Sustainable Development

WILEY

Sustainable Development

RESEARCH ARTICLE OPEN ACCESS

Women in the C-Suite and Carbon Mitigation Actions: Understanding the Impact of the Disruptive Shocks From the COVID19 Pandemic and the Ukraine War

Isabel-María García-Sánchez[1] | Cristina Aibar-Guzmán[2] | Nazim Hussain[3,4] | Beatriz Aibar-Guzmán[2]

[1]Instituto Multidisciplinar de Empresa, Universidad de Salamanca, Salamanca, Spain | [2]Facultad de Ciencias Económicas y Empresariales, Universidad de Santiago Compostela, Santiago Compostela, Spain | [3]Faculty of Economics and Business, University of Groningen. Universiteitscomplex, Groningen, the Netherlands | [4]International School, Vietnam National University, Hanoi, Vietnam

Correspondence: Isabel-María García-Sánchez (lajefa@usal.es)

Received: 21 March 2025 | **Revised:** 16 May 2025 | **Accepted:** 17 May 2025

Funding: Open access publishing facilitated by Universidad de Salamanca, as part of the Crue Spanish Universities-CSIC Alliance.

Keywords: carbon reduction | COVID19 | disruptive shocks | gender diversity | top management teams | ukraine invasion

ABSTRACT

Achieving carbon neutrality by 2050 requires the implementation of ambitious policies and initiatives to reduce carbon emissions at the corporate level, which typically requires strong commitment from the top management team. This study examines to what extent greater female representation on top management teams leads to the development of a more advanced and integrated carbon reduction strategy, and how the context of crisis and uncertainty arising from the COVID19 and the Russia–Ukraine war may affect this relationship. Based on an index that measures the level of development of carbon mitigation actions, the findings, based on panel data from 3,212 multinational firms from 2013 to 2022, confirm the driving role of gender diversity in the C-suite in the process of corporate decarbonization, especially in the timeframe leading up to the disruptive period 2020–2022. The results are robust to alternative methodological choices, confirming their research and practical implications.

1 | Introduction

Our time is grappling with the significant challenge of climate change, which has wide-ranging environmental, economic, and social consequences (Aibar-Guzmán et al. 2024; García-Sánchez, Aibar-Guzmán, et al. 2025). Despite the various initiatives developed around the world (Allam et al. 2022), the COP28 "first global stocktake" of global efforts to address the climate emergency recognizes that progress on all fronts has been slow and calls for more action. Tackling climate change will require a fundamental shift in current patterns of production and consumption (Markard and Rosenbloom 2020). Businesses in almost all sectors are not only one of the main contributors to climate change (García-Sánchez, Monteiro, et al. 2023), but their activities and performance are also significantly affected by it (Aliani 2023). Consequently, there is increasing pressure on them to reduce their carbon emissions (Leffel et al. 2024). Therefore, initiatives to reduce carbon emissions have become an essential element of business strategies (García-Sánchez et al. 2022; Aibar-Guzmán et al. 2024; García-Sánchez, Aibar-Guzmán, et al. 2024; García-Sánchez, Núñez-Torrado, et al. 2025).

Perceptions of climate change depend on individual psychological characteristics, including risk awareness, knowledge, and concern about climate change (Matiiuk et al. 2023). Demographic characteristics of decision makers affect business decisions by influencing perceptions of strategic risks and opportunities (Horbach and Jacob 2018). In particular, there are gender differences in attitudes towards the environment (Enciso-Alfaro and García-Sánchez 2024). Studies have shown that women worry more than men about climate change (Carlsson-Kanyama et al. 2010; Ali Gull et al. 2023) and are more supportive of

policies that aim to curb carbon emissions (Zahran et al. 2006). In this regard, the positive impact of gender diversity (GD) on companies' proactive climate change behavior has been extensively documented in the literature (Barg et al. 2024; García-Sánchez, Núñez-Torrado, et al. 2025). However, the focus of most studies has been on GD on the boardroom, and few have examined GD at the executive level (Chiao et al. 2025; Caby et al. 2022). Although the board defines a firm's environmental posture, many strategic decisions regarding environmental performance are made by the top management team (TMT) (Shahab et al. 2018; Liu et al. 2024). Thus, research on this subject is lacking, creating a significant gap in the existing body of knowledge (Chen et al. 2023; Haque et al. 2024).

Besides climate change, two recent shocks (the COVID19 and the Russia-Ukraine war) have had a strong knock-on effect on the global economy, affecting business activities worldwide and suggesting the need to adjust their sustainability strategies (García-Sánchez, Aibar-Guzmán, et al. 2024; García-Sánchez, Piñeiro-Chousa, et al. 2024). In this sense, there are two opposing positions (Mišík and Nosko 2023; Läger et al. 2025). Some authors take a pessimistic view, arguing that both shocks may represent a setback and delay the environmental transition (Gaind et al. 2022), while others claim that they may have a catalytic effect on achieving a decarbonized economy (Liobikienė et al. 2023). However, as Mattera and Soto (2022) point out, there is little understanding of how proactive environmental strategies work in complex and uncertain environments such as those arising from the COVID19 pandemic and the Russia-Ukraine war (RUW). Additionally, there is limited knowledge regarding how such contexts affect the dynamics of TMTs when implementing carbon reduction initiatives as part of corporate strategies.

Under these premises, this research has two main objectives. The first is to extend existing knowledge on the effect of GD on firms' carbon mitigation actions beyond the boardroom by examining the effect of GD in the C-suite on these actions, and the second is to analyze whether this effect is influenced by the uncertainty stemming from the COVID19 and RUW. In short, we intend to address two key questions: (1) Does GD in TMTs lead to the development of a more advanced and integrated carbon reduction strategy? and (2) Is the influence of GD in TMTs on carbon reduction initiatives affected by these recent disruptive shocks?

Based on an indicator that measures the level of development of corporate carbon mitigation actions during the period 2013–2022, the findings from a sample of 3212 companies (20,642 observations) support the role of GD in TMTs as a driving force in the corporate decarbonization process, except for those TMTs with more than 70% women managers, which represent a setback in corporate commitment to climate change. Moreover, the positive effect of GD in TMTs on corporate carbon reduction strategies is stronger in periods of stability than in the years of crisis and uncertainty associated with COVID19 and RUW (2020–2022), when there is an uncertainty-reducing effect associated with TMTs configured with a female presence of less than 20%.

Thus, we deviate from prior research focusing on GD in boards and thus seek to address a void in the existing knowledge, given the paucity of studies analyzing the impact of GD in TMTs on carbon reduction strategies and actions (Shahab et al. 2018; Altunbas et al. 2022). Moreover, as far as we know, no research has yet investigated the effect of both disruptive shocks on this relationship. Therefore, we are responding to the demand for more research on this topic (Saeed et al. 2022). Understanding how GD affects TMT dynamics is important because top managers can select and implement strategies related to environmental performance (Chiao et al. 2025; Roush et al. 2025). Empirically, we show that more gender diverse TMTs are more prepared and inclined to address environmental challenges, adding to the existing knowledge on the link between GD and climate change.

Moreover, we shed light on the conditions that strengthen or weaken the influence of women executives on environmental proactivity. We further explore the role of women managers in firms' decarbonization, showing that it depends on the proportion of women managers in the TMT and on contextual factors (the crisis context stemming from the COVID19 and RUW). Theoretically, we combine different theories with complementary postulates to account for the influence of GD on firms' environmental proactivity from a contingent perspective (García-Sánchez, Núñez-Torrado, et al. 2025; Roush et al. 2025). Methodologically, we enrich the existing literature by proposing an index that measures the level of development and implementation of carbon reduction strategies by companies. Finally, the breadth of the sample and the novelty of the data must be highlighted.

Following this introduction, the theoretical framework is outlined in the second section, along with a review of prior literature and the development of research hypotheses. The empirical framework is described in the third section. The main and complementary findings are reported in the fourth section, and their implications are discussed in the fifth section. Finally, the study's main conclusions are drawn in the last section.

2 | Theoretical Framework and Hypothesis Development

2.1 | Theoretical Framework

As García-Sánchez, Monteiro, et al. (2023) and García-Sánchez, Núñez-Torrado, et al. (2025) noted, the link between GD and firms' development of proactive environmental strategies transcends the scope of a single theory. Therefore, to account for the impact of GD in TMTs on the development of carbon reduction strategies, we draw on the Upper Echelons Theory (UET) and the Social Role Theory (SRT). Furthermore, we rely on contingency theory to examine how disruptive shocks impact such a relationship.

UET is the main theory used to analyze the link between TMT composition and firms' strategic decisions (Roberson et al. 2017; Liu et al. 2024). According to this theory, top managers' decisions are influenced by how they interpret reality, which in turn depends on their cognitive and demographic characteristics (Hambrick and Mason 1984). Among these attributes, gender leads to differences in the values and expertise of TMT members, influencing their risk-taking behavior and management

style (Mungai et al. 2020). Furthermore, women and men managers often have different backgrounds and work experiences (Konadu et al. 2022). From the standpoint of UET, women leaders integrate these considerations into their leadership style (Eagly et al. 2012; Liu et al. 2024). As a result, the composition of the TMT determines the strategic direction of the firm (Hambrick et al. 2015; Richard et al. 2019; García-Sánchez et al. 2023).

SRT suggests that women are generally more caring, compassionate, and empathetic than men, in accordance with socially ascribed gender roles (Eagly 1987). Thus, in line with their socially ascribed roles, women tend to be more altruistic and ethical (Atif et al. 2021). Furthermore, risk-taking behavior also differs between genders, with women having a higher risk awareness (Monteiro et al. 2022; Ali Gull et al. 2023). These attributes are transferred to women's behavior both in the private sphere and at work (Ciocirlan and Pettersson 2012) by influencing organizational dynamics.

According to contingency theory, firm performance depends on the extent to which organizational structure and business strategies fit the firm's external environment (Donaldson 2001). It posits that firms must adapt their structure and strategies to the changing environment (Tosi Jr. and Slocum Jr. 1984). Research on the link between firm performance and TMT diversity has relied on this theoretical framework to examine how external contingencies affect such a relationship (Roberson et al. 2017). In this sense, environmental complexity was shown to positively moderate the effect of TMT age diversity on firms' performance (Richard and Shelor 2002).

2.2 | Hypothesis Development

2.2.1 | Gender Diversity in TMTs and Carbon Mitigation Actions

Global warming associated with climate change not only causes severe and irreversible damage to biodiversity and ecosystems, leading to extreme and increasingly frequent natural disasters, but also has a negative effect on the global economy and on the well-being of people (García-Sánchez, Aibar-Guzmán, et al. 2024, 2025). At the same time, proactively addressing climate change allows companies to reduce risk and achieve higher performance (Aibar-Guzmán et al. 2024). Accordingly, it would be expected that women executives would be more likely to want to take action to mitigate climate change (Haque et al. 2024; García-Sánchez, Núñez-Torrado, et al. 2025).

From an SRT perspective, the fact that women executives are more involved in environmental matters is based on natural gender differences (Saeed et al. 2022; Roush et al. 2025). Due to the characteristics of women, they are more worried about ethical and environmental problems (Liu et al. 2024), and consequently, women executives are more inclined to endorse climate change mitigation initiatives than their male counterparts (Haque et al. 2024). Similarly, given the complexity that the implementation of initiatives related to climate change mitigation usually entails due to the greater conflict of interests between different stakeholders (Haque and Ntim 2020), GD in TMTs can lead to decisions that promote decarbonization and balance the needs of stakeholders in this regard (Altunbas et al. 2022; Roush et al. 2025). Moreover, from the perspective of UET, the "feminine leadership style" (Horbach and Jacob 2018) makes women executives more sensitive to stakeholder demands and more climate-conscious than their male peers (Altunbas et al. 2022; Barg et al. 2024). Thus, GD in TMTs will bring women's distinctive leadership styles to the team's decision-making process, resulting in better responsiveness to environmental and social issues (Haque et al. 2024; Chiao et al. 2025).

Most previous empirical works on the link between GD and firms' environmental proactivity have provided evidence of a positive impact of GD, although most of them are related to GD on boards (Galletta et al. 2022; Barg et al. 2024; García-Sánchez, Núñez-Torrado, et al. 2025). Similarly, previous empirical evidence supports a positive link between GD on boards and climate change mitigation initiatives (García-Sánchez, Monteiro, et al. 2023; Haque et al. 2024) and carbon emission reduction (Konadu et al. 2022; Haque et al. 2024). For TMTs, the few available studies also document a positive relationship between GD and environmental strategies (Shahab et al. 2018; Mungai et al. 2020; Rehman et al. 2020; Saeed et al. 2022; Chiao et al. 2025). In terms of climate change strategies, Altunbas et al. (2022) show that GD in TMTs is conducive to reducing carbon emissions, while Caby et al. (2024) find that the participation of women in the top operational management of technology businesses has a positive impact on the extent and quality of carbon disclosure, although in the case of TMTs, the presence of women needs to reach 30% to have such a positive impact. Using a sample of European quoted companies, Haque et al. (2024) document that GD in TMT positively affects both carbon management performance and carbon emissions performance, reinforcing the positive impact of gender diverse boards on firms' carbon mitigation efforts. Likewise, Roush et al. (2025) show that increasing the proportion of women in TMTs is related to a reduction in both the volume and toxicity of US firms' emissions.

In light of these arguments, we anticipate that GD in TMTs will favor the implementation of actions aimed at promoting carbon mitigation, and thus we propose the following hypothesis:

H1. *The presence of women in TMTs is positively related to the implementation of carbon mitigation actions.*

2.2.2 | The Effect of Disruptive Shocks on the Relationship Between Gender Diversity in TMTs and Carbon Mitigation Actions

In recent years, the climate emergency has coexisted with two disruptive shocks that have had a profound effect on the world economy, introducing new layers of uncertainty and complexity into the business environment (García-Sánchez, Piñeiro-Chousa, et al. 2024; Läger et al. 2025) and altering established business models and strategies (Su and Junge 2023; Nguyen et al. 2024). Both crises have challenged the transition to sustainability needed to address climate change (Allam et al. 2022). However, given the pessimistic view that the need to respond to

the economic and social consequences of both shocks may delay the environmental transition (Gaind et al. 2022), there are several authors who defend a catalytic effect in the transition to a decarbonized economy (Liobikienė et al. 2023).

This body of literature argues that transitions are more frequent to occur when existing systems are disrupted by external shocks and new options become possible (Markard and Rosenbloom 2020). In this sense, Aragón-Correa et al. (2025) note that disruptive events can focus the interest of firm managers on environmental issues, thereby resulting in changes in corporate environmental practices. Thus, responses to both shocks can foster eco-innovation and digital transformation (Bibri et al. 2022) and hasten the end of carbon-intensive production and business patterns (Markard and Rosenbloom 2020). For example, the COVID19 pandemic significantly affected energy consumption (Jiang et al. 2021) and promoted pro-environmental attitudes (Zebardast and Radaei 2022) and climate change innovation (García-Sánchez, Monteiro, et al. 2023). It also reinforced the benefits that companies can derive from carbon reduction strategies (Läger et al. 2025). Regarding the war between Russia and Ukraine, Liobikienė et al. (2023) show that it has had a positive impact on energy saving attitudes. It has also led to changes in energy policy in search of energy efficiency and clean energy sources (Mišík and Nosko 2023).

Therefore, we expect that both disruptive shocks will favor the adoption of carbon mitigation actions, and thus we propose the following hypothesis:

H2. *The COVID19 and RUW positively affect the implementation of carbon mitigation actions.*

According to Lu et al. (2023), the business environment not only affects organizational performance, but also moderates the effect of internal organizational factors on it. In this sense, the effect of the TMT's demographic structure on organizational performance has been shown to be influenced by the context in which the TMT has to make decisions (Richard et al. 2019; Liu et al. 2024). Research in this field has taken a contingency perspective, examining how contextual factors influence the direction and/or magnitude of the link between TMT diversity and firm performance (Roberson et al. 2017). For example, in complex and uncertain situations where more information processing is required from the TMT, the benefits of greater TMT diversity would be greater because it would increase the cognitive base of the TMT (Chen et al. 2023). In particular, GD brings new backgrounds, values, and sensitivities to the TMT (Liu et al. 2024; Roush et al. 2025).

From the perspective of SRT and UET, the distinctive characteristics of women leaders may make them more qualified to manage crises (Papangkorn et al. 2021). Along these lines, Francoeur et al. (2008) uncovered that companies that operate in complex environments and with greater GD in TMT generate positive monthly abnormal returns. Therefore, it is reasonable to expect that the impact of women executives on TMT decisions will be higher in the context of crisis and uncertainty stemming from the COVID19 and RUW. However, Konadu et al. (2022) analyzed the effect of board GD on carbon emission reduction before and after the 2007 world financial crisis and found that this effect was greater during periods of economic financial stability.

Accordingly, we expect both disruptive shocks to moderate the effect of GD in the TMT on the development of carbon mitigation practices, but we do not predict the sign of this moderating effect.

H3. *The COVID19 and RUW moderate the effect of GD in the TMT on the implementation of carbon mitigation actions.*

Figure 1 illustrates the hypothesized relationships.

3 | Methodology

3.1 | Sample

The selection of the population for the estimation of the empirical models was made based on the world's most important corporations. There are several reasons for this choice. According to Aibar-Guzmán et al. (2023, 2024), from an economic point of view, these companies' scale and activities determine their high environmental impact, and it is of great interest to know what commitments and actions they are implementing to achieve the desired decarbonization. In addition, their greater resources and capabilities allow them to be the most proactive companies in terms of sustainability. From a scientific perspective, the availability of their economic-financial and ESG information in databases allows a dynamic study of their actions.

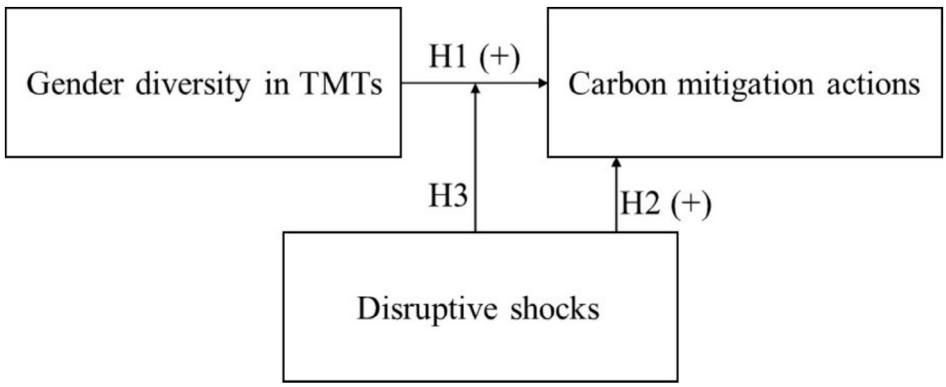

FIGURE 1 | Research model.

In this sense, we decided to use the Refinitiv database, which contains data on more than 15,000 companies from 76 different countries. The initial search for the last decade under study, from 2013 to 2022, provided us with 61,549 observations on 8905 companies. However, the availability of information for all the variables that configure our empirical models configured a sample of 20,642 observations on 3212 companies whose parent company is located in 42 different countries.

3.2 | Variables

The dependent variable (CO2Abatement) has been designed as a score ranging from 0 to 8 to denote the degree of development of the carbon abatement actions that a company has implemented. Contrary to the usual approach of measuring the company's commitment in terms of emissions or energy consumption, the score designed considers the existence of different programs aimed at promoting the decarbonization of the company, which involves the implementation of different initiatives in the different departments of the company.

More specifically, these actions are related to (i) investments in buildings to reduce emissions; (ii) the existence of certified green buildings; (iii) the existence of an energy efficiency policy with defined targets in terms of time and form; (iv) the use of clean and renewable energies; (v) investments in clean technologies and other technological solutions; (vi) the development of innovation projects focused on the creation of new low-carbon products; (vii) the implementation of programs to reduce emissions in transportation and distribution; and (viii) the existence of other initiatives to promote sustainable mobility.

Figure 2 shows the frequencies for the values of the CO2Abatement score (Panel A) and each of the items used to create this variable (Panel B). It is evident that the majority of firms have implemented only one of the carbon abatement initiatives, which corresponds mainly to the development of innovation projects focused on the creation of new low-carbon products and, to a lesser degree, the use of renewable energy.

The independent variable (WCsuite) is the percentage of women in the TMT. Following García-Sánchez, Aibar-Guzmán, et al. (2024, 2025), and García-Sánchez, Núñez-Torrado, et al. (2025), DisruptiveTimes assumes the value of 1 for the 2020–2022 period; otherwise, it assumes 0. Its decomposition in Equation (2) into COVID19, post-COVID19, and UkraineWar involves splitting this period for 2020, 2021, and 2022, respectively.

The control variables allow correcting the bias of the results by representing the capabilities and resources of a company through its size (Size), leverage (Leverage), profitability (ROA), working capital (WorkCap), dividends (Dividend), and tangible and intangible investments (CAPEXInv, RDInv, ADvInv). Other determinants of corporate environmental proactivity are also included, including the existence of strategic investors in the shareholder base (StrInv) and the corporate governance effectiveness (GovScore). The institutional context is represented by the EU dummy for the period 2014–2022 and two ordinal variables for the country of origin and the industry of the firms. Table 1 provides a summary of the definitions and measures of each of the variables.

3.3 | Models

The empirical models are reflected in Equations (1) and (2). Equation (1) enables us to test hypotheses about the influence of women's presence in the TMT (H1) and the period of uncertainty since 2019 (H2) on the development level of carbon mitigation practices by companies. The effects will be confirmed for $\beta_1 > 0$ and $\beta_2 > 0$. The value and significance of β_3 will allow us to determine whether the effect of GD in the TMT on the level of development of carbon mitigation practices is stronger in the period of uncertainty and economic instability.

$$\begin{aligned}\mathbf{CO2Abatment_{i,t}} = {} & \beta_0 + \boldsymbol{\beta_1}\mathbf{WCsuite_{i,t}} + \boldsymbol{\beta_2}\mathbf{UncertainTimes_{i,t}} \\ & + \boldsymbol{\beta_3}\mathbf{WCsuite} * \mathbf{DisruptiveTimes_{i,t}} + \beta_4 \mathrm{logSize}_{i,t} \\ & + \beta_5 \mathrm{Leverage}_{i,t} + \beta_6 \mathrm{ROA}_{i,t} + \beta_7 \mathrm{WorkCap}_{i,t} \\ & + \beta_8 \mathrm{Dividend}_{i,t} + \beta_9 \mathrm{CAPEXInv}_{i,t} + \beta_{10} \mathrm{RDInv}_{i,t} \\ & + \beta_{11} \mathrm{AdvInv}_{i,t} + \beta_{12} \mathrm{StrInv}_{i,t} + \beta_{13} \mathrm{GovScore}_{i,t} \\ & + \beta_{14} \mathrm{EU}_{i,t} + \beta_{15} \mathrm{Country}_i + \beta_{16} \mathrm{Industry}_i \\ & + \beta_{17} \mathrm{Year}_t + \varepsilon_{it} + \eta_i \end{aligned} \tag{1}$$

The estimation results of Equation (2) will allow us to know in more depth the impact and moderating effect of the different shocks, which have been grouped as disruptive events related to the emergence of the COVID19 pandemic in 2020, post-COVID19 period, and the beginning of the RUW. Thus, the impact of these individual events will be confirmed for $\delta_2 > 0$,

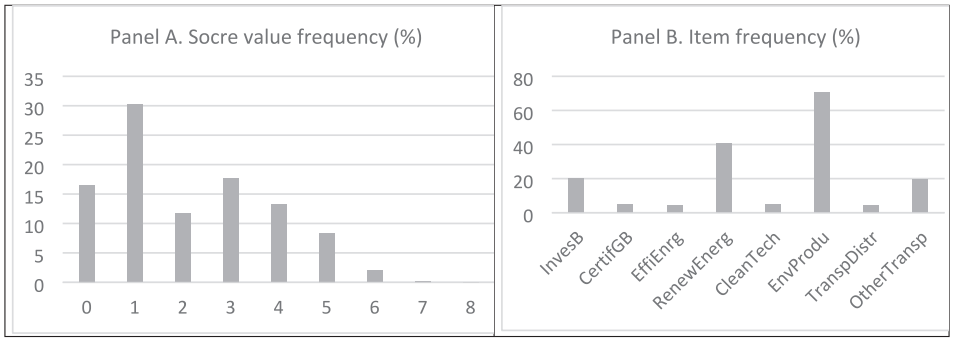

FIGURE 2 | CO2Abatement Score.

TABLE 1 | Variables.

Variable	Metric	Mean freq.	Std.Dv.
CO2Abatment	Score that measures the extent to which carbon abatement practices have been developed (values range from 0 to 8)	3.06	1.60
WCsuite	Percentage of female managers on TMT	27.51	15.37
DisruptiveTimes	Dummy that takes the value of 1 for the years 2020, 2021, and 2022	43.97%	
COVID19	Dummy that takes the value of 1 for the year 2020	15.56%	
postCOVID19	Dummy that takes the value of 1 for the year 2021	15.46%	
UkraineWar	Dummy that takes the value of 1 for the year 2022	12.94%	
Size	Total assets (logarithm)	22.73	1.97
Leverage	Ratio of debt level	0.18	0.16
ROA	Ratio of net income to total assets	0.07	0.11
WorkCap	Short term liquidity ratio	1.14	5.63
Dividend	Dividend distributed in the year	1.15	3.57
CAPEXInv	Annual monetary amount of capital investments	0.30	0.51
RDInv	Annual monetary amount of R&D investments	0.29	0.12
AdvInv	Annual monetary amount of advertisement spending	0.19	0.02
StrInv	Percentage of share of strategic investors	1.03	9.46
GovScore	Governance Score of ESG metrics of Refinitiv	58.68	21.03
EU	Dichotomous variable reflecting European Union member states' environmental and sustainable initiatives since 2014	23.23%	

$б_3 > 0$, and $б_4 > 0$, while the б of the three interactions ($б_5$, $б_6$, and $б_7$) will indicate whether the commitment of women top managers to climate neutrality was strengthened in these periods.

$$\begin{aligned}\mathbf{CO2Abatment_{i,t}} = {} & б_0 + б_1\mathbf{WCsuite_{i,t}} + б_2\mathbf{COVID19_{i,t}} \\ & + б_3\mathbf{postCOVID19_{i,t}} + б_4\mathbf{UkraineWar_{i,t}} \\ & + б_5\mathbf{WCsuite} * \mathbf{COVID19_{i,t}} \\ & + б_6\mathbf{WCsuite} * \mathbf{postCOVID19_{i,t}} \\ & + б_7\mathbf{WCsuite} * \mathbf{UkraineWar_{i,t}} \\ & + б_8 \text{logSize}_{i,t} + б_9 \text{Leverage}_{i,t} + б_{10} \text{ROA}_{i,t} \\ & + б_{11} \text{WorkCap}_{i,t} + б_{12} \text{Dividend}_{i,t} \\ & + б_{13} \text{CAPEXInv}_{i,t} + б_{14} \text{RDInv}_{i,t} \\ & + б_{15} \text{AdvInv}_{i,t} + б_{16} \text{StrInv}_{i,t} + б_{17} \text{GovScore}_{i,t} \\ & + б_{18} \text{EU}_{i,t} + \ б_{19} \text{Country}_i + б_{20} \text{Industry}_i \\ & + б_{21} \text{Year}_t + \varepsilon_{it} + \eta_i \end{aligned} \tag{2}$$

Tobit regressions for panel data are used to estimate both equations, taking into account the dependent variable's (CO2Abatement) censored nature. This approach allows one to control for unobservable heterogeneity. Causality is avoided by instrumenting the independent variables with a time lag. Multicollinearity arising from the presence of interactions is corrected by employing centered variables. In addition, robust results are obtained using other methodological specifications, such as linear regressions with fixed and random effects.

4 | Empirical Evidence

4.1 | Descriptives

Table 2 shows descriptives for the variables categorized by geographical area and economic stability over time.

Table 3 displays the results of the Pearson correlation analysis. Note that no collinearity problems exist among the variables.

4.2 | Main Results

Table 4 shows the results of estimating Equations (1) and (2). Additionally, two initial models are presented: Equation (0), which omits the interactions to ensure that the results obtained for each variable are unaffected by their inclusion.

The effect of the variable WCsuite on the dependent variable CO2Abatment is positive and significant at the 99% confidence level in the four estimated models presented in Table 4. Focusing on Equation (1), the effect is $\beta_1 = 0.00907$ (p value = 0.000), which allows us to accept hypothesis H1 regarding the driving role of GD in TMTs in the comprehensive

TABLE 2 | Descriptives by geographic zone and economic time stability.

	CO2Abatement	WCsuite	Skewed TMT	Tilted TMT	MaleDominated TMT	Balanced TMT	FemaleDominated TMT
Estable Times	2.88	0.26	0.38	0.44	0.82	0.16	0.02
Disruptive Times	3.21	0.29	0.29	0.48	0.76	0.21	0.03
Argentina	2.54	0.25	0.45	0.40	0.85	0.12	0.03
Australia	1.88	0.32	0.25	0.46	0.70	0.24	0.06
Austria	3.41	0.23	0.50	0.34	0.84	0.16	0.00
Belgium	3.76	0.27	0.26	0.60	0.86	0.14	0.00
Brazil	3.08	0.28	0.30	0.53	0.82	0.14	0.03
Canada	2.78	0.31	0.22	0.51	0.74	0.23	0.03
Chile	2.86	0.21	0.51	0.45	0.96	0.04	0.00
China	2.39	0.24	0.38	0.51	0.89	0.09	0.02
Colombia	3.20	0.36	0.11	0.45	0.56	0.44	0.00
Denmark	2.89	0.28	0.26	0.56	0.82	0.17	0.01
Finland	3.67	0.31	0.29	0.39	0.68	0.29	0.04
France	4.08	0.34	0.14	0.52	0.66	0.31	0.03
Germany	3.73	0.24	0.42	0.48	0.91	0.09	0.01
Greece	3.00	0.27	0.34	0.47	0.81	0.19	0.00
Hong Kong	3.34	0.29	0.31	0.39	0.70	0.30	0.00
India	3.79	0.13	0.82	0.16	0.98	0.02	0.00
Indonesia	3.03	0.30	0.27	0.37	0.64	0.31	0.04
Ireland	3.38	0.27	0.27	0.60	0.87	0.10	0.02
Israel	3.00	0.36	0.31	0.15	0.46	0.54	0.00
Italy	3.58	0.28	0.31	0.49	0.80	0.18	0.02
Japan	3.03	0.10	0.87	0.12	0.99	0.01	0.00
Korea. Republic	3.11	0.15	0.72	0.23	0.95	0.04	0.00
Luxembourg	3.16	0.27	0.38	0.42	0.80	0.15	0.05
Malaysia	2.60	0.35	0.15	0.45	0.60	0.38	0.02
Mexico	2.97	0.27	0.37	0.40	0.77	0.23	0.00
Netherlands	3.77	0.25	0.32	0.60	0.92	0.08	0.00
New Zealand	2.32	0.36	0.10	0.55	0.64	0.30	0.05
Norway	2.31	0.29	0.16	0.65	0.81	0.19	0.00
Philippines	2.84	0.48	0.02	0.22	0.24	0.56	0.21
Poland	2.72	0.43	0.19	0.25	0.44	0.35	0.21
Portugal	3.75	0.35	0.13	0.55	0.68	0.21	0.11
Russia	2.24	0.26	0.26	0.61	0.88	0.11	0.02
Singapore	3.51	0.38	0.12	0.46	0.58	0.30	0.12
South Africa	2.71	0.33	0.20	0.49	0.69	0.23	0.08

(Continues)

TABLE 2 | (Continued)

	CO2Abatement	WCsuite	Skewed TMT	Tilted TMT	MaleDominated TMT	Balanced TMT	FemaleDominated TMT
Spain	3.85	0.30	0.21	0.58	0.79	0.20	0.01
Sweden	3.22	0.31	0.19	0.57	0.76	0.21	0.03
Switzerland	3.63	0.27	0.30	0.54	0.84	0.16	0.00
Taiwan	3.19	0.27	0.39	0.37	0.76	0.21	0.03
Thailand	2.84	0.41	0.04	0.43	0.47	0.47	0.05
Turkey	3.36	0.27	0.36	0.41	0.77	0.23	0.00
United Kingdom	2.83	0.27	0.28	0.58	0.86	0.13	0.01
United States	3.36	0.33	0.17	0.53	0.70	0.26	0.05

implementation of programs aimed at promoting corporate decarbonization.

With respect to the DisruptiveTimes variable, its impact is also positive and significant at the 99% confidence level, taking the value $\beta_2 = 0.553$ ($p = 0.000$) in Equation (1). Thus, hypothesis H2 is accepted, confirming that the uncertain times we have experienced in recent years have a positive impact on companies' commitment to decarbonization.

Regarding hypothesis H3, the interaction between both variables, WCsuite*DisruptiveTimes, has a negative effect ($\beta_3 = -0.00475$; $p = 0.000$) and is significant at the 99% confidence level. This finding would indicate that the impact of GD is lower in uncertain environments ($\beta_1 - \beta_3 = 0.00907 - 0.00475 = 0.00432$) than in stable environments ($\beta 1 = 0.00907$). This evidence confirms our hypothesis H3 that both disruptive shocks moderate the effect of GD in the TMT on the level of development of carbon mitigation practices. Furthermore, the sign of this moderating effect is negative.

These findings are validated when estimating Equation (2). Again, at a 99% confidence level, it shows the positive effect of the WCsuite variables ($\delta_1 = 0.00809$) and the three variables that split the uncertainty period 2020–2022: COVID19 ($\delta_2 = 0.372$), postCOVID19 ($\delta_3 = 0.590$), and UkraineWar ($\delta_4 = 0.790$). Again, the effect of GD in the years of uncertainty is smaller than that observed in the previously analyzed time periods. In addition, the coefficients of the interaction of WCsuite with the three time-variables show that the diversity effect is reduced to a greater extent in the situation associated with the RUW ($\delta_7 = -0.00595$) than in the pandemic period ($\delta_5 = -0.00349$).

Regarding the control variables, larger companies with more effective corporate governance systems are found to have more entrepreneurial decarbonization practices. This situation also characterizes companies located in the European Union and those that are less indebted and allocate larger volumes of investment in advertising.

None of the VIF values shown in Table 4 are greater than 5, indicating the absence of multicollinearity problems.

4.3 | Robustness Analysis

To strengthen the previous findings, Equations (1) and (2) have been estimated with new methodological specifications based on linear regressions with fixed (fe) and random (re) effects. The procedure of these methods is simpler than the Tobit regression and reduces the overfitting of the relationship. The results presented in Table 5 support the positive and significant impact of the variables WCsuite, DisruptiveTimes, COVID19, and postCOVID19 and UkraineWar, as well as the inverse effect of the interactions.

On the other hand, Table 6 displays robust results, unaffected by changes in the dependent and independent variable measurement approaches. Specifically, the first four columns of Table 6 present the estimates of Equations (1) and (2) for the dependent variable relaCO2Abatment, an approximation that determines the percentage of corporate decarbonization actions that the company has implemented in relation to the eight variables considered in the construction of the CO2Abatment score.

The following four columns present the results for the BlauIndex variable as a robust measure of GD in TMTs. This measure of GD is determined by the formula $1 - \sum(p_i)^2$, where p_i is the proportion of managers and executives that make up the C-suite.

The last four columns include both robust approaches and reflect the results for Equations (1) and (2) estimated with the relaCO2Abatment and BlauIndex variables.

The results obtained guarantee the reliability of the previous findings and confirm acceptance of the three research hypotheses (H1–H3).

4.4 | Complementary Analysis

The findings indicate that the influence of TMT diversity on the implementation of corporate decarbonization projects varies according to the level of uncertainty that characterizes the period analyzed. To complement the existing knowledge, Table 7 synthesizes new complementary evidence focused on the study of

TABLE 3 | Bivariate correlations (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

		1	2	3	4	5	6	7
1	CO2Abatment	1						
2	WCSuite	0.08***	1					
3	UncertainTimes	0.10***	0.11***	1				
4	COVID19	0.02***	0.04***	0.55***	1			
5	postCOVID19	0.06***	0.06***	0.37***	−0.27***	1		
6	UkraineWar	0.11***	0.05***	0.34***	−0.24***	−0.16***	1	
7	Size	0.37***	0.02***	−0.06***	−0.05***	−0.03***	0.00	1
8	Leverage	0.08***	0.01	0.00	0.00	−0.01	0.00	0.07***
9	ROA	0.03***	0.00	−0.05***	−0.05***	0.00	0.00	−0.09***
10	WorkCap	0.11***	−0.06***	−0.01**	−0.01	0.00	0.00	0.23***
11	Dividend	0.10***	0.03***	−0.02**	−0.01	−0.01	−0.01	0.14***
12	CAPEXInv	0.01	0.01*	0.01	0.03***	−0.01	−0.01	−0.01
13	RDInv	−0.03***	0.04***	−0.01	0.00	0.00	−0.01	−0.07***
14	AdvInv	0.37***	−0.05***	−0.10***	−0.06***	−0.04***	−0.01	0.74***
15	StrInv	0.01	0.01	0.01***	0.00	0.01	0.01	0.00
16	GovScore	0.22***	0.04***	0.08***	−0.03***	0.06***	0.09***	0.26***
17	EU	0.17***	0.06***	0.05***	0.02**	0.01*	0.04***	0.00

		8	9	10	11	12	13	14
8	Leverage	1						
9	ROA	−0.03***	1					
10	WorkCap	−0.03***	0.05***	1				
11	Dividend	0.02***	0.05***	0.05***	1			
12	CAPEXInv	0.02**	0.00	0.00	0.00	1		
13	RDInv	−0.03***	−0.12***	0.00	−0.01	0.00	1	
14	AdvInv	0.02***	0.08***	0.19***	0.13***	−0.02***	−0.06***	1
15	StrInv	−0.01	−0.01	−0.01*	−0.03***	0.00	0.00	−0.01
16	GovScore	0.03***	0.04***	0.07***	0.03***	0.00	−0.03***	0.26***
17	EU	0.00	−0.03***	−0.03***	0.06***	0.01**	−0.01*	0.06***

		15	16	17
15	StrInv	1		
16	GovScore	−0.03***	1	
17	EU	0.05***	−0.01	1

TMT classifications according to different levels of women/men presence among its members.

In this regard, following García-Sánchez, Monteiro, et al. (2023), the percentage of women executives and its square have been introduced in the first column to identify the existence of an inverted U-shaped relationship. In this regard, it is observed that $\beta_1 = 0.0126 > 0$ and $\beta_2 = -0.0000905 < 0$, confirming the existence of a non-linear relationship. This relationship indicates that the level of the implementation of decarbonization projects increases with the presence of women in TMT, up to a maximum point, from which it begins to decrease. To determine this point, we calculate $\Phi 1 = -(\beta_1/2\beta_2)$; we observe that the point of change in the effect of the presence of women in the TMT occurs when the presence of women in the TMT reaches 70%.

TABLE 4 | Main models (***$p < 0.01$, *$p < 0.1$).

	Equation (0)		Equation (1)	Equation (2)
	Coef.	Coef.	Coef.	Coef.
	(SE)	(SE)	(SE)	(SE)
WCsuite	0.00652***	0.00533***	0.00907***	0.00809***
	(0.000962)	(0.000959)	(0.00106)	(0.00106)
DisruptiveTimes	0.432***		0.553***	
(DT)	(0.0137)		(0.0257)	
COVID19		0.286***		0.372***
(C19)		(0.0172)		(0.0339)
postCOVID19		0.444***		0.590***
(post C19)		(0.0171)		(0.0335)
UkraineWar		0.635***		0.790***
(UK)		(0.0185)		(0.0365)
WCSuite*UT			−0.00475***	
			(0.000850)	
WCSuite*C19				−0.00349***
				(0.00111)
WCSuite*postC19				−0.00563***
				(0.00108)
WCSuite*UK				−0.00595***
				(0.00117)
Size	0.304***	0.308***	0.305***	0.308***
	(0.0161)	(0.0161)	(0.0161)	(0.0161)
Leverage	−0.140*	−0.118	−0.142*	−0.115
	(0.0801)	(0.0796)	(0.0801)	(0.0795)
ROA	0.127	−0.0200	0.0923	−0.0596
	(0.0995)	(0.0992)	(0.0996)	(0.0992)
WorkCap	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Dividend	−8.36e−05	−0.000153	−8.04e−05	−0.000146
	(0.000831)	(0.000831)	(0.000831)	(0.000831)
CAPEXInv	−8.97e−05	−7.96e−05	−0.000176	−0.000171
	(0.000514)	(0.000508)	(0.000514)	(0.000507)
RDInv	3.29e−06	2.86e−06	3.64e−06	3.26e−06
	(1.30e−05)	(1.30e−05)	(1.30e−05)	(1.30e−05)
AdvInv	0.0798***	0.0719***	0.0803***	0.0730***
	(0.0149)	(0.0149)	(0.0149)	(0.0149)
StrInv	0.0189*	0.0170*	0.0186*	0.0167*
	(0.00981)	(0.00983)	(0.00981)	(0.00984)

(Continues)

TABLE 4 | (Continued)

	Equation (0)		Equation (1)	Equation (2)
	Coef.	Coef.	Coef.	Coef.
	(SE)	(SE)	(SE)	(SE)
GovScore	0.00723***	0.00619***	0.00730***	0.00627***
	(0.000509)	(0.000508)	(0.000509)	(0.000508)
EU	0.638***	0.640***	0.640***	0.641***
	(0.0516)	(0.0517)	(0.0516)	(0.0517)
Country	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Constant	−6.460***	−6.308***	−6.556***	−6.411***
	(0.275)	(0.275)	(0.276)	(0.276)
Log likelihood	−21013.38	−20867.81	−20997.79	−20848.52
p	0.000	0.000	0.000	0.000
VIF values WCSuite: 1.07; UncertainTimes: 1.04; COVID19: 1.25; postCOVID19: 1.22; UkraineWar: 1.20; Size: 2.59; Leverage: 1.12; ROA: 1.07; WorkCap: 1.08; Dividend: 1.03; CAPEXInv: 1.00; RDInv: 1.01; AdvInv: 2.32; StrInv: 1.02; GovScore: 1.10; EU: 1.04.				

The next three columns present the results for skewed, tilted, and balanced TMTs, which according to Atif et al. (2021) would identify the presence of less than 20% women in the TMT; a proportion of women executives between 20% and 40%; and a balanced TMT with a gender composition between 40% and 60%. The findings show that the mere presence of women, regardless of their proportion, drives the implementation of decarbonization projects. However, the impact is greater as the proportion of women executives increases (Tilted: $\beta_1 = 0.281$ vs. Skewed: $\beta_1 = 0.142$) and moves between 40% and 60% (Balanced: $\beta_1 = 0.375$). Furthermore, it is observed that in tilted (Tilted*UT: $\beta_2 = 0.112$) and balanced (Balanced*UT: $\beta_2 = 0.159$) TMTs, the effect of time instability enhances the role that women executives play in decarbonization, while in the skewed TMTs (Skewed*UT: $\beta_2 = -0.0534$) the observed reducing effect is maintained.

In this sense, the last two columns present the results for the classification of TMTs into men and women dominance groups, since they are composed of more than 60% of members of one gender or the other. The results show that TMTs with a greater male presence (MaleDom: $\beta_1 = 0.302$) promote decarbonization initiatives, while the opposite effect is evident for the female case (FemaleDom: $\beta_1 = -0.377$). These effects are not moderated by the level of temporal uncertainty analyzed.

5 | Discussion

5.1 | Summary of Findings

Our first hypothesis posited that GD in TMTs is positively related to the implementation of programs aimed at promoting corporate decarbonization. Confirming this hypothesis, our results indicate that a higher presence of women managers in TMTs has a positive impact on the implementation of climate change mitigation initiatives. This finding aligns with prior empirical studies on GD at the board level (Konadu et al. 2022; García-Sánchez, Monteiro, et al. 2023) and corroborates the positive link between GD in TMTs and environmental strategies and practices documented by Shahab et al. (2018), Rehman et al. (2020), Saeed et al. (2022), Chiao et al. (2025), and Roush et al. (2025).

Our second hypothesis conjectured a positive impact of the COVID19 and RUW on corporate environmental proactivity and posited that these disruptive shocks positively affect the comprehensive implementation of programs to promote corporate decarbonization. Consistent with this hypothesis, the results suggest that the context of crisis and uncertainty resulting from the crises of recent years positively impacts corporate commitment to decarbonization. This result is consistent with the positive previous results regarding energy consumption (Liobikienė et al. 2023; Mišík and Nosko 2023) and climate change innovation (García-Sánchez, Monteiro, et al. 2023).

Finally, consistent with our third hypothesis, we found that both disruptive shocks moderated the influence of GD in the TMT on the comprehensive implementation of programs to promote corporate decarbonization. Specifically, we found that the moderating effect is negative. This suggests that the crisis and uncertainty context associated with the COVID19 and RUW weakens the positive impact of GD in TMTs on the implementation of programs aimed at promoting corporate decarbonization. This finding aligns with Konadu et al.'s (2022) evidence of the negative impact of the financial crisis on the effect of board GD on reducing carbon emissions.

TABLE 5 | Robust results (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

	Equation (0)		Equation (1)		Equation (0)		Equation (2)	
	re	fe	re	fe	re	fe	re	fe
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)
WCsuite	0.0084***	0.00829***	0.0112***	0.0104***	0.00816***	0.00778***	0.0111***	0.00998***
	(0.00106)	(0.00148)	(0.00113)	(0.00151)	(0.00106)	(0.00148)	(0.00113)	(0.00151)
DisruptiveTimes	0.376***	0.372***	0.543***	0.551***				
(DT)	(0.0149)	(0.0163)	(0.0282)	(0.0295)				
COVID19					0.320***	0.316***	0.451***	0.459***
(C19)					(0.0173)	(0.0182)	(0.0338)	(0.0346)
postCOVID19					0.449***	0.459***	0.658***	0.680***
(post C19)					(0.0188)	(0.0207)	(0.0361)	(0.0381)
UkraineWar					0.001*	0.001*	0.001*	0.001*
(UK)					(0,000)	(0,000)	(0,000)	(0,000)
WCSuite*DT			−0.00653***	−0.00705***				
			(0.000938)	(0.000970)				
WCSuite*C19							−0.00519***	−0.00573***
							(0.00111)	(0.00113)
WCSuite*postC19							−0.00813***	−0.00868***
							(0.00120)	(0.00125)
WCSuite*UK							−0.001**	−0.001**
							(0,000)	(0,000)
Size	0.338***	0.420***	0.341***	0.435***	0.337***	0.404***	0.339***	0.420***
	(0.0173)	(0.0338)	(0.0173)	(0.0338)	(0.0173)	(0.0338)	(0.0173)	(0.0338)
Leverage	−0.271***	−0.224**	−0.277***	−0.235**	−0.261***	−0.212*	−0.263***	−0.217*
	(0.0889)	(0.112)	(0.0888)	(0.112)	(0.0888)	(0.112)	(0.0887)	(0.112)
ROA	0.121	−0.0685	0.0753	−0.123	0.0467	−0.175	0.00143	−0.227*

(Continues)

TABLE 5 | (Continued)

	Equation (0)		Equation (1)		Equation (0)		Equation (2)	
	re	fe	re	fe	re	fe	re	fe
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)
	(0.115)	(0.132)	(0.115)	(0.132)	(0.116)	(0.133)	(0.116)	(0.132)
WorkCap	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Dividend	0.00882	−0.186	0.00828	−0.173	0.00933	−0.178	0.00876	−0.165
	(0.00624)	(0.212)	(0.00624)	(0.212)	(0.00624)	(0.212)	(0.00624)	(0.211)
CAPEXInv	−5.65e−06	−0.000200	−0.000116	−0.000331	−1.39e−07	−0.000188	−0.000114	−0.000323
	(0.00052)	(0.000529)	(0.000519)	(0.000528)	(0.000519)	(0.000528)	(0.000518)	(0.000527)
RDInv	9.59e−06	0.648**	1.02e−05	0.593**	8.84e−06	0.629**	9.59e−06	0.584**
	(1.28e−05)	(0.265)	(1.28e−05)	(0.265)	(1.28e−05)	(0.265)	(1.28e−05)	(0.264)
AdvInv	0.0487***	0.0459	0.0483***	0.0465	0.0503***	0.0447	0.0501***	0.0459
	(0.0158)	(0.0288)	(0.0158)	(0.0287)	(0.0158)	(0.0288)	(0.0158)	(0.0287)
StrInv	0.0130	−1.524	0.0124	−1.422	0.0124	−1.537	0.0119	−1.423
	(0.0101)	(1.533)	(0.0101)	(1.529)	(0.0101)	(1.530)	(0.0101)	(1.525)
GovScore	0.0040***	0.00387***	0.00410***	0.00398***	0.00375***	0.00344***	0.00384***	0.00359***
	(0.00056)	(0.000628)	(0.000555)	(0.000626)	(0.000557)	(0.000629)	(0.000556)	(0.000628)
EU	0.666***	0.000	0.669***	0.000	0.660***	0.000	0.663***	0.000
	(0.0535)	(0,000)	(0.0535)	(0,000)	(0.0535)	(0,000)	(0.0535)	(0,000)
Country	Yes		Yes		Yes		Yes	
Industry	Yes		Yes		Yes		Yes	
Year	Yes		Yes		Yes		Yes	
Constant	−6.294***	−14.66***	−6.401***	−14.43***	−6.271***	−14.00***	−6.382***	−13.94***
	(0.294)	(3.687)	(0.294)	(3.677)	(0.294)	(3.679)	(0.294)	(3.669)
R^2	0.2220	0.1416	0.2222	0.1464	0.2218	0.1459	0.2221	0.1510
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 6 | Robust results for variables definition (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

	Relative CO2Abatment				Female Blau Index			Relative CO2Abatment and Female Blau Index				
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)
WCSuite	0.000815***	0.00113***	0.000666***	0.00101***								
	(0.000120)	(0.000133)	(0.000120)	(0.000133)								
DisruptiveTimes	0.0540***	0.0692***			0.429***	0.260***			0.0536***	0.0325***		
(DT)	(0.00171)	(0.00321)			(0.0137)	(0.0322)			(0.00171)	(0.00402)		
COVID19		−0.000594***										
(C19)		(0.000106)										
postCOVID19			0.0358***	0.0465***			0.284***	0.155***			0.0356***	0.0193***
(post C19)			(0.00215)	(0.00424)			(0.0172)	(0.0414)			(0.00215)	(0.00518)
UkraineWar			0.0555***	0.0738***			0.442***	0.246***			0.0553***	0.0307***
(UK)			(0.00214)	(0.00419)			(0.0172)	(0.0401)			(0.00214)	(0.00501)
WCSuite*DT			0.0794***	0.0987***			0.632***	0.416***			0.0790***	0.0520***
			(0.00232)	(0.00456)			(0.0186)	(0.0434)			(0.00233)	(0.00542)
WCSuite*C19				−0.000436***								
				(0.000139)								
WCSuite*postC19				−0.000703***								
				(0.000135)								
WCSuite*UK				−0.000743***								
				(0.000147)								
BlauIndex					0.0507***	0.0683***	0.0413***	0.0604***	0.00634***	0.00853***	0.00517***	0.00755***
					(0.00708)	(0.00770)	(0.00706)	(0.00766)	(0.000886)	(0.000962)	(0.000883)	(0.000958)
BlauIndex*DT						−0.0357***				−0.00446***		
						(0.00614)				(0.000767)		
BlauIndex*C19								−0.0266***				−0.00332***
								(0.00809)				(0.00101)
BlauIndex*postC19								−0.0418***				−0.00523***

(Continues)

TABLE 6 | (Continued)

	Relative CO2Abatment				Female Blau Index			Relative CO2Abatment and Female Blau Index				
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)
								(0.00789)				(0.000987)
BlauIndex*UK								−0.0463***				−0.00579***
								(0.00856)				(0.00107)
Size	0.0380***	0.0381***	0.0384***	0.0385***	0.304***	0.305***	0.308***	0.308***	0.0380***	0.0381***	0.0384***	0.0385***
	(0.00202)	(0.00201)	(0.00201)	(0.00201)	(0.0161)	(0.0161)	(0.0161)	(0.0161)	(0.00201)	(0.00201)	(0.00201)	(0.00201)
Leverage	−0.0174*	−0.0177*	−0.0148	−0.0144	−0.143*	−0.144*	−0.121	−0.116	−0.0178*	−0.0179*	−0.0151	−0.0144
	(0.0100)	(0.0100)	(0.00994)	(0.00994)	(0.0801)	(0.0801)	(0.0796)	(0.0795)	(0.0100)	(0.0100)	(0.00994)	(0.00994)
ROA	0.0159	0.0115	−0.00250	−0.00745	0.124	0.0883	−0.0224	−0.0637	0.0155	0.0110	−0.00280	−0.00797
	(0.0124)	(0.0124)	(0.0124)	(0.0124)	(0.0995)	(0.0995)	(0.0991)	(0.0992)	(0.0124)	(0.0124)	(0.0124)	(0.0124)
WorkCap	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Dividend	−1.04e−05	−1.00e−05	−1.91e−05	−1.82e−05	−9.00e−05	−8.17e−05	−0.000158	−0.000143	−1.12e−05	−1.02e−05	−1.98e−05	−1.79e−05
	(0.000104)	(0.000104)	(0.000104)	(0.000104)	(0.000831)	(0.000831)	(0.000831)	(0.000831)	(0.000104)	(0.000104)	(0.000104)	(0.000104)
CAPEXInv	−1.12e−05	−2.20e−05	−9.95e−06	−2.14e−05	−9.96e−05	−0.000190	−8.77e−05	−0.000185	−1.25e−05	−2.38e−05	−1.10e−05	−2.31e−05
	(6.43e−05)	(6.42e−05)	(6.35e−05)	(6.34e−05)	(0.000514)	(0.000514)	(0.000508)	(0.000507)	(6.43e−05)	(6.42e−05)	(6.35e−05)	(6.34e−05)
RDInv	4.12e−07	4.55e−07	3.57e−07	4.07e−07	3.22e−06	3.61e−06	2.80e−06	3.25e−06	4.02e−07	4.51e−07	3.50e−07	4.06e−07
	(1.62e−06)	(1.62e−06)	(1.62e−06)	(1.62e−06)	(1.30e−05)	(1.30e−05)	(1.30e−05)	(1.30e−05)	(1.62e−06)	(1.62e−06)	(1.62e−06)	(1.62e−06)
AdvInv	0.00998***	0.0100***	0.00899***	0.00912***	0.0801***	0.0807***	0.0721***	0.0734***	0.0100***	0.0101***	0.00901***	0.00917***
	(0.00186)	(0.00186)	(0.00186)	(0.00186)	(0.0149)	(0.0149)	(0.0149)	(0.0148)	(0.00186)	(0.00186)	(0.00186)	(0.00186)
StrInv	0.00236*	0.00233*	0.00213*	0.00209*	0.0188*	0.0185*	0.0169*	0.0166*	0.00235*	0.00231*	0.00212*	0.00207*
	(0.00123)	(0.00123)	(0.00123)	(0.00123)	(0.00981)	(0.00981)	(0.00983)	(0.00984)	(0.00123)	(0.00123)	(0.00123)	(0.00123)
GovScore	0.000904***	0.000912***	0.000774***	0.000784***	0.00720***	0.00729***	0.00617***	0.00627***	0.000900***	0.000911***	0.000772***	0.000784***
	(6.37e−05)	(6.36e−05)	(6.35e−05)	(6.35e−05)	(0.000510)	(0.000509)	(0.000508)	(0.000508)	(6.37e−05)	(6.36e−05)	(6.35e−05)	(6.35e−05)
EU	0.0798***	0.0799***	0.0800***	0.0802***	0.634***	0.635***	0.636***	0.638***	0.0792***	0.0794***	0.0795***	0.0797***
	(0.00645)	(0.00645)	(0.00647)	(0.00647)	(0.0516)	(0.0517)	(0.0518)	(0.0518)	(0.00645)	(0.00646)	(0.00647)	(0.00647)

(Continues)

TABLE 6 | (Continued)

	Relative CO2Abatment				Female Blau Index				Relative CO2Abatment and Female Blau Index			
	Coef.	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**
	(SE)	**(SE)**	**(SE)**	**(SE)**	**(SE)**	**(SE)**	**(SE)**	**(SE)**	**(SE)**	**(SE)**	**(SE)**	**(SE)**
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−0.807***	−0.819***	−0.788***	−0.801***	−6.045***	−5.990***	−5.969***	−5.910***	−0.756***	−0.749***	−0.746***	−0.739***
	(0.0344)	(0.0345)	(0.0344)	(0.0345)	(0.274)	(0.274)	(0.274)	(0.274)	(0.0343)	(0.0343)	(0.0343)	(0.0343)
Log likelihood	−12143.316	−12158.905	−12288.889	−12308.179	−21010.71	−20993.828	−20866.099	−20844.79	−12145.986	−12162.867	−12290.597	−12311.905
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

5.2 | Research Implications

This research adds to the existing evidence on the impact of GD on corporate environmental initiatives to combat climate change by looking beyond the board level and examining the influence of GD in the C-suite on firms' carbon reduction strategies. By doing so, we respond to the call to adopt a holistic perspective when examining the effects of GD on businesses (Saeed et al. 2022; Haque et al. 2024) and to deepen the analysis of how management team composition influences the initiatives they drive (Altunbas et al. 2022; Liu et al. 2024; Chiao et al. 2025).

First, we show that the positive impact of GD on firms' environmental proactivity is not limited to the board but also includes greater GD in the C-suite (Haque et al. 2024; Roush et al. 2025). Specifically, we show that TMTs are better equipped to deal with climate change when there is greater GD, confirming that, as SRT suggests, women in the C-suite behave in accordance with their socially ascribed gender roles, which promotes the development of a more advanced and integrated carbon reduction strategy. Our findings also confirm that, consistent with the precepts of UET, the composition of TMTs influences their strategic decisions, which in turn influence the strategic direction of the firm.

Second, we add to the stream of research supporting a positive impact of the COVID19 and RUW on the transition to a decarbonized economy (Liobikienė et al. 2023; Mattera and Soto 2022). By showing that the context of crisis and uncertainty stemming from both disruptive shocks positively affects the implementation of corporate decarbonization projects by firms, we confirm the driving role of external shocks in triggering transitions documented by previous studies (Markard and Rosenbloom 2020) and highlight that both shocks, despite their adverse effects on the economy and people's lives, can incentivize environmental transitions.

Finally, we extend existing knowledge about the circumstances in which women executives influence firms' environmental proactivity (Liu et al. 2024; Chiao et al. 2025; Roush et al. 2025). First, we demonstrate that although the results indicate the existence of women in TMTs promotes the implementation of decarbonization projects regardless of their proportion, their impact increases as the proportion of women managers rises. Furthermore, consistent with García-Sánchez, Monteiro, et al.'s (2023) findings, our results suggest that the link between GD and business strategies to mitigate climate change is nonlinear, with a shift in this relationship occurring when women comprise 70% of the TMT. These results suggest that female-dominated management teams, particularly those with over 70% female managers, may lead to decreased climate change commitment.

Second, our findings indicate that the effect of TMT diversity on the implementation of corporate decarbonization projects varies depending on the level of uncertainty that characterizes the period analyzed. Thus, we found that both disruptive shocks negatively moderate the effect of GD in the TMT on the development of carbon mitigation practices. This suggests that the positive influence of GD in TMTs on companies' commitment to decarbonization is stronger in periods of stability than

TABLE 7 | Results of complementary analysis (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$).

	Female square	Skewed TMT	Tilted TMT	Balanced TMT	Male dominated TMT	Female dominated TMT
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)
WCsuite	0.0126***					
	(0.00253)					
WCsuite2	−9.05e−05***					
	(3.50e−05)					
DisruptiveTimes	0.428***	0.596***	0.447***	0.393***	0.508***	0.517***
(DT)	(0.0137)	(0.0225)	(0.0200)	(0.0358)	(0.0149)	(0.0131)
Skewed		0.142***				
		(0.0203)				
Skewed*DT		−0.0534**				
		(0.0247)				
Tilted			0.281***			
			(0.0196)			
Tilted*DT			0.112***			
			(0.0224)			
Balanced				0.375***		
				(0.0345)		
Balanced*DT				0.159***		
				(0.0369)		
MaleDom					0.302***	
					(0.0165)	
MaleDom*DT					0.0310	
					(0.0190)	
FemaleDom						−0.377***
						(0.0160)
FemaleDom*DT						−0.0285
						(0.0188)
Size	0.304***	0.337***	0.333***	0.338***	0.326***	0.320***
	(0.0161)	(0.0118)	(0.0118)	(0.0118)	(0.0117)	(0.0116)
Leverage	−0.143*	−0.00190	−0.00862	−0.0254	0.00574	−0.0129
	(0.0801)	(0.0516)	(0.0515)	(0.0516)	(0.0514)	(0.0511)
ROA	0.121	−0.0407	−0.0458	−0.0293	−0.0606	−0.0592
	(0.0995)	(0.0592)	(0.0591)	(0.0592)	(0.0589)	(0.0587)
WorkCap	0.000	0.000	0.000	0.000	0.000	0.000
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)

(Continues)

TABLE 7 | (Continued)

	Female square	Skewed TMT	Tilted TMT	Balanced TMT	Male dominated TMT	Female dominated TMT
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	(SE)	(SE)	(SE)	(SE)	(SE)	(SE)
Dividend	−9.22e−05	0.00140*	0.00140*	0.00139*	0.00143*	0.00145**
	(0.000831)	(0.000740)	(0.000738)	(0.000737)	(0.000733)	(0.000725)
CAPEXInv	−0.000107	−0.000163	−0.000165	−0.000166	−0.000161	−0.000156
	(0.000514)	(0.000138)	(0.000138)	(0.000138)	(0.000137)	(0.000137)
RDInv	3.24e−06	7.05e−08	3.59e−08	−2.37e−08	2.66e−07	4.47e−07
	(1.30e−05)	(4.84e−06)	(4.83e−06)	(4.82e−06)	(4.80e−06)	(4.75e−06)
AdvInv	0.0805***	0.0942***	0.0927***	0.0936***	0.0912***	0.0891***
	(0.0149)	(0.0110)	(0.0110)	(0.0110)	(0.0109)	(0.0108)
StrInv	0.0187*	−0.00958	−0.00920	−0.00980	−0.00835	−0.00777
	(0.00981)	(0.00656)	(0.00654)	(0.00653)	(0.00650)	(0.00643)
GovScore	0.00719***	0.00881***	0.00865***	0.00881***	0.00832***	0.00796***
	(0.000510)	(0.000354)	(0.000353)	(0.000353)	(0.000353)	(0.000352)
EU	0.631***	0.895***	0.868***	0.889***	0.845***	0.811***
	(0.0517)	(0.0433)	(0.0433)	(0.0432)	(0.0430)	(0.0426)
Country	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−6.519***	−7.857***	−7.752***	−7.854***	−7.599***	−7.067***
	(0.276)	(0.202)	(0.202)	(0.202)	(0.201)	(0.201)
Log likelihood	−21010.035	−46885.707	−46821.076	−46866.134	−46718.956	−46579.041
p	0.000	0.000	0.000	0.000	0.000	0.000

in disruptive and uncertain periods associated with COVID19 and RUW. Nevertheless, a more detailed analysis shows that the uncertainty-reducing effect is associated with TMTs configured with a female presence of less than 20%. On the contrary, when the proportion of women managers is higher than 20%, the effect of time instability enhances the role that women managers play in decarbonization.

5.3 | Practical Implications

The following managerial, policy, and societal implications can be drawn from our findings. Regarding the former, the findings imply that to encourage the development of carbon reduction strategies and the implementation of decarbonization projects, companies should revise their hiring and promotion criteria to promote female representation in the TMT until it exceeds the 20% threshold. However, these criteria should be designed to prevent the presence of female managers in the C-suite from exceeding 70%, a threshold at which the positive effect of GD in TMTs is reversed. Similarly, investors and stakeholders could view GD in TMTs as a sign of the company's pro-environmental orientation.

In terms of policy implications, our results support policies that impose quotas to increase the number of women in senior management positions, like what has happened in many countries with respect to the boardroom, as these policies may not only promote social equality but also support the corporate response to climate change. In this way, our results suggest that these two goals are related and that they could, to a certain extent, be addressed together. Our findings also open the door to a broader discussion about GD in corporate leadership. While gender equality is often emphasized, gender equity is equally important. Equity recognizes the structural barriers hindering women's access to top management positions and their ability to make a meaningful contribution to corporate decision-making. Future policies should not only promote greater participation of women in leadership positions but also create equitable opportunities to ensure that women in leadership roles are empowered to drive

meaningful strategic change, particularly in sustainability and carbon reduction efforts.

From a societal perspective, in the current context of "polycrises" in which we are immersed (Mišík and Nosko 2023), our results offer some hope that crises, despite their negative effects, can have a bright side by promoting the development of decarbonization strategies by companies as well as encouraging women managers to exercise their voice in these decisions.

6 | Concluding Remarks

Achieving carbon neutrality by 2050 requires the implementation of ambitious corporate-level policies and initiatives to curb carbon emissions (Benlemlih et al. 2023; García-Sánchez, Aibar-Guzmán, et al. 2025). These initiatives typically involve a high degree of complexity at all levels of the organization and require a strong commitment from the company's TMT (Haque and Ntim 2020; Saeed et al. 2022). Moreover, the implementation of such initiatives has been affected by two recent shocks that have disrupted business activities worldwide, implying the need to adjust companies' sustainability strategies (García-Sánchez, Piñeiro-Chousa, et al. 2024).

This research sought to expand the understanding of how GD influences firms' carbon reduction strategies by investigating the impact of GD in C-suite positions on these strategies and examining how this impact is influenced by crises and uncertainties stemming from COVID19 and RUW. Using panel data from 3212 multinational corporations from 2013 to 2022, the findings support the idea that GD in TMTs is a driving force in corporate decarbonization, except in TMTs with over 70% female managers. These TMTs represent a setback in terms of corporate commitment to tackling climate change. Furthermore, the positive effect of GD in TMTs on corporate carbon reduction strategies is stronger in periods of stability than in the years of crisis and uncertainty associated with COVID19 and RUW, when there is an uncertainty-reducing effect associated with TMTs configured with a female presence of less than 20%.

Despite the relevance and usefulness of our findings, our study has several limitations. On the one hand, our analysis could be affected by endogeneity problems caused by the omission of variables that might interfere with the link between GD in TMTs and carbon reduction strategies. On the other hand, the findings may be due to reverse causality, that is, women executives may have chosen to work at firms that are more active in addressing climate change. These limitations deserve to be considered in future studies.

Future research could also explore how the background and demographic attributes (age, race, marital status, education, etc.) of women executives influence their impact on corporate decarbonization. Future studies could further explore the intersection of gender leadership and corporate decarbonization by considering regional and institutional differences. For example, analyzing whether the impact of female leadership on carbon reduction varies across different economic blocs, such as the BRICS countries or Latin American countries, could provide valuable insights. These regions have different gender equity dynamics and commitments to sustainability. While some BRICS countries, such as Brazil and South Africa, have made progress in women's representation in leadership roles, others still face structural barriers that limit women's access to top executive positions. Investigating whether these institutional and cultural differences shape the effectiveness of female leadership in driving corporate decarbonization efforts would be a valuable area for future study. Additionally, researchers could explore how female-led governments influence decarbonization policies at the national and/or regional levels, providing a broader perspective on how gender shapes sustainability initiatives beyond the corporate sphere. Finally, future research could examine other forms of TMT diversity or consider the different top management positions held by women managers.

Conflicts of Interest

The authors declare no conflicts of interest.

References

Aibar-Guzmán, B., C. Aibar-Guzmán, J. R. Piñeiro-Chousa, N. Hussain, and I. M. García-Sánchez. 2023. "The Benefits of Climate Tech: Do Institutional Investors Affect These Impacts?" *Technological Forecasting and Social Change* 192: 122536. https://doi.org/10.1016/j.techfore.2023.122536.

Aibar-Guzmán, B., N. Raimo, F. Vitolla, and I. M. García-Sánchez. 2024. "Corporate Governance and Financial Performance: Reframing Their Relationship in the Context of Climate Change." *Corporate Social Responsibility and Environmental Management* 31, no. 3: 1493–1509. https://doi.org/10.1002/csr.2649.

Ali Gull, A., N. Hussain, S. Akbar Khan, M. Nadeem, and A. Mansour Zalata. 2023. "Walking the Talk? A Corporate Governance Perspective on Corporate Social Responsibility Decoupling." *British Journal of Management* 34, no. 4: 2186–2211. https://doi.org/10.1111/1467-8551.12695.

Aliani, K. 2023. "Does Board Diversity Improve Carbon Emissions Score of Best Citizen Companies?" *Journal of Cleaner Production* 405: 136854. https://doi.org/10.1016/j.jclepro.2023.136854.

Allam, Z., S. E. Bibri, and S. A. Sharpe. 2022. "The Rising Impacts of the COVID-19 Pandemic and the Russia–Ukraine War: Energy Transition, Climate Justice, Global Inequality, and Supply Chain Disruption." *Resources* 11, no. 11: 99.

Altunbas, Y., L. Gambacorta, A. Reghezza, and G. Velliscig. 2022. "Does Gender Diversity in the Workplace Mitigate Climate Change?" *Journal of Corporate Finance* 77: 102303. https://doi.org/10.3390/resources11110099.

Aragón-Correa, J. A., N. Ortiz-de-Mandojana, and M. Barnett. 2025. "Heads Must Roll: How External and Internal Factors Combine to Improve Corporate Environmental Performance." *Business Strategy and the Environment* 34: 4912–4927. https://doi.org/10.1002/bse.4234.

Atif, M., M. Hossain, M. S. Alam, and M. Goergen. 2021. "Does Board Gender Diversity Affect Renewable Energy Consumption?" *Journal of Corporate Finance* 66: 101665. https://doi.org/10.1016/j.jcorpfin.2020.101665.

Barg, J. A., W. Drobetz, S. El Ghoul, O. Guedhami, and H. Schröder. 2024. "Board Ancestral Diversity and Voluntary Greenhouse Gas Emission Disclosure." *British Journal of Management* 35: 1512–1529. https://doi.org/10.1111/1467-8551.12778.

Benlemlih, M., M. Arif, and M. Nadeem. 2023. "Institutional Ownership and Greenhouse Gas Emissions: A Comparative Study of the UK and

the USA." *British Journal of Management* 34, no. 2: 623–647. https://doi.org/10.1111/1467-8551.12613.

Bibri, S. E., Z. Allam, and J. Krogstie. 2022. "The Metaverse as a Virtual Form of Data-Driven Smart Urbanism: Platformization and Its Underlying Processes, Institutional Dimensions, and Disruptive Impacts." *Computational Urban Science* 2, no. 1: 24. https://doi.org/10.1007/s43762-022-00051-0.

Caby, J., C. Coron, and Y. Ziane. 2022. "The Effect of Top Management Team Gender Diversity on Climate Change Management: An International Study." *Sustainability* 14, no. 2: 1032. https://doi.org/10.3390/su14021032.

Caby, J., C. Coron, and Y. Ziane. 2024. "How Does Gender Diversity in Top Management Teams Affect Carbon Disclosure and Its Quality: Evidence From the Technological Industry." *Technological Forecasting and Social Change* 199: 123077. https://doi.org/10.1016/j.techfore.2023.123077.

Carlsson-Kanyama, A., I. R. Juliá, and U. Röhr. 2010. "Unequal Representation of Women and Men in Energy Company Boards and Management Groups: Are There Implications for Mitigation?" *Energy Policy* 38, no. 8: 4737–4740. https://doi.org/10.1016/j.enpol.2010.03.072.

Chen, L., Y. Zhou, X. Luo, S. Chen, and Y. Cao. 2023. "Activating the Different Sides of Top Management Team Faultlines in Enterprise Sustainable Development: Is Environmental Responsibility a Burden or Boost to Small and Medium-Sized Enterprises in China?" *Business Strategy and the Environment* 32, no. 6: 3053–3072. https://doi.org/10.1002/bse.3286.

Chiao, Y. C., Y. C. Chang, Y. J. Hsu, C. H. Lu, and M. L. Chang. 2025. "Gender Diversity in Top Management Team and Corporate Social Responsibility Performance: Examining the Moderating Nature of TMT International Experience." *Gender in Management: An International Journal* 40, no. 2: 272–291. https://doi.org/10.1108/GM-01-2024-0033.

Ciocirlan, C., and C. Pettersson. 2012. "Does Workforce Diversity Matter in the Fight Against Climate Change? An Analysis of Fortune 500 Companies." *Corporate Social Responsibility and Environmental Management* 19, no. 1: 47–62. https://doi.org/10.1002/csr.279.

Donaldson, L. 2001. *The Contingency Theory of Organizations*. Sage.

Eagly, A. H. 1987. *Sex Differences in Social Behavior: A Social-Role Interpretation*. Lawrence Erlbaum Associates, Inc.

Eagly, A. H., A. Eaton, S. M. Rose, S. Riger, and M. C. McHugh. 2012. "Feminism and Psychology: Analysis of a Half-Century of Research on Women and Gender." *American Psychologist* 67, no. 3: 211–230. https://doi.org/10.1037/a0027260.

Enciso-Alfaro, S. Y., and I. M. García-Sánchez. 2024. "Do Boards Care About Planetary Boundaries? A Gender Perspective on Circular Economy Disclosures." *Business Strategy and the Environment* 33: 4562–4597.

Francoeur, C., R. Labelle, and B. Sinclair-Desgagné. 2008. "Gender Diversity in Corporate Governance and Top Management." *Journal of Business Ethics* 81: 83–95. https://doi.org/10.1007/s10551-007-9482-5.

Gaind, N., A. Abbott, A. Witze, et al. 2022. "Seven Ways the War in Ukraine Is Changing Global Science." *Nature* 607, no. 7919: 440–443. https://doi.org/10.1038/d41586-022-01960-0.

Galletta, S., S. Mazzù, V. Naciti, and C. Vermiglio. 2022. "Gender Diversity and Sustainability Performance in the Banking Industry." *Corporate Social Responsibility and Environmental Management* 29, no. 1: 161–174. https://doi.org/10.1016/j.jclepro.2014.08.047.

García-Sánchez, I. M., B. Aibar-Guzmán, N. Raimo, F. Vitolla, and G. Schiuma. 2024. "Climate Governance, Growth Opportunities, and Innovation in Addressing Climate Change: Empirical Evidence From Emerging Countries." *Finance Research Letters* 70: 106328. https://doi.org/10.1016/j.frl.2024.106328.

García-Sánchez, I. M., C. Aibar-Guzmán, M. L. López-Pérez, and B. Aibar-Guzmán. 2025. "Decarbonisation Strategies and Climate Governance: Are Institutional Investors Reshaping the Business Model of Multinationals?" *Journal of Innovation & Knowledge* 10, no. 3: 100698. https://doi.org/10.1016/j.jik.2025.100698.

García-Sánchez, I. M., C. Aibar-Guzmán, M. Núñez-Torrado, and B. Aibar-Guzmán. 2023. "Women Leaders and Female Same-Sex Groups: The Same 2030 Agenda Objectives Along Different Roads." *Journal of Business Research* 157: 113582. https://doi.org/10.1016/j.jbusres.2022.113582.

García-Sánchez, I. M., F. M. Somohano-Rodríguez, V. Amor-Esteban, and B. Gonzalez-Valdueza. 2022. "Circular Economy Projects and Firm Disclosures in an Encouraging Institutional Environment." *Sustainability* 14, no. 3: 1149. https://doi.org/10.3390/su14031149.

García-Sánchez, I. M., J. R. Piñeiro-Chousa, C. Aibar-Guzmán, and B. Aibar-Guzmán. 2024. "Environmental Products and Sustainability Awards: The Intangible Benefits of Sustainability Strategies." *ESIC Market. Economics and Business Journal* 55, no. 1: e353. https://doi.org/10.7200/esicm.55.353.

García-Sánchez, I. M., M. Núñez-Torrado, C. Aibar-Guzmán, and B. Aibar-Guzmán. 2025. "Beyond Climate Targets: Exploring When and How Female Directors Influence Corporate Decarbonization Transparency." *Business Strategy and the Environment* 34: 3892–3912. https://doi.org/10.1002/bse.4183.

García-Sánchez, I. M., S. Monteiro, J. R. Piñeiro-Chousa, and B. Aibar-Guzmán. 2023. "Climate Change Innovation: Does Board Gender Diversity Matter?" *Journal of Innovation & Knowledge* 8, no. 3: 100372. https://doi.org/10.1016/j.jik.2023.100372.

Hambrick, D. C., and P. A. Mason. 1984. "Upper Echelons: The Organization as a Reflection of Its Top Managers." *Academy of Management Review* 9, no. 2: 193–206. https://doi.org/10.5465/amr.1984.4277628.

Hambrick, D. C., S. E. Humphrey, and A. Gupta. 2015. "Structural Interdependence Within Top Management Teams: A Key Moderator of Upper Echelons Predictions." *Strategic Management Journal* 36, no. 3: 449–461. https://doi.org/10.1002/smj.2230.

Haque, F., and C. G. Ntim. 2020. "Executive Compensation, Sustainable Compensation Policy, Carbon Performance and Market Value." *British Journal of Management* 31, no. 3: 525–546. https://doi.org/10.1111/1467-8551.12395.

Haque, F., G. Adjei-Mensah, T. H. H. Nguyen, and C. G. Ntim. 2024. "Does Gender Diversity in Corporate Boards and Executive Management Teams Influence Carbon Performance? Evidence From Europe." *Accounting Forum*: 1–30. https://doi.org/10.1080/01559982.2024.2423989.

Horbach, J., and J. Jacob. 2018. "The Relevance of Personal Characteristics and Gender Diversity for (Eco-) Innovation Activities at the Firm-Level: Results From a Linked Employer–Employee Database in Germany." *Business Strategy and the Environment* 27, no. 7: 924–934. https://doi.org/10.1002/bse.2042.

Jiang, P., Y. Van Fan, and J. J. Klemeš. 2021. "Impacts of COVID-19 on Energy Demand and Consumption: Challenges, Lessons and Emerging Opportunities." *Applied Energy* 285: 116441. https://doi.org/10.1016/j.apenergy.2021.116441.

Konadu, R., G. S. Ahinful, D. J. Boakye, and H. Elbardan. 2022. "Board Gender Diversity, Environmental Innovation and Corporate Carbon Emissions." *Technological Forecasting and Social Change* 174: 121279. https://doi.org/10.1016/j.techfore.2021.121279.

Läger, F., Y. D. Bouzzine, and R. Lueg. 2025. "Carbon Performance and Corporate Financial Performance During Crises: Evidence From the COVID-19 Pandemic and the Global Financial Crisis." *Journal of Industrial Ecology* 29, no. 1: 246–263. https://doi.org/10.1111/jiec.13603.

Leffel, B., T. P. Lyon, and J. P. Newell. 2024. "Filling the Climate Governance Gap: Do Corporate Decarbonization Initiatives Matter as Much as State and Local Government Policy?" *Energy Research & Social Science* 109: 103376. https://doi.org/10.1016/j.erss.2023.103376.

Liobikienė, G., Y. Matiiuk, and R. Krikštolaitis. 2023. "The Concern About Main Crises Such as the Covid-19 Pandemic, the War in Ukraine, and Climate Change's Impact on Energy-Saving Behavior." *Energy Policy* 180: 113678. https://doi.org/10.1016/j.enpol.2023.113678.

Liu, X., Y. C. Liao, P. Ma, and Y. Dong. 2024. "Top Management Team Gender Diversity and Green Innovation: A Contingent Curvilinear Link." *Business Strategy and the Environment* 33, no. 7: 7118–7138. https://doi.org/10.1002/bse.3857.

Lu, Q., X. Meng, J. Su, A. A. K. Ming, Y. Wu, and C. Wang. 2023. "TMT Functional Background Heterogeneity and SMEs' Performance: The Role of Dynamic Capabilities and Business Environment." *Journal of Business Research* 160: 113807. https://doi.org/10.1016/j.jbusres.2023.113807.

Markard, J., and D. Rosenbloom. 2020. "A Tale of Two Crises: COVID-19 and Climate." *Sustainability: Science, Practice and Policy* 16, no. 1: 53–60. https://doi.org/10.1080/15487733.2020.1765679.

Matiiuk, Y., R. Krikštolaitis, and G. Liobikienė. 2023. "The Covid-19 Pandemic in Context of Climate Change Perception and Resource-Saving Behavior in the European Union Countries." *Journal of Cleaner Production* 395: 136433. https://doi.org/10.1016/j.jclepro.2023.136433.

Mattera, M., and F. Soto. 2022. "Dodging the Bullet: Overcoming the Financial Impact of Ukraine Armed Conflict With Sustainable Business Strategies and Environmental Approaches." *Journal of Risk Finance* 24, no. 1: 122–142. https://doi.org/10.1108/JRF-04-2022-0092.

Mišík, M., and A. Nosko. 2023. "Post-Pandemic Lessons for EU Energy and Climate Policy After the Russian Invasion of Ukraine: Introduction to a Special Issue on EU Green Recovery in the Post-Covid-19 Period." *Energy Policy* 177: 113546. https://doi.org/10.1016/j.enpol.2023.113546.

Monteiro, A. P., I. M. García-Sánchez, and B. Aibar-Guzmán. 2022. "Labour Practice, Decent Work and Human Rights Performance and Reporting: The Impact of Women Managers." *Journal of Business Ethics* 180, no. 2: 523–542. https://doi.org/10.1007/s10551-021-04913-1.

Mungai, E. M., S. W. Ndiritu, and T. Rajwani. 2020. "Raising the Bar? Top Management Teams, Gender Diversity, and Environmental Sustainability." *Africa Journal of Management* 6, no. 4: 269–294. https://doi.org/10.1080/23322373.2020.1830688.

Nguyen, H., M. T. T. Nguyen, D. Binh, L. D. X. Nguyen, and H. M. Phung. 2024. "Strategic Responses to Uncertainty Shocks and Consequences: A Study of Sustainability-Oriented Exporters in an Emerging Country." *Benchmarking: An International Journal*. https://doi.org/10.1108/BIJ-08-2023-0588.

Papangkorn, S., P. Chatjuthamard, P. Jiraporn, and S. Chueykamhang. 2021. "Female Directors and Firm Performance: Evidence From the Great Recession." *International Review of Finance* 21, no. 2: 598–610. https://doi.org/10.1111/irfi.12275.

Rehman, S., R. Orij, and H. Khan. 2020. "The Search for Alignment of Board Gender Diversity, the Adoption of Environmental Management Systems, and the Association With Firm Performance in Asian Firms." *Corporate Social Responsibility and Environmental Management* 27, no. 5: 2161–2175. https://doi.org/10.1002/csr.1955.

Richard, O. C., and R. M. Shelor. 2002. "Linking Top Management Team Age Heterogeneity to Firm Performance: Juxtaposing Two Mid-Range Theories." *International Journal of Human Resource Management* 13, no. 6: 958–974. https://doi.org/10.1080/09585190210134309.

Richard, O. C., J. Wu, L. A. Markoczy, and Y. Chung. 2019. "Top Management Team Demographic-Faultline Strength and Strategic Change: What Role Does Environmental Dynamism Play?" *Strategic Management Journal* 40, no. 6: 987–1009. https://doi.org/10.1002/smj.3009.

Roberson, Q., O. Holmes IV, and J. L. Perry. 2017. "Transforming Research on Diversity and Firm Performance: A Dynamic Capabilities Perspective." *Academy of Management Annals* 11, no. 1: 189–216. https://doi.org/10.5465/annals.2014.0019.

Roush, J., M. Lee, and S. H. Lee. 2025. "Are the Queens Green?: Corporate Executive Gender and the Environmental Performance of the Firm." *Journal of Economics and Finance* 49, no. 1: 1–23. https://doi.org/10.1007/s12197-025-09707-z.

Saeed, A., H. Riaz, T. A. Liedong, and T. Rajwani. 2022. "The Impact of TMT Gender Diversity on Corporate Environmental Strategy in Emerging Economies." *Journal of Business Research* 141: 536–551. https://doi.org/10.1016/j.jbusres.2021.11.057.

Shahab, Y., C. G. Ntim, Y. Chengang, F. Ullah, and S. Fosu. 2018. "Environmental Policy, Environmental Performance, and Financial Distress in China: Do Top Management Team Characteristics Matter?" *Business Strategy and the Environment* 27, no. 8: 1635–1652. https://doi.org/10.1002/bse.2229.

Su, W., and S. Junge. 2023. "Unlocking the Recipe for Organizational Resilience: A Review and Future Research Directions." *European Management Journal* 41, no. 6: 1086–1105. https://doi.org/10.1016/j.emj.2023.03.002.

Tosi, H. L., Jr., and J. W. Slocum Jr. 1984. "Contingency Theory: Some Suggested Directions." *Journal of Management* 10, no. 1: 9–26. https://doi.org/10.1177/014920638401000103.

Zahran, S., S. D. Brody, H. Grover, and A. Vedlitz. 2006. "Climate Change Vulnerability and Policy Support." *Society and Natural Resources* 19, no. 9: 771–789. https://doi.org/10.1080/08941920600835528.

Zebardast, L., and M. Radaei. 2022. "The Influence of Global Crises on Reshaping Pro-Environmental Behavior, Case Study: The COVID-19 Pandemic." *Science of the Total Environment* 811: 151436. https://doi.org/10.1016/j.scitotenv.2021.151436.