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Understanding the governance–disclosure nexus: board attributes, ownership structure and carbon emission disclosure in Egypt

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Abstract

Purpose – The aim of this research is to investigate the influence of board of directors' characteristics (BODC) on carbon emission disclosure (CED) and determine whether the relationship between BODC and CED is moderated by institutional ownership (IO) for Egyptian listed firms. This research particularly explores the effects of board size, independence, gender diversity and nationality diversity on CED.

Design/methodology/approach – The empirical analysis is based on 51 EGX70-listed non-financial companies between 2019 and 2023, which provides 255 firm-year observations. The data were obtained through the board reports, ESG disclosures and audited financial statements. A system generalized approach of moments (GMM) is used to conquer endogeneity issues and this approach is supplemented by two-stage least squares (2SLS) estimator and hypothesis are then tested.

Findings – The findings show that board size negatively affects CED, board independence positively affects CED and gender diversity also affects CED in a positive way. Diversity in board nationality is also found to have negative relationships with CED, which can be explained by the unfamiliarity with the culture and regulation. These relationships are also largely moderated by institutional ownership, which reduces the negative influence of board size and enhances the positive effect of board independence. The results indicate the importance of the board composition in promoting transparency of the environment of Egyptian listed firms.

Practical implications – The study provides valuable insights to market regulators, corporate boards and investors in emerging markets. The study provides insights to market regulators such as the Financial Regulatory Authority (FRA) to improve ESG mandates as suggested by El-Deeb *et al*. (2023). The study provides insights to corporate boards to improve gender diversity and independence to improve environmental transparency. The study also provides insights to investors to improve market efficiency by leveraging ownership stakes to improve stakeholder interests as suggested by Siew *et al*. (2016).

Originality/value – This study investigates the moderating role of institutional ownership in the relationship between board characteristics – size, independence, gender and nationality diversity – and carbon emission disclosure in Egypt. It provides novel evidence from an emerging market shaped by recent ESG reforms and COP27, showing that institutional investors enhance board effectiveness while nationality diversity may hinder transparency, extending legitimacy, stakeholder and resource-based perspectives.

Keywords Board characteristics, Institutional shareholding, Carbon emission disclosure, Corporate governance, Sustainability disclosure, Egyptian companies

Paper type Research article

1. Introduction

Severe environmental consequences arise from the increasing rate of greenhouse gas emissions (GHGs), especially carbon dioxide (CO_2), with significant implications for the environment and human well-being (Agus *et al*., 2023; AlQahtani and Elgharbawy, 2020). Consequently, carbon emissions disclosure (CED) has been recognized as a vital corporate tool in ensuring environmental responsibility, meeting the demands of stakeholders and supporting global environmental initiatives such as the United Nations Sustainable

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Development Goals 7 (Affordable and Clean Energy), 12 (Responsible Consumption and Production) and 13 (Climate Action) (Hardiyansah *et al*., 2021; Qian and Schaltegger, 2017).

Egypt, being the second-largest CO_2 emitter in the MENA region, is under immense pressure to improve environmental disclosure in response to its pledge to cut its GHGs by 33% by 2030 in accordance with the Paris Climate Agreement and hosting the 27th Conference of the Parties (COP27) in 2022 (Ramadan and Abdel-Fattah, 2022; Timilsina and Sebsibie, 2024). Therefore, the Financial Regulatory Authority (FRA) issued two decrees in 2021, with Decree 107 requiring listed companies with an issued capital/net worth of 100 million EGP or more to disclose the following environmental information: "carbon emissions, and in the case of larger companies, climate change-related financial risks in accordance with the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD)" (El-Deeb *et al*., 2023). Although there is recent regulatory encouragement for the disclosure of environmental information in the Egyptian stock exchange, the overall level of disclosure of carbon emissions among listed companies in the Egyptian stock exchange is relatively low (mean disclosure score ≈0.15), which is an indication of the early stage of disclosure in the emerging environment (Astuti and Setiany, 2021; Hardiyansah *et al*., 2021).

Board characteristics form an important internal governance process that affects corporate environmental disclosure (CED). In the Egyptian context, the publicly-traded companies have a mean board size of 8.517 members (4–16), a high level of board independence (0.750), low gender diversity (0.165) and insignificant nationality diversity (0.086), a trend that still exists despite the FRA requirement requiring a minimum of 25% of women on the board of non-financial companies (or at least two women) by the end of 2022. Therefore, such qualities, together with the possible coordination difficulties associated with larger boards and the lack of variety of opinions, make the board composition a significant but under-researched factor of carbon transparency in an environment of increasing sustainability demands in Egypt.

Another very important factor that stands out in this context is institutional ownership (IO), given its significant impact on corporate governance practices of Egyptian listed firms. On average, institutional investors own a significant 35.2% of the EGX70 non-financial firms sampled for this study, with considerable variability (SD = 0.332) (El-Diftar *et al*., 2017). The significant role of IO in facilitating corporate governance practices is also supported in previous studies conducted in emerging markets, which suggest its significant impact in aligning management with long-term stakeholder interests, including pressures for higher transparency in corporate activities, including environmental issues (Siew *et al*., 2016; Wicaksono and Octavio, 2025). In the context of Egypt, where the regulatory environment is still in a state of flux, IO is likely to reinforce (or mitigate inefficiencies in) the channels through which boards' characteristics impact CED.

The research has three contributions to literature. First, it helps to fill an important gap by studying how corporate governance promotes the implementation of carbon emission disclosure (CED) in the business environment of a developing country context. It is among the earliest empirical studies into an environment where there are characteristic regulatory developments (notably those by the FRA which were issued after 2021), unique environmental factors (being a regional high emitter and being a host to COP27) and where corporate governance structures were changing and had considerably low board diversity. Second, the research will build on current literature based on the legitimacy and stakeholder theories through offering contextualized findings within a developing market context. It shows how the system of governance functions under institutional and regulatory pressures unlike those that are normally witnessed in developed economies.

Third, and most importantly, the article is an original contribution, in terms of offering empirical data on the moderating effect of institutional ownership based on an exhaustive sample of board features. This entails comparably under-explored dimensions, especially board diversity on the aspect of nationality. The results yield new knowledge on the Egyptian context, which is the negative direct impact of nationality diversity on CED and the moderating effect of institutional ownership differently on-board size and independence.

These findings are inconsistent with the previous findings in already developed and other developing markets, thus contributing to the comparative knowledge of governance–disclosure relations.

The rest of this paper is organized as follows: Section 2 presents the literature review and hypotheses development; Section 3 is research design, Section 4 is data analysis and findings; and Section 5 presents conclusion, implications, limitations and future research directions.

2. Literature review and hypotheses development

2.1 Board characteristics and carbon emission disclosure

There is still no conclusive empirical evidence on the effect of board characteristics on corporate environmental disclosure (CED). This is often mediated by contextual variables, such as firm size and industry classification, and this trend is particularly strong in emerging markets, including Egypt (Astuti and Setiany, 2021). Board independence is widely regarded to be critical for effective governance and openness. Independent directors assist in prevention of managerial bias along with promoting environmental responsibility (Iswati and Setiawan, 2020). Several studies have been identified as being positively linked with CED and independent boards (Ararat and Sayedy, 2019; Krishnamurti and Velayutham, 2018; Alia and Mardawi, 2021). Agency theory also verifies this as it refers to monitoring by external directors, although findings could be mediated through institutional and cultural variations (Randunu *et al*., 2022; Bui *et al*., 2020).

Gender diversity improves environmental performance due to the injection of a wider range of perspectives and the improvement in stakeholder engagement. Theory of gender socialization posits that increased sensitivity of the environment by women leads to active sustainability conduct (Martínez *et al*., 2022; Mikhaylov *et al*., 2020). Empirical evidence forms a connection between female directors and elevated CED levels (Tingbani *et al*., 2020; Gonenc and Krasnikova, 2022; Ab Aziz *et al*., 2025a, b). Notably, significant contributions to this domain highlight how board composition and governance structures influence sustainability disclosure quality (Tingbani *et al*., 2020; Moussa *et al*., 2020). According to critical mass theory, the effect is strengthened where the board has three or more women (Ben-Amar *et al*., 2017), even though token representation occasionally creates small effects (Bui *et al*., 2020).

Board diversity in terms of gender and nationality is expected to be beneficial in terms of broader perspectives, better stakeholder engagement and better alignment of disclosure practices with the expectations of diverse societies (Zaid *et al*., 2020; Tingbani *et al*., 2020). Gender diversity is expected to bring in the ethical considerations and risk-taking behavior often seen in female board members, which is expected to result in higher levels of environmental accountability and CED quality (Gonenc and Krasnikova, 2022; Martínez *et al*., 2022). Nationality diversity is expected to bring in international experience and exposure to global best practices in terms of sustainability, which may result in negative outcomes in the form of cultural misfit and lack of knowledge about local regulations (Kao *et al*., 2018; Astuti and Setiany, 2021; Mardini and Elleuch Lahyani, 2022).

The overarching theoretical perspective is the legitimacy theory, which suggests that firms disclose their carbon emissions in order to conform to the norms set in the broader society, gain approval and thus obtain the "license to operate," especially in the face of increasing regulatory and stakeholder pressures (Qian and Schaltegger, 2017; Hardiyansah *et al*., 2021). In the context of emerging markets such as Egypt, which is in the midst of introducing ESG mandates (FRA Decrees 107/108, 2021), is in a region with high emissions and has an average CED level, board attributes can be considered an internal mechanism to fill the gap in terms of higher levels of disclosure. The resource-based view (RBV) is an extension of the above perspective, which considers board diversity in terms of gender and nationality to be an important strategic asset in terms of higher levels of capabilities in terms of environmental innovation and disclosure (Katmon *et al*., 2019). Although the results in developed markets

suggest positive outcomes, the results in the context of emerging markets are mixed, with moderators such as firm size and industry considered (Bui *et al*., 2020; Randunu *et al*., 2022). The recent scholarship started to discuss the issue of climate-related disclosure in the Egyptian context, albeit mostly through the prism of the financial reporting. As an example, Ismail and Obiedallah (2023) study how climate risk disclosure and accounting conservatism are connected with each other, noting the mediation effect of the quality of earnings. According to their work, environmental transparency in Egypt overlaps the financial reporting outcome greatly. Nonetheless, the amount of research in the setting of Egypt is still insufficient on the determinants of such disclosure in the context of governance. The governance peculiarity related to such low rates of gender and nationality diversity provides a significant gap in respect of perceiving correlation between the board qualities and CED.

Since there has been limited research conducted in the Egyptian environment and results were not homogeneous across previous research, the current research investigates the joint impact of board features on CED with the following hypothesis.

H1. Board of directors' characteristics (size, independence, gender diversity and nationality diversity) significantly affect carbon emission disclosure.

2.2 The moderating role of institutional ownership on the relationship between board characteristics and carbon emission disclosure

IO is a vital external corporate governance mechanism that significantly influences internal board processes due to its concentrated shareholdings and voting power (Habbash, 2016; Hermawan *et al*., 2018). The agency theory presupposes that the agency costs are minimized through the active participation of institutional investors in the corporate governance and the need to make sure that corporate decisions are beneficial to the long-term interests of shareholders, such as the necessity of environmental transparency to prevent possible business risks (Zhou *et al*., 2019; Cotter and Najah, 2012). The theory of legitimacy argues that institutional investors force companies to report their carbon emissions to conform to the demands of the society and the institutions, hence attaining social legitimacy to protect their investments (Oh *et al*., 2011; Gulzar *et al*., 2019; Qian and Schaltegger, 2017). This argument is also supported by the stakeholder theory that states that institutional investors as strong corporate shareholders spread the corporate responsibility to a larger group of people, through which the corporate boards are more capable of tackling the problem of environmental issues (Siew *et al*., 2016; Wicaksono and Octavio, 2025).

Research has indicated that the risks associated with climate change are being considered by institutional investors while making investment decisions with the aim of improving investment returns and reputation (Krueger *et al*., 2020; Serafeim, 2018; Flammer *et al*., 2021). IO is likely to demand transparent disclosure regarding the risk associated with climate change and might go through the process of divesting in companies that fail to disclose information regarding the risk associated with climate change with the aim of improving disclosure (Hong and Kacperczyk, 2009). However, research has indicated that companies might fail to disclose information regarding the risk associated with climate change with the aim of benefiting from it in the short term or as a result of the company's strategy (Samaha *et al*., 2012; Juhmani, 2013; Bushee *et al*., 2004). Some inconsistencies might arise in the disclosure of information regarding the risk associated with climate change as a result of greenwashing in developing economies (Raghunandan and Rajgopal, 2022).

According to the neo-institutional theory, institutional investors can use coercive, mimetic and normative pressures on companies with the aim of encouraging the adoption of standardized practices in the field of sustainability (Benlemlih *et al*., 2023; Akhtar and Abdullah, 2025). The existing literature shows that institutional ownership has a positive relationship with corporate environmental disclosure (CED) or climate actions in diverse settings, which can be explained by the availability of institutional investors (Wicaksono and

Octavio, 2025; Velayutham, 2014). Most importantly, institutional ownership can contribute to the high efficacy of the board by enhancing and strengthening board monitoring and strategic involvement in ESG-related issues (Jabin, 2025; Barko *et al*., 2022; Alharasis *et al*., 2026).

Independent and diverse boards are more likely to meet investors' expectations regarding environmental accountability with institutional backing (Wicaksono and Octavio, 2025; Hany, 2025). However, this relationship may depend on different horizons of institutional investors; long-term investors are more likely to strengthen the link between corporate governance and sustainability, whereas this link may weaken with short-term horizons (Siew *et al*., 2016). Despite the existing literature, very little empirical studies have investigated institutional ownership as a possible moderator in the relationship between a number of board characteristics, e.g. the size and independence and gender and nationality diversity and corporate environmental disclosure in different contexts, particularly in the emerging economy, such as Egypt, where institutional investors have relatively high stakes, where ESG regulatory reforms are relatively new (FRA Decrees 107/108, 2021), and where regulations enforcement is still in its infancy.

The resource-based perspective can also provide more knowledge as it considers board diversity as a strategic asset in the background of sustainability capabilities which can be capitalized by institutional ownership by being more effective in resource allocation and governance support (Katmon *et al*., 2019). By synthesizing agency, legitimacy, stakeholder theories and RBV, this research fills the gap by examining whether IO moderates the board characteristics–CED relationship in an emerging market with a lack of prior evidence (Mardini and Elleuch Lahyani, 2022).

According to that, the hypothesis is expressed as follows.

H2. IO moderates the relationship between the board of directors' characteristics and CED.

3. Data and methodology

3.1 Sample and data collection

The population of interest will also consist of all parties on Egyptian Stock Exchange (EGX) 2019–2023. The initial sample of this population was selected on the basis of EGX70 index that comprised 70 firms and 350 firm years. It has been chosen instead of the larger EGX100 to have enough liquidity and data available since it includes the most active companies on the exchange that are being scrutinized by the regulatory authorities and have the capacity to report on ESG. This selection criterion is similar to the previous governance and disclosure research that is concentrated in Egypt (e.g. El-Diftar *et al*., 2017). To avoid the risk of confounding factors that may arise as a result of the special regulatory and disclosure conditions of banks and financial institutions, banking institutions and financial markets (11 companies, 55 observations) were filtered out (El-Deeb *et al*., 2023). The remaining eight firms (40 observations) were eliminated due to lack of such important variables as board characteristics, institutional ownership or environmental disclosure (CED) items of firms. This will lead to a final sample of 51 non-financial firms included in the EGX70 that will be having 255 firm-years of observations (Table 1).

Table 1. Sample selection process for EGX70 non-financial firms, 2019–2023

Selection steps	No. of companies	Observations
Initial sample (EGX70 companies)	70	350
Less: Financial institutions and banks	(11)	(55)
Less: Companies with missing data	(8)	(40)
Final sample	51	255

The period 2019–2023 is inclusive of the pre- and post-regulatory years as compared to the Decrees of the FRA Decree 107 and 108 of 2021 that required ESG disclosure such as carbon emissions in listed companies with issued capital or net worth of EGP 100 million or above. Moreover, the bigger companies (equity > EGP 500 million) were to disclose the financial risks associated with climate as per the TCFD provisions. The years covered in this period include the years of the COVID-19 pandemic (2020–2022). To reduce possible pandemic-related disruptions (e.g. operational, supply-chain or reporting priority changes that may impact CED), the models include year fixed effects (implicit in the dynamic GMM estimation) and account for firm-specific organization (e.g. leverage and size) that can reflect the disruption caused by the pandemic.

Board diversity requirements were also contained in the FRA decrees, which mandate that non-financial companies have at least 25% women on the board (at least two women) by 31 December 2022. This period thus indicates the shift in Egypt toward being more conscious of sustainability and adherence to international standards.

The information on board characteristics, such as sizes, independence, gender and nationality diversity, and institutional ownership and CED were manually collected based on the board of directors' reports, corporate governance reports, sustainability/ESG reports and TCFD-oriented disclosures of the companies. The control variables (size, leverage, age) were obtained through financial data, which were annual financial statements, investing.com and mubasher.com. The gaps in the values were filled and cross-checked with the support of the Egypt for Information Dissemination (EGID) database and governance reports to maintain consistency (El-Diftar *et al.*, 2017).

Though the sample size (N = 51 firms, T = 5 years, and the total number of observations = 255) is quite small to estimate dynamic panel GMMs, it is sufficient and similar to the studies of governance and disclosure focused on Egypt (e.g. El-Diftar *et al.*, 2017). It is shown through simulation work that the system GMM estimator is reliable on small N, short T panel when instruments are properly restricted (e.g. by collapsing); in addition, the estimator is also consistent when there is moderate persistence in the lagged CED variable.

3.2 Study variables and research model

This research examines the effect of board characteristics (BC) on CED with IO as the moderating factor. Table 2 illustrates the variables of the study and their measurements.

CED is a dependent variable which is measured by 18 items index based on the Carbon Disclosure Project (CDP) framework as listed in Appendix (Choi *et al.*, 2013). This model has been actively used in the study of emerging markets (Qosasi *et al.*, 2022; Hardiyansah *et al.*, 2021). The index has five sub-dimensions namely climate change (2 items), GHGs (7 items), energy use (3 items), reduction and cost (4 items) and accountability (2 items). The items will be scored as 1 when they are disclosed in corporate reports and 0 when not. CED score is determined by the ratio of the disclosed items to the entire 18 without making any adjustment so that the resulting normalized disclosure index is computed as a proportion of 1 indicating the full 18. Although the use of CDP is voluntary among firms in Egypt, the use of this CDP-based approach is considered to be suitable in the Egyptian context, since the previous researches on similar emerging markets have successfully applied it through the use of manual content analysis of annual, sustainability and governance reports, thus covering both voluntary and compulsory disclosures. There were no major changes to make since the items are quite relevant to the FRA ESG reporting requirements namely GHGs, energy use and energy reduction targets, thus, being relevant and comparative to other developing disclosure regulations in Egypt.

Independent variables are board attributes: board size (BS), as the number of directors (Aliyu, 2019); board independence (BI), as the ratio of non-executive directors to total directors (Aliyu, 2019); board gender diversity (BGD), as the ratio of female directors to total directors (Mardini and Elleuch Lahyani, 2022); and board national diversity (BND), as the

Table 2. Variable definitions and measurement

Variable type	Variable	Measurement type	Measurement description	Reference
Dependent	Carbon emission disclosure (CED)	Index	Ratio of disclosed items to a total of 18 items in the Carbon Disclosure Project (CDP) index, scored as 1 for disclosed items and 0 otherwise	Qosasi *et al.* (2022), Hardiyansah *et al.* (2021)
Independent	Board size (BS)	Numeric	Total number of directors on the board	Aliyu (2019)
Independent	Board independence (BI)	Ratio	Proportion of non-executive directors to the total number of directors	Aliyu (2019)
Independent	Board gender diversity (BGD)	Ratio	Proportion of female directors to the total number of directors	Mardini and Elleuch Lahyani (2022)
Independent	Board national diversity (BND)	Ratio	Proportion of non-Egyptian directors to the total number of directors	Elleuch Lahyani (2022)
Moderator	Institutional ownership (IO)	Ratio	Percentage of shares owned by institutional investors (domestic or foreign, financial or non-financial)	Dintimala and Amril (2018), Krisnawanto and Solikhah (2019)
Control	Firm size (FSIZE)	Numeric	Natural logarithm of total assets	Elleuch Lahyani (2022)
Control	Firm leverage (LEV)	Ratio	Ratio of total liabilities to total assets	Chen *et al.* (2023)
Control	Firm age (AGE)	Numeric	Number of years since the firm's incorporation	Collevecchio *et al.* (2025)
Control	Firm industry (IND)	Dummy	Coded as 1 for manufacturing firms, 0 otherwise	

ratio of non-Egyptian directors to total directors (Elleuch Lahyani, 2022). IO, the moderator variable, is measured as percentage of institutional investor ownership, foreign and domestic, financial and non-financial institutions (Dintimala and Amril, 2018; Krisnawanto and Solikhah, 2019).

Control variables are firm size (FSIZE), measured as the natural logarithm of total assets (Elleuch Lahyani, 2022); firm leverage (LEV), measured as total liabilities to total assets (Chen *et al*., 2023); firm age (AGE), measured as years since incorporation (Collevecchio *et al*., 2025); and firm industry (IND), a dummy variable set equal to 1 for manufacturing firms and set equal to 0 for all other firms. These legitimacy and stakeholder theory enabled firm-specific determinants of disclosure practices argue that the more leveraged, older and sized firms, and the high-impact industry firms, are under more pressure to disclose environmental information (Knox *et al*., 2005; Patten, 1991; Andrikopoulos and Kriklani, 2013; Brammer and Pavelin, 2008). For the testing of the hypotheses, two regression models were specified.

3.2.1 Model (1) investigates the direct impact of BC on CED.

$$\text{CEDit} = \alpha + \beta 1\text{BSIZEit} + \beta 2\text{INDit} + \beta 3\text{BGENit} + \beta 4\text{BNATit} + \beta 5\text{FSIZEit} + \beta 6\text{LEVit} + \beta 7\text{AGEit} + \beta 8\text{IND} + \varepsilon\text{i}$$

In Model (2), the moderation effects were investigated through the inclusion of the interaction terms between each of the BC, namely, board size (BSIZE), board independence

(BI), board gender diversity (BGEN) and board nationality (BNAT) and IO. Also, terms of interaction between IO and theoretically relevant control variables were added to accommodate the possible combined effects. The specification allows the exploration of the question of whether IO adjusts the marginal effect of the board attributes on corporate environmental disclosure (CED); the coefficients of the interaction terms show the direction and statistical significance of this moderation. Continuous variables were log-transformed where necessary to reduce skewness and make them easy to interpret – e.g. lnBS was the log-transform used to make the effects of board size expressed in percentage terms. Model (2) utilizes interaction terms to investigate the moderating influence of IO between BC and CED.

3.2.2 Model (2) investigates the moderation influence of IO on the relation between BC and CED.

$$\mathrm{CEDit} = \alpha + \beta 1\mathrm{BSIZEit}\times\mathrm{IO} + \beta 2\mathrm{INDit}\times\mathrm{IO} + \beta 3\mathrm{BGENit}\times\mathrm{IO} + \beta 4\mathrm{BNATit}\times\mathrm{IO} + \beta 5\mathrm{FSIZEit}\times\mathrm{IO} + \beta 6\mathrm{LEVit}\times\mathrm{IO} + \beta 7\mathrm{AGEit}\times\mathrm{IO} + \beta 8\mathrm{IND}\times\mathrm{IO} + \varepsilon \mathrm{i}$$

The models were estimated through the GMM to address endogeneity issues and were tested with the Durbin–Wu–Hausman test ($p = 0.0000$). The robustness was established through a two-stage least squares (2SLS) approach to ensure the consistency of outcomes (Choi *et al*., 2013; El-Diftar *et al*., 2017; Ab Aziz *et al*., 2025a).

4. Data analysis

4.1 Descriptive statistics

The major variables are summarized in Table 3 based on 255 firm-years of 51 EGX70-listed non-financial firms (2019–2023). The average size of the board is 8.517 (SD = 2.493, 4–16) which shows that the number of board members varies moderately. The proportion of independent directors at the board is 0.750 (SD = 0.154), which is a high ratio of non-executives compared to the recommendations of Egyptian Corporate Governance Code (majority non-executive, at least two independents; EIoD/FRA guidelines) and typical emerging-market practices.

The mean of gender diversity is 0.165 (SD = 0.116, range = 0–0.5) and nationality diversity is lower with 0.086 (SD = 0.187, range = 0–0.8). IO means 0.352 (SD = 0.332, 0–0.939). The means of CED is 0.145 (SD = 0.200, range 0–0.944), which means that the average levels of disclosure are low with great dispersion. The average age of the firm is 37.235 (SD 19.411) years and other non-financial variables (size, leverage, and industry) are within the typical firms listed in Egypt. Such summary statistics describe the sample and indicate variability to be used in regression analysis. Where applicable, benchmarks are taken into account in interpretation (e.g. Egyptian CG Code of board composition).

Table 3. Descriptive statistics of key variables ($N = 255$ firm-year observations)

Variable	Mean	Std. dev	Min	Max
Board size	8.517	2.493	4	16
Board independence	0.750	0.154	0.272	1
Board gender diversity	0.165	0.116	0	0.5
Board nationality	0.086	0.187	0	0.8
Carbon emission disclosure	0.145	0.200	0	0.944
Institution ownership	0.352	0.332	0	0.939
Firm size	21.349	1.355	16.669	24.392
Firm leverage	0.565	0.292	0.095	3.177
Firm age	37.235	19.411	4	94

4.2 Correlation analysis

The correlation analysis, as evident in Table 4, gives preliminary evidence of correlation between CED and certain attributes of the board as well as institutional ownership.

Note that CED is negatively correlated with board size, foreign percentage of directors and institutional ownership at a 90% confidence level. This indicates that boards which are large, have a higher percentage of foreign directors and have greater institutional ownership are related to lower carbon emission disclosure. On the other hand, there is a positive relationship between board gender diversity and CED at the 95% confidence level, which suggests increased female board membership can contribute to enhanced environmental transparency. These initial findings are consistent with some existing literature that has examined the effect of board structure on corporate disclosure practice (Aliyu, 2019; Mardini and Elleuch Lahyani, 2022).

Additionally, the examination of control variables – firm size, firm age and firm leverage – fails to reveal any connection with carbon emission disclosure. This indicates that for this sample, the extent of CED in isolation is unaffected by these customary firm characteristics. From the correlation matrix, another remarkable feature discovered is the lack of any relationship more than 0.7 among the independent variables, which suggests initially the absence of multicollinearity. Though this is a positive sign, the paper is correct in stating that a more stringent test for multicollinearity based on variance inflation factor (VIF) is still needed in order to identify this observation. These correlations form the foundation step, which directs the other regression analyses in order to investigate causalities and moderating effects beyond.

To assess multicollinearity, VIFs were calculated for all independent and moderating variables. All VIF values are below 3.0 (maximum VIF = 2.41 for firm size), well below the conventional threshold of 5 or 10, indicating no serious multicollinearity concerns in the models.

4.3 Econometric considerations and model estimation

This section addresses critical econometric issues, namely endogeneity and heteroscedasticity, which are prevalent in panel data analysis and can compromise the validity of empirical findings if not appropriately managed. Subsequently, the selection and application of the

Table 4. Pearson correlation matrix of log-transformed variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) lnCED	1								
Sig									
(2) lnBS	−0.251	1							
Sig	0.072								
(3) lnBI	−0.54	−0.204	1						
Sig	0.039	0.001							
(4) lnBG	0.642	0.067	−0.055	1					
Sig	0.029	0.286	0.385						
(5) lnBN	−0.881	−0.058	−0.163	0.036	1				
Sig	0.009	0.354	0.009	0.566					
(6) lnInstitution	−0.13	−0.137	−0.128	−0.141	−0.325	1			
Sig	0.038	0.029	0.04	0.025	0				
(7) lnFA	−0.066	−0.063	0.231	−0.004	−0.022	0.512	1		
Sig	0.295	0.314	0	0.955	0.721	0			
(8) lnFL	−0.068	−0.128	−0.046	−0.077	−0.017	−0.171	−0.062	1	
Sig	0.28	0.041	0.465	0.219	0.792	0.006	0.326		
(9) lnFS	−0.085	−0.105	−0.087	−0.075	−0.052	−0.048	−0.027	−0.321	1
Sig	0.175	0.093	0.168	0.231	0.409	0.447	0.669	0	

Note(s): *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

GMM are detailed, followed by a comprehensive discussion of the estimation results, including the moderating effects of institutional ownership.

Regarding the suitability of the sample size for this estimator, though the sample size ($N = 51$ firms, $T = 5$ years, and the total number of observations = 255) is quite small to estimate dynamic panel GMMs, it is sufficient and similar to the studies of governance and disclosure focused on Egypt (e.g. El-Diftar *et al*., 2017). It is shown through simulation work that the system GMM estimator is reliable on small *N*, short T panel when instruments are properly restricted (e.g. by collapsing); in addition, the estimator is also consistent when there is moderate persistence in the lagged CED variable.

Endogeneity is a pervasive econometric model problem, which occurs when a regressor in a regression model is correlated with the error term. Endogeneity can occur due to numerous sources such as omitted variable bias, measurement error or simultaneity and results in inconsistent and biased parameter estimates (Namazi and Namazi, 2016). In order to determine whether there is endogeneity in the present model or not, the Durbin–Wu–Hausman test was utilized. The diagnostic test results are shown in Table 5.

As can be indicated in Table 5, the Durbin–Wu–Hausman test provides us with test statistics of 19.12 along with the corresponding *p*-value as 0.0000. The *p*-value being significantly lower than the typical level of significance of 0.05 results in a strong rejection of the null hypothesis that the regressors are exogenous. This result strongly indicates the existence of endogeneity in the model, hence suggesting the lagged carbon emission disclosure variable causes endogeneity at a 99% confidence level. As such, the choice of the appropriate estimation method with the ability to tackle such endogeneity is central to producing a robust and credible empirical result.

Homoscedasticity is yet another standard classical linear model of regression assumption under which constant variance of the error terms is assumed at all levels of the independent variables. Its failure, heteroscedasticity, has no effect on the estimates of coefficients but makes the standard errors inconsistent and thus invalidates hypothesis tests and confidence intervals. To test for the existence of heteroscedasticity between the panel data, both Modified Wald Test and Breusch–Pagan test have been performed. The findings are documented in Table 6.

As shown in Table 6, even the Modified Wald test and the Breusch–Pagan test also posted *p*-values (0.000 and 0.002, respectively) below the 0.01 significance level. This results in the rejection of the null hypothesis of homoscedasticity, confirming the existence of heteroscedasticity between panels at 99% confidence. Detection of both heteroscedasticity and endogeneity requires the application of an econometric model capable of addressing the two issues firmly, thus providing valid statistical inferences.

Table 5. Durbin–Wu–Hausman test for endogeneity

Test	Values
Test statistic	19.12
Significance	0.0000

Table 6. Tests for heteroscedasticity in panel data

Test	Value	*P*-value
Modified Wald Test	8,912	0.000
Breusch–Pagan Test	13.53	0.002

Diagnostic tests were conducted to confirm the presence of endogeneity and heteroscedasticity in the panel data. The Durbin–Wu–Hausman test was conducted to test for exogeneity, and the result indicated that the model was not exogenous ($\chi^2 = 19.12$, $p = 0.0000$). The Modified Wald test ($p = 0.000$) and Breusch–Pagan test ($p = 0.002$) were conducted to test for panel-level heteroscedasticity, indicating that the model was heteroscedastic. Therefore, the system GMM was used to address these issues in the model, and 2SLS was used to provide robustness to the findings of the study. The validity of the instrument was also confirmed through the test of under-identification ($p < 0.001$). The findings of the system GMM estimation of the baseline model and the model with interaction terms are presented in Tables 7–10.

Table 7 presents the findings of the system GMM estimation of the model of the direct effects of BC and IO on CED. Board size was negatively and significantly related to CED (−0.159, $p = 0.002$), supporting the expectations of agency theory regarding the challenges of coordination among board members in large boards. Board independence was positively and significantly related to CED (0.404, $p = 0.021$), and gender diversity was positively and significantly related to CED (0.599, $p = 0.000$), supporting the expectations of both agency

Table 7. System GMM estimation results – baseline model (no interaction terms)

Variable	Coefficient	Std. Error	z	*P* > z	[95% Conf. Interval]
lagCED	−0.31492	0.134924	−2.33	0.020	[−0.57936, −0.05047]
lnBS	−0.15903	0.050229	−3.17	0.002	[−0.25748, −0.06059]
lnBI	0.404399	0.17547	2.30	0.021	[0.060484, 0.748314]
lnBG	0.599136	0.156971	3.82	0.000	[0.291479, 0.906793]
lnBN	−0.31291	0.114332	−2.74	0.006	[−0.537, −0.08883]
lnFA	−0.00565	0.028201	−0.20	0.841	[−0.06092, 0.049627]
lnFL	0.090979	0.025773	3.53	0.000	[0.040464, 0.141494]
lnFS	0.175722	0.184876	0.95	0.342	[−0.18663, 0.538072]
inInstitution	−0.31262	0.086831	−3.60	0.000	[−0.48281, −0.14243]
industry	−0.07666	0.028842	−2.66	0.008	[−0.13318, −0.02013]
_cons	0.001105	0.58511	0.00	0.998	[−1.14569, 1.147898]

Note(s): *R*-squared: 47.4%, Root MSE: 0.16, Test statistic: 52.7 (Sig: 0.000)

Table 8. System GMM estimation results – moderated model (with interaction terms)

Variable	Coefficient	Std. Error	Z	*P* > z	[95% Conf. Interval]
lagCRD	−0.40887	0.130897	−3.12	0.002	[−0.66542, −0.15231]
lnBS	0.001842	0.086842	0.02	0.983	[−0.16837, 0.172049]
lnBI	0.151648	0.235749	0.64	0.520	[−0.31041, 0.613707]
lnBG	0.59958	0.31281	1.92	0.055	[−0.01352, 1.212676]
lnBN	−0.33348	0.332321	−1.00	0.609	[−0.98483, 0.317865]
lnFA	−0.00528	0.030349	−0.17	0.862	[−0.06477, 0.054199]
lnFL	0.105406	0.026408	3.99	0.000	[0.053647, 0.157164]
lnFS	0.249635	0.195597	1.28	0.202	[−0.13373, 0.632998]
lnInstitution	−0.04247	0.531593	−0.08	0.936	[−1.08437, 0.999432]
Industry	−0.07507	0.031091	−2.41	0.016	[−0.136, −0.01413]
Mod BS	−0.60023	0.232645	−2.58	0.010	[−1.05621, −0.14426]
Mod BI	1.610764	0.62139	2.59	0.010	[0.392863, 2.828665]
Mod BG	0.130875	0.872606	0.15	0.881	[−1.5794, 1.841151]
Mod BN	0.520302	0.690455	0.75	0.451	[−0.83296, 1.873568]
_cons	−0.41169	0.676715	−0.61	0.543	[−1.73803, 0.914649]

Note(s): *R*-squared: 48.2%, Root MSE: 0.16092, Test statistic: 75.96 (Sig: 0.000)

Table 9. Two-stage least squares (2SLS) estimation results – baseline model (robustness check)

lnCED	Coefficient	Std	z	*P*>|z|	95%	Conf
lagCED	−0.31492	0.130616	−2.41	0.016	−0.57092	−0.05891
lnBS	−0.15903	0.049541	−3.21	0.001	−0.25613	−0.06194
lnBI	0.404399	0.164035	2.47	0.014	0.082896	0.725902
lnBG	0.599136	0.161851	3.7	0	0.281913	0.916359
lnBN	−0.31291	0.10752	−2.91	0.004	−0.52365	−0.10218
lnInstitution	−0.31262	0.083381	−3.75	0	−0.47604	−0.1492
industry	−0.07666	0.029623	−2.59	0.01	−0.13472	−0.0186
lnFL	0.090979	0.029399	3.09	0.002	0.033358	0.148599
lnFS	0.175722	0.213969	0.82	0.412	−0.24365	0.595093
lnFA	−0.00565	0.028455	−0.2	0.843	−0.06142	0.050126
_cons	0.001105	0.662946	0	0.999	−1.29825	1.300456
R squared	53.48%					
Root MSE	0.161					
Test statistic	4.89					
Sig	0.000					
Under identification test	30.999 (0.000)					
Cragg–Donald Wald F	86.987 (>16.38 stated by Stock Yogo)					
Kleibergen–Paap F	54.234 (>16.38 stated by Stock Yogo)					

Table 10. Two-stage least squares (2SLS) estimation results – moderated model (robustness check)

lnCED	Coefficient	Std	Z	*P*>|z|	95%	Conf
lagCED	−0.40887	0.14216	−2.88	0.004	−0.68749	−0.13024
lnBS	0.001842	0.081934	0.02	0.982	−0.15875	0.16243
lnBI	0.151648	0.214815	0.71	0.48	−0.26938	0.572677
lnBG	−0.59958	0.313475	−1.91	0.056	−1.21398	0.014821
lnBN	−0.33348	0.228569	−1.46	0.18	−0.78148	0.114512
lnInstitution	−0.04247	0.533935	−0.08	0.937	−1.08896	1.004022
industry	−0.07507	0.031257	−2.4	0.016	−0.13633	−0.0138
lnFL	0.105406	0.030539	3.45	0.001	0.04555	0.165262
lnFS	0.249635	0.226349	1.1	0.27	−0.194	0.693271
lnFA	−0.00528	0.030385	−0.17	0.862	−0.06484	0.05427
Mod BS	−0.60023	0.221529	−2.71	0.007	−1.03442	−0.16605
Mod BI	1.610764	0.654679	2.46	0.014	0.327618	2.893911
Mod BG	0.130875	0.776904	0.17	0.866	−1.39183	1.653579
Mod BN	0.520302	0.690395	0.75	0.451	−0.83285	1.873452
_cons	−0.41169	0.747834	−0.55	0.582	−1.87742	1.054039
R squared	53.52%					
Root MSE	0.1609					
Test statistic	4.89					
Sig	0.000					
Under identification test	73.338 (0.0000)					
Cragg–Donald Wald F	83.738 (>16.38 stated by Stock Yogo)					
Kleibergen–Paap F	47.572 (>16.38 stated by Stock Yogo)					

and stakeholder theories regarding the positive contributions of independent and gender diversity to corporate social and ethical responsibility. Board diversity in terms of nationality was negatively related to CED (−0.313, $p = 0.006$), and IO was negatively related to CED (−0.313, $p = 0.000$). The model explained 47.4% of the variation in CED ($R^2 = 0.474$) and was highly significant (test statistic = 52.7, $p = 0.000$).

As presented in Table 8, the GMM estimation of the model with interaction terms between each of the BC and IO shows that the interaction between board size and IO is negative and

statistically significant (−0.600; $p = 0.010$). This indicates that IO helps to mitigate the negative influence of larger board sizes on CED. However, the interaction between board independence and IO is positive and statistically significant (1.611; $p = 0.010$). This implies that IO helps to enhance the positive influence of independent directors on CED. The interaction between gender diversity and IO (0.131; $p = 0.881$) as well as nationality diversity and IO (0.520; $p = 0.451$) are not statistically significant. The inclusion of interaction terms in the model slightly increases the explanatory power of the model ($R^2 = 0.482$) as well as its significance (test statistic = 75.96; $p = 0.000$).

4.4 Robustness test

As a robustness test and a validity test of the findings, a two-stage least squares (2SLS) model was also utilized, especially since it can solve for endogeneity, much like GMM, but at the cost of an assumption of homogeneity (Table 9). The 2SLS model has a higher *R*-squared value (53.48%) than that of GMM (48.2%), with similar root mean squared error (0.161 vs 0.16092). Validity of the instruments was established with the under-identification test ($p = 0.000$) and the over-identification tests (Cragg–Donald Wald F = 86.987, Kleibergen–Paap F = 54.234), all above Stock-Yogo critical value of 16.38. The overall significance of the model was established using a test statistic of 4.89 ($p = 0.000$).

The 2SLS outcome was observed to replicate that of the GMM with similar coefficients varying only in terms of standard error estimation. Consistent significant results were lagged carbon emission disclosure (lagCED) had negative impact on current CED ($p = 0.016$). Board size (lnBS) was a negative significant ($p = 0.001$), whereas board independence (lnBI) was positive significant ($p = 0.014$). Board gender diversity (lnBG) positively impacted CED ($p = 0.000$), whereas board nationality (lnBN) had a negative impact on it ($p = 0.004$). IO also negatively contributed ($p = 0.000$). Financial leverage, lnFL, also contributed positively ($p = 0.002$), while firm age, lnFA, and firm size, lnFS, remained insignificant. Other industries apart from manufacturing showed lower CED, $p = 0.010$.

Inserting interaction terms into the 2SLS model (Table 10) again testified to the strength of moderation analysis. The *R*-squared increased by a bit to 53.52%, and the Root MSE was nearly identical (0.1609). IO again prevailed in the moderation of the CED-board size relationship (Mod BS, $p = 0.007$) and board independence (Mod BI, $p = 0.014$), similar to the result in the case of GMM results. The board gender diversity effect remained positive and significant ($p = 0.056$). Replicative results of both GMM and 2SLS models confirm the validity of, as well as the robustness in, the study results.

5. Discussion of results

This research brings to light the strong correlation between board attributes (BC), CED and the moderating effect of IO on 51 Egyptian non-financial companies listed on the EGX70 for the period 2019–2023. The findings support a strong correlation between BC and CED, as in previous research (Alia and Mardawi, 2021; Bui *et al.*, 2020; Elsayih *et al.*, 2018) and providing new evidence to the body of literature, particularly in a developing market like Egypt. The following section compares the findings of the study with existing literature, places them in context and considers their theoretical and practical implications by combining legitimacy, stakeholder, agency and RBV theories.

Moreover, the empirical results reveal that there are distinct relationships between BC and CED in Egyptian non-financial organizations, depending on IO, as suggested by the integrated theoretical model of agency theory, legitimacy theory, stakeholder theory and RBV theory.

The negative relationship between board size and CED (coefficient = −0.159, $p = 0.002$) confirms the agency theory, which posits that a large board may experience problems related to coordination, hence limiting its role (Pucheta-Martínez and Gallego-Álvarez, 2019; Aliyu, 2019). With regard to Egyptian organizations, where a culture of

CED is yet to be developed, smaller boards may be more effective in their role in implementing CED, as stipulated by FRA Decrees 107/108.

Board independence positively influences CED (coefficient = 0.404, p = 0.021), supporting the agency theory, which argues that independent directors play a critical role in countering managerial opportunism (Ararat and Sayedy, 2019; Krishnamurti and Velayutham, 2018). Such a relationship could be even more significant in a country that has implemented changes that place more emphasis on ESG indicators. Gender diversity shows the highest relationship with CED (coefficient = 0.599, p = 0.000), supporting the stakeholder theory that suggests that gender diversity will positively affect CED because of gender socialization (Tingbani *et al*., 2020; Gonenc and Krasnikova, 2022). This supports the importance of the FRA's guideline of having at least 25% female representation to increase legitimacy-seeking behavior.

Conversely, a negative relationship is found between nationality diversity and CED (coefficient = −0.313, p = 0.006), contradicting the RBV theory that expects foreign directors' global skills to positively affect CED (Katmon *et al*., 2019). This supports the legitimacy theory's concerns about cultural differences and unfamiliarity with local ESG disclosure practices, which could affect the effectiveness of ESG disclosure in Egypt (Astuti and Setiany, 2021; Mardini and Elleuch Lahyani, 2022; Amara *et al*., 2025). In fact, IO moderates the negative relationship between board size and CED in the sense that the relationship is reduced, as indicated by the interaction p = 0.010, while it reinforces the positive relationship between independence and CED, as indicated by the interaction p = 0.010, in line with the suggestions of legitimacy theory and stakeholder theory regarding the role of institutional investors' monitoring pressure in compensating for the inefficiencies of large boards (Siew *et al*., 2016; Gulzar *et al*., 2019).

The non-significant moderation for gender and nationality diversity suggests that IO's influence might be more pronounced on structural dimensions than on diversity dimensions. Likewise, the study's findings extend the theoretical synthesis by providing empirical support for agency theory's and legitimacy theory's monitoring effect of independence on CED, as well as conformity effect of large boards on CED; stakeholder theory's view on firm responsiveness to diversity; and RBV theory's perspective on diversity as a conditional resource for firm behavior. In the context of Egypt's emerging market with low average CED, recent regulatory changes and high IO, the study's findings highlight the interplay between internal (board) and external (ownership) corporate governance on environmental transparency in response to evolving sustainability demands.

Practically, such findings can be used as vital guidelines in the application in the Egyptian corporate environment. To regulators, in this case, the FRA, one implication is that the implementation of Decree 107 must be accompanied by recommendations on the best board structure and strong emphasis should be placed on independent and gender diversity rather than increasing the size of the board (El-Deeb *et al*., 2023). To corporate practitioners, the adverse effect of nationality diversity implies that the diversity will require an orientation program to harmonize foreign directors with the local ESG laws, which will reduce the culture misfits (Mardini and Elleuch Lahyani, 2022). Moreover, institutional investors, who have a large stake (mean 35.2%), are in a position to be active monitors; they can contribute to CED not only through voting, but also by interacting with firms to increase board size inefficiency and weaken independent control, which aligns management with the interests of long-term stakeholders (Siew *et al*., 2016). These applications make sure that governance systems are implemented as practical environmental transparency to promote the national climate objectives of Egypt.

Table 11 is a comparative summary of this study's findings on BC and IO moderation effects on CED against prior literature. The table indicates similarities and differences between this study's findings and prior literature, including consistencies and contradictions, and provides a sense of context for understanding these similarities and differences, including potential limitations and nuances, such as coordination problems for boards of directors in

Table 11. Comparison of current findings with prior studies on board characteristics, institutional ownership moderation and carbon emission disclosure

Board characteristic	Current study finding	Supporting studies	Contrasting studies	Possible reasons for discrepancy
Board Size	Negative ($p = 0.002$)	Iswati and Setiawan (2020), Alia and Mardawi (2021), Pucheta-Martínez and Gallego-Álvarez (2019), Elfeky and Abdelaziz (2022), Bedi and Singh (2024)	Ntim and Soobaroyen (2013), Jizi *et al*. (2014), Astuti and Setiany (2021)	Coordination issues in Egypt's larger boards; limited ESG expertise
Board Independence	Positive ($p = 0.021$)	Ararat and Sayedy (2019), Krishnamurti and Velayutham (2018), Zanra *et al*. (2020), Anis and Metwalli (2025), Hassan and Omar (2025), Elleuch Lahyani (2022)	Randunu *et al*. (2022), Bui *et al*. (2020)	FRA's 2021 ESG mandates enhance independent directors' role
Board Gender Diversity	Positive ($p = 0.000$)	Tingbani *et al*. (2020), Alia and Mardawi (2021), Gonenc and Krasnikova (2022), Hollindale *et al*. (2019), Alfi *et al*. (2025)	Bui *et al*. (2020), Astuti and Setiany (2021)	High female representation; focus on broader sustainability metrics
Board Nationality	Negative ($p = 0.006$)	Masulis *et al*. (2012), Khatri (2024), Martinez *et al*. (2022)	Khan *et al*. (2019), Purnomo and Rizki (2020), Kılıç and Kuzey (2019), Mardini and Elleuch Lahyani (2022)	Unfamiliarity with Egypt's ESG regulations; cultural misalignment
IO Moderation (Board Size)	Negative ($p = 0.010$)	Jabin (2025), Puteri and Handayani (2026)	Siew *et al*. (2016)	Short-term investor focus in Egypt
IO Moderation (Independence)	Positive ($p = 0.010$)	Barko *et al*. (2022), Gulzar *et al*. (2019)	Siew *et al*. (2016)	Institutional investors' emphasis on transparency

Egypt, enhancements to independent directors' roles under FRA 2021, and unfamiliarity with international best practices for boards of directors, which positions this study's findings within the broader literature on governance–sustainability disclosure relationships, while also highlighting Egypt's emerging market characteristics.

6. Conclusion, limitations and future research

This paper explores the connection between BC, such as size, independence, gender and nationality, and CED, where the moderating effect of institutional ownership, which has not

been mentioned before in the Egyptian setting, is examined between 2019 and 2023. The study combines the agency, legitimacy, stakeholder and RBV theories to present new evidence regarding how internal governance mechanisms and the external ownership structure interplay to determine the environmental transparency in an emerging market affected by recent ESG reforms and COP27. The empirical findings indicate that the board size has a negative impact on the CED, but board independence and gender diversity have a positive impact on the disclosure practices. On the other hand, nationality diversity is negatively associated with CED, and probably because of the cultural misfits and not knowing the local regulations. The relationship between board size and independence was moderated by institutional ownership, which increased the negative effect of board size and the positive effect of independence but did not find any significant moderation of gender diversity and nationality diversity. These results broaden the theoretical synthesis as they support empirical evidence of the monitoring effect of independence and conformity effect of large boards and sheds light on contingent position of diversity as strategic resource.

Theoretically, this research study adds to the literature by showing how the governance systems work under both institutional and regulatory strains which are not usually witnessed in the developed economies. It makes an addition to the legitimacy and the stakeholder theories demonstrating how the attributes of boards act as internal mechanisms that seal the loopholes in environmental disclosure in the still evolving regulatory setting (El-Deeb *et al*., 2023; Ramadan and Abdel-Fattah, 2022). In practice, the results provide important advice to regulators, boards of directors and investors. To the regulators, which in this case is the FRA, the findings indicate that enforcement of Decree 107 ought to be accompanied by advice on the best board constructions, which should not be focused on having a larger board size but on independence and gender-balancing. In the context of corporate practitioners, the adverse effect of the nationality diversity suggests that the investor should be oriented according to the local regulations on ESG, avoiding cultural misfits (Mardini and Elleuch Lahyani, 2022). Moreover, institutional investors, with large interests in it, are well-placed to become active monitors; they can not only increase CED through voting but also through engaging firms in order to decrease the inefficiencies of board sizes to strengthen independent oversight and align management with the long-term stakeholder interests (Siew *et al*., 2016). These applications will help the governance mechanisms to be manifested into physical environmental transparency to support national climate objectives in Egypt.

Although these have been contributed, there are various limitations that need to be taken into consideration. First, the Egyptian setting is restricted, which restricts the ability to generalize the results to the other regions of the MENA or emerging markets with different regulatory frameworks. Second, the sample is limited to EGX70 non-financial companies, not taking into consideration smaller listed companies and informal economy, which might have varying disclosure patterns. Third, the analysis is based on disclosure index which is based on reported information and might not represent actual carbon performance or reduction of emissions. Fourth, the five-year interval (2019–2023) although including the latest regulatory alterations might not be long enough to include the long-term impacts of governance. Lastly, the research concentrates on the board features and institutional ownership and left out other possible mechanisms of governance like the ESG committees or managerial ownership. The limitation of the study should be overcome in future studies by covering geographical areas more broadly by involving cross-country comparisons within the MENA region to increase external validity. Studies would continue past 2023 and help evaluate the long-term effects of FRA Decrees 107/108 on quality of disclosure. Researchers are also advised to look into the difference between the quality of disclosure and actual carbon performance to find out whether the governance systems are motivated by substantial environmental action or cosmetic reporting. Also, it is possible to consider specific board committees (e.g. the sustainability committee or ESG committee) and other forms of ownership, including family or managerial ownership, as moderators of the relationship between governance and disclosure in future

research. Lastly, the qualitative methods, including interviewing the board members, may give more insight into the decision-making of the carbon emission disclosure in emerging markets.

7. Implications for research, practice and society

The empirical results suggest that for Egyptian listed non-financial firms, smaller board sizes, higher independence levels and higher gender diversity are positively related to CED, whereas nationality diversity shows a negative association with CED. Institutional ownership moderates these relationships by reducing the negative influence of board sizes and enhancing the positive influence of independence, although no moderation effect exists for gender or nationality diversity. The findings are based on low average CED (0.145) and recent ESG regulation changes (FRA Decrees 107/108 of 2021). They provide some practice-oriented, evidence-based insights with the limitation of being based on a specific group of listed non-financial firms during a period of change.

7.1 Implications for enhancing CED regulations

The low CED levels over the sample period suggest that the existing FRA disclosure standards may be supplemented with additional elements to enhance the quality and consistency of CED. This may include more alignment of the CED framework with global best practices such as TCFD or ISSB standards for Scope 1 and Scope 2 emissions. Additionally, capacity-building programs (such as workshops on greenhouse gas measurement and disclosure) for directors may be initiated to enhance CED practices. Penalties or incentives for improved CED may also be explored; however, this should be subject to more research on a larger population of firms beyond the scope of the present study on EGX70 non-financial firms.

7.2 Implications for board composition

The negative relationship with board size, as well as the positive relationships with independence and gender diversity, imply that corporate boards may benefit from maintaining relatively medium board sizes (around the sample's mean, i.e. approximately 8–9 board members) and aiming for higher levels of independence and gender diversity. Compliance with the FRA's current guideline of at least 25% female representation (equivalent to at least two female board members) is also in line with the current study's findings. As for the negative relationship between board diversity in terms of nationality, the following suggestion is made in order for the negative relationship between board diversity in terms of nationality and environmental transparency to become positive, the corporate board may consider launching voluntary orientation programs for its foreign board members regarding ESG regulations in Egypt.

7.3 Implications for institutional investors

The moderation results, where the positive independence effect is strengthened while the negative board size effect is reduced, imply that institutional investors, who hold an average of 35.2% of the sample's shares, may contribute toward higher levels of environmental transparency by preferring to engage with firms that boast high levels of independent board oversight. Furthermore, institutional investors may consider promoting long-termism in the form of corporate practices in terms of actively voting in ESG-related proposals at corporate general meetings. However, the lack of moderation in the relationships between institutional ownership and gender and nationality diversity implies that the impact of IOs may be more significant in terms of the structural attributes of the board rather than the diversity attributes. The development of a national stewardship code may also be considered, although its feasibility is beyond the scope of the current study.

7.4 Broader societal and sustainability alignment

By connecting the governance indicators with CED, the study's findings contribute, albeit modestly, to the body of knowledge concerning the route forward toward better environmental governance. More independent boards, improved gender diversity and active institutional shareholder engagement all correlate with national ambitions (33% reduction of GHG emissions by 2030) and UN SDGs 7, 12 and 13. However, the achievement of such positive outcomes at the national or regional level will be contingent upon the mitigation of the study's limitations via further research into diverse firm types, sectors and post-reform periods. Any sweeping claims regarding the potential of Egypt to become a MENA sustainability leader should be tempered with further research.

List of abbreviations used in the study.

Abbreviations

AGE	Firm Age
BC	Board characteristics
BG	Board Gender
BI	Board Independence
BN	Board Nationality
BS	Board Size
CED	Carbon Emission Disclosure
CG	Corporate governance
EGID	Egypt for Information Dissemination
ESG	Environmental, social, governance
FRA	Financial Regulatory Authority
IND	Firm Industry
IO	Institutional Ownership
LEV	Firm Leverage
Size	Firm Size

Appendix

Table A1. Carbon emission disclosure (CED) index items

Item	Category	Description
CC-1	Climate change (CC): risk and opportunity	Assessment or description of risk (specific or general rules or regulations) related to climate changes and actions taken to manage those risks
CC-2		Present (and future) assessments related to the implications of finance, business and opportunity on climate change
GHG-1	Greenhouse gas emission (GHG)	Description of the methodology used to calculate greenhouse gas emissions (e.g. GHG or ISO protocol).
GHG-2		The existence of external verification to calculate the GHG emission quantities, by whom and on what basis
GHG-3		Total greenhouse gas emissions (metric tons of CO_2-e) produced
GHG-4		Scope of disclosure 1 and 2, or direct GHG emission 3
GHG-5		GHG emission disclosure based on its origin or source
GHG-6		Disclosure of GHG emissions by facility or segment level
GHG-7		Comparison of GHG emissions in the previous years

(*continued*)

Table A1. Continued

Item	Category	Description
EC-1	Energy consumption (EC)	Amount of energy consumed (such as impression-joules)
EC-2		Calculation of energy used from renewable resources
EC-3		Disclosure by type, facility or segment
RC-1	Reduction and cost (RC)	Details of plans or strategies to reduce GHG emissions
RC-2		Details of the current GHG emission reduction target levels and emission reduction targets
RC-3		Reduction of emissions and costs or savings currently achieved as the result of reduction plan
RC-4		Costs of future emissions considered in capital expenditure planning
AEC-1	Accountability of emission carbon (AEC)	Indication that the board (or other executive body) is responsible for the climate change related actions
AEC-2		A description of the mechanism by which the board (or other executive body) reviews the development of the related company

Source(s): Adapted from Choi *et al*. (2013)

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