kyaw *et al.*, 2022; Luo and Tang, 2021; Nuber and Velte, 2021; Valls Martínez *et al.*, 2022) by investigating whether the impact of *BGEND* on carbon performance differs between countries adopting an emission trading system (ETS) and non-ETS countries. Prior literature (Choi and Luo, 2021; Orazalin *et al.*, 2024) posits that national regulations influence internal governance, sustainability practices, and performance outcomes. Consistent with this notion, our results suggest that increased *BGEND* leads to reduced emissions in ETS countries, indicating the role of female board directors in enhancing carbon performance in the context of national environmental regulations.

2. Theory, literature review, and hypotheses development

2.1 Theories

Our study builds on the theoretical foundation, drawing insights from gender socialization (GST), diversity (DVT), and institutional theories to explain the effects of *BGEND* on carbon emissions in countries with different gender-related reforms. Unlike other theoretical perspectives (e.g., agency, stakeholder, and legitimacy), these theories offer novel perspectives to capture different aspects of *BGEND* (Carlson, 1972; Dawson, 1997; Kanter, 1977) and explain the role of female board directors in tackling environmental issues in different institutional environments (DiMaggio and Powell, 1991; Orazalin and Mahmood, 2021). Given the increasing focus on the roles of *BGEND* and gender-related reforms in climate change mitigation, empirical research exploring the relationship between *BGEND* and organizational performance, especially in the context of global environmental challenges, should take an integrated approach by employing multiple theories (Terjesen and Sealy, 2016). Therefore, we rely on the above theoretical underpinnings to predict the effects of female board representation on carbon emissions across multiple countries with gender quotas and countries with governance codes.

GST posits that men and women, due to their early social interactions and upbringing, possess different preferences, traits, and attitudes toward societal issues and, hence, act and behave differently (Dawson, 1997; Gilligan, 1977). Men tend to focus more on personal goals, whereas women are more concerned about communal issues and demonstrate greater compassion toward the needs of others (Carlson, 1972). Generally, women are more sensitive to social issues and more ethical in their behavior (Byron and Post, 2016; Ibrahim *et al.*, 2009; Marchini *et al.*, 2022). Besides, women have a greater sense of mercy, sympathy, inclusiveness, and reciprocity (Eagly, 2009; Gilligan, 1977). Past literature (Adams and Funk, 2012; Usman *et al.*, 2022) also suggests that female directors on the board are different from male directors in their priorities, values, and behavior. They are more committed and diligent, less aggressive, more disciplined, less power-oriented, and more risk-averse (Adams and Funk, 2012; Barroso *et al.*, 2024; Liao *et al.*, 2015; Shahrour *et al.*, 2024). Hence, in line with GST, female directors, who are more sensitive to societal issues, including climate change challenges, can contribute to reduced carbon emissions.

In addition, DVT suggests that effective decision-making derives from a heterogeneous group of decision-makers with different perspectives and backgrounds (Forbes and Milliken, 1999; Pelled, 1996). Specifically, differences between decision-makers/group members are associated with differences in attributes/characteristics (e.g., age, ethnicity, gender, education, experience, expertise, etc.) that can enhance decision-making, effectiveness, and performance (Atif *et al.*, 2021; Milliken and Martins, 1996; Pelled, 1996). In this regard, female directors can bring a wide range of unique perspectives that may improve board dynamics, decision-making, and productivity (Byron and Post, 2016; Usman *et al.*, 2022). They are more creative in generating innovative ideas (Griffin *et al.*, 2021), better prepared for board/committee meetings (Huse and Solberg, 2006), and more proactive in initiating discussions (Van der Walt and Ingley, 2003), especially on social/environmental issues. Thus, consistent with DVT, greater *BGEND* is more likely to increase board dynamics/monitoring, facilitate access to critical resources, enhance decision-making, and ultimately improve carbon performance.

Institutional theory posits that intuitional factors and systems at the country level shape corporate practices and performance outcomes (DiMaggio and Powell, 1991). Under this view, firms need to integrate institutional policies, standards, and requirements into their business models in order to conform to societal expectations and needs (Haque and Ntim, 2020). As countries follow different reforms, rules, and regulations, firms are exposed to different institutional pressures and, therefore, respond to climate issues in different ways (Choi and Luo, 2021; Orazalin and Mahmood, 2021). Given that national governments vary in terms of their legal systems and regulatory frameworks (Maxfield and Wang, 2024), the impact of internal governance on firm performance is greatly influenced by institutional factors (Byron and Post, 2016). Hence, intuitional theory supports the viewpoint that the impact of BGEND on carbon performance is likely to differ between countries with quotas and countries with governance codes.

2.2 Prior literature and hypotheses development

According to GST, female directors can add value to board/organizational performance because they are more ethical (Lu and Herremans, 2019; Marchini *et al.*, 2022; Simga-Mugan *et al.*, 2005), less power-oriented, and more diligent (Adams and Funk, 2012; Liao *et al.*, 2015), and place greater emphasis on global societal issues (Gull *et al.*, 2022; Valls Martínez *et al.*, 2022). Further, DVT (Forbes and Milliken, 1999; Pelled, 1996; Siciliano, 1996) postulates that the benefits/values (e.g., experience, expertise, knowledge, and skills) that female directors bring to corporate boards may generate innovative ideas (Griffin *et al.*, 2021), enhance internal governance (Ye *et al.*, 2019), and improve environmental performance (Liu *et al.*, 2014). Nevertheless, GST and DVT cannot explain the varying effects of female directors' representation on environmental performance across countries with different gender-related reforms.

As documented in prior empirical studies (Barroso *et al.*, 2024; Bui *et al.*, 2020; Carvajal *et al.*, 2022; Haque and Jones, 2020; Muktadir-Al-Mukit and Bhaiyat, 2024; Nuber and Velte, 2021;

Orazalin and Mahmood, 2021; Toukabri and Jilani, 2023), the relationship between *BGEND* and carbon/environmental outcomes in terms of performance and disclosures is mixed. For example, Liao et al. (2015) report that female board directors are not associated with carbon initiatives/strategies aimed at reducing GHG emissions among UK companies. Using data from S&P 500 firms, Bui et al. (2020) find that *BGEND* is not effective in addressing climate issues and increasing carbon disclosures. By contrast, Atif et al. (2021) document that *BGEND* contributes to climate change mitigation by promoting and increasing clean/renewable energy consumption in the US. Because firms operating in different markets face different external pressures, the mixed findings in prior literature can be explained by the differences in intuitional settings that shape corporate practices and performance.

According to institutional theory, country-level institutional factors, such as reforms, regulations, and laws, play a key role in shaping *BGEND* and firm performance (Maxfield and Wang, 2024; Terjesen and Sealy, 2016). Empirical research (Byron and Post, 2016; Ginglinger and Raskopf, 2023) argues that the link between female members' representation and performance outcomes is influenced by national regulatory frameworks and legal systems. Nevertheless, evidence on how *BGEND* affects carbon performance in quota countries and governance code countries is inconclusive. Past research (Ferrari *et al.*, 2021; Griffin *et al.*, 2021; Marchini *et al.*, 2022) provides evidence that gender quota laws may increase *BGEND* and have a positive impact on boardroom quality in terms of female directors' characteristics. More specifically, gender quotas may provide incentives/opportunities to improve governance structures by identifying, retaining, and appointing talented female directors who can add considerable value to decision-making and performance (Martínez-García *et al.*, 2022).

In contrast, as governance codes/principles are largely voluntary, firms following the recommendations in codes do not face penalties for non-compliance, leading to symbolic acceptance of gender diversity (Mateos de Cabo *et al.*, 2022). These non-binding reforms do not lead to substantive changes, and their voluntary measures to foster *BGEND* are often ineffective at enhancing

board dynamics and firm performance (Mateos de Cabo *et al.*, 2022; Poletti-Hughes and Dimungu-Hewage, 2022). In line with this viewpoint, Martínez-García et al. (2022) provide evidence that corporate governance codes in the form of general recommendations for *BGEND* do not affect firm performance. From the above discussion, *BGEND* is expected to improve carbon performance in quota countries but will have no significant effect in governance code countries. Hence, we construct the following set of hypotheses:

H1a: *Board gender diversity has a negative impact on carbon emissions in countries with gender quotas.*

H1b: *Board gender diversity has a limited or no impact on carbon emissions in countries with governance codes.*

3. Data and Methodology

3.1 Sample and data

We employ a sample of all firms operating in countries with gender quotas and governance codes with available corporate carbon data from the ASSET4-ESG database for the period from 2002 to 2020[1]. We obtained data on corporate carbon emissions, board gender diversity, and other internal governance characteristics from the ASSET4-ESG, which presents objective, systematic, and detailed information on carbon/environmental and governance performance pillars of publicly listed firms (Orazalin and Mahmood, 2021). Then, we downloaded accounting and stock market data from the WorldScope and Datastream databases. To account for country-level factors, we also extracted national governance data from the World Governance Indicators (Kaufmann *et al.*, 2011) and macroeconomic indicators data (GDP and inflation) from the World Bank database.

[1]Our dataset started from 2002 because environmental data became available this year, and it ended in 2020 because of the availability of the main variables during our data collection process.

Following related literature (Awad *et al.*, 2023; Martínez-García *et al.*, 2022; Orazalin *et al.*, 2024), we excluded financial firms from the sample because they are subject to different governance systems and regulatory environments. After dropping firm-years with missing data on the main and control variables, our final dataset contained 5,104 firm-year observations from 307 firms operating in 10 different sectors and 27 countries over the 2002–2020 period.[2] Consistent with previous research (Chen *et al.*, 2019; Gull *et al.*, 2022), we also restricted our sample to countries with at least ten firm-year observations and winsorized the continuous variables at the 1% and 99% levels to reduce the possible effects of outliers. Appendix 1 outlines the sample breakdown by country and industry.

3.2 Dependent Variables

Following related studies (Benlemlih *et al.*, 2022; Muktadir-Al-Mukit and Bhaiyat, 2024; Orazalin *et al.*, 2024; Oyewo, 2023; Valls Martínez *et al.*, 2022), we measure corporate carbon performance by emissions (*CPEMS*) as the natural logarithm of actual levels of Scope 1 and 2 emissions (in tonnes), which represent actual and verifiable values of corporate carbon footprints. Scope 1 emissions include direct GHG emissions arising from sources owned/controlled by a firm, whereas Scope 2 emissions represent indirect emissions emanating through the consumption of purchased electricity, heating or cooling, and steam.[3] Scope 3 emissions, which represent other indirect emissions (resulting from assets not owned/controlled by a firm),[4] are not included as a proxy due to missing observations for the majority of firms and periods. In the robustness tests section, we also employ carbon intensity, measured as the ratio of total carbon emissions to total revenues (*EMSREV*), in line with past studies (Bui *et al.*, 2020; Luo and Tang, 2014). High *CPEMS* and *EMSREV* values indicate excessive GHG emissions and poor carbon performance.

[2] Following past research (Orazalin *et al.*, 2024), we retained firms with the data for at least five consecutive years to account for changes in the main variables over time.
[3] For more information, see https://www.epa.gov/climateleadership/scope-1-and-scope-2-inventory-guidance (accessed May 30, 2022)
[4] For more information, see https://www.epa.gov/climateleadership/scope-3-inventory-guidance (accessed May 30, 2022)

3.3 Independent Variables

We use board gender diversity (*BGEND*) as the main explanatory variable to assess female representation on corporate boards. Consistent with previous research (Awad *et al.*, 2023; Kara *et al.*, 2022; Shahrour *et al.*, 2024), we adopt a commonly used proxy for *BGEND*, which is the percentage of female directors on the board. In the robustness tests section, we also employ the Blau index (*BLAUIX*) of diversity as an alternative measure of *BGEND*, following past research (Campbell and Mínguez-Vera, 2008; Carvajal *et al.*, 2022). The Blau index is estimated as follows:

$$BLAUIX = 1 - \sum_{i=1}^{2} p_i^2 \quad (1)$$

where, *i* represents the gender categories (male and female) and *p* represents the proportion of each gender category.

3.4 Control variables

Following past research (Benlemlih *et al.*, 2022; Muktadir-Al-Mukit and Bhaiyat, 2024; Nuber and Velte, 2021; Orazalin *et al.*, 2024), we include three groups of control variables. The first group consists of internal governance characteristics that can be associated with carbon/environmental performance (Atif *et al.*, 2021; Konadu *et al.*, 2022). In particular, board size (*BSIZE*) is included as a control variable as it influences board decision-making and corporate outcomes (Liao *et al.*, 2015; De Villiers *et al.*, 2011). Board independence (*BINDP*) is controlled because independent directors tend to increase board monitoring of environmental issues/risks (Haque, 2017; Nadeem *et al.*, 2020). The presence of CSR/sustainability (*CSCOM*) and corporate governance (*CGCOM*) committees is controlled because such committees tend to play a key role in managing environmental issues and promoting sustainability (Orazalin *et al.*, 2024).

The second group includes firm-specific characteristics that may also affect carbon/environmental performance (Haque and Jones, 2020; Orazalin and Mahmood, 2021; Zhu *et al.*, 2021). CSR

performance (CSRPR) is controlled because firms committed to CSR initiatives/strategies tend to have superior actual carbon/environmental performance (Orazalin, 2020). Firm size (*FSIZE*) is controlled because larger firms tend to have higher levels of GHG emissions (Benlemlih *et al.*, 2022; Luo and Tang, 2021). Profitability (*FPROF*) is another determinant of carbon/environmental performance, as profitable firms tend to have more resources to combat climate change (Atif *et al.*, 2021; De Villiers *et al.*, 2011). Leverage (*LEVRG*) is included as a control variable because highly leveraged firms are less likely to engage in carbon mitigation activities (Ben-Amar *et al.*, 2017; Oyewo, 2023). Financial slack (*SLACK*) is controlled because financial capacity is an important factor that may influence carbon/environmental performance (De Villiers *et al.*, 2011). Capital intensity (*CAPIN*) is controlled since investments in new technologies lead to better carbon/environmental performance (Clarkson *et al.*, 2008).

Finally, the third group includes country-specific variables that may affect firms' carbon/environmental performance (Benlemlih *et al.*, 2022; Orazalin and Mahmood, 2021). Specifically, national governance quality (*NGVQL*) is included as country-level governance systems tend to influence corporate practices and performance (Elamer *et al.*, 2020; Orazalin and Mahmood, 2021). Furthermore, country groups (*SHARE*), GDP growth (*GDPGR*), and inflation (*INFLN*) are included as these indicators tend to affect corporate environmental initiatives/performance (Benlemlih *et al.*, 2022; Marin and Vona, 2021). The measurements of the control variables are summarized in Appendix 2.

3.5 Empirical Model

Consistent with related research (Haque and Jones, 2020; Shahrour *et al.*, 2024), we adopt the subsample analysis approach to test *H1a* and *H1b*. Specifically, we split the sample into two subsamples (quotas countries and governance codes countries) and estimate the following baseline model:

$$CPEMS=\beta_0+\beta_1 BGEND+\beta_2 BSIZE+\beta_3 BINDP+\beta_4 CGCOM+ \beta_5 CSCOM+\beta_6 CSRPR+\beta_7 FSIZE+\beta_8 FPROF+\beta_9 LEVRG+\beta_{10} SLACK+\beta_{11} CAPIN+\beta_{12} SHARE+\beta_{13} NGVQL+\beta_{15} GDPGR+ \beta_{15} INFLN+Year, Industry, Country effects+\varepsilon \quad (2)$$

where, *CPEMS* is corporate carbon performance by emissions, and *BGEND* is board gender diversity. The descriptions and measurements of other variables are presented in Appendix 2.

Further, to confirm the subsample results, we conduct a moderation analysis using the following model:

$$CPEMS=\beta_0+\beta_1 BGEND+\beta_2 QUOTA+\beta_3 BGEND*QUOTA+\beta_4 BSIZE+\beta_5 BINDP+\beta_6 CGCOM+ \beta_7 CSCOM+\beta_8 CSRPR+\beta_9 FSIZE+\beta_{10} FPROF+\beta_{11} LEVRG+\beta_{12} SLACK+\beta_{13} CAPIN+\beta_{14} SHARE+\beta_{15} NGVQL+\beta_{16} GDPGR+ \beta_{17} INFLN+Year, Industry, Country effects+\varepsilon \quad (3)$$

where, *QUOTA* is a binary variable that equals one if the firm is operating in a quota country, otherwise equals zero if the firm is operating in a governance code country, and *BGEND*QUOTA* is the interaction between *BGEND* and *QUOTA*. Appendix 3 presents an overview of board gender reforms (quota laws and corporate governance codes) implemented by the countries included in this work.

4. Empirical Results

4.1 Descriptive Statistics

Table 1 presents the summary statistics for the variables. The mean values of carbon performance by emissions (*CPEMS*) and carbon intensity (*EMSREV*) are 13.38 and 0.59, respectively. These statistics are comparable to those of Luo and Tang (2014). Further, the results show that the average board gender diversity (*BGEND*) is 17.95%, and the Blau index (*BLAUIX*) has

a mean value of 0.26 (ranging from 0 to 0.50). These descriptive statistics are generally comparable to those of related studies (Atif *et al.*, 2021; Campbell and Mínguez-Vera, 2008; Gull *et al.*, 2022).

4.2 Correlation Analyses

We estimate Pearson correlation coefficients to test multicollinearity. Table 2 displays a significant and positive correlation of 0.98 between *BGEND* and *BLAUIX*. Nevertheless, these variables are not used in the same model, so their correlation does not affect the regression results. The coefficients, among other explanatory variables, are below a threshold value of 0.80 (Gujarati, 2004), suggesting the absence of serious multicollinearity problems.[5]

4.3 Regression Results

Table 3 provides the regression results for the effects of *BGEND* on *CPEMS* for the full sample and the quota (countries with quotas) and governance code (countries with corporate governance codes) subsamples. As displayed in Column (1), *BGEND* is negative in predicting *CPEMS* ($p < 0.05$) for the full sample. This evidence implies that a higher proportion of female directors on the board leads to reduced carbon emissions and supports the gender socialization view (Dawson, 1997; Gilligan, 1977) and diversity theory (Forbes and Milliken, 1999; Pelled, 1996) in that female directors concerned about global societal issues and possessing valuable perspectives/backgrounds contribute to improved corporate sustainability through reduced carbon footprints. Further, Column (2) displays the results for the quota countries subsample. *BGEND* has a negative and significant link with *CPEMS* ($p < 0.01$), indicating that firms with higher *BGEND* are likely to have lower emissions and, thus, better carbon performance in the context of quota countries. This evidence is in harmony with past studies (Atif *et al.*, 2021; Konadu *et al.*, 2022; Muktadir-Al-

[5] We also estimated the variance inflation factor (VIF) for each explanatory variable. The un-tabulated VIF results confirm that multicollinearity is not a concern in this study.

Mukit and Bhaiyat, 2024; Nuber and Velte, 2021; Oyewo, 2023), suggesting that *BGEND* serves as a significant factor in improving carbon/environmental performance, especially in contexts with change mechanisms, such as quota laws (Marchini *et al.*, 2022; Martínez-García *et al.*, 2022). Finally, Column (3) reports the regression results for the governance code subsample. The coefficient of *BGEND* is insignificant ($p > 0.10$), indicating that female board directors are not associated with carbon emissions in governance code countries. This evidence supports the viewpoint that the efficacy of corporate governance codes in the form of broad/general recommendations for BGEND is limited (Martínez-García *et al.*, 2022; Mateos de Cabo *et al.*, 2022) and voluntary measures to foster *BGEND*, as adopted through governance codes, are ineffective in influencing board functioning and enhancing organizational performance (Poletti-Hughes and Dimungu-Hewage, 2022). In line with institutional theory, our results suggest that female board representation improves carbon performance in quota countries but has no impact in governance code countries.

As indicated before, we perform an additional analysis to test the moderating effect of the *QUOTA* variable on the *BGEND–CPEMS* nexus to confirm the different impacts of gender quotas and governance codes. Table 4 presents the regression results from this moderation analysis. Column (2) shows that the coefficient of *BGEND*QUOTA* is significant and negative ($p < 0.01$), indicating that quota laws strengthen the negative impact of *BGEND* on emissions. This evidence supports the results from the subsample analysis and suggests that gender quotas create a regulatory environment where boards with more female directors are more effective at reducing carbon emissions. Overall, our results from Tables 3 and 4 support *H1a* and demonstrate that increased *BGEND* leads to improved carbon performance in quota countries. Our evidence also supports *H1b* and suggests that *BGEND*'s ability to reduce carbon emissions is limited in countries with non-binding governance codes/principles.

4.4 Robustness Tests

In this section, we employ a set of robustness tests to estimate whether our main findings are sensitive to alternative measures, endogeneity, and self-selection bias. In particular, we re-estimate the baseline specifications to gauge whether the original results remain robust to using an alternative measure of CPEMS. Following past research (Bui *et al.*, 2020; Luo and Tang, 2014; Toukabri and Jilani, 2023), we use carbon intensity, which is measured as the ratio of actual carbon emissions to total revenues (*EMSREV*). We also apply the Blau index (*BLAUIX*) to measure *BGEND* and test the robustness of the main results. Prior research argues that the percentage of female board directors may not accurately reflect diversity as boards with more female directors can still be homogeneous, while the Blau index better captures *BGEND* by taking its maximum when both men and women are equally represented (Campbell and Mínguez-Vera, 2008). Hence, we employ Equation (1) to measure the Blau index, in line with past research (Campbell and Mínguez-Vera, 2008; Carvajal *et al.*, 2022). Table 5 shows that our main findings are robust to the alternative measures.

Second, we apply a two-stage least squares (2SLS) methodology to ensure that the findings regarding the relationship between *BGEND* and carbon performance are not driven by unobserved factors, thereby controlling for omitted variable bias. Following related studies (Kara *et al.*, 2022; Ye *et al.*, 2019), we introduce three variables as instruments: the industry-level mean values of the *BGEND* variables, the ratio of female to male labor participation rate, and the employment-to-population ratio.[6] These instrumental variables affect *BGEND* but cannot directly influence *CPEMS*. The statistics (Anderson canon. corr. LM, Cragg-Donald Wald F, and Stock Yogo weak ID test) reported in Table 6 indicate that the selected instruments are relevant and valid. Overall, the results

[6]We obtained the ratio of female to male labor participation rate and the employment to population ratio from the World Bank database.

show that *BGEND* and *BLAUIX* negatively affect *CPEMS* and *EMSREV* in quota countries but have no impact in governance code countries.

Third, we employ a two-stage Heckman model (Heckman, 1979) to address possible sample selection bias. Since the Heckman estimation requires a suitable exclusion restriction, the ratio of female to male labor participation rate is included as an exclusion restriction to satisfy this requirement. We also introduce the *FDPRES* variable, which takes a value of one if firm-years have female directors and zero if firm-years have no female directors. Then, in the first stage, we regress *FDPRES* on the explanatory variables to obtain the Mills ratio. In the second stage, we estimate the regression in which *CPEMS* and *EMSREV* are dependent variables and the obtained Mills ratio and firm- and country-level variables are explanatory variables. The results from the Heckman estimation reported in Table 7 are similar to the original ones, suggesting that the inferences are not driven by sample selection bias.

Finally, we adopt a propensity score matching (PSM) technique to verify that our main conclusions are not influenced by self-selection bias. For this purpose, we introduce *FDPRES*, which equals one if the board has female directors and zero if the board has no female directors. *FDPRES* is used to select firm-years with female directors for the treatment group and firm-years without female directors for the control group. We employ probit regression to assess the link between *FDPRES* and the firm-level variables for the pre-match sample. Following relevant research (Atif *et al.*, 2021; Gull *et al.*, 2022), we conduct a diagnostic test to ensure that firm-years in the treatment group are identical to those in the control group. In particular, we compare the mean values of the firm-level variables between the treatment and control groups. As displayed in Appendix 4, the differences in the mean values are statistically insignificant ($p > 0.10$), indicating the effectiveness of the PSM procedure in making the two groups comparable with respect to the firm-level explanatory variables. Table 8 reports the results from the PSM analysis and verifies the robustness of the inferences to self-selection bias.

4.5 Additional Analyses

In this section, we adopt the difference in differences (DID) analysis to gauge whether *BGEND* leads to substantial reductions in emissions after the introduction of gender quotas and governance codes. Using the PSM procedures, we construct the control group for the treated firms (firm-years without female directors and firms with female directors) based on the nearest-neighbor approach. The PSM-based DID analysis ensures that treated firm-years are not randomly selected by making controlled firms more comparable to treated firms. We perform the DID analysis estimating the following two models for the quota and the governance code subsamples, respectively:

$$CPEMS_{it}=\beta_0+\beta_1 FDPRES_{it}*QPOST_{it}+\beta_2 FDMED_{it}+\beta_3 Controls_{it}+Year,\ Industry,\ Country\ effects+\varepsilon_{it} \quad (4)$$

$$CPEMS_{it}=\beta_0+\beta_1 FDPRES_{it}*GPOST_{it}+\beta_2 FDMED_{it}+\beta_3 Controls_{it}+Year,\ Industry,\ Country\ effects+\varepsilon_{it} \quad (5)$$

FDPRES is an indicator variable that equals one if firm-years are in the treatment and zero otherwise. *QPOST* is an indicator variable that equals one if the firm-year is in the period after the quota introduction, and zero otherwise. *FDPRES***QPOST* represents the interaction between *FDPRES* and *QPOST*. *GPOST* is an indicator variable that equals one if the firm-year is in the period after the code introduction, and zero otherwise. *FDPRES***GPOST* represents the interaction between *FDPRES* and *GPOST*. Table 9 displays that the coefficient of *FDPRES***QPOST* is negative ($p < 0.10$), indicating that relative to firms with lower *BGEND*, firms with higher BGEND exhibit better carbon performance after the quota introduction. Further, the coefficient of *FDPRES***GPOST* is insignificant, implying that the introduction of codes does not lead to significant reductions in emissions for firms with higher *BGEND* compared to firms with lower *BGEND*. Overall, the results suggest that firms with higher *BGEND* have lower emissions following the introduction of quotas.

We further estimate the effects of *BGEND* and *BLAUIX* on carbon performance for ETS and non–ETS countries. Prior literature (Choi and Luo, 2021; Orazalin *et al.*, 2024) posits that

national climate-related regulations substantially influence internal governance, sustainability practices, and performance outcomes. Hence, we perform the subsample analysis for firms operating in ETS and non-ETS countries to assess whether the predicted relationships differ between these two groups. Panel A of Table 10 shows that *BGEND* and *BLAUIX* are negatively associated with *CPEMS* and *EMSREV*, implying that female directors play a key role in reducing emissions, and thus improving carbon performance in ETS countries. By contrast, Panel B displays that the coefficients of *BGEND* and *BLAUIX* are significant and positive, indicating that higher representation of female directors is associated with higher emissions in non-ETS countries. Further, we assess the moderating effect of the *ETS* variable, which is a binary variable that equals one if firm-years are in ETS countries, otherwise equals zero if firm-years belong to non–ETS countries. Panel C shows that the coefficients of *BGEND***ETS* and *BLAUIX**ETS are significant and negative, verifying that national climate-related regulations, such as ETS, amplify the negative impact of female board representation on emissions.

5. Conclusion

We examine the impact of female board representation on corporate carbon performance across multiple countries with gender quotas and countries with governance codes. Our results show that the relationship between *BGEND* and *CPEMS* differs between countries with gender quotas and countries with governance codes. In particular, a higher proportion of female board directors reduces carbon emissions in countries with quotas but has no impact on carbon performance in countries with governance codes. We also provide new evidence that firms with higher *BGEND* exhibit better carbon performance following the enactment of gender quota laws.

Our work offers distinct practical, policy, and societal implications. In particular, our findings suggest that corporate boards need to pay greater attention to appointing female directors who can bring unique skills and innovative ideas to the board, enhance corporate governance,

promote CSR/sustainability practices, and increase the monitoring of corporate impacts on the climate and ecosystems. Further, policymakers should promote guidelines/policies to encourage shareholders, business entities, and practitioners to appoint more female directors with relevant qualifications and valuable characteristics who may contribute to enhanced sustainability through reduced carbon emissions. In this case, firms seeking sustainable development can obtain long-term economic benefits and enhance sustainability through reduced carbon footprints by promoting *BGEND* and recruiting experienced female directors. In addition, our findings may encourage non-quota countries to enact gender quotas to foster gender equality and increase female representation on boards. Furthermore, governments should incorporate specific targets into gender diversity recommendations when developing corporate governance codes/principles. Our results also suggest that quota-driven increases in *BGEND* lead to significant reductions in emissions, emphasizing the importance of implementing quota laws. From a societal perspective, our results support the roles of legislative reforms, such as gender quotas, in building a climate-resilient society and promoting a carbon-free economy by reinforcing female board directors' influence on climate change and sustainability. Nevertheless, it is worth noting that female board directors appointed as a token to meet social pressures for diversity might have limited or no influence on decision-making even if the regulations are followed (Mateos de Cabo *et al.*, 2022). In this regard, regulators should introduce additional policies/measures to ensure that increasing *BGEND* is a substantive practice rather than a symbolic one.

Our work has several limitations that can offer new avenues for future research. In particular, it is based on a sample of the world's largest firms, and consequently, the observed relationships may not hold for other forms of businesses, e.g., small and medium-sized entities (SMEs). Therefore, future research could study SMEs and private entities to offer new insights into the relationship between *BGEND* and *CPEMS*. Further, our study focuses on female representation on corporate boards but does not consider other diversity values of female directors that may influence board decision-making, functioning, and performance. In this case, future research could

explore other individual characteristics and social backgrounds (e.g., education, experience, age, culture, religion, and ethnicity) of female directors and examine how these factors influence carbon mitigation systems, climate change initiatives, and their aftermath on actual carbon emissions.

References

Adams, R.B. and Funk, P. (2012), "Beyond the glass ceiling: Does gender matter?", *Management Science*, Vol. 58 No. 2, pp. 219–235, doi: 10.1287/mnsc.1110.1452.

Atif, M., Hossain, M., Alam, M.S. and Goergen, M. (2021), "Does board gender diversity affect renewable energy consumption?", *Journal of Corporate Finance*, Vol. 66, p. 101665, doi: 10.1016/j.jcorpfin.2020.101665.

Awad, A.B., Khalaf, B.A. and Afzal, A. (2023), "The power of board size and gender diversity on the value of companies listed on emerging markets", *Corporate Law and Governance Review*, Vol. 5 No. 2, pp. 128–139, doi: 10.22495/clgrv5i2p14.

Barroso, R., Duan, T., Guo, S. (Sarina) and Kowalewski, O. (2024), "Board gender diversity reform and corporate carbon emissions", *Journal of Corporate Finance*, Vol. 87, p. 102616, doi: 10.1016/J.JCORPFIN.2024.102616.

Ben-Amar, W., Chang, M. and McIlkenny, P. (2017), "Board Gender Diversity and Corporate Response to Sustainability Initiatives: Evidence from the Carbon Disclosure Project", *Journal of Business Ethics*, Vol. 142 No. 2, pp. 369–383, doi: 10.1007/s10551-015-2759-1.

Benlemlih, M., Arif, M. and Nadeem, M. (2022), "Institutional Ownership and Greenhouse Gas Emissions : A Comparative Study of the UK and the USA", *British Journal of Management*, Vol. 0, pp. 1–25, doi: 10.1111/1467-8551.12613.

Bui, B., Houqe, M.N. and Zaman, M. (2020), "Climate governance effects on carbon disclosure and performance", *British Accounting Review*, Vol. 52 No. 2, p. 100880, doi: 10.1016/j.bar.2019.100880.

Byron, K. and Post, C. (2016), "Women on Boards of Directors and Corporate Social Performance: A Meta-Analysis", *Corporate Governance: An International Review*, Vol. 24 No. 4, pp. 428–442, doi: 10.1111/corg.12165.

Campbell, K. and Mínguez-Vera, A. (2008), "Gender diversity in the boardroom and firm financial performance", *Journal of Business Ethics*, Vol. 83 No. 3, pp. 435–451, doi: 10.1007/s10551-007-9630-y.

Carlson, R. (1972), "Understanding Women: Implications for Personality Theory and Research", *Journal of Social Issues*, Vol. 28 No. 2, pp. 17–32, doi: 10.1111/j.1540-4560.1972.tb00015.x.

Carvajal, M., Nadeem, M. and Zaman, R. (2022), "Biodiversity disclosure, sustainable development and environmental initiatives: Does board gender diversity matter?", *Business Strategy and the Environment*, Vol. 31 No. 3, pp. 969–987, doi: https://doi.org/10.1002/bse.2929.

Chen, J., Leung, W.S., Song, W. and Goergen, M. (2019), "Why female board representation matters: The role of female directors in reducing male CEO overconfidence", *Journal of Empirical Finance*, Vol. 53, pp. 70–90, doi: 10.1016/J.JEMPFIN.2019.06.002.

Choi, B. and Luo, L. (2021), "Does the market value greenhouse gas emissions? Evidence from multi-country firm data", *British Accounting Review*, Vol. 53 No. 1, p. 100909, doi: 10.1016/j.bar.2020.100909.

Clarkson, P.M., Li, Y., Richardson, G.D. and Vasvari, F.P. (2008), "Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis", *Accounting, Organizations and Society*, Vol. 33 No. 4, pp. 303–327, doi: 10.1016/j.aos.2007.05.003.

Dawson, L.M. (1997), "Ethical differences between men and women in the sales profession", *Journal of Business Ethics*, Vol. 16 No. 11, pp. 1143–1152, doi: 10.1023/A:1005721916646.

Deloitte. (2022), *Women in the Boardroom: A Global Perspective*.

DiMaggio, P.J. and Powell, W.W. (1991), *The New Institutionalism in Organizational Analysis*, University of Chicago Press., Chicago, doi: 10.2307/258726.

Eagly, A.H. (2009), "The His and Hers of Prosocial Behavior: An Examination of the Social Psychology of Gender", *American Psychologist*, Vol. 64 No. 8, pp. 644–658, doi: 10.1037/0003-066X.64.8.644.

Elamer, A.A., Ntim, C.G. and Abdou, H.A. (2020), "Islamic governance, national governance, and bank risk management and disclosure in MENA countries", *Business and Society*, Vol. 59 No. 5, pp. 914–955, doi: 10.1177/0007650317746108.

Ferrari, G., Ferraro, V., Profeta, P. and Pronzato, C. (2021), "Do Board Gender Quotas Matter? Selection, Performance, and Stock Market Effects", *Management Science*, doi: 10.1287/mnsc.2021.4200.

Forbes, D.P.. and Milliken, F.J.. (1999), "Cognition and Corporate Governance: Understanding Boards of Directors as Strategic Decision-Making Groups", *Academy of Management Review*, Vol. 24 No. 3, pp. 489–505, doi: 10.2307/259138.

Garcia-Blandon, J., Argilés-Bosch, J.M., Ravenda, D. and Rodríguez-Pérez, G. (2023), "Female directors, board-gender quotas and firm performance: evidence from Norway", *Economic Research-Ekonomska Istrazivanja*, Vol. 36 No. 2, pp. 1–19, doi: 10.1080/1331677X.2022.2142822.

Gilligan, C. (1977), "In a Different Voice: Women's Conceptions of Self and of Morality", *Harvard Educational Review*, Vol. 47 No. 4, pp. 481–517, doi: 10.17763/haer.47.4.g6167429416hg5l0.

Ginglinger, E. and Raskopf, C. (2023), "Women directors and E&S performance: Evidence from board gender quotas", *Journal of Corporate Finance*, Vol. 83, p. 102496, doi: 10.1016/j.jcorpfin.2023.102496.

Griffin, D., Li, K. and Xu, T. (2021), "Board gender diversity and corporate innovation: International evidence", *Journal of Financial and Quantitative Analysis*, Vol. 56 No. 1, pp. 123–154, doi: 10.1017/S002210901900098X.

Gujarati, D.N. (2004), *Basic Econometrics*, 4th Editio., The McGraw-Hill Companies, New York.

Gull, A.A., Atif, M. and Hussain, N. (2022), "Board gender composition and waste management: Cross-country evidence", *The British Accounting Review*, Vol. 55 No. 1, p. 101097, doi: 10.1016/J.BAR.2022.101097.

Haque, F. (2017), "The effects of board characteristics and sustainable compensation policy on carbon performance of UK firms", *British Accounting Review*, Vol. 49 No. 3, pp. 347–364, doi: 10.1016/j.bar.2017.01.001.

Haque, F. and Jones, M.J. (2020), "European firms' corporate biodiversity disclosures and board gender diversity from 2002 to 2016", *British Accounting Review*, Vol. 52 No. 2, p. 100893, doi: 10.1016/j.bar.2020.100893.

Haque, F. and Ntim, C.G. (2020), "Executive compensation, sustainable compensation policy, carbon performance and market value", *British Journal of Management*, Vol. 31 No. 3, pp. 525–546, doi: 10.1111/1467-8551.12395.

Heckman, J.J. (1979), "Sample selection bias as a specification Error", *Econometrica*, Vol. 47 No. 1, pp. 153–161.

Huse, M. and Solberg, A.G. (2006), "Gender-related boardroom dynamics: How Scandinavian women make and can make contributions on corporate boards", *Women in Management Review*, Vol. 21 No. 2, pp. 113–130, doi: 10.1108/09649420610650693.

Ibrahim, N., Angelidis, J. and Tomic, I.M. (2009), "Managers' attitudes toward codes of ethics: Are there gender differences?", *Journal of Business Ethics*, Vol. 90 No. 3, pp. 343–353, doi: 10.1007/s10551-010-0428-y.

Kanter, R.M. (1977), "Some Effects of Proportions on Group Life: Skewed Sex Ratios and Responses to Token Women", *American Journal of Sociology*, Vol. 82 No. 5, pp. 965–990, doi: 10.1086/226425.

Kara, A., Nanteza, A., Ozkan, A. and Yildiz, Y. (2022), "Board gender diversity and responsible banking during the COVID-19 pandemic", *Journal of Corporate Finance*, Vol. 74, p. 102213, doi:

10.1016/J.JCORPFIN.2022.102213.

Kaufmann, D., Kraay, A. and Mastruzzi, M. (2011), "The worldwide governance indicators: Methodology and analytical issues", *Hague Journal on the Rule of Law*, Vol. 3 No. 2, pp. 220–246, doi: 10.1017/S1876404511200046.

Konadu, R., Ahinful, G.S., Boakye, D.J. and Elbardan, H. (2022), "Board gender diversity, environmental innovation and corporate carbon emissions", *Technological Forecasting and Social Change*, Vol. 174, p. 121279.

Kyaw, K., Treepongkaruna, S. and Jiraporn, P. (2022), "Board gender diversity and environmental emissions", *Business Strategy and the Environment*, doi: 10.1002/bse.3052.

Liao, L., Luo, L. and Tang, Q. (2015), "Gender diversity, board independence, environmental committee and greenhouse gas disclosure", *British Accounting Review*, Vol. 47 No. 4, pp. 409–424, doi: 10.1016/j.bar.2014.01.002.

Liu, Y., Wei, Z. and Xie, F. (2014), "Do women directors improve firm performance in China?", *Journal of Corporate Finance*, Vol. 28, pp. 169–184, doi: 10.1016/J.JCORPFIN.2013.11.016.

Lu, J. and Herremans, I.M. (2019), "Board gender diversity and environmental performance: An industries perspective", *Business Strategy and the Environment*, Vol. 28 No. 7, pp. 1449–1464, doi: 10.1002/bse.2326.

Luo, L. and Tang, Q. (2014), "Does voluntary carbon disclosure reflect underlying carbon performance?", *Journal of Contemporary Accounting and Economics*, Vol. 10 No. 3, pp. 191–205, doi: 10.1016/j.jcae.2014.08.003.

Luo, L. and Tang, Q. (2021), "Corporate governance and carbon performance: role of carbon strategy and awareness of climate risk", *Accounting and Finance*, Vol. 61 No. 2, pp. 2891–2934, doi: 10.1111/acfi.12687.

Marchini, P.L., Tibiletti, V., Mazza, T. and Gabrielli, G. (2022), "Gender quotas and the environment: Environmental performance and enforcement", *Corporate Social Responsibility and Environmental Management*, Vol. 29 No. 1, pp. 256–272, doi: 10.1002/csr.2200.

Marin, G. and Vona, F. (2021), "The impact of energy prices on socioeconomic and environmental performance: Evidence from French manufacturing establishments, 1997–2015", *European Economic Review*, Vol. 135, p. 103739, doi: 10.1016/j.euroecorev.2021.103739.

Martínez-García, I., Terjesen, S. and Gómez-Ansón, S. (2022), "Board Gender Diversity Codes, Quotas and Threats of Supranational Legislation: Impact on Director Characteristics and Corporate Outcomes", *British Journal of Management*, Vol. 33 No. 2, pp. 753–783, doi: 10.1111/1467-8551.12517.

Mateos de Cabo, R., Grau, P., Gimeno, R. and Gabaldón, P. (2022), "Shades of Power: Network Links with Gender Quotas and Corporate Governance Codes", *British Journal of Management*, Vol. 33 No. 2, pp. 703–723, doi: 10.1111/1467-8551.12454.

Maxfield, S. and Wang, L. (2024), "Board gender diversity, firm risk, and the intermediate mechanisms: A meta-analysis", *Corporate Governance: An International Review*, Vol. 32 No. 6, pp. 934–953, doi: 10.1111/corg.12572.

Mensi-Klarbach, H. and Seierstad, C. (2020), "Gender Quotas on Corporate Boards: Similarities and Differences in Quota Scenarios", *European Management Review*, Vol. 17 No. 3, pp. 615–631, doi: 10.1111/emre.12374.

Milliken, F.J. and Martins, L.L. (1996), "Searching for common threads: Understanding the multiple effects of diversity in organizational groups", *Academy of Management Review*, Vol. 21 No. 2, pp. 402–433, doi: 10.5465/AMR.1996.9605060217.

Muktadir-Al-Mukit, D. and Bhaiyat, F.H. (2024), "Impact of corporate governance diversity on carbon emission under environmental policy via the mandatory nonfinancial reporting regulation", *Business Strategy and the Environment*, Vol. 33 No. 2, pp. 1397–1417, doi: https://doi.org/10.1002/bse.3555.

Nadeem, M., Bahadar, S., Gull, A.A. and Iqbal, U. (2020), "Are women eco-friendly? Board gender diversity and environmental innovation", *Business Strategy and the Environment*, Vol. 29 No. 8, pp. 3146–3161, doi: 10.1002/bse.2563.

Nguyen, Y.T., Dang, C.T. and Trinh, H.T. (2023), "The impact of feminism on bank performance: the case of Vietnam", *Review of Accounting and Finance*, Vol. 22 No. 5, pp. 584–601, doi: 10.1108/RAF-10-2022-0292.

Nuber, C. and Velte, P. (2021), "Board gender diversity and carbon emissions: European evidence on curvilinear relationships and critical mass", *Business Strategy and the Environment*, Vol. 30 No. 4, pp. 1958–1992, doi: 10.1002/bse.2727.

Orazalin, N. (2020), "Do board sustainability committees contribute to corporate environmental and social performance? The mediating role of corporate social responsibility strategy", *Business Strategy and the Environment*, Vol. 29 No. 1, pp. 140–153, doi: 10.1002/bse.2354.

Orazalin, N. and Mahmood, M. (2021), "Toward sustainable development: Board characteristics, country governance quality, and environmental performance", *Business Strategy and the Environment*, Vol. 30 No. 8, pp. 3569–3588, doi: https://doi.org/10.1002/bse.2820.

Orazalin, N., Ntim, C. and Malagila, J. (2024), "Board sustainability committees, climate change initiatives, carbon performance, and market value", *British Journal of Management*, Vol. 35 No. 1, pp. 295–320, doi: 10.1111/1467-8551.12715.

Oyewo, B. (2023), "Corporate governance and carbon emissions performance: International evidence on curvilinear relationships", *Journal of Environmental Management*, Vol. 334, p. 117474, doi: 10.1016/J.JENVMAN.2023.117474.

Pelled, L.H. (1996), "Demographic Diversity, Conflict, and Work Group Outcomes: An Intervening Process Theory", *Organization Science*, Vol. 7 No. 6, pp. 615–631, doi: 10.1287/orsc.7.6.615.

Poletti-Hughes, J. and Dimungu-Hewage, D. (2022), "The Effectiveness of Gender Diversity Reforms and the Impact of a Familial Culture : A Spillover Effect on Board", *British Journal of Management*, Vol. 0, pp. 1–24, doi: 10.1111/1467-8551.12660.

Shahrour, M.H., Lemand, R. and Wojewodzki, M. (2024), "Board diversity, female executives and stock liquidity: evidence from opposing cycles in the USA", *Review of Accounting and Finance*, Vol. 23 No. 5, pp. 581–597, doi: 10.1108/RAF-01-2024-0014.

Siciliano, J.I. (1996), "The relationship of board member diversity to organizational performance", *Journal of Business Ethics*, Vol. 15 No. 12, pp. 1313–1320, doi: 10.1007/BF00411816.

Simga-Mugan, C., Daly, B.A., Onkal, D. and Kavut, L. (2005), "The influence of nationality and gender on ethical sensitivity: An application of the issue-contingent model", *Journal of Business Ethics*, Vol. 57 No. 2, pp. 139–159, doi: 10.1007/s10551-004-4601-z.

Su, W. and Yin, C. (2024), "Association between executives' foreign background and audit fees", *Review of Accounting and Finance*, Vol. 23 No. 2, pp. 186–204, doi: 10.1108/RAF-12-2022-0330.

Terjesen, S., Aguilera, R. V. and Lorenz, R. (2015), "Legislating a Woman's Seat on the Board: Institutional Factors Driving Gender Quotas for Boards of Directors", *Journal of Business Ethics*, Vol. 128 No. 2, pp. 233–251, doi: 10.1007/s10551-014-2083-1.

Terjesen, S. and Sealy, R. (2016), "Board Gender Quotas: Exploring Ethical Tensions from A Multi-Theoretical Perspective", *Business Ethics Quarterly*, doi: 10.1017/beq.2016.7.

Toukabri, M. and Jilani, F. (2023), "The power of critical mass to make a difference: how gender diversity in board affect US corporate carbon performance", *Society and Business Review*, Vol. 18 No. 4, pp. 592–617, doi: 10.1108/SBR-11-2021-0224.

Usman, M., Gull, A.A., Zalata, A.M., Wang, F. and Yin, J. (2022), "Female Board Directorships and Related Party Transactions", *British Journal of Management*, Vol. 33 No. 2, pp. 678–702, doi: 10.1111/1467-8551.12568.

Valls Martínez, M. del C., Santos-Jaén, J.M., Soriano Román, R. and Martín-Cervantes, P.A. (2022), "Are gender and cultural diversities on board related to corporate CO2 emissions?", *Journal of Cleaner Production*, Vol. 363, p. 132638, doi: 10.1016/J.JCLEPRO.2022.132638.

Vejarano Swinkels, Laurens, G.B. (2024), "Social, Sustainability, and Sustainability-Linked Bonds", *The Journal of Impact and ESG Investing*, Vol. 4 No. 4, pp. 71–95, doi: 10.3905/jesg.2024.1.100.

De Villiers, C., Naiker, V. and van Staden, C.J. (2011), "The effect of board characteristics on firm environmental performance", *Journal of Management*, Vol. 37 No. 6, pp. 1636–1663, doi: 10.1177/0149206311411506.

Van der Walt, N. and Ingley, C. (2003), "Board dynamics and the influence of professional background, gender and ethnic diversity of directors", *Corporate Governance: An International Review*, Vol. 11 No. 3, pp. 218–234, doi: 10.1111/1467-8683.00320.

Yang, P., Riepe, J., Moser, K., Pull, K. and Terjesen, S. (2019), "Women directors, firm performance, and firm risk: A causal perspective", *The Leadership Quarterly*, Vol. 30 No. 5, p. 101297, doi: 10.1016/J.LEAQUA.2019.05.004.

Ye, D., Deng, J., Liu, Y., Szewczyk, S.H. and Chen, X. (2019), "Does board gender diversity increase dividend payouts? Analysis of global evidence", *Journal of Corporate Finance*, Vol. 58, pp. 1–26, doi: 10.1016/J.JCORPFIN.2019.04.002.

Zhu, L., Luo, J., Dong, Q., Zhao, Y., Wang, Y. and Wang, Y. (2021), "Green technology innovation efficiency of energy-intensive industries in China from the perspective of shared resources: Dynamic change and improvement path", *Technological Forecasting and Social Change*, Vol. 170, p. 120890, doi: 10.1016/J.TECHFORE.2021.120890.

Table 1. Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
CPEMS (ln)	5104	13.38	2.34	7.85	18.52
EMSREV (ratio)	5104	0.59	0.08	0.40	0.77
BGEND (%)	5104	17.95	13.67	0.00	50.00
BLAUIX (index)	5104	0.26	0.17	0.00	0.50
BSIZE (ln)	5104	2.39	0.34	0.69	3.40
BINDP (%)	5104	54.74	28.07	0.00	100.00
CGCOM (binary)	5104	0.27	0.44	0.00	1.00
CSCOM (binary)	5104	0.73	0.44	0.00	1.00
CSRPR (%)	5104	61.74	18.23	15.05	91.38
FSIZE (ln)	5104	23.00	1.34	19.89	26.01
FPROF (%)	5104	5.59	6.49	-14.61	28.76
LEVRG (%)	5104	25.46	13.53	0.00	58.95
SLACK (ratio)	5104	0.05	0.06	0.00	0.31
CAPIN (ratio)	5104	0.31	0.22	0.00	0.87
SHARE (binary)	5104	0.42	0.49	0.00	1.00
NGVQL (score)	5104	0.00	2.23	-10.23	2.36
GDPGR (%)	5104	1.46	2.89	-10.84	25.18
INFLN (%)	5104	1.86	1.55	-4.48	16.33

Notes: This table presents the summary statistics of all the variables. Variable descriptions are summarized in Appendix 2.
Source: Table by authors.

Table 2. Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
CPEMS	1.00																	
EMSREV	0.94***	1.00																
BGEND	-0.01	-0.06***	1.00															
BLAUIX	-0.01	-0.05***	0.98***	1.00														
BSIZE	0.28***	0.15***	-0.01	0.01	1.00													
BINDP	0.12***	0.10***	0.31***	0.33***	-0.27***	1.00												
CGCOM	0.17***	0.10***	0.10***	0.11***	0.16***	0.21***	1.00											
CSCOM	0.16***	0.14***	0.34***	0.36***	0.09***	0.24***	0.17***	1.00										
CSRPR	0.26***	0.14***	0.44***	0.45***	0.20***	0.36***	0.32***	0.55***	1.00									
FSIZE	0.44***	0.21***	0.14***	0.15***	0.39***	0.15***	0.29***	0.17***	0.46***	1.00								
FPROF	-0.16***	-0.17***	-0.02	-0.01	-0.09***	0.00	-0.04**	-0.08***	-0.05***	0.22***	1.00							
LEVRG	0.10***	0.14***	-0.05***	-0.06***	0.04***	-0.03**	0.03*	0.04***	0.05***	-0.07***	-0.32***	1.00						
SLACK	-0.08***	-0.11***	-0.02	-0.02	0.02	0.01	0.08***	-0.03**	0.01	0.02*	0.14***	-0.19***	1.00					
CAPIN	0.50***	0.58***	-0.05***	-0.04***	0.00	-0.01	-0.02	0.04***	0.00	0.01	-0.03**	0.16***	-0.12***	1.00				
SHARE	-0.10***	-0.03**	0.02	0.04***	-0.39***	0.34***	0.03**	0.13***	-0.03**	-0.10***	0.09***	-0.03**	-0.05***	0.06***	1.00			
NGVQL	-0.14***	-0.16***	0.09***	0.11***	-0.28***	0.11***	-0.24***	-0.11***	-0.13***	-0.04***	-0.01	-0.08***	0.01	-0.15***	0.05***	1.00		
GDPGR	0.02	0.04***	-0.12***	-0.11***	-0.03*	0.02	-0.01	-0.16***	-0.14***	0.04***	0.21***	-0.13***	-0.01	0.01	0.07***	0.02	1.00	
INFLN	0.03**	0.07***	-0.18***	-0.18***	0.01	-0.04***	0.04***	-0.04***	-0.07***	-0.07***	0.11***	-0.04***	-0.05***	0.12***	0.26***	-0.43***	0.20***	1.00

Notes: This table presents the correlation coefficients. Variable descriptions are summarized in Appendix 2. **** p<0.01, ** p<0.05, * p<0.1*
Source: Table by authors.

Table 3. Board gender diversity and carbon performance

	Full sample	QUOTA countries	CGCODE countries
	(1)	(2)	(3)
	CPEMS	CPEMS	CPEMS
BGEND	-0.0051**	-0.0175***	0.0040
	(-2.30)	(-4.76)	(1.41)
BSIZE	0.4599***	0.3409**	0.4759***
	(5.21)	(2.37)	(4.21)
BINDP	0.0079***	0.0064***	0.0077***
	(9.06)	(4.73)	(6.91)
CGCOM	0.0621	0.1291*	0.1181*
	(1.20)	(1.67)	(1.83)
CSCOM	0.2691***	0.2667***	0.2884***
	(4.58)	(2.69)	(3.97)
CSRPR	0.0056***	0.0083***	0.0018
	(3.26)	(3.00)	(0.84)
FSIZE	0.7253***	0.7167***	0.7506***
	(32.41)	(22.22)	(25.24)
FPROF	-0.0633***	-0.0701***	-0.0539***
	(-16.59)	(-7.89)	(-13.38)
LEVRG	0.0048***	0.0040	0.0066***
	(2.88)	(1.46)	(3.16)
SLACK	-0.5676*	0.5183	-1.1421***
	(-1.71)	(0.79)	(-3.06)
CAPIN	2.5349***	1.3132***	3.0603***
	(18.67)	(5.11)	(19.43)
SHARE	1.3879**	-0.4333***	1.4224*
	(2.30)	(-2.59)	(1.83)
NGVQL	-0.1061*	-0.1388	-0.1158
	(-1.78)	(-1.42)	(-1.51)
GDPGR	-0.0101	-0.0078	-0.0086
	(-0.93)	(-0.32)	(-0.73)
INFLN	-0.0043	-0.0531	0.0421
	(-0.19)	(-1.56)	(1.42)
Constant	-7.6310***	-5.3848***	-8.4427***
	(-10.91)	(-6.92)	(-9.47)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Observations	5104	1940	3164
Adj. R-squared	0.7006	0.6501	0.7412

Notes: This table presents the results from regressing *CPEMS* on *BGEND* and other covariates for the whole sample and for the *QUOTA* and *CGCODE* subsamples. Robust *t-statistics* below estimated coefficients are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Source: Table by authors.

Table 4. Moderation analysis

	(1) CPEMS	(2) CPEMS
BGEND	-0.0051**	-0.0045**
	(-2.30)	(-2.02)
QUOTA	0.3914	0.4388
	(0.84)	(0.94)
BGEND*QUOTA		-0.0084***
		(-2.83)
BSIZE	0.4599***	0.4566***
	(5.21)	(5.16)
BINDP	0.0079***	0.0080***
	(9.06)	(9.11)
CGCOM	0.0621	0.0686
	(1.20)	(1.33)
CSCOM	0.2691***	0.2739***
	(4.58)	(4.65)
CSRPR	0.0056***	0.0055***
	(3.26)	(3.23)
FSIZE	0.7253***	0.7220***
	(32.41)	(32.20)
FPROF	-0.0633***	-0.0630***
	(-16.59)	(-16.50)
LEVRG	0.0048***	0.0050***
	(2.88)	(2.95)
SLACK	-0.5676*	-0.6157*
	(-1.71)	(-1.84)
CAPIN	2.5349***	2.5323***
	(18.67)	(18.60)
SHARE	1.3879**	1.4430**
	(2.30)	(2.39)
NGVQL	-0.1061*	-0.1212**
	(-1.78)	(-2.02)
GDPGR	-0.0101	-0.0091
	(-0.93)	(-0.84)
INFLN	-0.0043	-0.0063
	(-0.19)	(-0.29)
Constant	-7.5538***	-7.5256***
	(-13.00)	(-12.98)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Country FE	Yes	Yes
Observations	5104	5104
Adj. R-squared	0.7006	0.7011

Notes: This table presents the results from regressing *CPEMS* on *BGEND*, *BGEND*QUOTA*, and other covariates. Robust *t-statistics* below estimated coefficients are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.
Source: Table by authors.

Table 5. Alternative measures of carbon performance and board gender diversity

	QUOTA countries			CGCODE countries		
	(1) EMSREV	(2) EMSREV	(3) CPEMS	(4) EMSREV	(5) EMSREV	(6) CPEMS
BGEND	-0.0006***			0.0001		
	(-4.30)			(0.96)		
BLAUIX		-0.0459***	-1.4158***		0.0039	0.2389
		(-4.28)	(-4.70)		(0.44)	(1.02)
BSIZE	0.0048	0.0052	0.3525**	0.0116***	0.0116***	0.4711***
	(0.85)	(0.91)	(2.44)	(2.69)	(2.69)	(4.17)
BINDP	0.0002***	0.0002***	0.0065***	0.0003***	0.0003***	0.0078***
	(3.50)	(3.58)	(4.81)	(6.28)	(6.33)	(6.95)
CGCOM	0.0035	0.0034	0.1252	0.0021	0.0021	0.1170*
	(1.26)	(1.22)	(1.63)	(0.89)	(0.88)	(1.81)
CSCOM	0.0124***	0.0125***	0.2712***	0.0112***	0.0112***	0.2885***
	(3.21)	(3.24)	(2.73)	(4.12)	(4.12)	(3.97)
CSRPR	0.0001	0.0001	0.0083***	0.0000	0.0000	0.0019
	(0.59)	(0.62)	(3.03)	(0.16)	(0.24)	(0.89)
FSIZE	0.0121***	0.0121***	0.7156***	0.0148***	0.0148***	0.7501***
	(10.35)	(10.31)	(22.17)	(13.22)	(13.21)	(25.20)
FPROF	-0.0017***	-0.0017***	-0.0704***	-0.0016***	-0.0016***	-0.0538***
	(-5.77)	(-5.81)	(-7.94)	(-10.51)	(-10.47)	(-13.33)
LEVRG	0.0004***	0.0004***	0.0039	0.0003***	0.0003***	0.0066***
	(3.52)	(3.49)	(1.44)	(4.36)	(4.35)	(3.16)
SLACK	0.0194	0.0195	0.5201	-0.0379***	-0.0374***	-1.1302***
	(0.78)	(0.79)	(0.79)	(-2.73)	(-2.70)	(-3.03)
CAPIN	0.0796***	0.0794***	1.3060***	0.1318***	0.1319***	3.0584***
	(8.02)	(8.02)	(5.10)	(21.56)	(21.60)	(19.45)
SHARE	-0.0231***	-0.0235***	-0.4462***	0.0300	0.0300	1.4223*
	(-3.68)	(-3.75)	(-2.66)	(1.09)	(1.09)	(1.83)
NGVQL	-0.0033	-0.0030	-0.1262	-0.0023	-0.0021	-0.1136
	(-0.89)	(-0.79)	(-1.29)	(-0.83)	(-0.78)	(-1.47)
GDPGR	-0.0001	-0.0000	-0.0066	0.0001	0.0001	-0.0086
	(-0.09)	(-0.05)	(-0.28)	(0.13)	(0.12)	(-0.74)
INFLN	-0.0011	-0.0014	-0.0634*	0.0013	0.0013	0.0419
	(-0.83)	(-1.07)	(-1.86)	(1.25)	(1.25)	(1.42)
Constant	0.2143***	0.2156***	-5.3447***	0.1022***	0.1027***	-8.4214***
	(7.33)	(7.38)	(-6.85)	(3.19)	(3.20)	(-9.43)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1940	1940	1940	3164	3164	3164
Adj. R-squared	0.6156	0.6158	0.6502	0.7188	0.7187	0.7411

Notes: This table presents the regression results using alternative measures of carbon performance, which is carbon intensity (*EMSREV*), and board gender diversity, which is the Blau index (*BLAUIX*). Robust *t-statistics* below estimated coefficients are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Source: Table by authors.

Table 6. Two-stage least squares (2SLS)

Panel A: Quota countries				
	(1) **CPEMS**	**(2)** **CPEMS**	**(3)** **EMSREV**	**(4)** **EMSREV**
BGEND	-0.0350*		-0.0018**	
	(-1.65)		(-2.22)	
BLAUIX		-2.8191*		-0.1394**
		(-1.64)		(-2.14)
Controls	Included	Included	Included	Included
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	1940	1940	1940	1940
Anderson canon. Corr. LM statistic	53.488***	53.272***	53.488***	53.272***
Cragg-Donald Wald F statistic	17.834	17.760	17.834	17.760
Stock-Yogo weak ID test	13.91	13.91	13.91	13.91
Adj. R-squared	0.6456	0.6457	0.5981	0.6003
Panel B: CGCODE countries				
	(1) **CPEMS**	**(2)** **CPEMS**	**(3)** **EMSREV**	**(4)** **EMSREV**
BGEND	0.0016		-0.0001	
	(0.10)		(-0.20)	
BLAUIX		0.1255		-0.0068
		(0.10)		(-0.14)
Controls	Included	Included	Included	Included
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	3164	3164	3164	3164
Anderson canon. corr. LM statistic	84.235***	89.216***	84.235***	89.216***
Cragg-Donald Wald F statistic	28.299	30.021	28.299	30.021
Stock-Yogo weak ID test	13.91	13.91	13.91	13.91
Adj. R-squared	0.7411	0.7411	0.7183	0.7185

Notes: This table presents the 2SLS results from regressing carbon performance measures (*CPEMS* and *EMSREV*) on board gender diversity (*BGEND* and *BLAUIX*) variables. The industry-level mean values of *BGEND* variables, the ratio of female to male labor participation rate, and the employment-to-population ratio are used as instruments. Robust *z-statistics* below estimated coefficients are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Source: Table by authors.

Table 7. Heckman selection model

Panel A: Quota countries				
	(1)	**(2)**	**(3)**	**(4)**
	CPEMS	**CPEMS**	**EMSREV**	**EMSREV**
BGEND	-0.0147***		-0.0004***	
	(-3.32)		(-2.65)	
BLAUIX		-1.3145***		-0.0380**
		(-3.12)		(-2.39)
Controls	Included	Included	Included	Included
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	1940	1940	1940	1940
Wald chi2	0.000***	0.000***	0.000***	0.000***
Panel B: CGCODE countries				
	(1)	**(2)**	**(3)**	**(4)**
	CPEMS	**CPEMS**	**EMSREV**	**EMSREV**
BGEND	0.0037		0.0002	
	(1.19)		(1.31)	
BLAUIX		0.2530		0.0096
		(0.83)		(0.84)
Controls	Included	Included	Included	Included
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	3164	3164	3164	3164
Wald chi2	0.000***	0.000***	0.000***	0.000***

Notes: This table presents the two-stage Heckman selection results from regressing carbon performance measures (*CPEMS* and *EMSREV*) on board gender diversity (*BGEND* and *BLAUIX*) variables. Robust *z-statistics* below estimated coefficients are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Source: Table by authors.

Table 8. Propensity score matching (PSM)

Panel A: Quota countries				
	(1)	(2)	(3)	(4)
	CPEMS	CPEMS	EMSREV	EMSREV
BGEND	-0.0196***		-0.0007***	
	(-2.68)		(-2.78)	
BLAUIX		-1.5271***		-0.0550***
		(-2.98)		(-2.97)
Controls	Included	Included	Included	Included
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	605	605	605	605
Adj. R-squared	0.6970	0.6981	0.6648	0.6656
Panel B: CGCODE countries				
	(1)	(2)	(3)	(4)
	CPEMS	CPEMS	EMSREV	EMSREV
BGEND	0.0072		0.0002	
	(1.35)		(0.77)	
BLAUIX		0.5157		0.0096
		(1.33)		(0.68)
Controls	Included	Included	Included	Included
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	969	969	969	969
Adj. R-squared	0.7391	0.7391	0.7295	0.7295

Notes: This table presents the PSM results from regressing carbon performance measures (*CPEMS* and *EMSREV*) on board gender diversity (*BGEND* and *BLAUIX*) variables. Robust *z-statistics* below estimated coefficients are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Source: Table by authors.

Table 9. Difference in differences analysis (DID)

	(1) CPEMS	(2) CPEMS
FDPRES	-0.6758***	-0.0051
	(-2.98)	(-0.04)
QPOST	-0.2856	
	(-1.00)	
FDPRES*QPOST	-0.7450*	
	(-1.72)	
GPOST		0.4373**
		(2.11)
FDPRES*GPOST		-0.2634
		(-1.19)
Controls	Included	Included
Year FE	Yes	Yes
Industry FE	Yes	Yes
Country FE	Yes	Yes
Observations	494	870
Adj. R-squared	0.6300	0.7324

Notes: This table presents the results from the DID analysis for the quota (countries with quota laws) and governance code (countries with corporate governance codes) subsamples. The control group is constructed for treated firms (firm-years without female directors and firm-years with female directors) based on the nearest-neighbor approach. Robust *t-statistics* below estimated coefficients are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Source: Table by authors.

Table 10. Board gender diversity, carbon performance and policy on board gender diversity in ETS and non-ETS countries

Panel A: ETS countries				
	(1)	**(2)**	**(3)**	**(4)**
	CPEMS	**CPEMS**	**EMSREV**	**EMSREV**
BGEND	-0.0117***		-0.0004***	
	(-4.78)		(-4.60)	
BLAUIX		-1.0367***		-0.0387***
		(-5.24)		(-5.24)
PBGEN				-0.0115***
				(-4.88)
Controls	Included	Included	Included	Included
Year/Industry/Country FE	Yes	Yes	Yes	Yes
Observations	3983	3983	3983	3983
Adj. R-squared	0.7093	0.7097	0.6556	0.6581
Panel B: non–ETS countries				
	(1)	**(2)**	**(3)**	**(4)**
	CPEMS	**CPEMS**	**EMSREV**	**EMSREV**
BGEND	0.0143***		0.0005***	
	(3.32)		(3.32)	
BLAUIX		1.1347***		0.0410***
		(3.22)		(3.16)
Controls	Included	Included	Included	Included
Year/Industry/Country FE	Yes	Yes	Yes	Yes
Observations	1121	1121	1121	1121
Adj. R-squared	0.7250	0.7251	0.7396	0.7395
Panel C: Moderation analysis				
	(1)	**(2)**	**(3)**	**(4)**
	CPEMS	**CPEMS**	**EMSREV**	**EMSREV**
BGEND	0.0029		0.0000	
	(1.05)		(0.42)	
ETS	-0.5495***	-0.6112***	-0.0268***	-0.0286***
	(-5.96)	(-6.87)	(-7.83)	(-8.63)
BGEND*ETS	-0.0189***		-0.0005***	
	(-4.68)		(-3.47)	
BLAUIX*ETS		-1.6372***		-0.0438***
		(-4.57)		(-3.37)
Controls	Included	Included	Included	Included
Year/Industry/Country FE	Yes	Yes	Yes	Yes
Observations	5104	5104	5104	5104
Adj. R-squared	0.7017	0.7019	0.6740	0.6741

Notes: This table presents the results from regressing carbon performance measures (*CPEMS* and *EMSREV*) on board gender diversity (*BGEND* and *BLAUIX*) variables for ETS and non–ETS countries. Panel A presents the results for ETS countries. Panel B presents the results for non–ETS countries. Panel C presents the results from the moderation analyses. Robust *t-statistics* below estimated coefficients are shown in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.
Source: Table by authors.

Appendix 1. Sample breakdown

Panel A: Sample breakdown by country				
Country	**Firms(n)**	**Obs.(n)**	**Percent (%)**	**Cum.%**
Australia	26	426	8.35	8.35
Austria	2	32	0.63	8.97
Belgium	6	105	2.06	11.03
Denmark	10	184	3.61	14.64
Finland	9	155	3.04	17.67
France	27	444	8.70	26.37
Germany	28	466	9.13	35.50
Greece	3	52	1.02	36.52
Hong Kong	8	118	2.31	38.83
India	5	65	1.27	40.11
Ireland	6	99	1.94	42.05
Italy	12	212	4.15	46.20
Luxembourg	2	34	0.67	46.87
Malaysia	2	23	0.45	47.32
Mexico	4	57	1.12	48.43
Netherlands	13	230	4.51	52.94
Norway	6	99	1.94	54.88
Portugal	2	31	0.61	55.49
Singapore	2	33	0.65	56.13
South Africa	7	86	1.68	57.82
Spain	15	256	5.02	62.83
Sweden	20	335	6.56	69.40
Switzerland	15	275	5.39	74.78
Taiwan	1	12	0.24	75.02
Thailand	2	26	0.51	75.53
Turkey	2	20	0.39	75.92
United Kingdom	72	1229	24.08	100.00
Full sample	**307**	**5104**	**100.00**	

Panel B: Sample breakdown by industry				
Industry	**Firms(n)**	**Obs.(n)**	**Percent (%)**	**Cum.%**
Communication Services	22	380	7.45	7.45
Consumer Discretionary	32	529	10.36	17.81
Consumer Staples	24	378	7.41	25.22
Energy	23	377	7.39	32.60
Health Care	19	344	6.74	39.34
Industrials	73	1236	24.22	63.56
Information Technology	10	170	3.33	66.89
Materials	62	992	19.44	86.32
Real Estate	19	326	6.39	92.71
Utilities	23	372	7.29	100.00
Full sample	**307**	**5104**	**100.00**	

Source: Table by authors.

Appendix 2. Variable definitions

Name	Symbol	Description
Dependent variable		
Carbon performance by emissions	*CPEMS*	Natural logarithm of total carbon emissions in tonnes
Carbon intensity	*EMSREV*	Carbon emissions scaled by total revenues
Gender diversity variables		
Board gender diversity	*BGEND*	Percentage of female directors on the board
BLAU Index	*BLAUIX*	$BLAUIX = 1 - \sum_{i=1}^{2} p_i^2$ i represents the gender categories (male and female) and p represents the proportion of each gender category
Corporate governance variables		
Board size	*BSIZE*	Natural logarithm of total directors on the board
Board independence	*BINDP*	Percentage of independent directors on the board
Corporate governance committee	*CGCOM*	A binary variable that is equal to one if the board has a corporate governance committee and zero otherwise
CSR committee	*CSCOM*	A binary variable that is equal to one if the board has a CSR/sustainability committee and zero otherwise
Firm-specific control variables		
CSR performance	*CSRPR*	Environmental, social, and governance performance
Firm size	*FSIZE*	Natural logarithm of market capitalization
Profitability	*FPROF*	Net earnings after tax divided by total assets
Leverage	*LEVRG*	Total debts divided by total assets
Slack	*SLACK*	Cash and cash equivalents divided by total assets
Capital intensity	*CAPIN*	Property, plant, and equipment divided by total assets
Country-specific control variables		
Shareholder-based countries	*SHARE*	A binary variable that is equal to one if firm-years belong to shareholder-based countries and zero if firm-years belong to stakeholder-based countries.
National governance quality	*NGVQL*	The composite NGVQL score is calculated based on the World Governance Indicators.
GDP growth	*GDPGR*	Annual percentage change in the real GDP
Inflation rate	*INFLN*	Annual percentage change in inflation rates

Source: Table by authors.

Appendix 3. Board gender diversity reforms around the world

Country	Quota laws		Corporate governance codes	
	Adopted	Target	Adopted/updated	Names
Australia	No	—	2010	ASX CG Council Principles and Recommendations
			2015	Workplace Gender Equality Act
Austria	2017	30%	2009	Country CG Code
Belgium	2011	33%	2008	Country CG Code
Denmark	No	—	2010	Country CG Code
Finland	No	—	2008	Country CG Code
France	2011	40%	2010	Country CG Code
Germany	2015	30%	2019	Country CG Code
Greece	2021	25%	2013	Country CG Code
Hong Kong	No	—	2013	Country CG Code
India	2012	One FD	2018	Country CG Guidelines
Ireland	No	—	2010	Country CG Code
Italy	2011	33%	2019	Country CG Code
Luxembourg	No	—	2017	Country CG Code
Malaysia	No	—	2012	Country CG Code
Mexico	No	—	2018	Business Council's Code of Best Practices of CG
Netherlands	2011	30%	2008	Country CG Code
Norway	2003	40%	2007	Country CG Code
Portugal	2017	33%	2011	Country CG Code
Singapore	No	—	2012	Country CG Code
South Africa	No	—	2009	Country CG Code
Spain	2007	40%	2006	Country CG Code
Sweden	No	—	2005	Country CG Code
Switzerland	2021	30%	2015	Country CG Code
Taiwan	No	—	2013	Country CG Code
Thailand	No	—	2017	Country CG Code
Turkey	No	—	2012	Country CG Code
United Kingdom	No	—	2012	Country CG Code

Notes: One FD indicates one female director, and CG indicates corporate governance. Sources: (Deloitte, 2022; Ferrari *et al.*, 2021; Mensi-Klarbach and Seierstad, 2020; Poletti-Hughes and Dimungu-Hewage, 2022; Terjesen and Sealy, 2016).

Appendix 4. Diagnostic test

Variable	Treated	Control	t-test	p-value
BSIZE	2.353	2.346	0.370	0.708
BINDP	45.201	45.860	-0.450	0.655
CGCOM	0.189	0.191	-0.060	0.949
CSCOM	0.534	0.539	-0.200	0.840
CSRPR	52.331	52.316	0.020	0.986
FSIZE	22.668	22.655	0.200	0.843
FPROF	5.639	5.598	0.130	0.899
LEVRG	25.604	25.888	-0.400	0.688
SLACK	0.053	0.055	-0.660	0.508
CAPIN	0.307	0.309	-0.110	0.911
SHARE	0.399	0.393	0.260	0.797
NGVQL	-0.355	-0.290	-0.490	0.623
GDPGR	1.570	1.691	-0.860	0.391
INFLN	2.162	2.176	-0.160	0.876

Notes: This table reports the results from the diagnostic test. The mean values of the firm-level factors are shown for the treated and control groups. The t-tests and p-values are reported in the last two columns.

Source: Table by authors.