



The effect of board attributes on carbon disclosure; Evidence from Mexico

El impacto de las características del consejo de administración en la divulgación de carbono; evidencia de México

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Abstract

Corporate governance plays a crucial role in mitigating information asymmetry through financial reporting. However, its application to non-financial reporting remains uncertain, particularly in developing economies. Governments and stakeholders in this field have taken a keen interest in carbon disclosure among non-financial reporting practices due to its direct contribution to mitigating climate change and enhancing firm value. Nevertheless, there remains a dearth of consensus in the existing *corpus* of literature concerning the influence of board attributes on carbon disclosure. It is particularly valid in markets where the significant presence of family firms could influence governance practices. This paper investigates the existing literature on four board attributes (gender diversity, board independence, board size, and environmental committee) concerning carbon disclosure. We analyzed 140 publicly traded Mexican companies between 2015 and 2020. The findings indicate that all four board attributes positively influence carbon disclosure. Following stakeholder theory, we provide empirical evidence that corporate governance's monitoring and supervising mechanisms improve carbon disclosure, addressing various stakeholders' interests.

JEL Code: M14, N26, Q56

Keywords: board gender diversity; board independence; board size; environmental committee; stakeholder theory

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Resumen

La gobernanza corporativa desempeña un papel crucial en la mitigación de la asimetría de información a través de la presentación de informes financieros. Sin embargo, su aplicación a los informes no financieros sigue siendo incierta, particularmente en las economías en desarrollo. Los gobiernos y las partes interesadas en este campo han mostrado un gran interés en la divulgación de carbono entre las prácticas de presentación de informes no financieros debido a su contribución directa a la mitigación del cambio climático y la mejora del valor de las empresas. No obstante, sigue habiendo una escasez de consenso en el *corpus* de literatura existente sobre la influencia de las características del Consejo de Administración en la divulgación de carbono. Esto es particularmente válido en mercados donde la presencia significativa de empresas familiares podría influir en las prácticas de gobernanza. Este artículo investiga la literatura existente sobre cuatro características del Consejo (diversidad de género, independencia del consejo, tamaño del consejo y comité ambiental) relacionados con la divulgación de carbono. Analizamos 140 empresas mexicanas que cotizan en bolsa de valores entre 2015 y 2020. Los hallazgos indican que las cuatro características del Consejo influyen positivamente en la divulgación de carbono. Siguiendo la teoría de las partes interesadas, proporcionamos evidencia empírica de que los mecanismos de monitoreo y supervisión del gobierno corporativo mejoran la divulgación de carbono, abordando los intereses de varias partes interesadas.

Código JEL: M14, N26, Q56

Palabras clave: diversidad de género en el consejo; independencia del consejo; tamaño del consejo; comité ambiental; teoría de las partes interesadas

Introduction

Corporate governance is crucial in reducing information asymmetry through financial reporting (Abu-Allia et al., 2022; Salehi et al., 2022). Nonetheless, the effect of corporate governance still needs to be investigated in non-financial reporting, especially in emerging market companies (Dragomir et al., 2022). In the context of developing economies, it is relevant to know if the monitoring and supervision mechanisms of the board of directors act similarly in pursuing financial and non-financial objectives since firms usually face fewer regulatory environments.

In non-financial reporting, a specific practice that has gained significant interest among researchers and practitioners due to its crucial role in decarbonizing the economy is Carbon Disclosure (CD, hereafter). The work on CD has been analyzed concerning corporate governance (CG, hereafter) lately (e.g., see (Velte et al., 2020). For example, several board attributes and their effects have been examined with CD, including board diversity (e.g., Al-Qahtani & Elgharbawy, 2020; Kılıç & Kuzey, 2019), board independence (e.g., Jaggi et al., 2018; Liao et al., 2015), board size (e.g., Akbaş & Canikli, 2018; Ooi et al., 2019), board effectiveness (e.g., Ben-Amar & McIlkenny, 2015), climate governance (e.g., Bui et al., 2020), as well as the effect of environmental committees (Elsayih et al., 2018; Tingbani et al., 2020).

However, the results of these studies, especially those related to board composition, are still open to question due to their need for more consistency (Calza et al., 2017). For example, while some studies find that board gender diversity and board independence have a positive effect on carbon disclosure (e.g., Elsayih et al., 2018; Liao et al., 2015; Ooi et al., 2019), other authors have not found a significant effect between these variables (Akbaş & Canikli, 2018; Kılıç & Kuzey, 2019; Manurung et al., 2020). Similarly, board independence and size are other attributes that show mixed results (Velte et al., 2020). Additionally, Jiang et al. (2021) state that carbon disclosure increases firm value because it works as a tool that reduces information asymmetry. Hence, clarifying which aspects of the board enhance this practice becomes relevant.

Thus, the purpose of this paper is to analyze the effect of board gender diversity (BGD), board independence (BI), board size (BS), and environmental committee (EC) to explain what mechanisms of the board contribute to settling better governance that reduces information asymmetry, disclosing their carbon information. Mexico presents a unique context for this study due to its evolving market and distinct corporate governance structure. The country's corporate landscape is characterized by a high prevalence of family-owned businesses and a relatively recent emphasis on adopting corporate governance standards (Briano-Turrent & Poletti-Hughes, 2017; San Martín-Reyna, 2012). This environment presents specific challenges, such as the “*compadrazgo*” matter (Husted & Serrano, 2002), a traditionally low level of board independence, and limited representation of women in corporate leadership positions (Machuga & Teitel, 2009; Paludi et al., 2021). Additionally, Mexico's environmental concerns, particularly regarding carbon emissions and climate change, have also gained increasing attention (Arlinghaus et al., 2018; Mendoza-Cavazos et al., 2020).

The country's commitment to international agreements, such as the Paris Agreement, and the evolving regulatory landscape necessitate more transparent and robust environmental disclosures from companies (Olguin et al., 2018). These factors make the Mexican context particularly significant for studying the impact of board attributes on carbon disclosure practices. As asserted before, by establishing strategies that enhance practices that decrease information asymmetry, firms can raise their value, making them more attractive to their stakeholders.

The results show that this study's four board attributes (BGD, BI, BS, and EC) positively affect carbon disclosure. They also indicate that under the latest pressures focused on CSR practices and environmental engagement, setting suitable corporate governance mechanisms can help reduce information asymmetry regarding non-financial disclosure and benefit financial reporting.

The contribution of this paper is twofold. First, to the carbon disclosure literature, we contribute to the determinant conceptualization that Borghei (2021) proposes for carbon disclosure. Second, in corporate governance literature, our findings strongly support that the board of directors' monitoring and

supervising mechanisms significantly bolster stakeholder theory. The positive impact of board characteristics on carbon disclosure emphasizes the board's pivotal role in addressing a diverse range of stakeholders. These findings align seamlessly with the principles of stakeholder theory, highlighting the board's responsibility to balance interests and align corporate actions with the expectations of both internal and external stakeholders.

Literature review and hypotheses development

This section reviews corporate governance and carbon disclosure literature, providing a theoretical framework to support the research hypotheses. By examining prior studies, we identify gaps in the literature and establish the foundation for our research.

Carbon disclosure

Disclosure of non-financial information (i.e., social and environmental activities) has been crucial in the last few decades, particularly concerning carbon dioxide (CO₂) information (Fan et al., 2021). In the literature, scholars define carbon disclosure in various ways (Cumpean et al., 2022); for example, Hahn et al. (2015) mention that carbon disclosure involves corporate practices to systematically collect data, measure direct and indirect emissions, and communicate such information to the stakeholders of the firm to satisfy their demands for information and provide guidance in this regard. It is a phenomenon highly related to climate change due to its emphasis on carbon emissions. Nevertheless, how enterprises ought to react to the perpetual demands of institutions, investors, shareholders, and customers—primarily to decarbonize the global economy for the betterment of society at large—is well understood (He et al., 2021).

Carbon disclosure is a phenomenon that has become relevant within the business world for at least two decades. During the first decade (the 2000s), the emphasis was strictly on proactive reporting since firms considered it voluntary disclosure. However, since the beginning of the second decade (the 2010s), more stakeholders have increased pressure to incorporate carbon information, with only a few governments beginning to apply a mandatory CO₂ emissions disclosure regime (García-Sánchez & Noguera-Gámez, 2017). Consequently, there has been a gradual evolution in the methodology employed in carbon-related studies over time. Although conceptual articles were prevalent until 2011, a surge of empirical articles emerged in early 2012. Subsequently, the number of empirical articles began to increase in 2014. An additional body of data about the CD phenomenon could account for the aforementioned (He et al., 2021).

Research on carbon disclosure presents several challenges, starting with construct validity due to the condition of being voluntary in most of the world (Velte et al., 2020). Content analysis, binary variables on its disclosure, and, more recently, the Carbon Disclosure Project (CDP) score have been the three primary operationalizing metrics for carbon disclosure (Hahn et al., 2015). This ambiguity on its measures has consequences creating other problems concerning its variable, such as comparability, quality, and credibility problems, since, as Borghei (2021) mentions, stakeholders that seek to assess the risks related to carbon in organizations face high heterogeneity; therefore, a better measurement consistency is needed (Tang & Demeritt, 2018).

Relating to carbon studies, some issues that have been addressed are the influence of carbon disclosure on carbon performance over time (e.g., Qian & Schaltegger, 2017) and the difference between good and bad carbon performers with their carbon disclosure strategy (Datt et al., 2019). This paper addresses the effect of board attributes regarding carbon and voluntary disclosures: board gender diversity, board independence, board size, and whether firms have an environmental committee.

Moreover, in this study, we draw upon stakeholder theory, a framework consistent with the relationships between board responsibilities on firm activities and its disclosure (Barnett et al., 2018; Bueno et al., 2018; Goh et al., 2016; Hickman, 2020). Stakeholder theory focuses on recognizing a broader set of actors for which the firm is responsible and requires specific attention to provide strategic responses and information regarding firm activities (Barnett et al., 2018).

Within stakeholder theory, firms are usually influenced by internal (i.e., employees, shareholders) and external (i.e., activists, governments) individuals or organizations that are heterogeneous and set a challenge to firms to organize their demands (Freeman & McVea, 2005). One of the main challenges in stakeholder theory is identifying and classifying those actors as a first step in designing a strategy to attend to their claims and disclose their results. Some attempts to classify potential stakeholders consider their urgency, power, and legitimacy (Mitchell et al., 1997) or their role as claimers, influencers, recipients, or collaborators.

A second challenge in stakeholder theory is that firms' orientation should change from a single view (i.e., shareholder perspective) to a multiple view of relationships. Reasons for concentrating on a stakeholder approach found in the literature are that stakeholder engagement can promote firm behavior, decrease information asymmetries (Fan et al., 2021; García-Sánchez & Noguera-Gámez, 2017; Hickman, 2020) and influence decision making.

Particularly regarding information asymmetries, the traditional shareholder view states that the disclosure of financial information provides benefits to the firm in terms of reducing the cost of capital and increasing economic returns (Fan et al., 2021; Romito & Vurro, 2021). However, non-financial disclosure (i.e., Carbon Print, Sustainability, Corporate Social Responsibility reports) can also help close

the information gap between the corporation and its stakeholders. This information reduction is because non-financial disclosure provides complementary information to broader audiences, increasing firms' legitimacy and trust (Romito & Vurro, 2021).

In this sense, the board of directors is the preferred mechanism of corporate governance used by both shareholders and stakeholders to monitor management behavior and evaluate the work of top management to ensure attention to economic, social, and environmental objectives (Beiner et al., 2004; Bueno et al., 2018; Vitolla et al., 2020). For example, one of the objectives of boards of directors' states: "to protect interest of shareholders and various other stakeholders including customers, suppliers, employees, and society at large, to ensure full transparency and integrity in communication and to make available complete, accurate, and clear disclosure to all concerned" (Madhani, 2017, P. 7).

Corporate governance mechanisms and carbon disclosure

There has been an extensive debate about the effects of board composition on environmental and voluntary disclosure (Ben-Amar & McIlkenny, 2015; Guerrero-Villegas et al., 2018; Husted & Sousa-Filho, 2019; Krishnamurti & Velayutham, 2018). Nonetheless, research about board structure and carbon disclosure has been scarce. Therefore, our scope on the effects of board composition on carbon disclosure goes further to encompass environmental (CSR, ESG) and voluntary disclosure. We focus on four of the most common attributes of the board of directors on CSR practices: board diversity, board independence, board size, and environmental committees (Husted & Sousa-Filho, 2019; Pucheta-Martínez & Gallego-Álvarez, 2019).

Board gender diversity

First, the literature regarding board diversity has focused chiefly on board gender diversity (Hoang et al., 2018; Nguyen & Faff, 2006). The role of board gender diversity has gained attention in the last decade because most countries have started introducing new corporate governance legislation (Boulouta, 2013; Tingbani et al., 2020). Within board diversity, board gender diversity is an essential dimension of corporate governance, mainly because it provides different points of view which are culturally and socially distinct from men (Coffey & Wang, 1998; Liao et al., 2015). Moreover, evidence has shown that board gender diversity positively affects corporate social performance (Boulouta, 2013). Williams (2003) states that board gender diversity has important implications for CSR activities because they are less concerned about economic needs but are more engaged with socially responsible activities. Besides, female board

members provide wider communication channels for stakeholders than men because they deal better with environmental issues (Tingbani et al., 2020).

Various studies relate board gender diversity with greenhouse gas and climate change disclosure, verifying the stakeholder orientation of women on the board. For example, (Al-Qahtani & Elgharbawy, 2020) found that board gender diversity positively affects carbon disclosure, which means that women on the board could help balance the firm's financial and non-financial objectives. Consistently, other authors highlight that gender diversity has a positive effect on voluntary carbon disclosure and that this effect is more salient than other board attributes (Elsayih et al., 2018; Liao et al., 2015; Ooi et al., 2019; Tingbani et al., 2020).

Additionally, the presence of women on the board influences information asymmetry. Abad et al. (2017) find evidence in Spanish firms that a diverse board increases the amount of information to markets and stakeholders, reducing the information gap. More importantly, the presence and the number of women on the board are relevant (Seebeck & Vetter, 2021) and identify that a critical mass board gender diversity can affect disclosure and the benefits of information transparency to stakeholders. Therefore, we state the following hypotheses: Hypothesis 1: Board gender diversity positively impacts carbon disclosure.

Board independence

A second board attribute addressed in the literature is board independence due to its role as a monitoring mechanism for behaving toward shareholder and stakeholder interests (Idris et al., 2018). Emphasis on independent directors has increased since the most recent financial scandals, such as Enron and WorldCom (Fuzi et al., 2016). Board independence is essential for better performance based on efficiency and competitive strategy (Gani & Jermias, 2006).

Fuzi et al. (2016) state that independent directors play a vital role within the board since they are the ones who mainly look after the interests of the stakeholders, which is a monitoring mechanism to reduce information asymmetries, particularly in family firms (Wu et al., 2019). Therefore, the impartial criteria that independent board members potentially offer to companies serve as an efficient safeguard against adverse selection and moral hazards.

One way in which independent board members reduce information asymmetry is by disclosing the amount and quality of information to stakeholders (Healy & Palepu, 2001; van Buskirk, 2012). Consequently, the role of board independence in increasing mandatory disclosure could also influence voluntary disclosure (Romito & Vurro, 2021). For example, Chau and Gray (2010) find that board independence can help increase or decrease voluntary disclosure depending on the firm's family ownership

level. With a high level of family ownership, board independence helps enhance voluntary disclosure. Conversely, with low levels of family ownership, board independence cannot help to increase voluntary disclosure. In addition, the level of investor protection, institution, and legal context must be considered because board independence increases voluntary disclosure but only in countries with high levels of these characteristics (García-Meca & Sánchez-Ballesta, 2010).

In the literature on carbon disclosure and board independence, the focus has settled in two directions: if board independence helps to respond to the CDP questionnaire (e.g., (Kılıç & Kuzey, 2019; Liao et al., 2015) and if board independence increases the quantity of carbon disclosure (Elsayih et al., 2018; Jaggi et al., 2018a; Ooi et al., 2019). In this case, (Akbaş & Canikli, 2018) did not find any evidence that board independence affects GHG disclosure, either by boosting the level of response to the CDP questionnaire or by making the results of the questionnaire public. On the contrary, both Jaggi et al. (2018) and Liao et al. (2015) find that a more significant number of independent directors on the board of directors causes a higher level of response to the CDP questionnaire and increases the level of disclosure. In most of these studies, the evidence suggests that board independence positively affects carbon disclosure. Accordingly, we state the following hypotheses: Hypothesis 2: Board independence positively affects carbon disclosure.

Board size

The board of directors is a crucial mechanism through which stakeholders ensure managers behave appropriately. Several board attributes are practical monitoring and supervision mechanisms (Beiner et al., 2004). One of these attributes is board size, which can be an essential aspect of corporate governance (Beiner et al., 2004). A larger board can provide a broader range of insights, distribute power more evenly, and improve decision-making. These qualities are particularly relevant for representing diverse interests from multiple stakeholders (Eisenberg et al., 1998; Yermack, 1996).

These monitoring and supervision mechanisms are especially pertinent in the context of environmental disclosure in emerging economies. For instance, Husted and Sousa-Filho (2019) suggest that a larger board size positively impacts ESG disclosure in Latin America, highlighting that diverse boards are better equipped to address complex environmental issues and stakeholder concerns. However, the results are mixed across different regions. For example, Ooi et al. (2019) found no significant effect of board size on carbon disclosure in Malaysian firms, while Akbaş and Canikli (2018) reported a negative effect between board size and corporate responses to the CDP, suggesting that larger boards might struggle with communication and decision-making efficiency.

Given these mixed findings, it is essential to consider how a larger and potentially more diverse board could influence carbon disclosure. A larger and more diverse board may be more attentive to the varied interests of stakeholders, including those concerned with environmental sustainability (Chams & García-Blandón, 2019). Thus, aligned with the findings of Jiang et al. (2021), which suggest that carbon disclosure increases firm value, we hypothesize that larger boards may not always prioritize comprehensive carbon disclosure due to potential challenges in decision-making and communication. However, while larger boards can bring diverse perspectives, there is a possible drawback where too many voices may inhibit more robust discussions, which could otherwise lead to a greater emphasis on carbon disclosure practices (Tarus, 2020). Hence, we state the following hypotheses: Hypothesis 3: Board size harms carbon disclosure.

Environmental committee

Finally, one aspect of corporate governance that is less studied but no less important is the presence of certain committees in companies (Eberhardt-Toth, 2017; Harrison, 1987; Krishnamurti & Velayutham, 2018). The formation of different committees and the rise in the frequency of meetings in recent years are mainly due to legal requirements and the increasing complexity of the business environment (Kolev et al., 2019).

In the literature on corporate governance, only a few studies have examined environmental committees, mainly because they are not required by law but represent companies' concern for environmental issues (Kolev et al., 2019). Nonetheless, the board of directors has paid a little more attention to environmental issues over the past two decades; one solution to this dilemma is establishing environmental committees that oversee the company's activities in this field (DIXON). Harrison (1987) states two types of board committees: management support and monitoring. Environmental committees could be an example of the latter kind of board committee. For purposes of accountability and legitimacy, the monitoring committees are the appropriate type of board committee to oversee shareholders' interests (Harrison, 1987).

Therefore, when a company is interested in having a more efficient environmental performance, the evidence suggests that it should establish an environmental committee, given that it positively affects a better environmental performance (Dixon-Fowler et al., 2017). An additional rationale for doing so is to mitigate information asymmetry, as environmental committees perform a function similar to that of an audit committee, verifying accurate financial accounting disclosures (Liao et al., 2015). Following the same line, Jaggi et al. (2018) report that establishing environmental committees creates an expectation for higher transparency regarding firms' environmental activities, including carbon activities. Aligned with

this, within the literature about carbon activities, some authors have found that the presence of an environmental committee is positively associated with GHG disclosure and disclosure transparency as well (Jaggi et al., 2018a; Liao et al., 2015; Peters & Romi, 2014; Tingbani et al., 2020). Thus, we state the following hypotheses: Hypothesis 4: The presence of an environmental committee positively affects carbon disclosure.

Methods

This section outlines the research design, data collection, and analytical methods used in the study. We describe the sample selection, variables, and statistical techniques employed to test the proposed hypotheses, ensuring the robustness and reliability of our findings.

In this study, we employed an ordinal logistic regression (OLR) with random effects to analyze the impact of board attributes on carbon disclosure. The choice of OLR is justified by the ordinal nature of the dependent variable, carbon disclosure, which is measured on a nine-level ordinal scale. This statistical technique is suitable for handling ordered categorical data and allows us to model the relationship between multiple independent variables and an ordinal dependent variable (Britt & Weisburd, 2010). Additionally, the random effects component accounts for unobserved heterogeneity across firms, which is particularly important given the panel nature of our dataset (Tsonias, 2019).

We utilized STATA version 16 for all statistical analyses, including the descriptive statistics, correlation analysis, and OLR modeling. STATA is a widely recognized and robust statistical software package commonly used in econometrics and social sciences for its extensive capabilities in handling complex data structures and advanced statistical techniques (StataCorp, 2020).

Sample selection and data collection

In this study, we adopt a panel design for firms listed on the BMV from 2015 to 2020. Our dependent variable is Carbon Disclosure (CD), and we measured this variable on the Carbon Disclosure Project, which sends and collects greenhouse gas information from firms worldwide. CDP developed a methodology based on its questionnaire to evaluate each firm's response level. We analyze this period mainly because in 2015, they changed their methods to assess firms' responses, and this new methodology is inconsistent with previous years.

We started from a population of 153 firms listed on BMV from the abovementioned period, obtaining 918 firm-year observations. For this study, we dropped firm-year observations from firms considered “phantom companies” in the BMV (see Lara, 2018; Sánchez, 2016), which term denotes the

absence of substantial data movements for a specified duration, or the non-provision of fundamental information mandated by the BMV for a minimum of the past three years. The final sample comprised 140 companies with a total of 840 firm-year observations. The data gathering was conducted through two different sources. First, we collected information about the CD directly from the CDP website. We gathered financial and governance information from Bloomberg for the rest of the independent and control variables.

Measurement of variables

Dependent variable

We adopted as a source for the dependent variable the participation or not of Mexican companies in the Carbon Disclosure Project. The CDP has been a non-profit organization that has gathered greenhouse gas emissions through questionnaires since 2002 (Lewis et al., 2014). Every year, the CDP asks the largest companies in each country and region for their participation in their questionnaire, which is required mainly through institutional investors. Their classification falls into five levels of disclosure for companies: insufficient information (F), disclosure (D-, D), awareness (C-, C), management (B-, B), and leadership level (A-, A) (Al-Qahtani & Elgharbawy, 2020). Next, we follow the Bloomberg methodology based on CDP classification to obtain a nine-level ordinal scale to measure the firm's disclosure of carbon emissions. Consistent with Bloomberg methodology, we assign each letter a number so that F represents 0 and A represents 8, where eight means that they reported as much information as possible and 0 means that they reported an insufficient amount to be evaluated.

Independent variables

We use three of the most traditional board attributes in the literature, adding the presence of an environmental committee. First, we measure board gender diversity (BGD) as the percentage of female directors on the board (Al-Qahtani & Elgharbawy, 2020; Boulouta, 2013; Kılıç & Kuzey, 2019). Second, consistent with the previous measurement, we assess board independence (BI) as the percentage of independent directors on the board (Chau & Gray, 2010; García-Meca & Sánchez-Ballesta, 2010; Liao et al., 2015). For board size (BS), we used the total number of members for every board of directors of each firm (Beiner et al., 2004; Cheng, 2008; Nguyen & Faff, 2006). Finally, we employed a dichotomous

variable to measure an environmental committee's presence (or absence) (Liao et al., 2015; Tingbani et al., 2020).

Control variables

Regarding control variables, we used corporate governance, financial, and industry-related variables. First, we added CEO duality (CEO_D) to control corporate governance mechanisms (Khairredine et al., 2020; Pucheta-Martínez & Gallego-Álvarez, 2019). CEO duality refers to the practice where the Chief Executive Officer (CEO) also serves as the Chairman of the Board (Brickley et al., 1997). This dual role can create a unified leadership structure but may also lead to a concentration of power that can affect board independence and firm oversight (Krause et al., 2014). It is expected that CEO_D negatively affects CD because CEOs may be focused on other interests.

Next, within financial variables, we included Firm Size (FirmS), Profitability (Profit), and Leverage (Lev). Firm size is a fundamental characteristic of a company, typically measured by the total assets, sales, number of employees, or market capitalization (Dang et al., 2018). Profitability is a crucial indicator of a company's financial health and efficiency in generating profits from its operations (Kayakus et al., 2023). It is commonly assessed using ratios such as return on assets (ROA) and return on equity (ROE). Leverage refers to using borrowed funds to finance a firm's assets (Admati et al., 2018). It is typically measured by the debt-to-equity ratio, which indicates the proportion of a company's capital that comes from debt.

Table 1
 Variable's measurements.

Variable	Measurement	Data source
CD	CDP score classification based on Bloomberg methodology	CDP website
BGD	Percentage of female directors on the board	Bloomberg
BI	Percentage of independent directors on the board	Bloomberg
BS	Total number of board members	Bloomberg
EC	The dummy variable equals 1 if the firm has an environmental committee, 0 otherwise.	Bloomberg
CEO_D	Dummy variable that equals 1 if the CEO is the chairperson, 0 otherwise	Bloomberg
FirmS	Log of total assets	Bloomberg
Profit	Return on assets	Bloomberg
Lev	Long-term liabilities divided by total assets	Bloomberg
Industry	The dummy variable that equals 1 if the firm belongs to the industry indicated, 0 otherwise.	BMV

Source: Authors' own, 2023

Firm Size will likely positively affect CD because larger firms are under multiple economic and environmental pressures. Profitability is expected to negatively affect CD because more profitable firms take fewer environmental actions. We estimate that leverage negatively affects CD because firms want to show creditors, they are aligned with climate change issues. Table 1 shows the variable measurements and sources employed for this study.

Data analysis

Considering the nine-level ordinal scale measurement of our dependent variable (CD) for this study, we consider the longitudinal Ordinal logistic regression (OLR) with random effects as the most appropriate tool for testing our direct and moderating hypotheses. The OLR is an extension of logistic regression where the response logit is linearly related to the independent variables (Al-Qahtani & Elgharbawy, 2020; Dawkins & Fraas, 2011). The estimated modeling for this study is as follows:

$$\text{Log} \left(\frac{P_{(CD \leq j)}}{1 - P_{(CD \leq j)}} \right) = \beta_0 + \beta_1 \text{BGD} + \beta_2 \text{BI} + \beta_3 \text{BS} + \beta_4 \text{EC} + \beta_5 \text{Controls} + \varepsilon \quad (1)$$

Where:

$P_{(CD \leq j)}$ is the probability of the dependent variable CD (Carbon Disclosure) being less than or equal to category j.

BGD stands for Board Gender Diversity

BI stands for Board Independence

BS stands for Board Size

EC stands for Environmental Committee

Controls includes control variables such as CEO Duality (CEO_D), Firm Size (FirmS), Profitability (Profit), and Leverage (Lev)

ε is the error term

Results

This section presents the key findings, including descriptive statistics, correlations, and the ordinal logistic regression (OLR) analysis results. We detail how board attributes affect carbon disclosure, supporting or refuting the proposed hypotheses.

Descriptive and correlation results

Table 2 shows the main descriptive statistics and correlations of the variables present in the study, including mean and standard deviation. The variables with the most observations are profitability (Profit) and leverage (Lev), with 683 observations. On the other hand, the variable with fewer observations is our dependent variable, CD, with 291 observations. The average carbon disclosure shows deficient levels of disclosure, with only 1.31 out of 8, showing that most Mexican public firms barely get a “disclosure” level, according to CDP criteria.

Similarly, BGD presents a mean of 6.20%, and the maximum level in this sample is 40%, which shows a low gender diversity among Mexican companies’ boards. This statistic is similar to other studies in both developed and developing countries like the United Kingdom, Australia, Turkey, and Malaysia, where they show that female participation on the board of directors is scarce (Elsayih et al., 2018; Kılıç & Kuzey, 2019; Liao et al., 2015; Ooi et al., 2019).

On the other hand, the average BI is 52.51%, double what Mexican law requires for the independence of the board (25%). This data is more frequently found in developed countries, where they average 50% independence of the board of directors (Al-Qahtani & Elgharbawy, 2020; Elsayih et al., 2018), while in developing countries, the average varies between 25-30% (Akbaş & Canikli, 2018). These actions align with good practices that reduce information asymmetry and demonstrate more efforts to pursue greater transparency.

For BS the average was near 12, which is, on average, 30% bigger than other studies (Al-Qahtani & Elgharbawy, 2020; Kılıç & Kuzey, 2019; Liao et al., 2015a; Ooi et al., 2019). Most Mexican companies are family-owned and managed, following (San Martin-Reyna & Duran-Encalada, 2012). Therefore, they tend to establish several family members within the board of directors. This may scare away external investors; however, it is a fact that they try to trade off by adding a high number of independent directors.

Finally, regarding control variables, Profit average was 3.12%, which is highly questionable for a firm. Nevertheless, this is consistent with other studies (Akbaş & Canikli, 2018; Jaggi et al., 2018a; Kılıç et al., 2020). On the other hand, the level of leverage seems to behave normally, with an average of 22.38%. This result is more in line with the level of debt of companies in countries such as the United Kingdom and Australia since in developing countries such as Turkey and Malaysia, their level of debt is around 50-60% on average (Akbaş & Canikli, 2018; Elsayih et al., 2018; Kılıç & Kuzey, 2019; Liao et al., 2015). Finally, the correlations between our independent variables are under ± 0.5 , which is awaited and expected. These correlation levels help to show that there are no multicollinearity issues in our sample.

Ordinal logistic regression (OLR) analysis

We conducted a longitudinal OLR with random effects analysis once we got our main descriptive and correlation results. The model's information of OLR is in Table 3, where we present three different models. The parameter estimates here are the principal outputs of the OLR, where the model specifies the association between the independent variables and our dependent variable. We perform model 3 to test our four hypotheses.

Table 2
 Descriptive Statistics and Correlations

Variable	Obs	Mean	Std. Dev.	Min	Max	CD	BGD	BI	BS	EC	CEO_D	FirmS	Profit	Lev
CD	291	1.31	2.24	0.00	8.00	1.00								
BGD	341	6.21	7.72	0.00	40.00	0.17	1.00							
BI	326	52.51	15.62	19.05	84.62	0.05	-0.04	1.00						
BS	341	11.77	3.46	4.00	21.00	0.38	-0.02	-0.15	1.00					
EC	333	0.19	0.39	0.00	1.00	0.33	0.24	0.08	0.07	1.00				
CEO_D	335	0.20	0.40	0.00	1.00	0.02	-0.06	-0.02	-0.09	-0.12	1.00			
FirmS	683	10.41	1.51	6.45	14.42	0.47	-0.02	0.02	0.42	0.00	0.03	1.00		
Profit	679	3.12	8.88	-55.26	102.78	-0.09	0.18	-0.10	-0.16	0.12	0.10	-0.20	1.00	
Lev	683	22.38	16.67	0.00	98.36	0.07	-0.13	0.09	0.12	0.11	-0.09	-0.11	-0.22	1.00

Source: Authors' own, 2023

We highlight that in this model, the board attributes seem to behave similarly, showing a positive and statistical effect on CD. For example, in Table 3, we can observe the three models where we use model 3 for testing hypotheses 1 to 4. The model was statistically significant at probability (χ^2) < 0.05. Besides, BGD, BI, and EC positively and significantly affect CD at 1%. These results support our H1, H2, and H4. It is worth noting that four models were analyzed to examine the individual effect of each corporate governance mechanism. The results for BGD, BI, and EC remained consistent with those shown in Model 3, with no significant changes observed. However, it is interesting to note the effect of BS ($\beta = 0.18$, p -value = 0.253), where, although it maintains a positive effect, its statistical significance diminishes, similar to the findings of Ooi et al. (2019). This indicates that for board size to have a positive impact on environmental practices such as carbon disclosure, it is essential to ensure strong corporate governance in other areas, such as gender diversity, board independence, and the presence of an environmental committee, as observed in (Liao et al., 2015; Khairiddine et al., 2020).

Table 3
 OLR Results for Models 1-3

	Model 1			Model 2			Model 3		
	Number of obs	222		Number of obs	232		Number of obs	222	
	Number of groups	49		Number of groups	52		Number of groups	49	
	Wald chi2(4)	22.81		Wald chi2(4)	14.06		Wald chi2(4)	28.69	
	Prob > chi2	0.0001		Prob > chi2	0.0071		Prob > chi2	0.0261	
	Log likelihood	-162.06		Log likelihood	-168.12		Log likelihood	-149.61	
CD	β	S.E.	P> z	β	S.E.	P> z	β	S.E.	P> z
BGD	0.10	0.05	*				0.14	0.05	**
BI	0.08	0.03	*				0.10	0.04	**
BS	0.50	0.15	***				0.37	0.16	*
EC	2.91	0.99	**				3.16	1.03	**
CEO_D				-0.22	0.87		-0.67	0.92	
FirmS				2.61	0.73	***	1.58	0.66	*
Profit				-0.01	0.05		-0.02	0.05	
Lev				0.05	0.04		0.03	0.04	
Industrial							-5.32	4.00	
Materials							-1.66	3.82	
PC_Freq							-3.70	3.69	
Health							-27.34	43858.92	
S_Telecom							-0.88	4.17	
S_Financ							-6.88	4.25	
SyBCB							-4.62	4.09	
Tec_com							-25.03	57380.45	
/cut1	14.41	3.11		34.54	9.27		28.90	8.77	
/cut2	15.28	3.15		35.48	9.32		29.85	8.81	
/cut3	16.92	3.20		37.13	9.41		31.60	8.89	
/cut4	17.12	3.21		37.32	9.42		31.80	8.90	
/cut5	20.43	3.44		40.78	9.72		35.45	9.20	
/cut6	22.85	3.60		43.09	9.80		37.93	9.29	
/sigma2_u	11.91	5.43		15.40	8.06		9.28	4.59	

All significant tests are two-tailed at † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (two-tailed).

Source: Authors' own, 2023

Discussion

We interpret the empirical results, comparing them with existing literature. This section explores the implications of board attributes on carbon disclosure and discusses their broader environmental, social, and economic impacts.

Our BGD result is consistent with Al-Qahtani and Elgharbawy (2020), Elsayih et al. (2018), and Liao et al. (2015). However, this contradicts Kılıç and Kuzeý (2019), who found that BGD does not affect CD in Turkey. Our outcome aligns with the findings of Seebeck and Vetter (2021), who claimed that board gender diversity provides more dynamism to discussions within the board of directors about relevant information and that their participation is not just an indicator of “best practices” that impoverishes the

meritocracy. Gender-diverse boards are more likely to engage in comprehensive discussions on environmental issues, enhancing the overall quality of carbon disclosures (Nuhu and Alam, 2024)

One of the most doubtful results regarding carbon disclosure is the board of directors' independence. For instance, Akbaş and Canikli (2018), Al-Qahtani and Elgharbawy (2020), and Kılıç and Kuzey (2019) didn't find any effect between them. In opposition, our result is consistent with Elsayih et al. (2018), Jaggi et al. (2018), and Liao et al. (2015) and contributes to the evidence that BI enhances non-financial reporting as carbon disclosure, promoting more transparency for stakeholders (Goh et al., 2016). Moreover, in a context such as the Mexican Stock Exchange, where most companies have traditionally been family-owned (San Martín-Reyna & Duran-Encalada, 2012), maintaining high independence on the board of directors can help minimize the risk of losing attractiveness for various stakeholders through financial and non-financial disclosure. Independent directors can reduce conflicts of interest and improve oversight, leading to better environmental reporting (Fernandes et al., 2018; Giannarakis et al., 2020).

On the other hand, our finding for EC is consistent with previous literature that has been steady with the results regarding EC on CD, showing a positive effect between them (Jaggi et al., 2018; Kılıç & Kuzey, 2019; Liao et al., 2015). This result confirms that establishing monitoring committees helps to improve practices for the benefit of shareholders, and it has a substantive effect on corporate practices, as is the case with establishing environmental committees to promote actions that favor the fight against climate change and enhance their transparency level (Baalouch et al., 2019; Salazar-García et al., 2024). Environmental committees can play a crucial role in ensuring that companies adhere to environmental regulations and proactively manage their carbon footprint (Dixon-Fowler et al., 2017; Jaggi et al., 2018).

However, a surprising and exciting finding is that BS presents a positive and significant effect, which differs from what we established. Therefore, we cannot support our H3. Nevertheless, this result contradicts Akbaş and Canikli (2018) and Ooi et al. (2019), whose findings were that BS has a negative and no effect, respectively. These contradictory results may be because, in the Mexican context, a large board of directors represents diverse interests for the benefit of shareholders and a wide range of stakeholders who constantly monitor corporate climate change issues. Thus, this rejects the idea that board size negatively influences the level of consensus on decisions that increase firm value and reduce information asymmetry (Cheng, 2008; Jiang et al., 2021). Larger boards can bring a broader range of expertise and perspectives, which can enhance the quality of environmental disclosures (Akbas, 2016; De Villiers et al., 2011).

Concerning control variables, FirmS consistently showed a positive and statistical effect on CD in every model. It's reasonable to think that more significant firms are under more pressure to commit to CSR and environmental practices due to their vast impact (Akbaş & Canikli, 2018; Al-Qahtani & Elgharbawy, 2020; Elsayih et al., 2018; Liao et al., 2015). In addition, this finding is consistent with the

findings of Luo et al. (2013), who state that firms with more significant resources tend to participate more in the CDP questionnaire.

The board attributes examined in this study—board gender diversity, board independence, board size, and environmental committee—show significant positive effects on carbon disclosure. Moreover, these findings have important environmental, social, and economic implications. Environmentally, better governance can lead to improved carbon disclosure practices, which are critical for climate change mitigation (Kılıç & Kuzey, 2019; Toukabri & Mohamed-Youssef, 2023). Socially, diverse and independent boards can ensure that the interests of various stakeholders, including those concerned with environmental sustainability, are better represented (Burke et al., 2019; Naciti, 2019). Economically, enhanced transparency and better carbon disclosure can reduce information asymmetry, potentially lowering the cost of capital and increasing firm value (He et al., 2013; Yu et al., 2018).

Conclusions

This study aims to analyze the effect of four board attributes to explain what mechanisms of the board contribute to establishing better governance, reducing information asymmetry, and enhancing carbon disclosure. Set in the context of Mexico's unique corporate landscape, characterized by a high prevalence of family-owned businesses, evolving corporate governance standards, and increasing environmental concerns, our research provides valuable insights into how these specific attributes influence non-financial disclosure practices.

Given the vast information asymmetry between insiders and outsiders about relevant information on the risks of climate change that concern companies, it is vital for stakeholders, especially the shareholders, to be able to monitor the environmental practices carried out by firms. In this study, we evaluate the effects of board attributes on carbon disclosure to analyze the role of some corporate governance mechanisms on non-financial disclosure and contribute to the literature with interesting findings.

The results show that board gender diversity (BGD) has a significant positive impact on carbon disclosure. Future research could explore how different levels of gender diversity affect other aspects of corporate sustainability and how these practices can be implemented in various organizational contexts, including small and medium-sized enterprises. The independence of the board (BI) is also positively related to carbon disclosure, suggesting that a higher number of independent directors can improve corporate transparency. Future analyses should examine the impact of board independence on other forms of non-financial disclosure and in different emerging markets. Additionally, research could investigate how to strengthen board independence in family-owned firms.

The presence of an environmental committee (EC) has a significant effect on improving carbon disclosure practices. Upcoming studies may explore how the effectiveness of these committees can be optimized and how they can influence other areas of environmental performance. It would also be valuable to analyze the benefits of establishing environmental committees in specific industries or public sector organizations. Contrary to our expectations, board size (BS) showed a positive effect on carbon disclosure. Ongoing research could focus on understanding how different board sizes affect decision-making in terms of sustainability and how these practices can be applied across various industries and regions.

This study has limitations, causing us to interpret the results cautiously. For example, we take a small sample size and a few years of study for the ordinal logistic panel regression since not all the companies on the Mexican Stock Exchange have answered the annual CDP questionnaires. Given that participation in our dependent variable has been scarce, we suggest treating these results with prudence since, on the one hand, they mention that the mechanisms of the board of directors help to increase non-financial reporting (carbon disclosure). On the other hand, the level of Mexican firms' carbon disclosure is low, barely reaching the "disclosure" level according to CDP criteria.

This level of disclosure is consistent with the findings of Jeswani et al. (2008) research, where they find that firms in emerging markets position in the indifferent or beginner clusters, which refers to companies taking a listless stance on environmental issues or having started making little significant changes to their operations to mitigate their carbon emissions recently.

The practical implications of this study indicate that while managers are committed to addressing environmental and climate change demands, their efforts often meet only the minimum required standards. Firms that establish an environmental committee, maintain a larger board of directors, and exceed the minimum requirements for board independence and gender diversity are better equipped to meet carbon mitigation pressures. Future research should assess the quality of voluntarily disclosed information and evaluate the consequences of carbon disclosure by examining other Latin American markets. Additionally, further studies should address the reliability of voluntary disclosures, particularly in emerging markets with low investor protection.

The practices and findings from this study can be applied in other companies and organizations to improve their carbon disclosure and sustainability strategies. Companies can adopt more diverse and independent boards, establish environmental committees, and consider adjustments in board size to enhance their transparency and environmental performance.

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