From Boardrooms to Employees: Gender Diversity and the Institutional Work of Embedding Scenario Analysis

Abstract

This study examines the influence of gender diversity at three hierarchical levels—board directors, firm management, and employees—on the adoption of climate change scenario analysis. Drawing on Institutional Work Theory and an international sample of 10,175 firm-year observations from 2017 to 2022, the empirical findings reveal that gender diversity at all levels actively shape the adoption of scenario analysis within their organizations, with board directors exerting the strongest impact. The study identifies a critical mass threshold: at least 20% female representation on the board is necessary to meaningfully influence male counterparts, while a lower threshold of 10% is sufficient at the management and employee levels. In addition, our cross-sectional analyses highlight the role of external factors in shaping this relationship. A firm's institutional environment, including cultural masculinity, legal system, and industry context, moderates the ability of gender-diverse actors to perform institutional work that embeds climate governance practices. These findings highlight how inclusive leadership across organizational levels supports the adoption of forward-looking climate risk planning and reinforces the role of distributed institutional work in advancing corporate climate strategies. Finally, the empirical evidence suggests there is significant tension in scenario analysis. Tension of adoption of scenario analysis exists because the outcome of scenario analysis will affect subsequent changes in business strategy, policy, green investment and lead to new business models. That can challenge existing systems and practices. This would cause considerable resistance.

Keywords: Scenario analysis, climate change, gender diversity, Institutional Work Theory

1 Introduction

Growing stakeholder awareness and acceptance of climate change have intensified demands for stronger climate risk management strategies (Fan and Zhao 2024). These strategies are essential for enhancing firms' preparedness to navigate climate-induced challenges and minimising disruptions to their value chains. Effective climate risk management ensures better access to critical resources and mitigates the impacts of extreme weather events (Prabhakar et al. 2009), climate-driven diseases (Rosenzweig et al. 2001) and rising sea levels (Haines et al. 2006; Nejat et al. 2015). One of the most powerful tools in this strategic approach is scenario analysis, which enables firms to evaluate climate-related risks and assess their exposure to potential future disruptions (Swart et al. 2004). The Task Force on Climate-related Financial Disclosures (TCFD) strongly recommends firms to conduct and disclose scenario analysis to provide stakeholders with insights into their forward-looking strategies and risk mitigation efforts. In response, an increasing number of firms are adopting scenario analysis to tailor strategies that align with their unique risk profiles and business objectives. Scenario analysis offers methodological flexibility, allowing firms to employ quantitative, qualitative, or mixed methods approaches. They can design scenarios based on different time horizons and climate trajectories, such as 1.5°C or 2.5°C global average surface temperature increases, to refine their risk adaptation and mitigation strategies. This tailored approach empowers firms to craft strategies that directly address climate-related uncertainties within their operations and industry contexts.

Despite its clear benefits, scenario analysis remains largely voluntary in many jurisdictions, leaving firms with the discretion to decide whether to adopt it. While regulatory pressure is mounting, the decision to implement scenario analysis ultimately hinges on the firm's recognition of its strategic value in strengthening resilience, ensuring long-term sustainability, and maintaining investor confidence in an increasingly complex climate landscape.

Although scenario analysis is critical, research in this area remains limited, with much of the existing work focusing on its methodological design and how firms communicate findings to external stakeholders (Aversa 2024). This aligns with the broader carbon literature, which has primarily examined voluntary disclosure, carbon assurance, emission reduction initiatives and the choice of assurance provider (He et al. 2022). To fill this gap, this study explores the role of gender diversity at the board, management, and employee levels in driving the adoption of scenario analysis. We conceptualise scenario analysis as an emerging and not yet institutionalised climate governance practice, whose adoption depends not only on external pressures or regulatory mandates but also on the purposive actions of internal actors. To frame our analysis, we draw on Institutional Work Theory, which focuses on the purposive actions of individuals and groups in creating, maintaining, or disrupting institutional practices (Lawrence and Suddaby, 2006). This perspective allows us to explore how gender-diverse actors actively shape the internal legitimacy and operational embedding of scenario analysis within firms.

In the context of climate scenario analysis, we view gender-diverse actors at different organisational levels as institutional agents who contribute to embedding this practice. Female directors, managers, and employees may engage in different forms of institutional work, such as introducing, operationalising, and reinforcing scenario analysis as part of organisational routines. Such work is especially important in the context of scenario analysis, where institutional norms are still developing and adoption remains discretionary. Our empirical analysis further reveals threshold effects, indicating that a minimum level of female representation may be necessary for such institutional work to generate observable change.

This study utilises an international sample of 10,175 firm-year observations, representing 2,944 firms that responded to the CDP2018-2023 surveys. The empirical results show that greater gender diversity at all levels significantly increases the probability of scenario analysis adoption, highlighting the role of inclusive leadership and diverse workforce in strengthening corporate climate risk management. We also find that while gender diversity across all levels contributes to climate risk management, its effectiveness varies by organisational hierarchy: board-level gender diversity has the strongest influence, followed by management, which drives execution, and employees, who influence organisational culture but have limited formal decision-making authority.

Next, we establish critical mass thresholds for gender diversity at different organisational levels. Specifically, while a 20% representation of female directors is necessary to influence scenario analysis adoption at the board level, a lower threshold of 10% is sufficient at the management and employee levels.

Furthermore, we explore whether the relationship between gender diversity and scenario analysis is influenced by external institutional factors, including national culture, legal systems, and industry affiliation. Given that firms operate in distinct regulatory landscapes, these external factors shape the extent to which gender diversity translates into climate risk management decisions. The cross-sectional results reveal that national culture dimension of masculinity moderates the relationship between gender diversity and scenario analysis adoption differently across hierarchical levels. At the board level, the positive relationship is strengthened, suggesting that female directors adopt assertive leadership traits to drive strategic decisions. In contrast, at the managerial and employee levels, the relationship is weakened, indicating that rigid gender norms may limit female influence on sustainability initiatives.

Moreover, we find that the positive relationship between gender diversity and scenario analysis adoption is stronger in common law countries. Firms with higher gender diversity across all hierarchical levels in common law jurisdictions are more likely to adopt scenario analysis compared to those in civil law countries, suggesting that the flexibility and investor protection mechanisms inherent in common law systems facilitate proactive climate risk management. Additionally, industry carbon intensity strengthens the influence of gender diversity, particularly in high-emission sectors, where female leaders may face greater stakeholder pressure to champion climate strategies. However, the COVID-19 pandemic weakens the relationship, as firms reallocate resources away from voluntary climate risk initiatives to address immediate financial and operational challenges. These findings underscore the critical role of female leadership, regulatory frameworks, and industry pressures in shaping scenario analysis adoption, while also highlighting the vulnerability of climate risk planning to external economic shocks and resource constraints.

The findings of this study make the following contributions. First, this study advances the climate change and carbon literature by shifting the focus from disclosure outcomes to the organisational adoption of scenario analysis as an emerging climate governance practice. While the TCFD recommends scenario analysis, existing research has primarily examined it through a disclosure quality lens (Cosma et al. 2022), leaving a gap in understanding its internal drivers. This study is among the first to systematically investigate scenario analysis adoption and, more importantly, to examine gender diversity as a key internal determinant. We go beyond correlational analysis by applying Institutional Work Theory to explain how gender-diverse actors at different organisational levels purposively shape the institutionalisation of this practice. By exploring the influence of gender representation across board, management, and employee levels, this research contributes to the growing literature on gender diversity and corporate environmental responsibility (Ben-Amar et al. 2017; Haque et al. 2024). Existing studies have established that gender diversity influences corporate environmental and sustainability practices (Peng et al. 2023), yet limited research has explored its role in scenario analysis adoption. Our findings add theoretical depth to this discussion by showing how gender-diverse actors act as institutional agents who introduce, enable, and reinforce forward-looking climate practices. This offers new perspectives on how corporate responses to climate change are shaped from within (Ferrary and Déo 2023; Gonenc and Krasnikova 2022).

Second, this study advances the gender diversity literature by extending the focus beyond board-level representation to include management and employees. While prior research, particularly in carbon accounting, has predominantly examined board diversity (Liao et al. 2015), recent studies emphasise that gender diversity at multiple hierarchical levels contributes to corporate environmental performance (Islam et al. 2024). This study is among the first to systematically analyse how gender diversity at all three hierarchical levels influences scenario analysis adoption. The findings align with studies that show gender diversity at the management level enhances carbon management performance and strengthens environmental commitment (Haque et al. 2024). By applying a multi-level lens, we show that climate governance is enacted not only through board-level strategic decisions but also through institutional work carried out by managers and employees in implementing, reinforcing, and legitimising new practices. The findings demonstrate that while board diversity is critical for strategic decision-making, diversity at the management and employee levels reinforces commitment and execution, offering a more comprehensive understanding of how gender diversity shapes firms' climate risk management. This layered view of institutional work highlights how inclusive leadership contributes to the bottom-up and top-down embedding of scenario analysis.

Third, this study contributes to the international literature by examining how institutional and cultural factors shape the relationship between gender diversity and scenario analysis adoption. Recent studies suggest that institutional factors, such as national gender equality policies and legal frameworks, moderate the effectiveness of gender diversity in corporate sustainability efforts (Peng et al. 2023). Prior research on gender diversity in carbon practices has largely been conducted within single-country contexts, focusing primarily on carbon disclosure (Liao et al. 2015). This study extends these limitations by adopting an international perspective and analysing how national masculinity orientation, legal systems, and industry characteristics influence the extent to which gender diversity drives climate risk management.

By applying Institutional Work Theory across diverse institutional contexts, we demonstrate how external environments can enable or constrain the institutional work of gender-diverse actors, thereby shaping the internal adoption of climate strategies. This cross-country approach provides deeper insights into the contextual factors that condition the effectiveness of gender diversity in shaping firms' climate strategies.

The results have implications for directors, management, employees, policymakers and investors. The results show that gender diversity remains an important driving force for corporate sustainability and positive (green) company action, but it is not restricted to only the board of directors. This underscores that gender diversity across all organisational levels influences firms' climate strategies. It indicates that forward-looking climate risk tools, like scenario analysis, are being adopted as part of firms' strategic responses to climate challenges. The findings also highlight that institutional and cultural environments influence the ability of internal actors to perform institutional work, suggesting that policymakers and regulators must consider how contextual conditions shape the internal dynamics of scenario analysis adoption. In addition, the findings highlight the critical role of individual decision-makers in shaping stakeholder concerns and interests, reinforcing the importance of awareness and engagement in scenario analysis adoption. Policymakers should consider these factors as mandatory scenario analysis reporting requirements expand across jurisdictions.

The remainder of the paper is structured as follows. Section 2 presents the literature review. Section 3 outlines the theoretical framework and hypothesis development, Section 4 details the research design and models, Section 5 discusses the results and additional tests, and Section 6 concludes the study.

2 Literature Review

2.1 Review of gender diversity

Gender diversity in the literature has typically been examined at the board level, mostly due to the board's strategic decision-making power (Reddy and Jadhav 2019). Several carbon accounting studies have found that greater gender diversity at the board level enhances the likelihood of voluntary carbon disclosures (Ben-Amar et al. 2017; Hollindale et al. 2019; Hossain et al. 2017). These studies establish that female board members better understand stakeholder demands for greater transparency regarding carbon and climate change-related information. Liao et al. (2015), in particular, find that gender-diverse boards effectively balance firms' financial and nonfinancial goals while moderating stakeholder expectations. This is consistent with the broader sustainability literature that has found that females have a heightened stance on environmental protection over their male counterparts (Bord and O'Connor 1997; Davidson and Freudenburg 1996). Additionally, female members have been associated with fostering stronger corporate social responsibility (CSR) initiatives and sustainability commitments (Larrieta‐Rubín de Celis et al. 2015). Research also suggests that female directors positively influence CSR assurance (Liao et al. 2015), and strengthen carbon assurance practices (Simic et al. 2024; Velte 2024).

While the board of directors holds the highest decision-making authority, managers play a crucial role in implementing strategies and policies (Dwyer et al. 2003). However, the literature has placed significantly less emphasis on female management representation compared to board-level diversity, despite evidence suggesting that female managers also shape firm practices. For example, middle managers are instrumental in strategic decision-making (Kanter 1982). del Mar Alonso-Almeida (2013) finds that female restaurant managers are more likely to adopt water and energy-saving practices. Similarly, Altunbas et al. (2022) find a one-percentage-point increase in female firm managers leads to a 0.5 percentage-point reduction in carbon emissions, demonstrating the tangible impact of gender diversity at the management level. This indicates that female managers contribute meaningfully to improving environmental practices. Overall, studies suggest that female managers may be more effective in achieving long-term corporate sustainability goals and implementing environmental objectives set by the board of directors (Berrone and Gomez-Mejia 2009).

Employees serve as the direct link between firms and stakeholders, engaging with customers and executing policies developed by management. Yet, the influence of female employees on corporate climate action remains largely overlooked. Research suggests that female employees exhibit distinct attitudes toward CSR and climate change compared to their male counterparts (Ballew et al. 2020). Rosati et al. (2018) find that female employees express lower satisfaction with their firm's CSR performance, suggesting higher expectations for corporate sustainability efforts. Moreover, female employees have demonstrated stronger support for climate change policies (Ballew et al. 2020; Ciocirlan and Pettersson 2012). Lu et al. (2020) highlight that, from a stakeholder perspective, firm with a higher proportion of female employees are more likely to drive CSR initiatives. Additionally, research indicates that firms with more female employees tend to be more risk-averse and ethical in their decision-making processes (Rhee et al. 2019). Since scenario analysis is a forward-looking strategy that enables firms to enhance risk management and climate resilience, gender diversity among employees may play a significant role in shaping firms' sustainability outcome. Although much of the literature explains these outcomes through individual values or stakeholder orientation, emerging research on institutional work suggests that such outcomes may result from purposive actions taken by individuals to influence institutional practices (Lawrence and Suddaby, 2006; Bjerregaard, 2011; Smets and Jarzabkowski, 2013). Gender-diverse directors, managers, and employees may contribute to change by initiating, translating, or reinforcing sustainability practices within organizations. These actions reflect not only personal values but also deliberate efforts to shape organizational routines and institutionalize climate-related strategies. This perspective highlights the potential for gender-diverse actors to engage in different forms of institutional work that advance environmental governance, which we explore further in the next section.

2.2 Review of scenario analysis

Scenario analysis has increasingly been recognized as a vital tool for strategic climate risk assessment, especially under the guidance of the Task Force on Climate-related Financial Disclosures (TCFD). Its traditional role in market forecasting has expanded into a central mechanism for evaluating firms' exposure to climate-related risks and opportunities under multiple plausible futures. Despite its growing importance, the uptake of scenario analysis across firms remains limited and uneven. Many companies struggle to incorporate scenario analysis into decision-making and disclosures, particularly in sectors such as banking and finance where the complexity of climate risk is high and internal capabilities vary (Friedrich et al. 2023; Eccles and Krzus 2019).

The literature to date has largely approached scenario analysis from the perspective of voluntary disclosure, focusing on the extent and quality of reported outputs. While some studies explore the relationship between board composition and forward-looking climate reporting, the findings remain mixed. Gender diversity at the board level has been associated with improved overall climate performance and higher quality disclosures in some cases, though not consistently with scenario analysis-specific reporting (Cosma et al. 2022). More recent evidence suggests that gender-diverse boards may influence the likelihood of aligning with TCFD recommendations, including scenario analysis, but not necessarily the depth of that disclosure (Dias et al. 2024). This reflects a broader pattern where scenario analysis remains aspirational for many firms, often adopted symbolically or partially rather than as a deeply embedded process.

Importantly, the adoption of scenario analysis represents more than a technical decision; it reflects the internalization of new institutional logics around climate risk and resilience. Unlike traditional disclosures, scenario analysis demands a forward-looking, strategic mindset and often challenges established practices. As such, its diffusion is unlikely to occur through coercion or conformity alone. Rather, it requires active engagement by organizational actors who interpret, advocate for, and embed the practice into their firm's routines and risk systems. This underscores the importance of examining the internal processes and agents that shape adoption outcomes. Institutional Work Theory offers a useful framework in this regard, by focusing on how individuals and groups within organizations perform purposive actions to create, maintain, or disrupt institutional practices (Lawrence and Suddaby, 2006; Smets and Jarzabkowski, 2013). The next section develops this theoretical foundation and positions institutional work as a means to understand how gender-diverse actors at multiple levels contribute to the institutionalization of scenario analysis.

2.3 Institutional Work Theory

Institutional Work Theory has emerged as a major development in institutional scholarship, aiming to address the limitations of traditional neo-institutional theory by introducing a more agentic understanding of institutional dynamics. Pioneered by Lawrence and Suddaby (2006), institutional work is defined as "the purposive action of individuals and organizations aimed at creating, maintaining, and disrupting institutions" (p. 215). This framework places greater emphasis on how actors, embedded in institutional environments, actively participate in the construction, alteration, or reinforcement of institutions, rather than passively conforming to external pressures. This shift has enabled researchers to examine more closely the micro-foundations of institutional change and stability (Lawrence et al., 2009; Lawrence et al., 2011).

A substantial body of work has since applied Institutional Work Theory to a range of empirical settings. Early studies focused largely on institutional entrepreneurs, such as elite actors who introduced new logics into established fields. However, more recent scholarship highlights the role of distributed agency, demonstrating that institutional work is carried out by a variety of actors, including middle managers, professionals, and frontline workers

(Bjerregaard, 2011; Smets and Jarzabkowski, 2013; Dansou and Langley, 2012). This broader perspective has revealed that institutional work can vary across roles, organizational hierarchies, and that power, resources, and context shape the scope and form of such work (Zietsma and Lawrence, 2010; Gidley and Palmer, 2021). For example, Smets and Jarzabkowski (2013) detail how professionals manage institutional complexity in practice through continuous, relational negotiation of competing logics, while Bjerregaard (2011) highlights how ethnographic approaches can uncover the subtle, everyday forms of institutional work within organizations.

Sustainability and corporate social responsibility (CSR) have become prominent domains for institutional work research. In these areas, actors often face conflicting logics and institutional pressures. Wickert and Risi (2019) show how CSR managers in multinational corporations engage in day-to-day micro-practices—such as alliance-building, nudging, and leveraging informal influence—to embed CSR principles into organizational routines. Similarly, Gawer and Phillips (2013) and Gond et al. (2016) highlight how institutional work underpins the implementation of sustainability standards and reporting tools. In the context of sustainability assurance, Farooq and de Villiers (2018) illustrate how institutional competition between accounting and non-accounting assurance providers shapes the field and practice of assurance. Arenas et al. (2020) examine how sustainable entrepreneurs perform institutional work while navigating structural constraints, contributing to incremental sustainability transitions. These studies collectively demonstrate that embedding environmental practices like scenario analysis requires ongoing, situated efforts from a variety of organizational and field-level actors. Institutional work has also been studied in the context of making sustainability reporting mandatory. Ardiana et al. (2025), for example, document how a coalition of regulators and financial institutions in Indonesia engaged in sustained institutional work—through policy design, advocacy, and coalition-building—to institutionalize sustainability reporting practices. Wilde and Hermans (2024) similarly demonstrate how the transition to a bioeconomy involved multi-level institutional work shaped by industry-specific conditions and inter-actor dynamics.

A growing stream of research explores the gendered dimensions of institutional work. Roos et al. (2020) introduce the concept of *defensive institutional work*, showing how gender equality policies in Flemish universities were undermined by actors defending status quo practices. Styhre (2014) examines how gender equality efforts in the Church of Sweden involved both enabling and constraining forms of institutional work, shaped by religious logics and historical norms. Karam and Jamali (2013) extend this discussion to the Middle East, demonstrating how CSR can act as a platform for institutional work challenging gender norms in conservative settings. Nilsson (2015) further contributes to this discourse by proposing "positive institutional work," emphasizing how actors purposefully construct life-enhancing institutions from positions of marginality. These studies underscore that institutional work is not gender-neutral and that gender-diverse actors may enact change differently, particularly when working from structurally disadvantaged positions.

Despite these advances, several areas remain underexplored. First, the application of Institutional Work Theory to climate scenario analysis, a forward-looking but still emergent corporate sustainability tool, has been limited. While institutional work has been studied in the context of CSR and sustainability more broadly, little is known about how actors inside firms engage in purposive action to embed scenario analysis into organizational routines. Second, although the concept of distributed agency is well established, few studies have examined how institutional work unfolds across multiple organizational levels, such as boards, management, and employees. Most research tends to focus on elite actors or isolated roles, overlooking how institutional work may operate in a layered, hierarchical structure. Third, research on the gendered dimensions of institutional work has highlighted how actors from marginalized positions enact or resist change. However, there is limited empirical insight into how gender-diverse actors at different levels within a firm engage in institutional work related to environmental governance. The intersection of gender, hierarchy, and sustainability remains especially understudied. These gaps motivate the present study, which applies Institutional Work Theory to examine how gender-diverse actors at the board, management, and employee levels engage in the institutionalization of climate scenario analysis. By exploring these dynamics within a global dataset, this study extends existing literature on multi-level and gendered institutional work in the context of climate risk management.

3 Hypothesis Development

3.1 Board Gender Diversity

The board of directors plays a central role in corporate governance, particularly in setting strategic direction and overseeing climate-related risk management (Post et al. 2011). Extensive research shows that gender-diverse boards influence firms' environmental and sustainability practices. Female directors often bring a broader range of perspectives due to differences in educational and professional backgrounds (Hillman et al. 2002), support more deliberative and inclusive decision-making (Daily et al. 2000; Swartz and Firer 2005), and improve overall board effectiveness (Coffey and Wang 1998). Their presence is positively linked to corporate social responsibility performance (Bear et al. 2010), stronger environmental disclosure, and more robust carbon assurance practices (Liao et al. 2015; Liao et al. 2018; Ben-Amar et al. 2017; Hossain et al. 2017).

These empirical patterns suggest that female board members contribute not only through representational diversity but also through active engagement in institutional processes. According to Institutional Work Theory, organizational actors perform purposive actions that aim to create, maintain, or disrupt institutions (Lawrence and Suddaby 2006). Within the context of scenario analysis, which remains an emerging and voluntary climate governance tool, female directors may serve as institutional agents who help embed this practice into corporate routines. This involves reorienting organizational attention, mobilizing support, and legitimizing scenario analysis as a forward-looking risk management approach.

Research on institutional work identifies these actions as enabling and transformative, especially when actors introduce new logics or practices within established structures (Smets and Jarzabkowski 2013; Gidley and Palmer 2021). Board members are structurally positioned to influence strategic priorities, making them key actors in promoting the institutionalization of scenario analysis. Female directors, in particular, have been associated with promoting ethical and stakeholder-oriented values that align closely with environmental responsibility and long-term planning (Karam and Jamali 2013; Nilsson 2015).

Studies have also shown that women in leadership contribute to institutional change by challenging dominant norms and advocating for underrepresented issues such as sustainability. For example, Styhre (2014) and Roos et al. (2020) demonstrate how female leaders engage in institutional work from non-dominant positions to promote gender equality and social change. These insights can be extended to environmental governance, where female directors may advocate for climate planning and embed sustainability tools like scenario analysis into board-level priorities.

Moreover, female directors have been shown to participate more actively in governance functions such as audit and risk committees (Hillman and Dalziel 2003; Adams and Ferreira 2009). Through these formal mechanisms, they can institutionalize climate-related tools by integrating them into disclosure processes and strategic oversight. These efforts reflect a form of institutional work that contributes to embedding emerging practices within the organization.

Taken together, the literature supports the proposition that female board members play an active role in shaping firms' climate strategies through institutional work. Their influence enhances the likelihood that scenario analysis is adopted as a tool for addressing long-term climate-related risks. Therefore, we propose the following hypothesis:

H1: There is a positive and significant relationship between board gender diversity and the adoption of scenario analysis.

3.2 Management Gender Diversity

While boards determine strategic direction, managers are responsible for translating high-level decisions into concrete actions, embedding strategies into daily operations, and coordinating across departments to ensure policy implementation (Dwyer et al. 2003). In the context of scenario analysis, this managerial role is critical. Scenario analysis requires firms not only to recognize long-term climate risks but to operationalize risk frameworks, collect forward-looking data, and coordinate inputs from various business units. These tasks fall primarily within the domain of firm management.

Institutional Work Theory highlights that institutional change does not occur only through disruption at the top, but also through the efforts of embedded actors who work to translate and stabilize new practices in their organizational context. Managers perform this form of translational and embedding institutional work by adapting strategic directives into practical systems, aligning internal processes with new expectations, and sustaining practices once introduced (Smets and Jarzabkowski, 2013; Lawrence and Suddaby, 2006). Recent studies have further shown that middle managers perform institutional work by mediating between strategic imperatives and day-to-day practices, facilitating the internalization of new governance tools such as sustainability reporting and CSR norms (Wickert and Risi 2019; Gidley and Palmer 2021). These roles are particularly relevant when new practices require cross-functional coordination and cultural adjustment, as is the case with scenario analysis.

Gender-diverse management teams may be especially effective in enabling this type of institutional work. Research shows that female managers bring distinct perspectives to sustainability and are more attuned to climate-related risks than their male counterparts (Ciocirlan and Pettersson 2012; Bord and O'Connor 1997). These differences in perception can influence how climate strategies such as scenario analysis are adapted and institutionalized.

Empirical studies suggest that female managers are more likely to champion environmentally responsible practices, including energy and water efficiency measures (del Mar Alonso-Almeida 2013), and contribute to measurable reductions in firm carbon emissions (Altunbas et al. 2022). Female leadership has also been linked to stronger execution of environmental objectives and more effective delivery of long-term sustainability results (Berrone and Gomez-Mejia 2009). These contributions reflect purposeful engagement with climate governance practices and align with the notion of institutional work as ongoing, adaptive, and enacted by individuals within operational hierarchies. Through their direct control over internal systems and performance targets, gender-diverse managers play a key role in embedding emerging practices such as scenario analysis into the fabric of the organization. Furthermore, research finds that female managers are more likely to align operational practices with stakeholder expectations around emissions and risk disclosure (Liao et al. 2015; He et al. 2022) and are more responsive to sustainability concerns raised by customers, suppliers, and employees (Galletta et al. 2022). These patterns reinforce the idea that female managers engage in institutional work not only by implementing formal policies but also by reinforcing evolving climate norms through their interaction with internal and external stakeholders. Their influence strengthens the internal legitimacy of climate tools such as scenario analysis, contributing to their long-term adoption.

Based on this theoretical perspective and empirical evidence, we propose the following hypothesis:

H2: There is a positive and significant relationship between management gender diversity and the adoption of scenario analysis.

3.3 Employee Gender Diversity

Although employees do not typically hold formal strategic authority, they play a foundational role in shaping corporate culture, influencing operational practices, and reinforcing sustainability initiatives. Within Institutional Work Theory, employees can engage in what is often referred to as everyday institutional work, where micro-level actions contribute to the reproduction or gradual transformation of organizational practices (Lawrence and Suddaby 2006; Bjerregaard 2011). In the context of climate scenario analysis, employees help implement new tools, adapt internal behaviors, and legitimize sustainability values through their ongoing participation and cultural influence.

Research shows that female employees are more likely to demonstrate concern for climate change and support strong environmental policies compared to their male counterparts (Ballew et al. 2020; Ciocirlan and Pettersson 2012). They also report higher dissatisfaction with inadequate CSR efforts, indicating elevated expectations for corporate sustainability (Rosati et al. 2018). These traits contribute to a workplace culture that is more supportive of forward-looking climate strategies. Firms with a higher proportion of female employees tend to exhibit more ethical decision-making, greater risk aversion, and improved reporting quality (Rhee et al. 2019; Kim 2022), all of which align with the adoption of proactive climate tools like scenario analysis.

Institutional Work Theory recognizes that even actors without formal authority can play a role in institutionalizing change through what has been described as normative and relational work. This involves influencing norms and expectations within the organization by participating in collective meaning-making processes (Gidley and Palmer 2021). In this view, female employees may help reinforce the legitimacy of climate risk management tools by aligning daily behaviors and peer norms with sustainability values. Their influence contributes to the social embedding of practices like scenario analysis, particularly in organizations where inclusive culture and strong employee engagement are valued.

Moreover, female employees frequently interact with stakeholders such as customers, local communities, and civil society groups, acting as bridges between the firm and external expectations. Through these relationships, they indirectly shape how firms respond to climate-related pressures and ensure that sustainability commitments are enacted rather than merely symbolic. As such, their contributions represent a form of institutional maintenance and adaptation, reinforcing the organizational uptake of climate scenario analysis over time. Based on this reasoning and empirical support, we propose the following hypothesis:

H3: There is a positive and significant relationship between employee gender diversity and the adoption of scenario analysis.

4 Research Design

4.1 Sample and Data

All carbon information for the study is collected from the CDP. The CDP contains a comprehensive collection of carbon information due to their annual voluntary and standardised questionnaire. Due to these factors, the CDP is commonly adopted in studies examining carbon and climate change-related factors (Datt et al. 2018; Fan et al. 2021; Liao et al. 2015; Simic et al. 2024; Zhou et al. 2016). Overall, this creates consistency between firms and studies alike.

The sample period covers the CDP2018-2023 period, corresponding to the 2017-2022 financial years. We start from CDP 2018 because it marks the first year the CDP aligned its annual survey with the TCFD framework, which includes questions on scenario analysis. Financial and corporate governance data are gathered via LSEG Eikon, DataStream and ESG database. In addition, country data is collected from World Bank. All continuous variables are winsorised at the 1st and 99th percentiles. The sample selection process, as outlined in Table 1 Panel A, shows that a final sample of 10,175 firm-year observations is used. The initial sample consisted of 49,360 firm-year observations invited by the CDP to participate in the questionnaire. In total, 22,406 firm-year observations participated in the CDP survey; however, 12,231 firm-year observations were missing country-level, financial or corporate governance data. The final sample is representative of 2,944 firms from 50 regions and all 11 Global Industry Classification Standard (GICS) sectors.

[Insert Table 1 here]

Panel B of Table 1 presents the sample distribution by year and the adoption rate. The results show an increase of scenario analysis adoption over the period. While Panel C presents the sample distribution by the GICS sector. Among 11 GICS sectors, the Industrials sector (25.49%) dominates the sample, followed by Materials (16.73%), Financials (13.28%), Consumer Staples (9.61%) and Utilities (6.29%). Most firms are based in less carbon-intensive industries like the consumer discretionary, industrials and financials, with less environmental risks but a wider range of stakeholders. Table 1 Panel D presents the sample distribution by country. The largest number of observations that undertake scenario analysis come from the US (23.30%), followed by Japan (15.04%) and the United Kingdom (9.75%).

4.2 Empirical Model

To test the hypotheses a series of regression models are utilised. The following model is used to examine Hypotheses 1-3 and is considered the main model:

$$\begin{aligned} SA = \beta_0 + \beta_1 FDIRECTOR + \beta_2 FMANAGER + \beta_3 FEMPLOYEE \\ + \beta_4 CSRCOM + \beta_5 INC + \beta_6 BSIZE + \beta_7 INDEP + \beta_8 INT \\ + \beta_9 SIZE + \beta_{10} ROA + \beta_{11} TOBQ + \beta_{12} LEV + \beta_{13} GDP \\ + \beta_{14} ETS + Sectors\ Fixed\ Effects \\ + Country\ Fixed\ Effects + Year\ Fixed\ Effects \end{aligned} \qquad (1)$$

The dependent binary variable, *SA*, is coded as 1 if firms use climate-related scenario analysis and otherwise 0 (See Appendix A for a full definition of variables). The three variables of interest are *FDIRECTOR*, *FMANAGER* and *FEMPLOYEE*. *FDIRECTOR* is the percentage of females acting as a company's board of directors, *FMANAGER* is the percentage of female managers, and *FEMPLOYEE* is the percentage of female employees. A positive and significant sign is expected between all the variables of interest and *SA*.

To avoid misspecification, control variables are added. First several corporate governance variables are added. *CSRCOM is* assigned a value of 1 if board-level CSR committee is present and 0 otherwise. Firms with CSR committees better understand stakeholder interests and will establish targets and strategies (Liao et al. 2015). *INC* is coded 1 if senior executives' compensation is linked to CSR, health and safety, or sustainability targets, and otherwise 0. Without compensation firm agents will be less inclined to invest in costly long term green projects that will likely influence their compensation (Liao et al. 2015). Board size (*BSIZE*) is the total number of acting board of directors. Board size influences the board's composition in terms of its collective experience, age, education, cultural and gender diversity (Denis and Sarin 1999; Lim et al. 2007). Board independence (*INDEP*) is calculated as the percentage of independent members on a board of directors. Due to their separation from day-to-day management and decision making, independent directors are seen as a less influenced and vital monitoring tool (de Villiers et al. 2011).

Moreover, firm related variables are included. *INT* or emissions intensity is calculated as the natural logarithm of the total of Scope 1 and Scope 2 emissions over firm sales revenue. Firms with greater emission levels have increased public attention as do larger firms (Liao et al. 2015). Firm size (*SIZE*) is calculated as the natural logarithm of firm market capitalisation. *ROA* is measured as the ratio of net income over total assets and is a historical accounting profitability measure. The second profitability measure is Tobin's Q a forward-looking market measure (Bozec et al. 2010). *TOBQ* is calculated as the 'total market value based on the year-end price and the number of shares outstanding, plus preferred shares, the book value of long-term debt, and current liabilities, divided by book value of total assets' Datt et al. (2020, 162). Leverage (*LEV*) is defined as the ratio of total debt to total assets. *GDP* is calculated as the natural logarithm of gross domestic product per capita in USD. *ETS* is coded as 1 if the country has a country-level Emissions Trading System and if not 0. Lastly, industry, country and year fixed effect are controlled for.

5 Empirical Results

5.1 Descriptive Statistics

Table 2 contains the descriptive statistics for the main model. Approximately 70% of firm observations undertake scenario analysis, a similar adoption rate to other carbon mechanisms like carbon assurance (Datt et al. 2018; Fan et al. 2021; Luo et al. 2023; Simic et al. 2024). Firms undertaking scenario analysis tend to have greater female director representation (26.03%) than their non-adopting counterparts (25.15%). They also tend to have more female managers (Yes = 20.20% vs No = 16.99%), and female employee representation (Yes = 29.01% vs No = 26.90%). Firms that adopt scenario analysis also typically have more CSR committee presence, linked incentives, and board members, but lower board independence. Further, scenario adopting firms have greater carbon intensity (11.40) than non-adopting firms 10.20. Showing that scenario adopting firms have greater emission levels, they are also larger in size (15.94 vs 15.49) and have a greater ROA and equal leverage. In contrast, they have a lower Tobin's Q, and come from countries with a lower GDP per capita, and less ETS.

[Insert Table 2 here]

5.2 Univariate Results

Table 3 shows the Pearson correlation coefficient, which is undertaken to check for multicollinearity that can impact the model's ability to determine the influences of independent variables. Based on the findings the strongest relationship is determined between *LEV* and *TOBQ* (0.6171), which does not indicate multicollinearity. Further, the results show a positive correlation and significant relationship between *SA* and *FMANAGER* and *FEMPLOYEE*. However, a non-significant and positive relationship is found between *FDIRECTOR* and *SA*. This offers some preliminary support for ***H2*** and ***H3***, but not ***H1***. Further, a positive correlation is found between *LEV* and *SA*, and a significant and positive correlation is also noted between *SA* and *CSRCOM*, *INC*, *BSIZE*, *INT*, and *SIZE*. While *INDEP*, *ROA*, *TOBQ*, *GDP* and *ETS* are significant but negatively correlated with *SA*.

[Insert Table 3 here]

5.3 Multivariate Results

Table 4 presents the logit regression results for the main model. ***H1*** predicted a positive and significant relationship between board gender diversity and scenario analysis adoption. The results support this hypothesis as a positive and significant relationship exists between *FDIRECTOR* and *SA* ($z = 4.71$, $p < 0.01$). This result furthers the argument that gender diversity at the board level is critical in improving firm climate change and carbon-related practices. ***H2*** postulates a significant and positive relationship between *FMANAGER* and *SA*. The results showed for *FMANAGER* ($z = 3.16$, $p < 0.01$) support this hypothesis, as it is positive and significantly associated with *SA*. This finding shows that female managers are also critical in the decision to undertake scenario analysis. Similarly, the results support ***H3***, which hypothesises a positive and significant relationship between *FEMPLOYEE* and *SA* ($z = 1.94$, $p < 0.1$). Although females in leadership positions influence the adoption of scenario analysis, so can female employees.

There are also several control variables that are also significantly associated with *SA*. *CSRCOM* has a positive and significant association with *SA* ($z = 3.69$, $p < 0.01$). This shows that firms with CSR committees present are more likely to undertake scenario analysis adoption. Firms with CSR committees have a better understanding of stakeholder needs. Firms with CSR-linked incentives are also more likely to under scenario analysis ($z = 3.53$, $p < 0.01$). This finding is consistent with the literature, which states that firms with CSR compensation undertake more carbon strategies (Haque 2017). Firms with larger boards are also more likely to undertake scenario analysis ($z = 2.31$, $p < 0.05$), as are those with more independent members ($z = 2.08$, $p < 0.05$). Overall, the corporate governance control variables show better corporate governance led to better scenario analysis practices. Similarly, firms with greater carbon emissions intensity ($z = 10.02$, $p < 0.01$) and larger in size ($z = 13.46$, $p < 0.01$) are more likely to undertake scenario analysis. This finding shows that firms with greater stakeholder pressures and media attention are more likely to undertake positive carbon practices (Simic et al. 2024).

In contrast, *GDP* is negatively and significantly related to *SA* ($z = -4.27$, $p < 0.01$). While the remaining control variables are found not to have a significant influence on scenario analysis adoption.

Overall, the results indicate that gender diversity at the board, managerial and employee levels influences the adoption of scenario analysis. The coefficient size suggests that the board of directors is the most influential, followed by female managers and then employees. This finding is consistent with the hierarchical power of individuals in those positions. An additional test examining the chi-square between each of the different groups (directors vs. managers, directors vs. employees and managers vs. employees). The results further show that the gender diversity of the board of directors has the most significant influence as there is a statistical difference between the portions of female directors and female managers ($Chi^2 = 4$, $p < 0.05$) and female directors and female employees ($Chi^2 = 8.08$, $p < 0.05$). However, the final test between female employees and managers is not significant. Overall, this suggests that there are potential inequalities in the leadership roles of females, particularly with the underrepresentation of female directors over female managers and employees.

[Insert Table 4 here]

5.4 Robustness tests and sensitivity analysis

To check the robustness of the results, several additional tests are conducted. First, a probit model is conducted, with the results presented in Table 4 remaining consistent with those of the logit model. A slight variation in coefficient values is noted, which is expected between these two regression types. Second, variations are applied to the sample, with observations meeting certain criteria excluded, followed by running the main model after each variation, before reintegrating the observations for the next variation test. Specifically, firms from the largest sector (Industrials) are dropped. Firms from the Financials sector are also dropped due to their unique asset nature and regulatory environment (Datt et al. 2019). Observations from the year 2023 are excluded and countries with less than 10 observations are removed.

Additionally, firms from the US are dropped, as they presented the largest portion of the sample. Overall, the un-tabulated results do not show indicate significant changes.

Further, to mitigate concerns of reverse causality, we conduct a forward-looking robustness check by measuring the dependent variable *SA* at time *t+1*, while keeping all independent variables at time *t*. This approach ensures that current firm characteristics are used to predict future outcomes, thereby helping to establish temporal precedence and reducing the likelihood that *SA* influences gender diversity. The results of this test are reported in Column 1 of Table 5, Panel A. Second, to address simultaneity bias and ensure the correct temporal ordering of effects, we re-estimate our baseline models using one-year lagged values of independent variables (measured at *t-1*), while keeping *SA* measured at time *t*. This approach helps confirm that the observed association is not driven by concurrent feedback effects or contemporaneous shocks. The results are presented in Table 5, Panel B. Furthermore, a generalised method of moments (GMM) model is also estimated, with instrumental variables lagged by one year and fixed effects applied. The results, shown in Column 2 of Table 5 Panel A, are consistent with our main findings, further reinforcing the robustness of the analysis.

[Insert Table 5 here]

Since the CDP is a voluntary, self-reported survey, there is an inherent risk of self-reporting bias. To address this risk, Heckman (1979) two-stage test is conducted, along with the Heckman maximum likelihood analysis as outlined by Matsumura et al. (2014). In the first stage, the model considers the decision to disclose to the CDP or not, whereas in the second stage, Model 1 is used. The decision model in the first stage is outlined as follows:

$$\begin{aligned} DISC = {} & \beta_0 + \beta_1 INDMEAN + \beta_2 LAGDISC + \beta_3 DUAL + \beta_4 ENVSCORE \\ & + \beta_5 ROE + \beta_6 CSRCOM + \beta_7 BSIZE + \beta_8 INDEP + \beta_9 SIZE \\ & + \beta_{10} TOBS + \beta_{11} GDP + \beta_{12} ETS + Sectors\ Fixed\ Effects \\ & + Country\ Fixed\ Effects + Year\ Fixed\ Effects \end{aligned} \tag{2}$$

The dependent binary variable *DISC* is coded as 1 if the firm responded to the CDP questionnaire; otherwise 0 (Datt et al. 2020; Fan et al. 2021; Simic et al. 2024; Zhou et al. 2016). *INDMEAN* is the propensity to disclose and is based on the likelihood of firm disclosure (Datt et al. 2020). *LAGDISC* is coded as 1 if the firm disclosed in the previous period, and otherwise 0. The following control variables from Model 1 are also added: *CSRCOM*, *BSIZE*, *INDEP*, *SIZE*, *GDP*, *ETS*, and industry, year, and country fixed effect. Three additional variables are added: *DUAL*, *ENVSCORE,* and *ROE*. *DUAL* is coded as 1 if the CEO and the chairperson of the board of directors are the same individual. When duality is present, there is an inherent power imbalance due to the CEO's higher position and the impact on the chairperson's role in monitoring the CEO (Prado-Lorenzo and Garcia-Sanchez 2010). Historically, this has been found to be negatively associated with carbon disclosure. *ENVSCORE* is representative of a firm's impact on the ecosystems of both living and non-living natural systems. *ROE*, or return on equity, is measured as net income over shareholder equity. The variables of interest are positive and significant, which is consistent with the main model. Therefore, the results in Table 5 Panel B are considered robust.

6 Further Analysis

6.1 Critical Mass

The existing gender diversity literature has established that female representation, particularly at the director level, is critical in influencing firm practices, including carbon disclosures (Hossain et al. 2017; Liao et al. 2015).However, even some carbon studies fail to identify an influence (Cosma et al. 2022; Hayes 2001; Kılıç and Kuzey 2018; Prado-Lorenzo and Garcia-Sanchez 2010). For instance, board gender diversity did not affect the disclosure of forward-looking information, such as short- or long-term forecasts like scenario analysis (Cosma et al. 2022). On the other hand, Waheduzzaman et al. (2024) failed to observe that female employees contribute to carbon emission reduction. While these findings appear inconsistent with the broader literature, they may be reconciled through the lens of critical mass theory.

Critical mass theory suggests that unless a sufficient proportion of individuals from an underrepresented group is present, their potential contributions may be suppressed due to conformity pressures (Asch 1951). In such situations, female directors, managers or employees may lack the psychological safety and influence needed to engage in transformative initiatives. Importantly, Institutional Work Theory offers further insight into this process by highlighting that agents need sufficient critical support and relational embeddedness within a group to initiate and sustain institutional work (Lawrence and Suddaby, 2006). Without reaching a critical mass, individuals may be unable to engage meaningfully in the creation, maintenance, or reinforcement of institutional practices such as scenario analysis.

Overall, increasing the presence of women reduces tokenism and enhances their ability to contribute substantively to group dynamics (Guldiken et al. 2019). Studies in the governance literature often equate a critical mass with three female directors or approximately 30 percent representation (Konrad et al. 2008). Upon reaching this threshold, firms begin to benefit from the unique insights and leadership approaches of female directors (Post et al. 2011; Torchia et al. 2011; Williams 2003). However, recent carbon-related studies suggest that a lower threshold—such as two female directors or 20 percent representation—can also trigger influence in this context (Ben-Amar et al. 2017; Hollindale et al. 2019).

From the Institutional Work Theory perspective, this suggests that a threshold level of gender diversity is necessary for institutional agents to engage effectively in normative and cognitive work that embeds scenario analysis within organizational routines. Below this threshold, even well-intentioned individuals may lack the legitimacy or collective agency to influence strategic practices.

Moreover, critical mass theory is applicable not only to the board level but also across different organizational strata. Prior research has primarily focused on the board unless specific team dynamics are studied (Reddy and Jadhav 2019). Extending the logic to management and employees, we argue that a minimum representation is also required at these levels for gender-diverse actors to meaningfully influence their male counterparts. Institutional Work Theory supports this multi-level perspective, highlighting that institutional work is not confined to formal leaders but also arises from middle managers and employees who engage in day-to-day practices that shape organizational fields. When a critical mass is reached, female managers and employees are more likely to articulate their climate-related concerns and proactively shape corporate practices. This collective influence enhances the firm's responsiveness to climate risks, including the adoption of scenario analysis.

[Insert Table 6 here]

The empirical results in Table 6 support these arguments. A critical mass of 20 percent is required for female directors to positively influence the adoption of scenario analysis ($z = 3.65$, $p < 0.01$). This is consistent with earlier carbon studies that identified a 20 percent threshold as sufficient for female directors to shift firm practices (Ben-Amar et al. 2017; Hollindale et al. 2019; Liao et al. 2015) . Notably, a lower critical mass threshold of 10 percent is found for both female managers ($z = 2.26$, $p < 0.05$) and female employees ($z = 2.53$, $p < 0.05$). These findings highlight how the positional power of organizational actors interacts with representational thresholds to enable institutional work. For example, a 10 percent share of female employees within a large workforce may represent a numerically substantial and socially visible cohort capable of influencing organizational culture and sustainability values.

These findings suggest that gender-diverse actors can only engage effectively in institutional work to promote scenario analysis when they are present in sufficient numbers to overcome tokenism and activate collective agency. This has important implications for firms seeking to institutionalize climate risk practices, as achieving critical mass is a prerequisite for unleashing the transformative potential of gender-diverse actors across the organizational hierarchy.

6.2 Cross-sectional analysis

6.2.1 Masculinity vs Femininity

A country's masculinity influences the development and role of females and its culture (Hofstede 1998). When countries are more masculine-oriented, their culture focuses on societal traits related to competitiveness, whereas more feminine countries have an emphasis on community and cooperation (Hofstede 1998). The traditional role of males, such as family heads and the primary decision-makers, is also more prevalent in more masculine countries (Hofstede 2011). Consequentially, these countries will also have fewer female politicians and will focus on firm financial performance over long-term sustainability. Female directors are found to have been impacted by the masculinity orientation of the country, including their risk aversion (Mohsni et al. 2021), influence on CSR (Peng et al. 2022) and water disclosure (Peng et al. 2023).

From an Institutional Work perspective, national cultural norms such as masculinity may shape the legitimacy and pathways through which actors perform institutional work. In masculine cultures, gendered expectations may limit the institutional capacity of female employees and middle managers to introduce or reinforce new practices. However, women in higher leadership positions, such as directors, may gain sufficient authority and strategic positioning to navigate or even adopt culturally dominant traits such as assertiveness, enabling them to perform institutional work that advances climate governance goals.

As a result, female directors may retain their advocacy for scenario analysis while simultaneously demonstrating strategic leadership aligned with competitive expectations. Female managers may similarly adapt, although with less institutional power. In contrast, female employees may have limited structural authority and face stronger cultural constraints, making it more difficult for them to engage in institutional work that challenges dominant logics. Thus, the institutional environment can either enable or suppress the ability of gender-diverse actors to enact change, depending on their position in the organizational hierarchy and the cultural context.

As competing arguments exist on the influence of masculinity on females in higher leadership positions, we do not make any prior prediction for their moderating effect. In contrast, we predict a negative moderating effect for female employees.

[Insert Table 7 here]

The results in Table 7 Panel A show that *MASC×FDIRECTOR* is positive and significant ($z = 2.13$, $p < 0.05$, in Column 1). This finding indicates that the relationship between female directors and scenario analysis is strengthened in more masculine countries. This may reflect their ability to adopt assertive leadership styles while legitimising climate strategies through institutional work. However, the results do not show a significant moderating influence for *MASC×FMANAGER*, although it should be noted a negative sign is observed. Similarly, a negative but significant result is found for *MASC×FEMPLOYEE* ($z = -1.79$, $p < 0.01$, in Column 3). This finding supports the theoretical expectation that female employees in lower-tiered positions are more constrained by the cultural context and thus less able to influence climate strategy. These results underscore how the institutional environment interacts with positional authority to shape the capacity for institutional work. In more masculine cultures, female leaders appear to adapt and maintain influence, while those in lower positions face reduced opportunity to engage in meaningful change.

6.2.2 Legal System

The legal system (common law or non-common law) of a country has also been known to impact firm decision-making. In the common law legal system, the judgements made by the court set precedents that are considered in future cases (La Porta et al. 1997). In contrast, in non-common law legal systems, like code law, prior decisions by judges do not affect the country's laws (Salhi et al. 2020). Firms operating in a common law country have been found to have better corporate governance and higher CSR activities even when a firm from a civil law country has comparable corporate governance. Firms from common law countries also have been found to have greater disclosure levels than code law countries (Beekes et al. 2016).

From an Institutional Work Theory perspective, legal systems shape the institutional context in which actors operate, influencing both the legitimacy and effectiveness of their actions. Common law systems, with their more flexible and precedent-based legal environments, may provide greater space for purposive actors to introduce and legitimise emerging practices such as scenario analysis. In contrast, code law systems may constrain such efforts due to their emphasis on formal rules and lower tolerance for voluntary innovation.

Firms domiciled in common law legal systems may feel a greater level of pressure to undertake voluntary practices, like scenario analysis, to mitigate risks and increase their reputation, unlike firms in the rigid regulatory nature in code law countries that limit adaptability and innovation. Therefore, we expect that institutional actors in common law settings, especially those from underrepresented groups, are better positioned to perform institutional work that promotes scenario analysis adoption.

Table 7 Panel B contains the moderating influences of legal system. In Column 1 a positive and significant association is observed for *LAW×FDIRECTOR* ($z = 1.85$, $p < 0.1$). This finding is consistent with Column 2, for *LAW×FMANAGER* ($z = 2.29$, $p < 0.05$), and in Column 3 for *LAW×FEMPLOYEE* ($z = 1.80$, $p < 0.1$). Thus, the results overall indicate that the common law legal environment enables gender-diverse actors across hierarchical levels to more effectively engage in institutional work that embeds scenario analysis into firm practice.

6.2.3 Carbon Intensive Industries

The industry firms operate in has also been known to impact their stakeholder relationships and expectations. Firms from carbon-intensive sectors (materials, utilities and energy) typically have higher emissions and face increased stakeholder scrutiny (Datt et al. 2018). These firms are often expected to take more proactive measures in addressing climate risks, including forward-looking planning tools that can reduce the impact of climate change.

Firms in these sectors typically rely on raw materials such as gas, coal, and oil, and maintain infrastructure that spans multiple regions—making them especially vulnerable to natural disasters that may occur more frequently due to climate change.

In such industries, actors within firms may experience intensified external pressure to adopt new environmental governance practices like scenario analysis. This creates a fertile context for institutional work, particularly by gender-diverse actors who may be more attuned to climate-related risks and stakeholder concerns. Therefore, we expect that the relationship between gender diversity and scenario analysis adoption is stronger in carbon-intensive sectors, where field-level pressures increase the urgency and legitimacy of institutional work related to climate resilience.

Table 7 Panel C shows the results of the influence of carbon intensive industries. The coefficients for *IND×FDIRECTOR* ($z = 2.98$, $p < 0.01$, in Column 1), *IND×FMANAGER* ($z = 2.40$, $p < 0.05$, in Column 2), and *IND×FEMPLOYEE* ($z = 1.83$, $p < 0.1$, in Column 3) are all positive and significant, showing that the positive impact of gender diversity at all levels on the scenario analysis adoption are stronger in the carbon intensive sectors. These findings indicate that in industries facing heightened climate scrutiny, gender-diverse directors, managers, and employees are more likely to engage in institutional work that introduces and reinforces climate-related practices such as scenario analysis. Their diverse perspectives and environmental orientations enhance firms' responsiveness to emerging norms and support the internal institutionalisation of forward-looking climate governance tools.

6.2.4 COVID-19

As the sample period examines the 2017-2022 period, it crosses over a unique occurrence in the modern business landscape. The COVID-19 pandemic created global challenges and uncertainty for many business operations, including impacting supply chains and manufacturing operations. These challenges lead to firms having to shift their focus, including maintaining their value chain. Further, during this time there was a reduction in global carbon emissions credited to increased work from home arrangements (Ray et al. 2022). As a result, firms during this time may have deprioritised long-term climate planning, including scenario analysis, in favour of short-term crisis management.

To test the influence of COVID-19, *COV* is introduced and interacted with the variables of interest. *COV* is coded as 1 if the year is 2020 and 2021[1], otherwise 0. The years, 2020 and 2021 saw the most disruptions worldwide due to global lockdowns, travel restrictions, and supply chain issues. The results are presented in Table 7 Panel D. The moderator *COV×FDIRECTOR* is negative, but not significant. A similar result is observed for *COV×FEMPLOYEE*. However, a negative and significant result is found between *SA* and the moderator *COV×FMANAGER* ($z = -1.77$, $p < 0.1$. in Column 3). This suggests that during the COVID-19 pandemic, female managers were less able to engage in institutional work to promote scenario analysis, possibly due to resource constraints and the pressing need to address immediate operational and financial challenges.

From an Institutional Work Theory perspective, crisis events such as COVID-19 may disrupt the conditions under which institutional actors are able to perform change-oriented work. Under heightened uncertainty and limited slack resources, even well-positioned managers may be forced to suspend or delay engagement with emerging governance practices like scenario analysis. In this context, the observed reduction in influence does not reflect a lack of commitment, but rather a reallocation of attention toward short-term organizational survival.

7 Conclusion

Scenario analysis, as a forward-looking mechanism, is crucial for stakeholders because it mitigates uncertainty and enhances corporate preparedness. The results show that gender diversity at the board, management and employee levels enable firms to better understand

[1] This corresponds to CDP2021 and CDP2022.

stakeholder needs and respond to climate concerns through scenario analysis adoption—an area that has been scarcely researched. A logit regression model, using an international sample of 10,175 firm-year observations over the CDP2018-2023 period, tests these hypotheses. The results show that gender diversity at any level in a firm's structure significantly influences firms' decision to undertake scenario analysis. Furthermore, a lower critical mass of female representation is required to encourage firms to adopt scenario analysis.

The results also show that institutional and environmental factors, such as national masculinity norms, legal systems and industry characteristics, moderate the relationship between gender diversity and scenario analysis adoption. These moderating effects demonstrate how the impact of gender diversity varies depending on the institutional setting. The study also considers the influence of COVID-19 as a moderating factor, finding that during this period, the effect of gender diversity on scenario analysis adoption is weakened, likely due to a shift in attention and resources away from long-term initiatives and toward short-term survival priorities.

By framing our analysis within Institutional Work Theory, this study highlights how gender-diverse actors across organizational levels engage in purposive actions to embed scenario analysis as an emerging climate governance practice. The findings reveal that the presence and positioning of these actors—combined with enabling or constraining institutional contexts—are critical to shaping how new practices become legitimized and sustained within firms.

These findings have important implications for the adoption and regulation of scenario analysis. As firms navigate an increasingly uncertain business environment, they must address stakeholder concerns, as future uncertainties can impact production, operations and long-term viability. Scenario analysis is essential for addressing these uncertainties due to its forward-looking nature and adaptability to firm-specific needs. Regulators should consider mandating scenario analysis practices and providing support mechanisms for firms with fewer resources, particularly small and medium-sized enterprises. Incorporating scenario analysis into corporate strategy will contribute to a more climate-conscious and well-prepared society, ultimately aiding countries in achieving their carbon-neutral transition plans.

These findings reinforce that board and workforce diversity are critical drivers of positive corporate practices, which can be achieved by increasing female representation. When designing boards, firms should prioritise appointing individuals who are knowledgeable about climate change and committed to managing both corporate sustainability and financial performance. However, diversification should extend beyond the boardroom to managerial and employee levels, as these groups engage with a broader range of stakeholders, like customers and suppliers, who are typically not involved in board-level decision-making.

This supports the view that institutional work is distributed and enacted throughout the organizational hierarchy—not only at the top—which is essential for embedding sustainability practices.

Further, corporate leaders and regulators must anticipate the evolving regulatory landscape, which will increasingly mandate scenario analysis disclosures. Another key challenge is the limited availability of expertise in carbon accounting, as only a few institutions have begun introducing relevant courses. Given the growing importance of scenario analysis for future reporting, this study provides valuable insights into an emerging area of corporate carbon management, climate risk assessment, and uncertainty mitigation.

This study also has certain limitations. Although the CDP dataset is widely regarded as the most comprehensive source of carbon-related information, it has inherent constraints. Many CDP respondents are large companies, which raises concerns about the generalizability of these findings to small and medium-sized enterprises. In addition, as the CDP relies on self-reported data, there is a risk of self-reporting bias. Whilst Heckman's two-stage test is applied to address this bias, it does not eliminate it entirely.

While our study provides novel insights, it also opens several avenues for future research. First, beyond adoption, future studies could explore how gender diversity affects the quality and depth of scenario analysis implementation, including the rigor of assumptions, scenario complexity, and integration into strategic decision-making. Second, given the growing regulatory focus on mandatory climate risk reporting, it remains unclear whether gender-diverse firms will continue to lead in scenario analysis or whether compliance will dilute voluntary leadership. Finally, future research could examine whether gender-diverse leadership translates into better financial or environmental outcomes, such as improved investor confidence or lower carbon transition risks. As scenario analysis becomes a cornerstone of corporate sustainability reporting, these questions will be vital for academics, practitioners, and policymakers alike.

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Table 1 Sample Distribution

Panel A Sample Selection

	2018	2019	2020	2021	2022	2023	Total
Received questionnaire CDP2018-2023	6,040	5,867	6,227	7,070	9,993	14,163	49,360
Less: those that did not participate	(3,567)	(3,231)	(3,275)	(3,567)	(4,922)	(8,392)	(26,954)
Less: not Public	(634)	(566)	(647)	(800)	(1,491)	(1,520)	(5,658)
Less: missing responses	(43)	(58)	(62)	(13)	0	(11)	(187)
Total CDP invitee responses	1,796	2,012	2,243	2,690	3,580	4,240	16,561
Add: non-invited participants	1	1	2,280	3,213	4,813	6,592	16,900
Total usable CDP responses	1,797	2,013	4,523	5,903	8,393	10,832	33,461
Less: firms missing data	(632)	(645)	(2,989)	(4,000)	(6,225)	(8,795)	(23,286)
Final sample	1,165	1,368	1,534	1,903	2,168	2,037	10,175

Panel B Sample distribution by Year

Year	N	%	Mean *SA*	Mean *FDIRECTOR*	Mean *FMANAGER*	Mean *FEMPLOYEE*
2018	1,165	11.45%	0.50	21.49	15.45	25.19
2019	1,368	13.44%	0.55	23.43	17.14	26.41
2020	1,534	15.08%	0.64	24.63	18.40	27.47
2021	1,903	18.70%	0.70	26.27	19.90	28.74
2022	2,168	21.31%	0.74	27.33	20.26	29.20
2023	2,037	20.02%	0.90	28.49	22.04	31.00
Total	10,175	100%	0.70	25.76	19.30	28.38

Panel C Sample distribution by GICS Sector

GICS Sector	N	%[a]	Mean *SA*	Mean *FDIRECTOR*	Mean *FMANAGER*	Mean *FEMPLOYEE*
Energy	468	4.60%	0.83	23.53	17.26	22.01
Materials	1,702	16.73%	0.75	23.94	14.35	18.59
Industrials	2,594	25.49%	0.68	23.71	12.81	22.25
Consumer Discretionary	580	5.70%	0.58	29.23	28.89	40.49
Consumer Staples	978	9.61%	0.67	26.58	20.71	30.12
Health Care	584	5.74%	0.60	27.13	27.88	38.31
Financials	1,351	13.28%	0.71	28.22	27.42	42.91
Information Technology	400	3.93%	0.64	26.47	17.39	27.72
Communication Services	490	4.82%	0.62	27.65	21.81	31.49
Utilities	640	6.29%	0.87	26.51	18.29	20.83
Real Estate	388	3.81%	0.74	28.01	28.19	41.19
Total	10,175	100%	0.70	25.76	19.30	28.38

Panel D Sample distribution by Country

Country	N	%[a]	Mean *SA*	Mean *FDIRECTOR*	Mean *FMANAGER*	Mean *FEMPLOYEE*
Argentina	5	0.05%	0.60	9.56	19.43	21.29
Australia	232	2.28%	0.76	33.76	27.12	33.63
Austria	63	0.62%	0.86	27.87	17.61	30.21
Belgium	88	0.86%	0.75	37.04	21.83	33.96
Bermuda	5	0.05%	0.80	28.94	14.96	31.86
Brazil	300	2.95%	0.75	13.50	23.57	31.96
Canada	450	4.42%	0.62	31.75	22.64	28.51
Cayman Islands	2	0.02%	0.50	32.39	22.50	36.50
Chile	26	0.26%	0.92	16.91	19.65	22.21
China	119	1.17%	0.59	16.24	7.67	30.49
Colombia	44	0.43%	0.86	15.18	34.70	41.92
Czechia	10	0.10%	0.50	11.89	1.20	2.11
Denmark	104	1.02%	0.65	32.44	25.98	33.56
Egypt	7	0.07%	0.43	23.19	3.04	20.90
Finland	160	1.57%	0.62	34.36	20.64	30.92
France	458	4.50%	0.83	44.83	28.96	37.54
Germany	333	3.27%	0.71	32.25	19.60	29.24
Greece	24	0.24%	0.63	20.61	30.16	45.17
Hong Kong	68	0.67%	0.57	14.49	18.01	36.02
Iceland	4	0.04%	0.50	41.43	24.03	32.83
India	244	2.40%	0.77	17.16	6.37	13.71
Ireland	107	1.05%	0.61	30.67	22.54	30.07
Israel	17	0.17%	0.41	24.13	28.06	29.51
Italy	206	2.02%	0.75	38.98	24.79	28.94
Japan	1,530	15.04%	0.82	9.72	7.60	19.35
Kazakhstan	6	0.06%	0.33	18.29	6.17	5.83
Kuwait	5	0.05%	0.80	1.82	9.38	28.60
Luxembourg	17	0.17%	0.82	27.32	14.57	22.41
Malaysia	20	0.20%	0.50	30.08	27.44	36.91

Malta	4	0.04%	0.25	26.43	18.48	35.04
Mexico	70	0.69%	0.79	13.13	19.89	25.82
Netherlands	137	1.35%	0.82	34.19	20.88	33.50
New Zealand	77	0.76%	0.60	30.82	4.62	6.12
Norway	171	1.68%	0.75	41.34	17.77	30.05
Philippines	20	0.20%	0.60	15.24	10.91	31.84
Poland	15	0.15%	0.47	24.63	26.03	38.52
Portugal	41	0.40%	0.80	26.81	34.35	38.72
Qatar	5	0.05%	0.20	0.00	33.00	47.40
Republic of Korea	325	3.19%	0.88	7.82	12.35	24.11
Russian Federation	49	0.48%	0.67	11.64	18.08	33.85
Singapore	39	0.38%	0.74	20.29	29.34	35.17
South Africa	294	2.89%	0.49	29.21	3.52	5.44
Spain	211	2.07%	0.71	28.88	28.40	38.31
Sweden	267	2.62%	0.64	37.74	25.81	32.80
Switzerland	209	2.05%	0.67	25.53	25.01	35.41
Thailand	54	0.53%	0.94	13.62	25.88	24.11
Turkey	158	1.55%	0.89	16.17	22.50	27.21
United Arab Emirates	12	0.12%	0.58	9.31	20.75	22.42
United Kingdom	992	9.75%	0.67	32.68	24.95	34.48
United States of America	2,371	23.30%	0.60	28.21	21.77	30.44
Total	10,175	100.00%	0.70	25.76	19.30	28.38

Notes: *SA* = 1 if the firm undertakes scenario analysis and 0 otherwise.
%[a] is the percentage of the full sample, based on 10,175 firm year observations
%[b] is the percentage of the sample is *SA* = 1, based on 7,115 firm year observations
%[c] is the percentage of the full sample, based on 3,060 firm year observations

Table 2 Descriptive Statistics

Variable	Full Sample N =10,175			*SA* = 1 N = 7,115			*SA* = 0 N = 3,060		
	Mean	Median	Std. dev.	Mean	Median	Std. dev.	Mean	Median	Std. dev.
SA	0.70	1.00	0.46	1.00	1.00	0.00	0.00	0.00	0.00
FDIRECTOR	25.76	27.27	14.05	26.03	27.27	14.33	25.15	25.00	13.33
FMANAGER	19.30	18.60	17.54	20.29	20.00	17.20	16.99	13.90	18.08
FEMPLOYEE	28.38	27.00	19.88	29.01	27.10	19.19	26.90	26.00	21.34
CSRCOM	0.89	1.00	0.31	0.92	1.00	0.27	0.82	1.00	0.38
INC	0.50	1.00	0.50	0.54	1.00	0.50	0.43	0.00	0.49
BSIZE	10.65	10.00	2.94	10.81	11.00	2.99	10.29	10.00	2.78
INDEP	62.94	65.00	24.18	62.04	63.64	24.21	65.04	69.23	24.00
INT	11.04	10.94	3.09	11.40	11.37	3.11	10.20	10.23	2.88
SIZE	15.80	15.79	1.47	15.94	15.94	1.46	15.49	15.45	1.45
ROA	5.60	4.80	6.88	5.58	4.65	6.72	5.65	5.19	7.25
TOBQ	0.41	0.42	0.22	0.40	0.41	0.22	0.45	0.46	0.22
LEV	0.28	0.27	0.17	0.28	0.27	0.17	0.28	0.26	0.18
GDP	10.54	10.74	0.78	10.52	10.68	0.78	10.58	10.76	0.78
ETS	0.69	1.00	0.46	0.66	1.00	0.47	0.75	1.00	0.43

Note: SA = 1 if the firm undertakes scenario analysis and 0 otherwise. Financial variables are in USD. All continuous variables are winsorized at the 1st and 99th percentiles. Please see the definitions and sources of variables in Appendix A.

Table 3 Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SA (1)	1														
FDIRECTOR (2)	0.006	1													
FMANAGER (3)	0.085***	0.300***	1												
FEMPLOYEE (4)	0.047***	0.249***	0.603***	1											
CSRCOM (5)	0.115***	0.201***	0.229***	0.213***	1										
INC (6)	0.084***	0.357***	0.240***	0.149***	0.247***	1									
BSIZE (7)	0.057***	0.174***	0.088***	0.063***	0.283***	0.122***	1								
INDEP (8)	-0.068***	0.376***	0.177***	0.112***	0.126***	0.313***	-0.052***	1							
INT (9)	0.179***	-0.010	-0.147***	-0.282***	0.246***	0.146***	0.302***	0.012	1						
SIZE (10)	0.137***	0.079***	0.137***	0.112***	0.201***	0.099***	0.425***	0.133***	0.319***	1					
ROA (11)	-0.019**	-0.008	0.012*	-0.033***	0.038***	-0.009	-0.029***	-0.024***	-0.019**	0.180***	1				
TOBQ (12)	-0.093***	0.024***	-0.045***	-0.092***	0.047***	0.015***	0.028***	-0.012**	0.235***	-0.051***	-0.054***	1			
LEV (13)	0.009	0.049***	0.047***	0.022***	0.063***	0.058***	0.066***	0.060***	0.195***	-0.014**	-0.119***	0.617***	1		
GDP (14)	-0.032***	0.286***	0.178***	0.134***	-0.024***	0.262***	-0.041***	0.390***	-0.036***	0.079***	-0.103***	0.001	0.018***	1	
ETS (15)	-0.096***	0.340***	0.074***	0.086***	-0.082***	0.164***	0.033***	0.329***	-0.011	0.131***	-0.065***	0.091***	0.071***	0.443***	1

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 4 Main Model Regression Results

Variable	[1] Logit SA	[2] Probit SA
FDIRECTOR	0.014***(4.71)	0.008***(4.67)
FMANAGER	0.006***(3.16)	0.004***(3.07)
FEMPLOYEE	0.004*(1.94)	0.002*(1.92)
CSRCOM	0.306***(3.69)	0.184***(3.82)
INC	0.33***(5.53)	0.203***(5.83)
BSIZE	0.027**(2.31)	0.017**(2.48)
INDEP	0.003**(2.08)	0.002**(2.14)
INT	0.132***(10.02)	0.077***(10.18)
SIZE	0.342***(13.46)	0.201***(13.7)
ROA	-0.003(-0.65)	-0.002(-0.81)
TOBQ	0.283(1.43)	0.145(1.27)
LEV	-0.07(-0.33)	-0.026(-0.21)
GDP	-2.364***(-4.27)	-1.309***(-4.26)
ETS	-0.548(-0.92)	-0.324(-0.94)
Constant	12.783**(2.47)	6.804**(2.36)
Sector effects	Controlled	Controlled
Year effects	Controlled	Controlled
Country effects	Controlled	Controlled
N	10,175	10,175
Wald $\chi 2$	1864.42***	2082.65***
Pseudo-R^2	0.2174	0.2186
Log likelihood	–4869.31	–4861.98
Significance Tests		
FDIRECTOR=FMANAGER	$Chi^2(1)$ = 4.00, p=.0456	$Chi^2(1)$ = 4.02, p=.0449
FDIRECTOR=FEMPLOYEE	$Chi^2(1)$ = 8.08, p=.0045	$Chi^2(1)$ = 8.03, p=.0046
FMANAGER=FEMPLOYEE	$Chi^2(1)$ = 0.69, p=.4060	$Chi^2(1)$ = 0.64, p=.4247

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Robust Z statistics are in parentheses. Financial variables are in USD. All continuous variables are winsorized at the 1st and 99th percentiles. Please see the definitions and sources of variables in Appendix A.

Table 5 Robustness Tests

Panel A Forward Approach and GMM Model

Variable	[1]	[2]
	Forward Approach	GMM Model
	Logit	Logit
	SA_{t+1}	*SA*
FDIRECTOR	0.014***(3.58)	0.003***(3.52)
FMANAGER	0.005*(1.89)	0.002***(3.11)
FEMPLOYEE	0.004*(1.87)	0.001***(2.72)
CSRCOM	0.317***(3.16)	0.102***(4.77)
INC	0.322***(4.22)	0.059***(4.93)
BSIZE	0.017(1.15)	0.006***(3.07)
INDEP	0.002(0.82)	0(0.67)
INT	0.136***(7.74)	0.02***(8.35)
SIZE	0.356***(10.47)	0.037***(7.94)
ROA	-0.008(-1.42)	0(-0.42)
TOBQ	0.489*(1.75)	0.019(0.56)
LEV	-0.41(-1.36)	0.015(0.43)
GDP	-0.939(-1)	0.434***(6.32)
ETS	11.92***(11.6)	-0.126(-1.18)
Constant	12.783**(2.47)	-4.555***(-6.08)
Sector effects	Controlled	Controlled
Year effects	Controlled	Controlled
Country effects	Controlled	Controlled
N	7,255	6,959
Wald $\chi 2$	1864.42***	2334.50***
Pseudo-R^2	0.2293	0.1709
Log likelihood	–3024.02	

Panel B Lag Approach

Variable	Lag Approach
	Logit
	SA
$FDIRECTOR_{t-1}$	0.014***(3.51)
$FMANAGER_{t-1}$	0.004*(1.71)
$FEMPLOYEE_{t-1}$	0.006**(2.19)
$CSRCOM_{t-1}$	0.288***(2.79)
INC_{t-1}	0.298***(3.82)
$BSIZE_{t-1}$	0.017(1.11)
$INDEP_{t-1}$	0.002(0.9)
INT_{t-1}	0.126***(6.93)
$SIZE_{t-1}$	0.354***(10.03)
ROA_{t-1}	-0.01*(-1.68)
$TOBQ_{t-1}$	0.395(1.47)
LEV_{t-1}	-0.404(-1.32)
GDP_{t-1}	-0.629(-0.65)
ETS_{t-1}	12.305***(32.01)
Constant	-3.401(-0.38)

Sector effects	Controlled
Year effects	Controlled
Country effects	Controlled
N	6,944
Wald χ2	-
Pseudo-R^2	0.2247
Log likelihood	–2891.99

Panel C Heckman results

Variable	[1]	[2]	[3]	[4]
	Stage 1: Decision to disclose	Stage 2: Decision to undertake SA	Stage 1: Decision to disclose	Stage 2: Decision to undertake SA
	DISC	*SA*	*DISC*	*SA*
FDIRECTOR		0.002***(4.4)		0.002***(4.41)
FMANAGER		0.001***(3.27)		0.001***(3.29)
FEMPLOYEE		0.001*(1.84)		0.001*(1.88)
CSRCOM	0.253***(6.04)	0.056***(4)	0.241***(5.76)	0.059***(4.22)
INC		0.058***(5.99)		0.059***(6.01)
BSIZE	0.02***(2.88)	0.004**(2.16)	0.019***(2.77)	0.004**(2.24)
INDEP	0.008***(9.54)	0(1.29)	0.008***(9.5)	0(1.41)
INT		0.02***(9.88)		0.02***(9.93)
SIZE	0.081***(5.36)	0.046***(11.49)	0.078***(5.13)	0.046***(11.67)
ROA		0(-0.3)		0(-0.29)
TOBQ	-0.282***(-3.22)	0.032(1.03)	-0.272***(-3.11)	0.032(1.04)
LEV		-0.002(-0.06)		-0.002(-0.06)
GDP	-1.767***(-5.75)	0.044(0.63)	-1.784***(-5.81)	0.039(0.56)
ETS	-0.254(-0.78)	-0.09(-0.95)	-0.289(-0.89)	-0.089(-0.94)
INDMEAN	2.413**(2.07)		2.365**(2.03)	
LAGDISC	2.842***(81.98)		2.834***(81.63)	
ENVSCORE	0.012***(14.58)		0.013***(15.19)	
DUAL	-0.027(-0.71)		-0.021(-0.55)	
ROE	0.001(1)		0.001(1.07)	
Constant	10.69***(3.73)	-1.093(-1.61)	10.903***(3.81)	-1.079(-1.59)
Sector effects	Controlled	Controlled	Controlled	Controlled
Year effects	Controlled	Controlled	Controlled	Controlled
Country effects	Controlled	Controlled	Controlled	Controlled
N	23,471	23,471	23,471	23,471
Selected N	10,010		10,010	
Non-selected N	13,461		13,461	
Log pseudo-	-		-8686.92	
λ	-0.089		-0.076	
Wald χ^2	2679.99***		2703.05***	

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Robust Z statistics are in parentheses. Financial variables are in USD. All continuous variables are winsorized at the 1st and 99th percentiles. Please see the definitions and sources of variables in Appendix A.

Table 6 Regression Results for Testing Critical Mass

Variable	[1]	[2]	[3]
	Logit	Logit	Logit
	SA	*SA*	*SA*
BMASS10%	0.045(0.43)		
BMASS20%	0.32***(3.65)		
BMASS30%	0.047(0.69)		
MMASS10%		0.193**(2.26)	
MMASS20%		-0.014(-0.15)	
MMASS30%		0.059(0.7)	
EMASS10%			0.241**(2.53)
EMASS20%			-0.071(-0.77)
EMASS30%			0.115(1.44)
FDIRECTOR		0.014***(4.75)	0.014***(4.74)
FMANAGER	0.007***(3.24)		0.006***(3.2)
FEMPLOYEE	0.004**(2.08)	0.004**(2.39)	
CSRCOM	0.303***(3.65)	0.302***(3.65)	0.294***(3.54)
INC	0.329***(5.51)	0.332***(5.57)	0.334***(5.59)
BSIZE	0.027**(2.23)	0.028**(2.37)	0.028**(2.32)
INDEP	0.004**(2.21)	0.003**(1.99)	0.003**(2.07)
INT	0.132***(10.05)	0.131***(9.91)	0.13***(9.87)
SIZE	0.34***(13.37)	0.342***(13.42)	0.341***(13.42)
ROA	-0.003(-0.62)	-0.003(-0.7)	-0.003(-0.76)
TOBQ	0.286(1.45)	0.285(1.44)	0.268(1.35)
LEV	-0.082(-0.39)	-0.075(-0.35)	-0.06(-0.28)
GDP	-2.397***(-4.31)	-2.353***(-4.25)	-2.378***(-4.3)
ETS	-0.546(-0.92)	-0.54(-0.9)	-0.568(-0.95)
Constant	13.201**(2.54)	12.619**(2.44)	12.844**(2.49)
Sector effects	Controlled	Controlled	Controlled
Year effects	Controlled	Controlled	Controlled
Country effects	Controlled	Controlled	Controlled
N	10,175	10,175	10,175
Wald $\chi 2$	1862.17***	1869.56***	1866.25***
Pseudo-R^2	0.2172	0.2174	0.2181
Log likelihood	–4870.33	–4869.38	–4865.05

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Robust Z statistics are in parentheses. Financial variables are in USD. All continuous variables are winsorized at the 1st and 99th percentiles. Please see the definitions and sources of variables in Appendix A.

Table 7 Cross-sectional Tests

Panel A The Moderating Effect of Masculinity

Variable	[1]	[2]	[3]
	Logit	Logit	Logit
	SA	*SA*	*SA*
MASC×FDIRECTOR	0.012**(2.13)		
MASC×FMANAGER		-0.004(-1.12)	
MASC×FEMPLOYEE			-0.005*(-1.79)
MASC	4.767***(3.47)	5.242***(3.86)	5.333***(3.92)
FDIRECTOR	0.01**(2.59)	0.015***(4.9)	0.015***(4.88)
FMANAGER	0.006***(3.07)	0.007***(3.15)	0.006***(2.81)
FEMPLOYEE	0.003*(1.74)	0.003*(1.83)	0.005**(2.36)
CSRCOM	0.323***(3.72)	0.322***(3.71)	0.323***(3.72)
INC	0.334***(5.45)	0.335***(5.48)	0.335***(5.47)
BSIZE	0.029**(2.37)	0.029**(2.38)	0.029**(2.36)
INDEP	0.003*(1.86)	0.003**(1.97)	0.003**(2)
INT	0.13***(9.42)	0.13***(9.42)	0.131***(9.44)
SIZE	0.33***(12.65)	0.331***(12.67	0.331***(12.6
ROA	-0.002(-0.58)	-0.002(-0.58)	-0.002(-0.56)
TOBQ	0.245(1.2)	0.233(1.14)	0.225(1.1)
LEV	-0.063(-0.29)	-0.047(-0.21)	-0.031(-0.14)
GDP	-2.482***(-	-2.551***(-	-2.578***(-
ETS	-0.583(-0.93)	-0.594(-0.96)	-0.588(-0.95)
Constant	14.124***(2.61	14.693***(2.71	14.923***(2.7
Sector effects	Controlled	Controlled	Controlled
Year effects	Controlled	Controlled	Controlled
Country effects	Controlled	Controlled	Controlled
N	9,439	9,439	9,439
Wald $\chi2$	1741.22***	1740.41***	1739.97***
Pseudo-R^2	0.2123	0.2120	0.2122
Log likelihood	–4589.51	–4591.31	–4590.33

Panel B The Moderating Effect of Legal System

Variable	[1]	[2]	[3]
	Logit	Logit	Logit
	SA	*SA*	*SA*
LAW×FDIRECTOR	0.01*(1.85)		
LAW×FMANAGER		0.008**(2.29)	
LAW×FEMPLOYEE			0.005*(1.8)
FDIRECTOR	0.008*(1.84)	0.013***(4.59)	0.014***(4.68)
FMANAGER	0.006***(3.03)	0.001(0.48)	0.006***(2.99)
FEMPLOYEE	0.004*(1.96)	0.004*(1.93)	0.001(0.27)
CSRCOM	0.308***(3.72)	0.311***(3.75)	0.31***(3.73)
INC	0.329***(5.51)	0.338***(5.64)	0.335***(5.6)
BSIZE	0.027**(2.24)	0.027**(2.29)	0.027**(2.24)
INDEP	0.003**(2.14)	0.003**(2.08)	0.003**(2.13)
INT	0.132***(10.02)	0.131***(9.92)	0.131***(9.94)
SIZE	0.343***(13.47)	0.342***(13.45)	0.343***(13.46

ROA	-0.003(-0.64)	-0.003(-0.64)	-0.003(-0.63)
TOBQ	0.276(1.39)	0.254(1.28)	0.257(1.29)
LEV	-0.06(-0.28)	-0.048(-0.23)	-0.037(-0.17)
GDP	-2.445***(-	-2.397***(-	-2.386***(-
ETS	-0.565(-0.95)	-0.524(-0.88)	-0.527(-0.89)
Constant	13.599***(2.63)	13.216**(2.55)	13.073**(2.53)
Sector effects	Controlled	Controlled	Controlled
Year effects	Controlled	Controlled	Controlled
Country effects	Controlled	Controlled	Controlled
N	10,175	10,175	10,175
Wald χ2	1872.42***	1868.92***	1866.26***
Pseudo-R^2	0.2177	0.2178	0.2177
Log likelihood	–4867.49	–4866.48	–4867.60

Panel C The Moderating Effect of Carbon Intensive Sector

Variable	[1]	[2]	[3]
	Logit	Logit	Logit
	SA	*SA*	*SA*
IND×FDIRECTOR	0.014***(2.98)		
IND×FMANAGER		0.011**(2.4)	
IND×FEMPLOYEE			0.008*(1.83)
IND	-0.555**(-2.4)	-0.408*(-1.85)	-0.424*(-1.81)
FDIRECTOR	0.011***(3.48)	0.013***(4.62)	0.013***(4.66)
FMANAGER	0.006***(3.18)	0.005**(2.27)	0.006***(3.17)
FEMPLOYEE	0.004**(1.98)	0.004**(2.04)	0.003(1.4)
CSRCOM	0.302***(3.64)	0.309***(3.73)	0.304***(3.67)
INC	0.327***(5.49)	0.329***(5.52)	0.33***(5.54)
BSIZE	0.029**(2.43)	0.027**(2.3)	0.027**(2.3)
INDEP	0.003**(2.02)	0.003**(2.09)	0.003**(2.09)
INT	0.133***(10.08)	0.133***(10.08)	0.134***(10.12
SIZE	0.34***(13.32)	0.34***(13.34)	0.34***(13.36)
ROA	-0.002(-0.6)	-0.003(-0.65)	-0.003(-0.63)
TOBQ	0.3(1.52)	0.278(1.4)	0.28(1.42)
LEV	-0.091(-0.43)	-0.072(-0.34)	-0.075(-0.35)
GDP	-2.419***(-	-2.429***(-	-2.429***(-
ETS	-0.571(-0.96)	-0.562(-0.94)	-0.56(-0.94)
Constant	13.649***(2.63)	13.667***(2.64)	13.669***(2.64
Sector effects	Controlled	Controlled	Controlled
Year effects	Controlled	Controlled	Controlled
Country effects	Controlled	Controlled	Controlled
N	10,175	10,175	10,175
Wald χ2	1864.83***	1869.09***	1865.79***
Pseudo-R^2	0.2183	0.2180	0.2178
Log likelihood	–4863.87	–4865.62	–4867.03

Panel D The Moderating Effect of COVID-19

Variable	[1]	[2]	[3]
	Logit	Logit	Logit
	SA	*SA*	*SA*
COV×FDIRECTOR	-0.006(-1.49)		
COV×FMANAGER		-0.005*(-1.77)	
COV×FEMPLOYEE			-0.002(-0.65)
COV	1.834***(12.9	1.792***(14.61	1.746***(13.47
FDIRECTOR	0.016***(4.86	0.014***(4.72)	0.014***(4.71)
FMANAGER	0.006***(3.15	0.009***(3.62)	0.006***(3.17)
FEMPLOYEE	0.004*(1.92)	0.004*(1.93)	0.004**(2.02)
CSRCOM	0.306***(3.69	0.304***(3.67)	0.306***(3.69)
INC	0.332***(5.56	0.332***(5.56)	0.33***(5.53)
BSIZE	0.027**(2.3)	0.027**(2.31)	0.027**(2.32)
INDEP	0.003**(2)	0.003**(2.03)	0.003**(2.06)
INT	0.131***(9.98	0.132***(10.01	0.132***(10)
SIZE	0.343***(13.4	0.342***(13.46	0.342***(13.46
ROA	-0.003(-0.7)	-0.003(-0.7)	-0.003(-0.67)
TOBQ	0.288(1.45)	0.287(1.45)	0.286(1.45)
LEV	-0.074(-0.35)	-0.073(-0.34)	-0.071(-0.34)
GDP	-2.343***(-	-2.421***(-	-2.426***(-
ETS	-0.568(-0.95)	-0.545(-0.91)	-0.549(-0.92)
Constant	12.539**(2.41	13.279**(2.57)	13.335**(2.58)
Sector effects	Controlled	Controlled	Controlled
Year effects	Controlled	Controlled	Controlled
Country effects	Controlled	Controlled	Controlled
N	10,175	10,175	10,175
Wald χ2	1868.88***	1862.42***	2088.18***
Pseudo-R^2	0.2177	0.2177	0.2175
Log likelihood	–4867.57	–4867.08	–4868.45

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Robust Z statistics are in parentheses. Financial variables are in USD. All continuous variables are winsorized at the 1st and 99th percentiles. Please see the definitions and sources of variables in Appendix A.

Appendix A Definitions and measurement of variables

Variable	Description	Source
SA	A binary variable coded as 1 if the firm undertakes scenario analysis and 0 otherwise	CDP
FDIRECTOR	The percentage of females on the board of directors	Eikon
FMANAGER	The percentage of female managers	Eikon
FEMPLOYEE	The percentage of female employees	Eikon
BMASS10%	A binary variable coded as 1 if the board contains at least 10% female representation and 0 otherwise	Eikon
BMASS20%	A binary variable coded as 1 if the board contains at least 20% female representation and 0 otherwise	Eikon
BMASS30%	A binary variable coded as 1 if the board contains at least 30% female representation and 0 otherwise	Eikon
MMASS10%	A binary variable coded as 1 if at least 10% of managers are female and 0 otherwise	Eikon
MMASS20%	A binary variable coded as 1 if at least 20% of managers are female and 0 otherwise	Eikon
MMASS30%	A binary variable coded as 1 if at least 30% of managers are female and 0 otherwise	Eikon
EMASS10%	A binary variable coded as 1 if at least 10% of employees are female and 0 otherwise	Eikon
EMASS20%	A binary variable coded as 1 if at least 20% of employees are female and 0 otherwise	Eikon
EMASS30%	A binary variable coded as 1 if at least 30% of employees are female and 0 otherwise	Eikon
MASC	A binary variable coded as 1 a firm is domiciled in a country with a masculinity score above the sample median	Hofstede (1998)
LAW	A binary variable equal to 1 if the company is domiciled in a common law country and 0 if otherwise	La Porta et al. (1997)
IND	A binary variable coded as 1 if a firm operates in a carbon intensive sectors (energy, materials or utilities) and 0 otherwise 0	CDP
COV	*COV* is coded as 1 if the year is 2020 and 2021, otherwise 0	Manually Calculated
CSRCOM	A binary variable coded as 1 if the firm has a CSR committee and 0 otherwise	Eikon
INC	A binary variable coded 1 if senior executives' compensation is linked to corporate social responsibility, health and safety, or sustainability targets and 0 otherwise	Eikon
BSIZE	The total number of board of directors	Eikon
INDEP	The percentage of independent members acting on a board of directors	Eikon
INT	Calculated as the natural logarithm of the total of Scope 1 and Scope 2 emissions over firm revenue	CDP
SIZE	The natural logarithm of total market capitalisation in USD	Eikon
ROA	Net income divided by total assets	Eikon
TOBQ	Total market value based on the year-end price and the number of shares outstanding, plus preferred shares, book value of long-term debt, and current	Eikon

	liabilities, divided by book value of total assets	
LEV	Total debts divided by total assets at the end of the fiscal year	Eikon
GDP	The natural logarithm of gross domestic product per capita in USD	World Bank
ETS	A binary variable coded 1 if the firm is in a country that has a national emissions trading scheme and 0 otherwise	CDP
DISC	A binary variable coded 1 if the company responded to the CDP and 0 otherwise	CDP
INDMEAN	The mean proportion of companies in an industry that disclose carbon emissions to the CDP	CDP
LAGDISC	Binary variable coded 1 if the company responded to the CDP in the previous year and 0 otherwise	CDP
ENVSCORE	An environmental score measuring the impact the firm has on living and nonliving natural systems, which includes the air, land, and water, as well as complete ecosystems.	Eikon
DUAL	A binary variable coded 1 if the CEO is also the chairperson and 0 otherwise	Eikon