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FEMALE REPRESENTATION ON BOARDS AND CARBON DISCLOSURE QUALITY AMONG MALAYSIAN FIRMS: EMPIRICAL EVIDENCE FROM CARBON-INTENSIVE INDUSTRIES

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Abstract: The growing interest concerning climate change-related risk and the necessity of providing more information related to carbon emissions to the public reflects firms' efforts to contribute to climate change issues. The current study examined the effect of female representation on the board of directors on the quality of carbon disclosure provided by 96 publicly listed firms in Bursa Malaysia covering the period of 2015 to 2019. Content analysis of annual reports was used to measure carbon disclosure quality via establishing a comprehensive carbon reporting checklist based on several international and Malaysian carbon reporting guidelines; for example, sustainability reporting standards GRI 305, bursa Malaysia sustainability guideline, sustainability accounting standards board framework CDSB. Accordingly, the carbon reporting checklist is used to assess the quality of carbon disclosure. In addition, female representation was measured as the percentage of female directors on a firm's board, controlling for firm age, firm profitability, firm size, leverage, liquidity and audit quality. There was a positive and significant relationship between female representation on the board of directors and the carbon disclosure quality provided, suggesting that the presence of female directors on firms' boards can be seen as a determinant element of carbon disclosure quality.

Keywords: Female representation, corporate governance, carbon disclosure quality, carbon-intensive industries, Malaysian code on corporate governance.

Abbreviations: Corporate Governance (CG), Malaysian Code on Corporate Governance (MCCG), Carbon Disclosure Quality (CDQ), Carbon Disclosure Project (CDP), Greenhouse Gas (GHG).

Introduction

The Kyoto Protocol's ratification in 1997 motivated various regulatory bodies worldwide to find effective ways to mitigate and control carbon emissions and set regulations or guidelines for carbon disclosures (Jaggi *et al.,* 2018). This protocol determined the following procedures to reduce carbon footprints and specified a series of vital issues about the future path of climate change strategies and policies (Bernstein *et al.,* 1999). The protocol went into effect on 16 February 2005 after Russian ratification on 18 November 2004, and numerous countries worldwide have joined the protocol (Prado-Lorenzo *et al.,* 2009). However, many countries refused to ratify the protocol (including Australia, Switzerland, and the US). Countries that established the protocol are committed to issuing regulations, including the protocol's provisions and greenhouse gas-related issues (nitrous oxide, methane, and carbon dioxide) (Freedman and Jaggi, 2005).

Further, voluntary initiatives such as the carbon disclosure project (CDP), a non-profit organisation supporting 767 financial institutions with assets of $92 trillion in 2014, demand that the largest firms from several countries respond by disclosing their greenhouse gas emissions, climate change strategies and risks, and opportunities (Ben *et al*., 2017). Besides that, many regions such as Europe, America, and New

Zealand, have responded to climate change by issuing mandatory guidelines and regulations for firms to disclose more information about carbon emissions (Faisal *et al*., 2018). As a result, firms have faced growing pressure to reduce, assess and report information related to climate change such as carbon emissions information to their stakeholders (Akbaş and Canikli, 2019).

Various parties such as governments and multilateral organisations, have made numerous efforts to reduce the climate change impact on world economies by pushing all parties, particularly firms, to be more accountable regarding sustainability and climate change concerns (Omar and Amran, 2017). Consequently, climate change is recognised as one of the major dangers threatening the resilience of life on the planet. Moreover, it is considered a severe obstruction to social development and economies (Ararat and Safety, 2019). As a result, firm managers have increasingly known climate change and its related risks as one of the main challenges facing businesses in the twenty-first century (Haque and Deegan, 2010). In addition, stakeholders understand that firms generate ecological degradation and natural resource degeneration externally, leading to more pressure from those stakeholders on the business market to mitigate their adverse environmental influence (Bukhari *et al*., 2019).

Previously, corporate disclosures were concentrated on a firm's economic and financial performance. However, disclosure mechanisms have recently extended, leading to remarkable increases in the number of companies that disclose information about their social and environmental performance (Tiong and Anantharaman, 2011). Therefore, corporate environmental reporting and its practices have become a priority in firm performance worldwide. This trend is fuelled by institutional and global pressures to report more information about their environmental impacts due to environmental sustainability forces (e.g., deforestation, climate change, energy scarcity, food, water, population growth, and urbanisation) (Jaaffar *et al*., 2019). However, with the growing awareness and the number of firms providing carbon emissions-related information, the disclosure of carbon information remains relatively low, which is observed by firms' inability to meet the growing demand for carbon information (de Faria *et al*., 2018; Zhang and Liu, 2020).

Although more businesses are disclosing carbon information, these disclosures' quality, content, and volume are still insufficient to satisfy investors' needs (Tang *et al*., 2020). Additionally, the comparability of carbon data is still very poor (Zhang and Liu, 2020). Furthermore, many flaws have been identified in various corporate sustainability mechanisms, such as a lack of standardisation that impedes comparability, managers' intent to conceal the actual practices of their activities through these mechanisms, and deliberate manipulation of stakeholders (Giannarakis *et al*., 2018). As a result, carbon disclosure remains suspect, and many obstacles stand in the way of such disclosure, such as a lack of emissions data. This makes it difficult to gain insight into the information on carbon emissions revealed in firm reports, l*et al*one the actual accomplishments of the firm (Kolk and Pinkse, 2008). As a result, stakeholders' ability to accurately assess differences in carbon performance is diminished (Liesen *et al*., 2015).

Consequently, in light of the need for mitigation and adaptation measures for the transition toward low-carbon economies and to close the highlighted gap between firms and their stakeholders. Haque and Deegan (2010) suggested that paying more attention to climate change disclosure practices would improve firms' disclosure practices related to climate change as a result and send a message to stakeholders that firms are accountable for climate change. As a result, firms are expected to be more accountable on this new path and encouraged to assess, report and identify the financial implications of climate change on markets (Amran *et al*., 2014). There has been a notable surge in interest surrounding the governance of carbon disclosure, which has

attracted considerable attention from academic scholars. As a result, an increasing number of studies have emerged that explores the correlation between corporate governance (CG) and carbon disclosures (e.g., Ben *et al*., 2017; Elsayih *et al*., 2018; Nasih *et al*., 2019; Luo and Tang, 2021). Governance practices significantly motivate firms to integrate carbon disclosures into their business strategies (Giannarakis *et al*., 2018).

Regarding this, numerous studies have begun investigating the association between different CG mechanisms and disclosures related to carbon emissions (e.g., Liao *et al*., 2015; Hossain *et al*., 2017; Elsayih *et al*., 2018; Husted *et al*., 2019; Kouloukoui *et al*., 2020). However, although the impact of various CG mechanisms, such as board composition on carbon disclosures, is well known, the effect of female representation remains unexplored sufficiently, and the number of studies investigating this relation appears to be limited or scarce (Ben *et al*., 2017; Ararat and Sayedy, 2019; Tingbani *et al*., 2020; Elsayih *et al*., 2021). As a result, little is known about the connection between businesses' quality of carbon disclosures and female's representation on firm boards (Lahyani, 2022). Thus, we contribute to the existing carbon disclosure literature by examining how the representation of females on corporate boards influences company responses to stakeholder demands for increased public disclosure of carbon emissions. This is an essential issue because measuring greenhouse gas (GHG) emissions and disclosing them to stakeholders can be viewed as a first step toward addressing climate change issues and reducing the company's carbon footprint (Ben *et al*., 2017).

Further, the majority of related studies that investigate such relationships were conducted in developed countries (Choi *et al*., 2013; Luo and Tang, 2014; Ben and McIlkenny, 2015; Liao *et al*., 2015; Ben *et al*., 2017; Demeritt, 2018; Tingbani *et al*., 2020; Dhanda and Malik, 2020). Given that results from developed states do not apply to developing states because of the disparities in political, social, and economic factors as well as in policy and regulation (Sudibyo, 2018). Therefore, there is a pressing need for additional research that adds to the body of knowledge, offers fresh viewpoints, and provides the most recent developments on the relationship between female representation on company boards and carbon disclosure in developing nations. According to Konadu *et al*. (2022), female participation in the board room is one of the critical governance mechanisms considered to be linked to improving overall firm performance. Thus, the current study argues that female representation on the board of directors of publicly listed Malaysian firms is related to the extent to which firms respond to carbon emissions information demand.

The current study involved analysing 480 observations for 96 listed firms belonging to various sectors such as infrastructure, equipment, and service, oil and gas producers, chemicals, energy, construction, and other energy resource sectors based on the Bursa Malaysia classification. Our findings demonstrate a significant and positive relationship between the representation of females on boards and the quality of carbon information provided by Malaysian firms. This suggests that the greater the number of females on the board of directors, the more detailed carbon-related information is reported. There have been great calls for scholars and academic researchers to specifically pay more attention to the impact of female directors on the disclosures related to climate change (Liao *et al*., 2015). Therefore, conducting this study provides a unique opportunity to understand better and assess the influence of female representation on carbon disclosure quality (CDQ); moreover, introducing new empirical evidence about this relationship contributes to the gap in the literature regarding this issue.

Most related studies were conducted in developed states (e.g., Al-Shaer and Zaman, 2016; Haque, 2017; Al-Qahtani and Elgharbawy, 2020; Nuber and Velte, 2021). On the other hand, only a few studies considered the effect

of female representations on carbon disclosures in developing countries (e.g., Alazzani *et al*., 2017; Kılıç and Kuzey, 2018; Saraswati, 2021). Accordingly, there is a serious need to conduct more carbon disclosure studies and to shed light on the association between female representations and CDQ provided. Therefore, the current study adds to the body of knowledge on carbon disclosure by offering fresh insight into the issues by examining the direct impact of female representation on firms' boards on the quality of carbon disclosure. Since there is no widespread consensus regarding how board gender affects the disclosure of carbon emissions (Tingbani *et al*., 2020; Elsayih *et al*., 2021), by addressing this issue, the current study contributes to the body of literature on the connection between female representations and carbon disclosure by offering logical explanations for the differences in findings among researchers.

The remainder of the paper is organised as follows: Section 2 discusses the institutional background. In Section 3, literature review and research, hypotheses are presented. The research design is presented in Section 4. Section 5 debates the empirical findings. Finally, section 6 provides a set of robustness tests and concludes the paper.

Institutional background

Climate change refers to any direct or indirect change in climate that impacts natural systems and human lives. It is envisaged that the effects of climate change cannot be avoided entirely in the next few decades, even with the most stringent enforcement of reduction measures (National Policy on Climate Change, 2019). Malaysia is not in isolation or exception from the international system. In recent years, Malaysia has experienced several issues related to climate change, like other countries worldwide, such as water shortages, prolonged drought, and devastating year-end floods, which caused a loss of income worth hundreds of millions of ringgit (Omar and Amran, 2017). As a developed nation, the Malaysian government has recognised such effects, shown through the ratification of the United Nations Framework Convention on Climate Change (UNFCCC) on 9 June 1993 and ratified on 17 July 1994. Subsequently, the government established a national climate committee comprising the Ministry of Science, technology and the Environment (MOSTE) as Chair and representatives from relevant sectors to help meet its obligations under the convention. The Malaysian Meteorological Service (MMS), under MOSTE, was designated as the secretariat to the committee (UNFCC, 2000), followed by the ratification of the Kyoto Protocol (KP) on 4 September 2002 (UNFCC, 2018).

In May 2013, Malaysia established an initiative, namely, the national corporate greenhouse gas reporting programme or MYCarbon. The primary purpose of this initiative was to introduce a framework for carbon emissions reporting in Malaysia. This step is critical to achieving standardisation in carbon reporting that is recognised on the global stage (Ministry of Natural Resources and Environment, 2013). Further, the program proposed a tax incentive for eligible firms that incur expenditures in preparing and verifying their carbon emissions (Omar and Amran, 2017). Lately, the finance ministry of Malaysia has approved the proposed tax incentives for participating in the national corporate greenhouse gas reporting programme for 2015 and 2016 (Eco Business, 2016). As a result, the carbon tax policy motivated various stakeholders to avoid investing in higher carbon emissions projects and forced firms to disclose carbon-related information and achieve sustainable development goals in Malaysia (Wong *et al*., 2019).

Bursa Malaysia launched a sustainability framework in 2015 as an advanced step toward climate change disclosure and to move beyond Malaysia's traditional concept of CSR (Bakar *et al*., 2019). This framework seeks to evaluate, manage, and identify the material sustainability opportunities and risks so that companies can

pay more attention to what is significant to their stakeholders in creating long-term value for their various stakeholders and communities. The framework also aims to enhance the depth and quality of sustainability disclosure to meet better sustainability information users' expectations and needs (Bursa Malaysia, 2015). This guideline sheds light on the business case for sustainability. It gives case studies to demonstrate how companies achieve added value by practising good sustainability and provides example disclosures to be followed to prepare the sustainability report according to the listing requirements of Bursa Malaysia (Bursa Malaysia, 2018).

Companies that comply with this framework are required to involve the national audit department, accounting practitioners, and local authorities to improve the disclosure transparency level (Johari and Komathy 2019). Along with this framework, Malaysia issued a toolkit for sustainability reporting to guide companies. This sustainability framework is a foundation stone for moving toward issuing the mandatory framework for sustainability reporting in Malaysia (Jamil *et al*., 2020). Besides the improvement regarding climate change regulations in Malaysia, CG practices have also witnessed remarkable improvement following the revision of the Malaysian Code on Corporate Governance MCCG over time. On 28 April 2021, the Securities Commission Malaysia issued the latest update of MCCG, which witnessed the introduction of further guidance and best practices designed to strengthen the CG culture of Malaysian listed firms. What differentiates MCCG 2021 from other codes? The latest revision of the code has mainly focused on board and senior management roles in addressing sustainability risks and opportunities of the firms. Further, MCCG 2021 supports the board of directors to establish long-term resilience by implementing and adopting CG practices and policies to strengthen listed firms in meeting challenges in a fast-evolving business landscape (Securities Commission Malaysia, 2021).

Literature Review and Hypothesis Development

Female Representation and Carbon Disclosures

Female representation is one of the most generally debated topics in the board room, particularly about environmental and social matters (Haque, 2017). Female participation on the corporate board refers to the adequate mix of female and male executives. However, there is a global concern that males dominate corporate boardrooms, and this asymmetry could lead to several problems and challenges in both the private and public sectors (Modiba and Ngwakwe, 2017). Therefore, the issue of gender diversity has received great attention from various parties due to its significant influence on corporate sustainability and overall performance. In European countries, female representation is considered an indicator of good CG. The National Association of Corporate Directors and the interfaith centre on Corporate Responsibility recommend racial diversity and board gender quotas (Alazzani *et al*., 2017).

Studies investigating the effect of female representation continue to grow extensively on the academic front. For example, Liao *et al*. (2015) stated that diversified boards may be able to balance corporate financial and non-financial goals. Al-Shaer and Zaman (2016) reported that the presence of more than one woman in the boardroom significantly affects the quality of sustainability disclosure. Similarly, Nadeem *et al*. (2017) concluded that an appropriate female presence on boards encourages corporations to adopt more environmentally friendly practices through practising good CG. Hossain *et al*. (2017) revealed that female representation on the board of directors plays a significant role in carbon disclosure. In other words, the existence of females has a positive relationship with the carbon disclosure score. Ghaeli (2019) concluded that firms with females on the board have more concerns about greenhouse gas impacts than male-oriented companies. In line with this result, Ooi *et al*. (2019) found that the greater the gender diversity on the board, the more proactive, inclusive, and comprehensive

the business's CSR orientation, which leads to the higher practice of climate change disclosure. Female participation was the most outstanding board attribute influencing climate change disclosure.

Zahid *et al*. (2020) illustrated that there is a significant role of gender diversity in enhancing corporate sustainability disclosures. Furthermore, gender diversity is positively associated with each dimension of corporate sustainability disclosure - environmental, workplace, social, and economic. In a recent study, Buallay *et al*. (2022) suggested that corporations should consider improving female representation on their board as a fillip to transparency, resulting in enhanced disclosure related to sustainability. Therefore, corporations are required to establish a minimum threshold level of female representation or quota to assure an optimal board female representation level.

In summary, the previous literature supports that female board representation improves board governance quality. Female participation on the board brings a larger range of opinions and views, which assists the board in performing its duties efficiently. Thus, it can be argued that female representation contributes to enhanced corporate governance by bringing a variety of abilities, views and qualities to the table and infusing corporate board meetings with new dynamics. As a result, it motivates board members to consider climate change issues by integrating carbon emissions into corporate strategies and providing more carbon-related information to the report's users.

Hypothesis development

A firm's board of directors is a body assigned with ultimate authority to make several decisions impacting various stakeholders such as employees, communities and the well-being of investors' capital (Molz, 1985). It is the firm's highest executive unit that supervises the firm's managers and is ethically and legally responsible for the firm's stakeholders. In addition, the board works as a shareholder agent (Makhlouf *et al*., 2017). Accordingly, the board of directors' effectiveness assessment has received substantial attention in accounting and management literature. Many economic and management theories were introduced to provide theoretical foundations to explain and understand the influence of female directors on firms' disclosure. For example, the agency theory is the leading theoretical approach underlying the idea that improving female participation in the board room can enhance firms' performance. This theory focuses on conflicts based on the contractual relationship between stakeholders and managers (principal and agent). Accordingly, low CG creates agency costs and negatively impacts corporate performance (Reguera *et al*., 2017).

Agency theory assumes that the representation of female directors on the firm's board may support these firms in minimising agency problems between shareholders and managers. Female directors are more likely to raise more questions than male directors and be tougher and more active monitors (Boubaker and Nguyen, 2014). Besides the agency perspective, stakeholder theory's descriptive approach suggests a strategic orientation towards stakeholders' satisfaction besides maximising their wealth. It explains and reflects particular corporate behaviours and characteristics to manage corporate sustainability disclosures. Consequently, stakeholder theory suggests that improving female representation on a firm's board enhances corporate sustainability disclosures (Zahid *et al*., 2020). In line with these identical theories, several researchers have relied on agency and stakeholder theories to explain the effect of female representation on the board of directors on the disclosures related to climate change. Konadu *et al*. (2022) used the agency theory to explain the relationship between board gender and carbon emissions. The study reported that females use unique values such as cooperative behaviour, flexibility and assertiveness to impact directors' decisions on practices of environmental innovation to mitigate carbon emissions. Ben *et al*. (2017) stated that female participation on the board affects corporate decisions to respond

voluntarily to carbon initiatives such as the carbon disclosure project annual questionnaire, suggesting that board gender diversity improves its effectiveness and promotes sustainability initiatives adoption. Similarly, Guping *et al*. (2020) confirmed that female representation on the board positively affects information related to corporate responsibility, such as environmental information.

In Malaysia, June 2011 witnessed the Malaysian authorities' announcement of at least a 30 per cent female representation policy for those in decision-making positions in the public sector as an initial stage toward gender equality in the workplace. This strategy was the continuation of a similar policy set for the public sector in 2004. However, there are no formal sanctions for non-compliance with either the 2004 or 2011 policies (Ahmad *et al*., 2018). Since the first introduction of the MCCG, the issue of gender diversity has always been a central discussion point among various parties. As a result, the Malaysian securities commission addressed the gender diversity issue by requesting the board of publicly listed companies to be one-third composed of independent directors. It is worth noting that the importance of gender diversity has been highlighted in the code revision 2012 (Abdullah, 2014), which specifically addressed the issue of female participation. In addition, the Malaysian Code on Corporate Governance (MCCG) of 2012 made an explicit recommendation that the board of directors should establish targets and policies on gender diversity, as well as outline the measures taken to achieve them in the company's annual report. The improvement regarding female representation has followed the updates and instructions in MCCG (2017) and MCCG (2021). Emphasising that female representation on a board of directors must be at least 30% of the board structure indicates that Malaysia has recognised the importance of female representation on a firm's board.

Female representation remains an ongoing topic in Malaysia; therefore, several empirical studies were conducted investigating the effect of female representation on the board on disclosure, resulting in significant results. For instance, Ooi *et al*. (2019) indicated that Malaysian listed firms enhance female participation at the corporate board level as climate change-related disclosure increases, suggesting that the more females in the board room, the greater the extent of climate change disclosures. In line with this result, Wasiuzzaman and Wan Mohammad (2020) reported that the diversification of board directors through rising female numbers significantly positively affects environmental and social governance disclosure. Hence, increasing female directors' numbers enhances the transparency of environmental and social governance disclosure.

According to Lim *et al*. (2019), despite formulating various policies and guidelines to encourage publicly listed firms to address female representation when constructing their boards. Malaysian firms still have relatively fewer female representatives in higher managerial positions and on their boards, indicating that males in Malaysia dominate firms' boards of directors. In short, female representation awareness has grown over time in Malaysia due to the governmental intention to achieve gender equality and improve CG practices. Furthermore, the latest revision of MCCG for 2017 and 2021 gives direct instruction that female participation must not be less than 30% of board members. However, due to the lack of formal sanctions for non-compliance with MCCG, female participation remains relatively low compared to male participation. Thus, in light of the ongoing debates concerning the effect of female participation on firms' environmental disclosures, including carbon disclosure, the current study assumes and expects that enhancing female participation on Malaysian firms' boards would positively impact firms' decisions to provide more information related to their carbon emissions. Additionally, the females' presence is expected to have a positive effect on firm responses to stakeholders' demands for carbon information; hence, the following hypothesis is developed:

H1: The females' representation on corporations' boards is positively related to the quality of carbon disclosure.

Data and Methodology

The study sample comprises 96 listed firms, all traded on Bursa Malaysia and classified as carbon-intensive industries. The current study focuses on carbon-intensive industries: building materials, oil and gas producers, chemicals, energy, infrastructure, equipment and service, other energy resources and construction. As firms belonging to such industries face high climate-risk-related costs and liabilities, those firms are subject to the regulation of these emissions (Stanny and Ely, 2008). Consequently, firms in these industries are expected to practice good CG by considering the representation of females on their boards and to be more sensitive to carbon emissions-related issues. In this regard, Bewley and Li (2000) stated that enterprises involved in high-polluting industries are more likely to be exposed to media coverage pressure. Hence, these enterprises attempt to provide more useful environmental information. Furthermore, Cadez *et al*. (2019) pointed out that directors respond to stakeholders' demands by enforcing business strategies considering all economic and ecological concerns in carbon-intensive industries.

Further, the study period will be limited from 2015 to 2019. This is the period that Bursa Malaysia launched the first framework for sustainability reporting. The framework's target is to enhance the depth of understanding of sustainability matters and disclosure quality to meet users' expectations of sustainability disclosures (Bursa Malaysia, 2015). The initial sample comprised 660 firm-year observations. Due to the unavailability of annual reports and missing data, a total of 180 observations were rejected. Female representation and carbon information data were collected manually from published firms' annual reports. Table 1 provides a breakdown of the study sample.

Dependent Variable: Quantifying the Carbon Disclosure Quality

Disclosure quality is a complex concept and has a subjective and multifaceted nature. The lack of theoretical support prevents building proxies for such a concept. As a result, previous researchers adopted several methods to measure disclosure quality, relying on the assumption that what is being measured reflects disclosure quality (Urquiza *et al*., 2009). Accordingly, studies that used the disclosure index as an indicator for environmental disclosure quality assume that the amount of environmental information disclosed about quantified topics can compensate for disclosure quality (e.g., Gonzalez and Ramírez, 2016; Jaggi *et al*., 2018; Luo *et al*., 2019). Furthermore, quantitative disclosure is a proxy of information quality since numbers almost assure facts and show reliability (García and Martínez, 2005). Therefore, the reporting scoring system is used to quantify the quality of information contained in firms' annual reports into testable measures (Cormier *et al*., 2005).

Table 1: Sample Breakdown

Sector	Initial Sample	Rejected Firms	Final Sample
Building Materials	31	7	24
Oil and Gas	5	2	3
Chemicals	17	4	13
Energy, Infrastructure, Equipment, and Service	25	10	15
Other Energy Resources	2	0	2
Construction	52	13	39
Total	**132**	**36**	**96**

Thus, to construct our dependent variable, the CDQ was captured by developing a carbon reporting checklist. Contrasting prior studies (e.g., Prado-Lorenzo *et al*., 2009; Herold and Lee, 2017; Luo, 2019), which were based on CDP or single carbon reporting guidelines, the current study includes items as stipulated in the following carbon reporting guidelines: the environment and climate change Canada: technical guidance on reporting greenhouse gas emissions TGRGGE (2016), sustainability reporting standards GRI 305 (2016), bursa Malaysia sustainability guideline (2015), sustainability accounting standards board framework CDSB (2019), Malaysian greenhouse gas reporting program MYCarbon (2014), corporate accounting and reporting standard GHG protocol (2004) and UK environmental reporting guidelines: including streamlined energy and carbon reporting guidance ERG (2013, updated 2019). As a result, this carbon reporting index is comparatively extended and more comprehensive than the prior index developed by Prado-Lorenzo *et al*. (2009), Choi *et al*. (2013), and Faisal *et al*. (2018). As a result, findings can be generalised accordingly.

The current study uses the content analysis technique to quantify carbon disclosure quality, which is extensively used in carbon disclosure studies (e,g., Kalu *et al*., 2016; Pitrakkos and Maroun, 2019; Tingbani *et al*., 2020). Further, the disclosure quantification may either be done on a weighted or an unweighted basis (Chithambo and Tauringana, 2014). According to Freedman *et al*. (2012), there is no difference in the outcomes when researchers utilise a weighted or unweighted approach to score items. However, utilising the weighted approach, which is based on the authors' perceptions, may threaten the subjectivity of the index (Tauringana and Chithambo, 2015). Hence, to avoid subjectivity issues inherent in applying any weighted scoring method, the current study utilises the unweighted approach to scoring carbon items. Accordingly, if the firm reports an item of information included in the developed carbon reporting index, it is assigned a score of 1, and 0 if it is not disclosed. The total disclosure index score was then captured for each sample company as a ratio of the total disclosure score divided by the maximum possible disclosure for the company (56 items). This is in line with Chithambo and Tauringan (2014), Tauringana and Chithambo (2015), Akhiroh and Kiswanto (2016), and Datt *et al*. (2019), finally expressed as a proportion.

Independent Variable

The current study's independent variable is female representation on the board of directors; hence, to test the effect of female representation on the CDQ, female representation was measured by the number of female directors divided by the total number of directors on a company's board (Ben *et al*., 2017; Naveed *et al*., 2021). This study recognises the significance of controlling for CG in assessing the effect of female representation on the CDQ in Malaysia. Thus, in line with prior studies, firms' characteristics: firm age, firm profitability, firm size, leverage, liquidity and audit quality are used as control variables (e.g., Velayutham *et al*., 2014; Liao *et al*., 2015; Ben *et al*., 2017; Charumathi and Rahman, 2019; Tingbani *et al*., 2020) as shown in Table 2. The study model is specified as follows:

$$CDQ = \beta 0 + \beta 1\ Female + \beta 2\ FAGE + \beta 3\ ROA + \beta 4\ FSIZE + \beta 5\ LEV + \beta 6\ LIQ + \beta 7\ BIG4 + \varepsilon$$

Results

Descriptive statistics

The descriptive statistics results indicate that the CDQ for the five years of the study period ranged from 0% to 89.28%, with an overall mean of 17.49%, indicating that the CDQ provided by publicly listed Malaysian firms is still relatively low. This finding can be compared with Ooi and Amran (2018), who stated that the CDQ, on average, is 19.7%, suggesting that carbon disclosure awareness and practices are still very low in Malaysia. Meanwhile, female representation on the firms' board ranges from 0% to a maximum of .4444%, with an overall average of 13.05%. These ratings imply that

Table 2: Variables measurement

Dependent Variable	Acronym	Measurement
Carbon disclosure quality	CDQ	Checklist = The minimum is 0, and the maximum is 56 items.
Independent Variable		
Female representation	Female	Percentage of female on the board = (female board members)/ (total number of board members)*100%
Control Variables		
Firm age	AGE	The number of years the firm has operated to the end of 2019
Firm Profitability	PRO	Net income divided by total assets
Firm size	SIZE	The logarithm of total assets
Leverage	LEV	Total debt divided by total assets
Liquidity	LIQ	Current assets divided by current liabilities
Audit quality	BIG4	Dummy 1 if the firm is audited by big four audit firms and 0 otherwise

despite female representation reforms, the Malaysian firms' boards are dominated by males at almost 86% of the total sample. This finding is also comparable with Yasser *et al*. (2017) and Katmon *et al*. (2019), who reported an average female representation on Malaysian firms' boards at 8.40% and 9.0%, respectively.

Concerning control variables, firm age (measured by firm operating years to the end of 2019) ranged from 3 to 83 years with a mean of 31.30%, while the firm profitability mean is 10%, suggesting that sample firms were slightly profitable over the study period. Regarding the firm size, the results of descriptive statistics show that Malaysian firm size ranged from 4.489 to 9.518 with an average of 7.42 per sampled firm. Liquidity ranged from 6.34% to a maximum of 63.48% with a mean of 2.50%, which reflects the good financial position of firms. The leverage ranged from 5% to a maximum of 1.41%, with a mean of 45.86%, reflecting firms' ability to meet their financial obligations. Finally, the result shows audit quality means 50%, demonstrating that 50% of sampled firms were audited by one of Malaysia's big four audit firms.

Table 4 demonstrates the correlation matrix among study variables (independent, dependent and control variables). The correlation matrix shows a positive relationship between female representation on boards and the CDQ provided by Malaysian firms. The more female directors on the firm board, the more the tendency of firms to offer higher quality carbon information to the public. There

Table 3: Descriptive Statistics

Variables	Mean	SD	Min	Max
CDQ	0.1749	0.1818	0.0000	0.8928
Female	0.1305	0.1233	0.0000	0.4444
Age	31.306	13.3125	3.0000	83.0000
Profitability	0.0109	0.0949	-0.6966	0.2802
Size	7.4201	1.3179	4.4890	9.5186
Liquidity	2.5014	3.6923	0.0634	63.487
Leverage	0.4586	0.2092	0.0491	1.4111
Audit	0.5041	0.5005	0.0000	1.0000

are also positive recorded correlations between firm age, profitability, leverage, audit quality and CDQ, while the firm size and liquidity negatively correlate with CDQ. Generally, the established association is in line with the developed hypothesis.

Regression Analysis and Diagnostic Tests

Carbon information is quite sensitive, so it is expected that many causality issues may occur between used variables. Therefore, applying the ordinary least squares in this study may lead to several problems or may not be appropriate. Thus, to choose between a fixed and a random effect regression model, two different tests, Breusch and Pagan Lagrangian and Hausman, were performed. After running the Hausman test, a systematic difference between fixed and random effect regression was documented, suggesting that the fixed effect model may be more appropriate to gain consistent and efficient estimates, as shown in Table 5. Further, many diagnostic tests were carried out to ensure the validity of obtained data and avoid misleading results. Thus, the heteroscedasticity, multicollinearity, autocorrelation, linearity, normality and outliers were tested. Firstly, the correlation matrix shows that multicollinearity did not represent any problem for this study since there are no high correlations among variables. Furthermore, all the recorded correlations were below the (VIF) value of 10, which is the acceptable variance inflation factor (Moroney *et al*., 2012).

Concerning the linear relationship assumption, the scatter plot result indicated the linear relationship between female representation on boards and CDQ in the model (Casson and Farmer, 2014). As for heteroscedasticity and autocorrelation, two common tests, Wooldridge and modified Wald, were performed. Accordingly, the findings of both tests confirmed the presence of heteroscedasticity and autocorrelation issues, which are shown in

Table 4: Correlation matrix for all variables

	CDQ	Female	Age	Profitability	Size	Liquidity	Leverage	Audit
CDQ	1.0000							
Female	0.2304	1.0000						
Age	0.1495	-0.0024	1.0000					
Profitability	0.0267	0.0793	0.1614	1.0000				
Size	-0.2171	-0.0494	-0.1428	0.0714	1.0000			
Liquidity	-0.0344	-0.0652	-0.0803	0.0772	0.0572	1.0000		
Leverage	0.0022	-0.0082	-0.0887	-0.2324	-0.0262	-0.3209	1.0000	
Audit	0.1604	0.1790	-0.0069	-0.1002	-0.2137	-0.0013	-0.0277	1.0000

Table 5: Variance inflation factor

Variables	VIF	Tolerance
Female	1.05	.952
Age	1.07	.934
Profitability	1.111	.9
Size	1.08	.926
Liquidity	1.138	.879
Leverage	1.184	.844
Audit	1.096	.912
Mean Vif	1.104	.

Table 7. Thus, to correct the estimated model and as Rogers (1993) suggested, we used the robust standard errors clustered at the firm level presented in Table 8.

Table 8 presents the findings of fixed effect regression for the impact of female representation on boards on CDQ provided by publicly listed Malaysian firms. The regression analysis indicates that the model is appropriate and statistically significant at $p < 0.05$ with an F-value of 39.17. This result implies that CDQ was statistically valid. Further, regression analysis revealed that the R square within the model was 0.0273, indicating that the independent variable could explain almost 2% of the dependent variable variance. However, it should be noted that the low value of R square is common when investigating issues related to CG mechanisms and social science at large (Rahmat *et al*., 2009; Alodat *et al*., 2021; Salleh *et al*., 2022). As a result, the R square value in this study is within a satisfactory CG research range.

Concerning the study hypothesis, the regression findings report a positive, significant relationship between female representation on the board of directors and CDQ provided, suggesting that the presence of female directors

Table 6: Hausman and Breusch-Pagan Test Results

	Hausman Test	**Breusch-Pagan Test**
chi2 (7)	407.73	***
chibar2 (01)	***	227.45
Prob > chi2	< 0.05	< 0.05

Table 7: Modified Wald test and Wooldridge Tests Results

	Modified Wald	**Wooldridge test**
chi2 (96)	11685.08	***
F(1, 96)	***	86.807
P	< 0.05	< 0.05

Table 8: Fixed effect regression results for the effect of female representation on boards on carbon disclosure quality

Variables	**Coef.**	**Std. Err.**	**t-stat**	**P > T**	**95% Conf.**	**Interval**
Female	0.2204	0.10012	2.20	0.030	0.02171	0.4192
Age	0.0623	0.00430	14.48	0.000	0.0538	0.0709
Profitability	0.0020	0.05844	0.04	0.972	-0.11397	0.1180
Size	-0.0156	0.02129	-0.74	0.463	-0.05794	0.0265
Liquidity	0.0024	0.00084	2.85	0.005	0.00073	0.0040
Leverage	-0.0821	0.05317	-1.54	0.126	-0.1877	0.0234
Audit	0.0437	0.01961	2.23	0.028	0.00479	0.0826
_cons	-1.6790	0.19836	-8.47	0.000	-2.0737	-1.286
No of obs	480					
Prob > F	< 0.05					
R-squared	0.0273					

on firms' boards can be seen as a determinant fact of CDQ. Firms that report higher CDQ are likelier to have an appreciable number of female directors on their boards. This finding is consistent with the findings of Ben *et al*. (2017) and Charumathi and Rahman (2019), who confirmed that there is a significant positive association between the proportion of female directors on the board and disclosures related to climate change. The tendency to provide more voluntary carbon disclosure increases with the female proportion on boards.

The study model includes a total of six control variables to test CDQ, as shown in Table 2. Accordingly, the firm age coefficient is positively linked to CDQ ($t = 14.48$, $P < 0.05$). This finding is consistent with Leung and Philomena (2013), who confirmed that firm age has a positive and significant effect on carbon disclosure provided by Australian firms. As for firms' profitability, the result revealed that profitability is positively but not significantly related to CDQ ($t = 0.04$, $P > 0.05$). This suggests that highly profitable firms reduce carbon-associated risks and maintain a good image in the eyes of the community by providing more carbon information on their annual reports. This result aligns with the findings of Ben and McIlkenny (2015), who stated that a firm's profitability has a positive association with the firm's decision to respond to the CDP questionnaire and CDQ.

Similar to firm age, coefficient results show that liquidity is positive and significantly related to CDQ ($t = 2.85$, $P < 0.05$). This finding suggests that Malaysian firms with good financial positions tend to provide higher-quality carbon information than firms with insufficient liquidity. This result is consistent with the findings of Choi *et al*. (2013), who indicated that the overall carbon disclosure score is positively linked to firms' liquidity. As for audit quality, regression findings confirmed a positive and significant relationship between audit quality and CDQ ($t = 2.23$, $P < 0.05$). This finding implies that the presence of the Big 4 auditors increases the disclosure quality. Therefore, Malaysian firms audited by one of the Big 4 audit firms tend to provide more carbon information. This result aligns with Johl *et al*. (2021), who documented a positive association between the extent of disclosure transparency and audit quality.

In contrast, coefficient results indicate that firm size and leverage have a negative relationship with CDQ ($t = -0.74$, $P > 0.05$) ($t = -1.54$, $P > 0.05$), respectively. However, these findings are inconsistent with the results of Matsumura *et al*. (2014) and Karim *et al*. (2021), who confirmed that leverage and firm size have a positive effect on disclosure related to climate change, suggesting that larger and leveraged companies are exposed to great pressure from public and regularity bodies. Therefore, firms tend to disclose more information about their carbon activities to minimise such pressure.

Additional sensitivity checks

The study of the relative influence of various input elements on model output is referred to as sensitivity analysis. (Saltelli *et al*., 2004). First, a composite governance score is developed to evaluate the board of directors' effectiveness. A composite score is based on the idea that CG is an interconnected system that works best in specific combinations rather than individual (female representation) best practices. (Aguilera *et al*., 2008). Therefore, in creating a composite indicator of the board of directors' effectiveness. By assigning 1 to the variable that is greater than or equal to the median for all samples and 0 if otherwise in sum, each non-binary variable is converted to a binary form. The four indicators (independence, size, female representation, and meeting) are added to create the composite board index. A higher score typically indicates a board of directors' effectiveness, which aligns with Bin-Ghanem and Ariff (2016) and Makhlouf *et al*. (2018). Table 9 shows the results of sensitivity tests that refer to the robustness of our main findings.

Model 2 (additional test), as shown in Table 9, was statistically significant and fit at $p < 0.001$ with an R squared value of 0.0288 per cent. Table 9 shows that the sensitivity checks' findings support the study's main findings regarding the effect relationship between female

representation, control variables, and carbon disclosure quality. As a result of the regression, there is a significant positive relationship between board effectiveness and carbon disclosure quality at (t = 3.51, p 0.01). Regression analysis revealed that Age, Liquidity, and Audit were all positively and significantly associated with CDQ at (t = 13.70, p < 0.01: t = 2.89, p > 0.05; t = 2.26, p < 0.01). Profitability, Size, and Leverage, on the other hand, were discovered to have a negative effect at (t = -0.28, p > 0.05; t = -0.81, p < 0.05; t = -1.78, p > 0.05), respectively.

Further, lagged independent and dependent variables are used in dynamic panel models; because these variables exist, it is possible to model a partial adjustment mechanism (Tehranian *et al*., 2006; Rusmanto and Herlina, 2020). For each unit of analysis, we lagged the independent variable by one year before the dependent variable. The latter action is also required to address any endogeneity bias. As a result, our independent variable covered 2015 to 2017, while our dependent variable covered 2018 to 2019. In the study Models, the sum of the coefficients of female representation and its effect with a one-year lag is significant. This suggests that the primary findings with lagged independent variables remain the same and validate the earlier findings.

Conclusion

This study investigated the effect of female representation on the board of directors on CDQ provided by publicly listed firms in Bursa Malaysia, particularly the carbon-intensive industries. Based on a sample of 96 Malaysian firms from 2015-2019. We measured female participation by calculating the number of female directors divided by the total number of directors on a company's board expressed as a proportion. In contrast, CDQ was measured based on a carbon reporting checklist developed by several international and Malaysian guidelines related to climate change reporting and well-grounded literature. In comparison with previous studies, this carbon checklist is considered more comprehensive as it includes 56 disclosure items, which are highly appreciated (Prado-Lorenzo *et al*., 2009; Choi *et al*., 2013; Faisal *et al*., 2018). Therefore, the findings may be generalised to other countries with the same governance and environmental settings as Malaysia. The results document a positive relationship between female representation on the board of directors and CDQ, suggesting that female representation brings different views and opinions into the boardroom, resulting in a higher tendency to disclose carbon information in the firm's annual reports.

Table 9: Fixed effect regression results for the effect of the board of director effectiveness on carbon disclosure quality

Variables	Coef.	Std. Err.	t-stat	P > T	95% Conf	Interval
Board Effectiveness	0.029	0.008	3.51	0.001	0.013	0.045
Age	0.059	0.004	13.70	0.000	0.050	0.067
Profitability	-0.016	0.057	-0.28	0.782	-0.130	0.098
Size	-0.017	0.021	-0.81	0.420	-0.060	0.025
Liquidity	0.002	0.001	2.89	0.005	0.001	0.004
Leverage	-0.091	0.051	-1.78	0.078	-0.192	0.010
Audit	0.044	0.019	2.26	0.026	0.005	0.083
Constant	-1.596	0.202	-7.92	0.000	-1.996	-1.196
No of obs	480					
Prob > F	< 0.05					
R-squared	0.0288					

Similar to previous studies, the current study is not without limitations. First, the study focused on firms that are classified or belonging to carbon-intensive industries, assuming those industries are the main contributors to carbon emissions in Malaysia. However, future research must investigate and focus on other industries which are less sensitive to carbon emissions to have a full image of the carbon disclosure status in Malaysia. Second, we relied on the females' percentage to measure their representation on the board; for a better understanding of the female representation effect, future research should focus not only on their presence but also on other attributes such as education, age and experience.

Third, the primary goal of this research is to assess the impact of female board representation on the quality of carbon disclosure provided by Malaysian companies. This study estimated an empirical model that reflects the estimated relationship to investigate such an effect. However, there is growing evidence in the literature that other CG mechanisms, such as board independence, board size, audit committee independence, audit committee meeting and ownership structure, are essential. (e.g., Navarro and Urquiza 2015; Al-Shaer and Zaman, 2016; Ben *et al*., 2017; Ghaeli 2019; Konadu *et al*., 2022). As a result, future research should consider other CG mechanisms when estimating an empirical model to assess carbon disclosure quality. Despite these limitations, this study contributes to the literature by introducing new empirical evidence about the effect of female representation on CDQ from emerging economies such as Malaysia. Moreover, since the carbon checklist was developed following various international and Malaysian carbon guidelines, the findings of this study may be interesting to several related groups, such as regulatory bodies, to assess or update the existing guidelines.

Finally, our method attempts to simultaneously address both major limitations that will be inherited in future related studies. There are constraints stemming from the non-linearity of the relationship (Kyaw *et al*., 2015; Hedija and Němec, 2021; Đặng *et al*., 2022). Prior investigations adopt quadratic values of female representation in linear models to address the non-linearity of the relationship (Ben-Amar *et al*., 2017; Kuzey *et al*., 2022). In this study, we maintain that the relationship is complex, and quantile regressions could drive more insightful outcomes. Further, the limitation suggests that the female representation and carbon disclosure quality relationship is more likely to be endogenous. Prior studies have tried to deal with this issue by implementing diverse econometric techniques in parametric models (Shaukat *et al*., 2016; Ben-Amar *et al*., 2017; Baalouch *et al*., 2019). Thus, future research can apply a two-stage quantile regression method to control for endogeneity that arises through simultaneity or omitted variable bias in the female representation and carbon disclosure quality relationship.

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Conflict of Interest

All authors declared that they have no conflicts of interest.

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