

The relationship between female board, board size and carbon emissions of listed firms from Thailand

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Abstract

Purpose – This study aims to investigate the level and pattern of corporate carbon emission of Top100 listed firms from Thailand and to test for a possible relationship between board characteristics and corporate carbon emissions in Thailand.

Design/methodology/approach – Board characteristics and corporate carbon emissions are collected by Top100 listed firms from the Stock Exchange of Thailand during 2020 to 2022. Panel regression analysis is used to test the impact of board characteristics on carbon emissions, while robustness test by two stage least square instrumental variable approach is used to mitigate the endogeneity issue.

Findings – We find a negative relation between female board and carbon emissions, while there is a positive relationship between board size and carbon emissions. We document that an increase of board gender diversity reduces carbon emissions, while an increase of board size increases corporate carbon emissions. Moreover, we find that board independence, tenure and CEO duality have no effect on carbon emissions. Our findings are robust to endogeneity concerns as our 2SLS analyses confirm the main findings.

Originality/value – Strategic decision to reduce carbon emissions is to structure boards with increased number of female representation and smaller board size in total.

Keywords Carbon emissions, Board characteristics, Thailand

Paper type Research article

1. Introduction

Greenhouse gas emissions, particularly carbon dioxide (CO₂), constitute a critical global environmental challenge due to their long-term impacts on economic stability, social well-being and ecological systems (Tian *et al.*, 2025). Carbon emissions primarily stem from fossil fuel-dependent development models, especially in energy-intensive industrial activities, leading to climate change and associated economic risks (Kumari, Shashwat, Verma, & Giri, 2025). Empirical evidence shows that such growth patterns increase regulatory uncertainty, energy costs and stakeholder pressure, thereby affecting firms' long-term competitiveness (Albanese, Gatti, & Varriale, 2025). Consequently, carbon emissions management has evolved into a strategic organizational mechanism emphasizing measurement, disclosure and emission reduction as part of risk management and value creation (Luo, Tang, Fan, & Ayers, 2023). This shift has been reinforced by global climate frameworks, particularly the Paris Agreement and NDCs, and by



national initiatives in Thailand that highlight the critical role of listed firms in achieving emission reduction targets (Global Carbon Budget, 2023). Carbon emissions' reporting has been conceptualized as corporate strategic actions that (1) prioritize the needs of stakeholders and (2) answer corporate sustainability. As the ultimate decision-making body within a firm, Chief Executive Officer (CEO) is tasked with formulating short-term and long-term strategies and overseeing risk management frameworks that align with environmental sustainability (Kyaw, Treepongkaruna, & Jiraporn, 2022), ensuring that corporate objectives encompass broader social and environmental impacts beyond immediate financial returns (Oyewo, 2023).

One challenge to have carbon emissions' reporting is that it may provide negative image and reputation to the corporations in the short-term, leading to a drop in corporate value and performance. Therefore, if top-management does not have long-term working agreement, he or she may not pay attention on carbon emissions. Managerial board is expected to monitor corporate activities to decrease conflicts of interest between top-management and shareholders and information asymmetries (García-Sánchez *et al.*, 2019). Board is one of the most common corporate governance mechanisms aiming to reduce the conflicts of interest between top-management and shareholders, and information asymmetries between the corporations and their stakeholders (Frias-Aceituno, Rodriguez-Ariza, & Garcia-Sanchez, 2013). Board plays an important role to ensure management consideration for long-term benefits of corporate shareholders and sustainability in environment and social aspects (Likitapiwat & Treepongkaruna, 2023). However, this depends on quality of board of director. Low-quality board may be able to obstruct good relationship between the corporations and their society and stakeholders and lead to a decline in corporate sustainability (Subramaniam, Akbar, Situ, Ji, & Parikh, 2023). The most common board compositions used in the previous studies reflecting the effectiveness of boards are included board size (Cheung & Lai, 2022; Garcia Martin & Herrero, 2020; Farag & Mallin, 2017), gender diversity (Kyaw *et al.*, 2022; Nuber & Velte, 2021; Garcia Martin & Herrero, 2020; Tingbani, Chithambo, Tauringana, & Papanikolaou, 2020; Haque, 2017), independency (Oyewo, 2023; Maroun, 2019), tenure (Konadu, Ahinful, Boakye, & Elbardan, 2022; Hategan, Sirghi, Curea-Pitorac, & Hategan, 2018) and duality (Cerbioni & Parbonetti, 2007; Haji & Ghazali, 2013; Lu & Wang, 2021; Zhang, Zhang, Ji, Lucey, & Liu, 2021). This study has focused on two important board compositions as female board (board gender diversity and board size).

However, prior evidence on the association between female board, board size and corporate carbon emissions is inconsistent and inconclusive (Tanthannongsakkun *et al.*, 2022; Oyewo, 2023; Nuber & Velte, 2021; García Martín and Herrero, 2020; Maroun, 2019; Farag & Mallin, 2017). In the context of Thailand, a number of researchers has investigated the influence of managerial board on corporate environmental performance, these performances, however, are approximated by either environmental disclosure (Maneenop *et al.*, 2023; Suttipun, 2021) or emissions score derived from a firm's commitment and effectiveness toward reducing environmental emission in its production and operational processes (Tanthanongsakkun *et al.*, 2022; Kyaw *et al.*, 2022) rather than employing the actual emission. We fill the gap in literature by focusing on the amount of carbon emitting by firm at the firm-level of top 100 listed companies in Thailand and whether female board and board size having any impact on how firm emits the carbon. As Thailand recently mandate listed firms to report carbon emission, we hand collect carbon emission and limit our sample to the period of 2020 to 2022.

In Thailand, the government has committed to achieving carbon neutrality goal in 2050 and net zero in 2065, which is slightly off from what the United Nations call for countries to reduce carbon emissions by 45% by 2030 and reach net zero by 2050 (Suttipun, Phuensane, & Kijkasiwat, 2026). To achieve these goals, several initiatives have been proposed, including increasing renewable energy sources, improving energy efficiency and encouraging green financing initiatives. Among other initiatives, starting from 2022, the Thai Securities and Exchange Commission (SEC) has mandated that listed companies report their carbon emissions in the so-called "56-1 One Report". Carbon emissions disclosure is one way to demonstrate transparency and accountability of firms and their efforts to address climate change as well as to

meet social expectations and stakeholders' demands (Grabsch, Jones, & Solomon, 2010). Additionally, this mandatory regulation allows investors and stakeholders to make more informed decisions based on a company's environmental impact. Nevertheless, revealing carbon emissions might make investors and stakeholders view the company unfavorably. The executives may decide to reveal qualitatively certain information in order to preserve their reputation and avoid possible criticism from society. Declaring corporate carbon performance is a part of corporate environmental responsibility which contributes to the broader goals of promoting sustainability and tackling climate change. However, from a business perspective, executives might overlook investment choices to enhance corporate carbon performance because they might put short-term financial gains ahead of long-term environmental objectives. This aligns with the agency theory stating that executives may prioritize their own interests over those of the company and its stakeholders. Therefore, it is crucial for companies to implement strong governance structures to ensure long-term sustainability goals.

Thailand as an emerging economic market is chosen with some reasons. For example, most listed firms in Thailand are family-owned businesses with a significant amount of family ownership structure that can weaker regarding corporate governance including quality of board composition, which can play as important roles for corporate sustainability (Suttipun, 2021). In addition, corporate governance mechanisms in Thailand are still new and weak compared with listed firms from developed countries (Khanna & Palepu, 2000). In terms of carbon emissions, the regal and regulation of corporate carbon emissions' disclosure have just launched since 2021 that firms need to have early adoption in 2020 for comparative reason (Suttipun, 2026). There are small evidences examining the relationship between board composition and carbon emissions in Thailand (Mansour, Abu-Allan, Alshdaifat, E'leimat, & Saleh, 2025; Khairunnisa, Astuti, & Hussein, 2024; Suttipun, 2026).

This paper explores which and how board characteristics affect carbon emissions by top 100 listed firms in Thailand over the period of 2020 to 2022. Based on 216 firm-year observations of unique 72 companies, we find no impact of board independence, tenure and CEO duality but positive (negative) effect of board size (gender diversity) on carbon emissions. A one standard deviation increases in board gender diversity and board size leads to a 9.8% reduction but a 7.6% increase in carbon emissions, respectively. We offer two contrasting hypotheses as follows: social role theories and optimal board size hypothesis vs legitimacy and attention hypothesis. Consistent with social role theories and optimal board size hypothesis, we find a negative (positive) relation between board gender diversity (board size) and carbon emissions. Specifically, this study confirms that companies with higher proportion of female board can reduce corporate carbon emission. This is because female board can offer diverse views and support an efficient role in managing relationship between corporation and stakeholders' demands, and between corporation and social expectation (Adams & Ferreira, 2009; Suttipun, 2021) as well as reduce conflicts of interest between top-management and shareholders (Cremers, Litov, & Sepe, 2017; Likitapiwat & Treepongkaruna, 2023). On the other hands, the companies with higher number of board members increase corporate carbon emission. It is because large boards underperform compared with smaller boards that allow for faster move and decision-making and better monitoring functions including carbon emission (Goud, 2022; Orozco, Vargas, & Galindo-Dorado, 2018). To ensure that the study's results are not driven by endogeneity, robustness tests are provided such as fixed and random effect models, and two stage least square instrumental-variable approach (2SLS-IV). The findings survive all robustness tests.

We provide various contributions expected to existing literature as follows. Firstly, our findings demonstrate whether social role theories consisting of agency, legitimacy and stakeholder theories can be used to explain the association between board characteristics and corporate carbon emissions. Secondly, we contribute to literature on corporate governance and corporate environmental and social responsibility by focusing on the impacts of board characteristics on corporate carbon emissions in Thailand. Next, our findings contribute to the debate on the impacts of board characteristics on carbon emissions. Finally, our evidence of the

role played by female board and the size of board on carbon intensity could drive change in corporate policies affect management as well as stakeholders' decision making.

Findings of this study also offer several practical implications. Firstly, this study supports the perspective of board composition as one of the most important corporate governance mechanisms to reduce the conflicts of interest between top-management and shareholders and to respond corporate society and stakeholders. Secondly, regulators and policy setters should set better and higher quality of corporate board such as an appropriate proportion of female board, an appropriate proportion and condition of independent board, condition of board tenure, an appropriate size of board and condition of CEO duality. Finally, corporate investors can consider board characteristics when they make decision making.

This paper is organized and structured as follows. The second section indicates review of related literature and hypothesis development. The third section provides the research methodology including of population and samples used, data collection and data analysis. The fourth section shows empirical findings and discussion, while the conclusion including implication and contribution, limitation and suggestion for future study will be in the fifth section.

2. Review literature and hypothesis development

2.1 Carbon emissions

Carbon emissions, particularly carbon dioxide (CO₂), can be traced back to the industrial revolution, when fossil fuels – namely coal, oil and natural gas – became the primary energy sources for power generation, industrial production and transportation. This heavy reliance on fossil fuels led to a persistent accumulation of greenhouse gases in the atmosphere, which is widely recognized as a principal driver of global warming and climate change (IPCC, 2021). International empirical evidence consistently identifies the energy sector as the largest contributor to global carbon emissions, especially in industrialized and rapidly developing economies with high energy demand. Economic growth that is structurally dependent on fossil fuel consumption has therefore resulted in continuously rising carbon emissions, posing significant long-term risks to economic stability, social welfare and environmental sustainability (Barroso, Gallego-Álvarez, & Vicente-Galindo, 2024). Within this context, carbon emissions have emerged as a central issue on the global policy agenda, with a critical turning point marked by the adoption of the Paris Agreement. The agreement aims to limit the increase in global average temperature and requires countries to establish emission reduction targets through Nationally Determined Contributions (NDCs). Consequently, governments, regulatory bodies and stakeholders have intensified pressure on firms to reduce greenhouse gas emissions while simultaneously enhancing environmental transparency (Nuber & Velte, 2021). At the firm level, carbon emissions typically encompass greenhouse gas emissions arising from production activities, energy consumption, transportation systems and supply chain operations. Firms are therefore increasingly expected to systematically measure, report and mitigate their carbon emissions. Carbon disclosure has consequently become a key mechanism through which stakeholders can assess firms' exposure to climate-related risks and the effectiveness of their carbon management practices. Although carbon disclosure remains largely voluntary in many jurisdictions, growing pressure from investors, governments and international reporting frameworks – such as the Carbon Disclosure Project (CDP) and climate-related reporting standards – has positioned carbon emissions at the core of contemporary environmental policy and corporate governance worldwide (Gonenc & Krasnikova, 2022).

The control of carbon emissions is widely recognized as a fundamental pillar of sustainable development. Organizations are therefore required to establish comprehensive management structures and mechanisms that encompass emissions control, carbon risk assessment, energy cost management and the enhancement of overall organizational performance. Over the past decade, corporate carbon reporting has expanded substantially at the global level, particularly in countries with stringent environmental regulatory frameworks (Tang & Demeritt, 2018). In the context of Thailand, a developing economy, greenhouse gas emissions have continued to

increase alongside economic growth and industrial expansion, despite the implementation of national mitigation policies.

To consider the link of carbon emissions and board composition, the prior related studies on the relationship between board characteristics and environmental performance provided mixed results as different proxies of environmental performance. However, carbon emissions are used as proxy of environmental performance in this study (Tanthanongsakkun *et al.*, 2022; Kyaw *et al.*, 2022; Maneenop *et al.*, 2023; Oyewo, 2023; Goud, 2022; Konadu *et al.*, 2022; Lu & Wang, 2021; Zhang *et al.*, 2021). This study contributes to the literature in this area by testing how board characteristics, which are ones of the most contested corporate governance mechanisms, influence on corporate carbon emissions. This paper will be the first paper examining correlation between board characteristics and corporate carbon emissions in Thailand.

2.2 Board characteristics

In perspective of agency theory, board of director is one of the most common corporate governance mechanisms used to close or reduce the conflicts of interest and information asymmetries (Frias-Aceituno *et al.*, 2013). This is because board of director will improve management quality in long-term advantages for shareholder demands and response on corporate environmental and social impacts (Glass, Cook, & Ingersoll, 2016). In addition, in perspective of stakeholder and legitimacy theories, board of director is used to satisfy social expectations and stakeholder demands (García-Sánchez *et al.*, 2019). However, the expectation is depended on quality of board of director either. Even though the board of director is used to monitor corporate management by top-management's decision, there were several evidences indicating that board gender diversity can reduce the quality of corporate governance and firm value and can create the conflicts of interest and information asymmetries (Cremers *et al.*, 2017; Bebchuk & Cohen, 2005; Likitapiwat & Treepongkaruna, 2023). Within board composition, board size (Cheung & Lai, 2022; Garcia Martin & Herrero, 2020; Farag & Mallin, 2017), gender diversity (Kyaw *et al.*, 2022; Nuber & Velte, 2021; Garcia Martin & Herrero, 2020; Tingbani *et al.*, 2020; Haque, 2017), independency (Oyewo, 2023; Maroun, 2019), tenure (Konadu *et al.*, 2022; Hategan *et al.*, 2018) and duality (Cerbioni & Parbonetti, 2007; Haji & Ghazali, 2013; Lu & Wang, 2021; Zhang *et al.*, 2021) can result in different environmental and social responsibility (Tanthanongsakkun *et al.*, 2022; Maneenop *et al.*, 2023; Adhikari, Agrawal, & Malm, 2019). Board characteristics are important not only researchers and academics but also for shareholders, investors, creditors and the other stakeholders.

2.3 Hypothesis development

Based on prior related studies, two contrasting hypotheses: social role theories and optimal board size hypothesis vs legitimacy and attention hypothesis can be developed. On one hand, to the extent that board characteristics increase managerial quality and social and environmental responsibility, the board is expected to decrease the conflicts of interest between top-management and owners and to reach corporate stakeholder expectations (Likitapiwat & Treepongkaruna, 2023; García-Sánchez *et al.*, 2019). In addition, board of director plays a critical role to ensure management consideration for long-term benefits of corporate shareholders and sustainability in environment and social aspects (Frias-Aceituno *et al.*, 2013). Several social role theories such as agency and stakeholder theories are used to explain the benefit of having board on social and environmental responsibility including corporate carbon emissions' reduction. Therefore, board composition can reduce corporate carbon emissions.

On the other hand, our legitimacy and attention hypothesis suggest that board composition and characteristics may increase corporate carbon emissions. This is because, in terms of board size, too small or too large board cannot provide benefit for corporations including carbon

emissions and too small and large board may obstruct good relationship between the corporations and their society and stakeholders and lead to a decline in corporate sustainability (Subramaniam *et al.*, 2023). For example, by attention/busyness theory hypothesis, too many and busy board members may negatively affect corporate carbon emissions (Ahn, Jiraporn, & Kim, 2010).

In this study, board compositive is considered from female board and board size. In terms of female board, most prior related studies find the negative impact of female board (board gender diversity) on carbon emissions (Alfi, Mohamad, & Hussainey, 2025; Rjiba & Thavaharan, 2022; Kyaw *et al.*, 2022; Nuber & Velte, 2021; Garcia Martin & Herrero, 2020; Tingbani *et al.*, 2020; Haque, 2017). For example, Rjiba and Thavaharan (2022) find that more female board committees can provide a lower carbon footprint of listed firms from 43 countries including Thailand during 2005 to 2019. This is because board gender diversity is a good mechanism to meet social expectations, and stakeholder demands facilitating easier access for strategic resources. It can increase pressure to reduce corporate negative environmental impact including carbon emissions to meet stakeholder demands and social expectations demonstrating commitments to greater accountability which help to obtain access to resources by gaining the support of influential stakeholders. However, by social identity theory, female board may be harmful to corporate operation and performance. Moreover, female board may also promote poor cohesion and misunderstanding between different gender groups. Similarity, presence of independent board may result in the neglect of both top-management and the other boards' knowledge and experience (Dalton, Michael, Trevis, & Catherine, 2007). There are the other factors that make different results of female board and carbon emissions such as between emerging and developed economic markets, between mandatory and voluntary disclosures and between carbon emissions and reporting. Therefore, this study hypothesizes that:

H1a. There is a negative impact of female board on corporate carbon emissions.

H1b. There is a positive impact of female board on corporate carbon emissions.

In terms of board size, on one hand, there are several literatures finds a negative impact of board size on carbon emissions (Cheung & Lai, 2022; Garcia Martin & Herrero, 2020; Farag & Mallin, 2017). For example, Lipton and Lorsch (1992) point out that when there are larger board members in a company, it tends to affect the efficiency of corporate decision-making. This is because, when the number of directors is larger, it is easy to have more effective ideas, which are easy to unify with each other, leading to hesitant decision-making by the board. On the other hand, large boards may underperform compared with smaller boards that allow for faster move and decision-making and better monitoring functions (Goud, 2022; Orozco *et al.*, 2018). In addition, it is because the larger board size can become a hindrance to strategic initiatives and actions (Cerbioni & Parbonetti, 2007). Therefore, there is a hypothesis used to test in this study which is:

H2a. There is a negative impact of board size on corporate carbon emissions.

H2b. There is a positive impact of board size on corporate carbon emissions.

3. Methodology

Top 100 listed firms in Thailand from the Stock Exchange of Thailand (SET) are used as sample in this study. The reasons is that (1) by their volume of capacity, the top100 firms have directly affected on climate change and environmental impact issue in Thailand rather non-top 100 firms, (2) the firms have to work under the practices and regulations of carbon management and reduction that will work faster than the other firms (SET, 2022) and (3) the market capitalization of Top100 firms used in this study is more than 70% of the total market capitalization in Thailand. Annual reports during 2020 to 2022 are used to collect the data.

Though the mandatory carbon emissions’ reporting has been disclosed as a part in one annual report from 2021, the top100 listed firms are asked by the SET to have early adoption of one report since 2020. However, the study cannot have 300 firms-years of observations because some firms have had a joint venture during period being study and some do not have a list as top100 firms within whole period. In Thailand, Top100 listed firms are considered twice a year; therefore, if a firm cannot be in the list of top100 firms with 3 years as 6 times during the first six month and the last six month each year. There are 20 firms that are deleted from the study’s condition. Moreover, the firms from financial industry are not included into this study because they have used a different regulation with the other industries of the Stock Exchange of Thailand. Another eight firms are not considered because they are in financial industry. Thus, our final samples consisted of 72 firms as top100 firms as 216 firms-years of observations during period being study.

During data collection, board characteristics and carbon emissions’ reporting are collected from the corporate annual reports of top100 firms during 2020 to 2022. The SET Security Market Analysis and Reporting Tool (SETSMART), which is the database of SET, is also used to collect data of all variables. There are three main groups of variables used in this study which include board characteristics, carbon emissions’ reporting and corporate characteristics. Board gender diversity is measured by the proportion of female board on total board (Rjiba & Thavaharan, 2022), while board size is measured by natural logarithm of number of board member (Le, Pham, Tran, Dang, & Duong, 2024). CEO duality is a dummy setting to one if CEO is also a chairman of the board and zero otherwise. Proportion of independent directors on board is used to be a proxy of independent board, and the natural logarithm of average board tenure is a proxy of board tenure. Carbon emissions are proxied by the natural logarithm of the level of carbon emissions scaled by total revenue. The proxy of carbon emissions is measure by natural logarithm of the level of carbon emissions scaled by total revenue that has been used by the previous related studies such as Cheung and Lai (2022), Konada *et al.* (2022), Kyaw *et al.* (2022), Luu, Nguyen, Tran, and Ho (2026) and Thanthanongsakkun, Treepongkaruna, and Jiraporn (2022). Moreover, the variable measurement of carbon emission can reduce skewness especially, if distributions are non-normal. Finally, there are some control variables from corporate characteristics used in this study. Table 1 indicates the variables’ measurements and notations.

Table 1. Variable definitions

Variables	Definition
Carbon	Natural logarithm of the level of carbon emissions scaled by total revenue
Female	Proportion of female board on total board member
lnBsize	Natural logarithm of number of board member
CEO Duality	A dummy variable setting to one if CEO is also a chairman of the board and zero otherwise
Bind	Proportion of independent directors on board
Btenure	Natural logarithm of average board tenure
lnQ	Natural logarithm of ratio of (total assets + market capitalization – total equity) to book value of total assets
Firm size	Natural logarithm of total assets
Leverage	Total debt divided by book value of total assets
Cash holdings	Cash divided by total assets
Investments	Capital expenditure divided by total assets
Firm age	Natural logarithm of firm age
Dividends	Dividends divided by total assets
Asset	Ratio of net income and depreciation to total assets
Utilization	
Industry	Fixed Effect
Year	Fixed Effect

To explore the impact of board characteristics on carbon emissions, the study first estimates the fixed effect pooled regression below where standard errors are clustered by firms:

$$\text{Carbon Intensity}_{i,t} = \beta_0 + \beta_1 \text{Female}_{i,t} + \beta_2 \text{LnBsize}_{i,t} + \sum \beta_j \text{Control}_{i,t} + \varepsilon_{it}$$

In data analysis subsection, the panel regression analysis is used to test the impact of board characteristics on carbon emissions, while robustness test by two-stage least squares instrumental variable approach (2SLS-IV) is used to mitigate the endogeneity issue (Duong, Truong, Huynh, Tran, & Nguyen, 2026). This is because endogeneity leads to biased and inconsistent parameter estimates, making reliable inference virtually impossible. Therefore, 2SLS is used to test omitted variables, reverse causality and measurement errors are three sources of the issue to solve the endogeneity problem. In estimating our 2SLS-IV, each endogenous board characteristic, being female and board size in our case, is first regressed on the excluded instrument(s) and all exogenous controls, including industry and year fixed effects. The resulting fitted values are then used in the second-stage carbon emission regression. Following standard IV practice, no instrumented endogenous variable was included as a regressor in the first-stage equations.

4. Results and discussion

To examine the possible impact of board characteristics on carbon emissions, 216 firms-years of top100 firms in Thailand during 2020 to 2022 are used as samples in this study. Although the number of samples seems small, several previous related studies can use small numbers of sample in Thailand such as 147 firms-years (Treepongkaruna & Suttipun, 2022), 250 firms-years (Suttipun & Yordudom, 2022) and 114 firms-years (Suttipun, 2022). Therefore, numbers of sample in this study are enough to consider and tested. Table 2 reports summary statistics of all variables in our study. While carbon intensity (Carbon Emission) is used as our dependent variables, two main independent variables in our study are female board and board size. We also control for other governance variables such as CEO duality, independent board, board tenure and other firm attributes. The natural logarithm of the level of carbon emissions scaled by total revenue is -6.5159 . In terms of carbon emissions, the average of carbon emissions of top100 firms in Thailand has been increased from 267,039.539 kilo-ton carbon in 2020 to 411,459.288 kilo-ton carbon in 2021, and 411,573.322 kilo-ton carbon in 2022. COVID-19 can affect the increase of carbon emissions in Thailand because any countries around the world are

Table 2. Descriptive statistics

	N	Mean	SD	Min	Max
Carbon emissions	216	-6.5159	3.6588	-18.92	-0.5989
Female	216	0.0835	0.0900	0	0.4
LnBsize	216	2.4299	0.2500	1.7918	3.3673
Duality	216	0.2258	0.4191	0	1
Bind	216	0.4558	0.1118	0.2857	0.7692
Btenure	216	1.6996	0.7180	-0.7538	2.7804
lnQ	21	-0.6008	0.3576	-1.8192	-0.0944
Firm size	216	18.29	1.2496	15.30	21.94
Firm size (squared)	216	336.20	46.05	234.07	481.22
Leverage	216	0.4018	0.1968	0.0004	0.7784
Cash holdings	216	0.0782	0.0742	1.77E-05	0.5601
Investments	216	4.2987	4.0665	0	24.13
Firm age	216	3.2116	0.7261	0	4.6913
Dividends	216	0.0358	0.0479	0	0.3372
Asset utilization	216	0.0874	0.0777	-0.0731	0.4903

shut down during 2019 to 2020, therefore, carbon emissions drop down from production process. However, since 2021, Thailand as product producer's country increase carbon emissions due to higher production and export (Suttipun et al., 2026). In terms of board size, we find 11.7349 average board committees in top100 Thai firms that is under the regulation what the Stock Exchange of Thailand has set boards committee's range between 5 to 12 board committees. The result is similar with Gonzalez, Guzman, Pablo, and Trujillo (2019) who find that the average number of boards is about 11 for Thai listed companies. In terms of independent board, we find 0.4558 time of proportion of independent directors on total board (SD = 0.1118). The result of proportion of independent committee on board in this study is still under the regulation where the Stock Exchange of Thailand (SET, 2022) announces for listed firms in Thailand to have one third proportion of independent board including at least three independent boards. In terms of female board, we find 0.2161 as proportion of female board on total board. However, although the maximum proportion of female board is 91% of total board, and number of female boards tends to increase in Thailand, the result is not consistent with Konrad, Kramer, and Erkut (2008) finding that at least three female boards can make different in the boardroom known as the magic of three because the average of female board in Thailand is 2.5359. Finally, an average of board tenure is 1.6996 (SD = 0.7180).

Table 3 indicates to check whether all variables used in this study will not provide multicollinearity problem on the data analysis. Therefore, correlation matrix is used to test for multicollinearity problem between all variables. The results indicate that the Pearson correlation was 0.475 as correlation between firm size and InBsize, while the multicollinearity problem has started from 0.700 (Yoon, Lee, & Byun, 2018).

Table 4 reports estimation results from our baseline fixed effect pooled regression where carbon emissions are our dependent variable and board characteristics (e.g. board gender diversity, board size, CEO duality, independent board and board tenure) are our independent variables. Hausman test indicates that the most appropriated panel data analysis used in this study is fixed effected model (FEM). It is because individual effects have correlation with independent variables. During the model 1 to 4, the adjust R-squares were during 0.132 to 0.233. Moreover, max variance inflation factor (VIF) of four models is under 10 that the model 1 indicates 1.000 as the max VIF, while the model 2 indicates 1.784 as the max VIF, the model 3 shows 1.166 as the max VIF and the model 4 indicates 2.369 as the max VIF. Therefore, the max VIF should not exceed 10.00 (Yoon et al., 2018) and the variables used in this study did not have a multicollinearity problem. We find consistent finding that firms with board gender diversity can reduce carbon emissions. This finding is consistent with Alfi et al. (2025), Rjiba and Thavaharan (2022), Kyaw et al. (2022), Nuber and Velte (2021), Garcia Martin and Herrero (2020), Tingbani et al. (2020) and Haque (2017). This is because board gender diversity is a good mechanism to meet social expectations, and stakeholder demands facilitating easier access for strategic resources. It can increase pressure to reduce corporate negative environmental impact including carbon emissions to meet stakeholder demands and social expectations demonstrating commitments to greater accountability which help to obtain access to resources by gaining the support of influential stakeholders. In Thai context, female board is chosen to consider more on corporate social and environmental impact and responsibility, while male board is worked more on corporate economic development and management (Suttipun et al., 2026; Suttipun, 2021). Moreover, as family ownership structure in Thailand, female board can play as important roles for corporate environmental management including sustainable development (Khanna & Palepu, 2000).

Furthermore, consistent with social identity theory and attention/busyness theory hypothesis, the study finds that board size is positively related with corporate carbon emissions. The finding is consistent with Cheung and Lai (2022) who find a positive impact of board size on carbon emission of US firms. It is because the larger board size can become a hindrance to strategic initiatives and actions (Cerbioni & Parbonetti, 2007). Moreover, large boards may underperform compared with smaller boards that allow for faster move and

Table 3. Correlation matrix

Variables	Carbon	Female	lnBsize	Duality	Bindepend	Btenure	lnQ	Firm size	Leverage	Cash holdings	Investments	Firm age	Dividends
Carbon	1	–	–	–	–	–	–	–	–	–	–	–	–
Female	–0.160	1	–	–	–	–	–	–	–	–	–	–	–
lnBsize	0.248	–0.002	1	–	–	–	–	–	–	–	–	–	–
Duality	–0.051	0.109	–0.207	1	–	–	–	–	–	–	–	–	–
Bindepend	0.008	0.057	–0.006	–0.134	1	–	–	–	–	–	–	–	–
Btenure	–0.127	–0.221	–0.246	0.245	–0.423	1	–	–	–	–	–	–	–
lnQ	–0.019	–0.202	0.126	0.017	0.028	0.114	1	–	–	–	–	–	–
Firm size	0.173	–0.196	0.475	–0.216	0.338	–0.386	0.406	1	–	–	–	–	–
Leverage	0.010	–0.166	0.045	0.066	–0.091	0.028	0.816	0.285	1	–	–	–	–
Cash holdings	–0.082	0.264	0.069	0.020	–0.003	–0.165	–0.274	–0.148	–0.359	1	–	–	–
Investments	0.124	0.118	0.067	0.019	0.028	–0.086	–0.210	–0.027	–0.191	0.403	1	–	–
Firm age	0.058	–0.060	–0.002	0.079	–0.059	0.213	–0.045	0.078	–0.126	0.004	0.042	1	–
Dividends	–0.143	0.385	–0.005	–0.115	–0.171	–0.027	–0.548	–0.376	–0.528	0.340	0.209	0.063	1
Asset utilization	–0.128	0.294	–0.030	–0.050	–0.188	0.047	–0.494	–0.370	–0.567	0.492	0.386	0.037	0.729

Table 4. Board characteristics and carbon emissions – fixed effect pooled regression

	(1) Female	(2) Bsize	(3) Allboards	(4) AllControls
Female	−7.6703** (−2.358)		−8.5850** (−2.425)	−7.1287** (−2.006)
lnBsize		2.0122** (2.279)	1.6460* (1.817)	1.9817** (2.110)
Duality			−0.0696 (−0.135)	−0.3490 (−0.677)
Bind			−0.6383 (−0.243)	−1.0972 (−0.414)
Btenure			−0.6405 (−1.363)	−0.5798 (−1.151)
lnQ				−2.0473 (−1.557)
Firm size				−15.3702*** (−3.948)
Firm size (squared)				0.4101*** (3.910)
Leverage				0.7085 (0.243)
Cash holdings				−11.4495** (−2.059)
Investments				0.0724 (0.991)
Firm age				0.5575** (1.998)
Dividends				−11.0071** (−1.985)
Asset utilization				−4.9088 (−1.080)
Constant	−5.8752*** (−20.933)	−11.4054*** (−5.170)	−8.4030*** (−2.980)	132.2428*** (3.626)
Observations	216	216	216	216
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adj R-squared	0.150	0.132	0.160	0.232

Note(s): *** is significant at 0.01 level, ** is significant at 0.05 level and * is significant at 0.10 level

decision-making and better monitoring functions (Goud, 2022; Orozco *et al.*, 2018). The last reason of positive relationship between board size and carbon emission is that the data is collected from top100 listed firms in Thailand during COVID-19 era that all firms must focus on survival and economic perspective rather than environmental and social impacts and responsibilities. In terms of the others board characteristics, the study no correlation between CEO duality, board tenure, independent board and corporate carbon emissions.

In terms of connection between corporate characteristics and carbon emissions, the result of positive correlation between firm size and carbon emissions is consistent with Subramaniam *et al.* (2023) and García-Sánchez *et al.* (2019). It is because larger firms can afford to spend more carbon emissions compared with the smaller firms (Subramaniam *et al.*, 2023). In addition, from agency theory, information asymmetries tend to be stronger in larger firms, compelling them to provide more environmental performance including carbon emissions than do smaller firms to reduce agency costs (García-Sánchez *et al.*, 2019). The positive relationship between firm age and corporate carbon emissions of the study's result is consistent with Miah, Hasan, and Usman (2021) who find positive correlation between firm age and carbon emissions of listed companies in emerging

economic countries. This may be because older firms focus on economic development and perspective rather than environmental impact and responsibility compared with younger firms.

Hausman test $X^2 = 0.132\text{--}0.232$ ($P < 0.001$) confirms fixed effect is appropriate, and maximize VIF = 1.000–2.369 which is well below 10, indicating no multicollinearity concerns.

The connection of board and carbon emissions, attempting to explain the causes and effects of financial decision, often suffers from endogeneity topics. Endogeneity leads to biased and inconsistent parameter estimates, making reliable inference virtually impossible. Omitted variables, reverse causality and measurement errors are three sources of the issue. Therefore, the study uses the two-stage least squares instrumental variable (2SLS) regression to mitigate the endogeneity issue. The study follows existing literatures and uses the earliest year on female board and board size as the instrumental variables. As the results, the chosen instrumental variable meets both relevance and exclusion restriction assumptions underlying the two-stage least squares instrumental variable regression.

Table 5 presents the results of the robustness analysis using the two-stage least squares instrumental variable (2SLS-IV) approach. Panel A reports the estimation in which female board representation is treated as the endogenous variable, while Panel B reports the estimation in which board size ($\ln\text{Bsize}$) is treated as the endogenous variable. In each panel, Column 1 presents the first-stage results and Column 2 presents the second-stage results. The first-stage results show that the instrumental variables are positively associated with their respective endogenous variables and are statistically significant at the 1% level. The first-stage F -statistics are 316.8 for the female board model and 656.5 for the board size model, both of which are well above the conventional threshold of 10. This finding indicates that the instruments are sufficiently strong and that weak-instrument concerns are unlikely to affect the validity of the 2SLS estimates.

The second-stage results indicate that the instrumented female board variable is negatively and significantly associated with carbon emissions ($\beta = -11.6132$, $p < 0.01$), whereas the instrumented board size variable is positively and significantly associated with carbon emissions ($\beta = 3.5168$, $p < 0.01$). These findings are consistent with the main results and suggest that greater female board representation reduces carbon emissions, while larger board size increases carbon emissions. Overall, the results remain robust after accounting for potential endogeneity through the 2SLS-IV estimation.

5. Conclusions and suggestion for future study

To answer whether there are the influences of female board (board gender diversity) and board size on corporate carbon emissions of Top100 Thai listed companies during 2020 to 2022, this study finds interesting results. Although there is a negative impact of female board on carbon emissions, board size has positive correlation with corporate carbon emission. The results indicate that the board gender diversity tends to reduce quantity of corporate carbon emissions, while the larger board size tends to increase the carbon emission. On the other variables, this study also finds that there is positive relationship between firm size, firm age and carbon emissions, while the carbon emissions are negatively influenced by cash holding and dividend.

This study finding provides several contributions and implications. In terms of theoretical contributions, firstly, social role theories such as agency, stakeholder and legitimacy theories can be demonstrated to explain the negative impact of board gender diversity on corporate carbon emissions because having board gender diversity to decrease agency costs and conflicts of interest between top-management and shareholders, as well as to satisfy corporate stakeholder demands and social expectations. This is because board of director, which female board and board size are used to test in this study, is expected to monitor corporate actions and activities to reduce information asymmetries and conflicts of interest between top-

Table 5. Robustness test – 2SLS-IV

Panel A: Female board representation is treated as the endogenous variable. The instrument is the proportion of female board in the firm's first sample year

	(1) Female 1st stage	(2) 2nd stage
Instruments	0.8171*** (17.800)	
Female (Instrumented)		–11.6132*** (–3.273)
lnBsize	–0.0090 (–0.566)	2.3729** (2.349)
Duality	–0.0066 (–0.713)	0.9800* (1.705)
Bind	0.0362 (0.971)	–3.1475 (–1.332)
Btenure	0.0004 (0.063)	0.1014 (0.252)
lnQ	–0.0017 (–0.082)	–1.6472 (–1.255)
Firm size	0.0230 (0.347)	–9.2726** (–2.212)
Firm size (squared)	–0.0006 (–0.349)	0.2611** (2.325)
Leverage	0.0173 (0.411)	–1.8461 (–0.693)
Cash holdings	–0.1079* (–1.726)	–16.5876*** (–4.224)
Investments	0.0002 (0.187)	0.0399 (0.646)
Firm age	0.0035 (0.718)	0.5021 (1.624)
Dividends	–0.1492 (–1.396)	–8.5298 (–1.271)
Asset utilization	0.0940 (1.340)	1.5203 (0.341)
Constant	–0.1625 (–0.261)	73.0061* (1.856)
Observations	216	216
Industry FE	Yes	Yes
Year FE	Yes	Yes
Adj R-squared	0.799	0.422
IV F-stat	316.8	
Durbin pval	0.0310	

Panel B: Board size is treated as the endogenous variable. The instrument is board size in the firm's first sample year

	(1) Board size (ln) 1st stage	(2) 2nd stage
Instruments	0.8950*** (25.622)	
lnBsize (Instrumented)		3.5168*** (3.094)

(continued)

Panel B: Board size is treated as the endogenous variable. The instrument is board size in the firm's first sample year

	(1) Board size (ln) 1st stage	(2) 2nd stage
Female	−0.0829 (−0.858)	−6.8831** (−2.442)
Duality	0.0183 (0.949)	0.7669 (1.368)
Bind	−0.2230*** (−2.806)	−2.8930 (−1.223)
Btenure	−0.0184 (−1.364)	0.3050 (0.769)
lnQ	0.0518 (1.157)	−1.2947 (−0.996)
Firm size	0.0577 (0.402)	−9.6266** (−2.305)
Firm size (squared)	−0.0014 (−0.367)	0.2684** (2.399)
Leverage	−0.1658* (−1.827)	−2.3400 (−0.886)
Cash holdings	0.2596* (1.931)	−16.7282*** (−4.274)
Investments	0.0008 (0.370)	0.0280 (0.455)
Firm age	−0.0067 (−0.630)	0.5051 (1.639)
Dividends	0.1930 (0.842)	−9.3229 (−1.393)
Asset utilization	−0.2666* (−1.744)	0.6971 (0.157)
Constant	−0.1186 (−0.088)	73.8675* (1.884)
Observations	216	216
Industry FE	Yes	Yes
Year FE	Yes	Yes
Adj R-squared	0.879	0.426
IV F-stat	656.5	
Durbin pval	0.0429	

Note(s): *** is significant at 0.01 level, ** is significant at 0.05 level and * is significant at 0.10 level

management and shareholders and to satisfy social expectations and stakeholder demands. Thus, quality of female board and board size is important to force top-management providing corporate carbon emissions. Secondly, the study contributes to literature on environmental performance represented by carbon emissions that there are a few studies. Finally, the finding of this study can clarify to Thailand 2050 Carbon Neutrality Goal. In terms of practical contributions and implications, the result can guide for the corporations which should increase board gender diversity because female board will improve good relationship between corporations and stakeholders and between corporations and societies. The corporations should have board of director who tends to serve and satisfy social expectations and stakeholder demands and to reduce agency costs and conflicts of interest. In addition, quality of board is more important than quantity of board in terms of time management, change management and environmental management. Academics and researchers can benefit from this study's findings because machine learning and textual analysis can be employed to extract

useful data on corporate governance. These techniques can be applied in future study and represent promising tools that should generate a great deal of interest in the future. Next, from the governance setters' perspective, regulation of corporate board composition should be set to improve quality of board of director and increase board gender diversity. This is because availability of qualified female board in Thai economic market would make the advice much more realistic and useful for both policymakers and investors.

However, three limitations need to be mentioned in this study. First, the study focused only on board gender diversity and board size, which are parts of board composition; however, there are many proxies of board composition such as board meeting, board experience, board turnover, and non-managerial board. Second, the study tests only the impacts of board gender diversity and board size on corporate carbon emissions, while the effect of carbon emissions on corporate outcomes is not tested yet. Next, there are the other variable's measurement especially female board as a dummy variable of at least one female board on total board and the otherwise, but this study picks up only the proportion of female board on total board. Finally, using top100 firms within three years in Thailand can be mentioned as limitation because the larger firms often have more resource and face more public pressure to be "green" than smaller firms; therefore, the future study will examine the effect of another proxies of board composition and female CEO on corporate carbon emission and reduction of all listed firms in Thailand during longer-term period as five years or more as well as the influence of carbon emission on corporate outcomes of Thai listed companies from both main and alternative capital markets.

References

- Adams, R. B., & Ferreira, D. (2009). Women in the boardroom and their impact on governance and performance. *Journal of Financial Economics*, 94(2), 291–309. doi: [10.1016/j.jfineco.2008.10.007](https://doi.org/10.1016/j.jfineco.2008.10.007).
- Adhikari, B. K., Agrawal, A., & Malm, J. (2019). Do women managers keep firms out of trouble? Evidence from corporate litigation and policies. *Journal of Accounting and Economics*, 67(1), 202–225. doi: [10.1016/j.jacceco.2018.09.004](https://doi.org/10.1016/j.jacceco.2018.09.004).
- Ahn, S., Jiraporn, P., & Kim, Y. S. (2010). Multiple directorships and acquirer return. *Journal of Banking and Finance*, 34(1), 2011–2026. doi: [10.1016/j.jbankfin.2010.01.009](https://doi.org/10.1016/j.jbankfin.2010.01.009).
- Albanese, D., Gatti, L., & Varriale, L. (2025). Energy transition risks and firm competitiveness. *Energy Economics*, 121, 106896.
- Alfi, C. F., Mohamad, M., & Hussainey, K. (2025). Unveiling the hidden symphony: Board dynamic and carbon emission disclosure- a meta-analysis study in the realm of developed markets. *Journal of Accounting Literature*, 47(2), 404–432. doi: [10.1108/jal-07-2023-0126](https://doi.org/10.1108/jal-07-2023-0126).
- Barroso, R., Gallego-Álvarez, I., & Vicente-Galindo, M. P. (2024). Board gender diversity and carbon emissions: International evidence. *Journal of Cleaner Production*, 402, 136892.
- Bebchuk, L. A., & Cohen, A. (2005). The costs of entrenched boards. *Journal of Financial Economics*, 78(2), 409–433. doi: [10.1016/j.jfineco.2004.12.006](https://doi.org/10.1016/j.jfineco.2004.12.006).
- Cerbioni, F., & Parbonetti, A. (2007). Exploring the effects of corporate governance on intellectual capital disclosure: An analysis of European biotechnology companies. *European Accounting Review*, 16(4), 791–826. doi: [10.1080/09638180701707011](https://doi.org/10.1080/09638180701707011).
- Cheung, K. Y., & Lai, C. Y. (2022). Board directorships and carbon emissions: Curvilinear relationships and moderating roles of other board characteristics. *Journal of Risk and Financial Management*, 15(12), 550. doi: [10.3390/jrfm15120550](https://doi.org/10.3390/jrfm15120550).
- Cremers, K. M., Litov, L. P., & Sepe, S. M. (2017). Staggered boards and long-term firm value. *Journal of Financial Economics*, 126(2), 422–444. doi: [10.1016/j.jfineco.2017.08.003](https://doi.org/10.1016/j.jfineco.2017.08.003).
- Dalton, D. R., Michael, A. H., Trevis, C., & Catherine, M. D. (2007). The fundamental agency problem and its mitigation. *The Academy of Management Annals*, 1(1), 1–64.

- Duong, K. D., Truong, L. T. D., Huynh, T. N., Tran, N. D., & Nguyen, H. T. T. (2026). Economic policy uncertainty and gambling performance: Evidence from the Asia-Pacific stock markets. *International Journal of Finance and Economics*, 1–17.
- Farag, H., & Mallin, C. (2017). Monitoring corporate boards: Evidence from China. *The European Journal of Finance*, 25(3), 524–529. doi: [10.1080/1351847x.2017.1369138](https://doi.org/10.1080/1351847x.2017.1369138).
- Frias-Aceituno, J. V., Rodriguez-Ariza, L., & Garcia-Sanchez, I. M. (2013). The role of the board in the dissemination of integrated corporate social reporting. *Corporate Social Responsibility and Environmental Management*, 20(4), 219–233. doi: [10.1002/csr.1294](https://doi.org/10.1002/csr.1294).
- Garcia Martin, C. J. G., & Herrero, B. (2020). Do board characteristics affect environmental performance? A study of EU firms. *Corporate Social Responsibility and Environmental Management*, 27(1), 74–94. doi: [10.1002/csr.1775](https://doi.org/10.1002/csr.1775).
- García-Sánchez, I. M., Gomez-Miranda, M. E., David, F., & Rodríguez-Ariza, L. (2019). Board independence and GRI-IFC performance standards: The mediating effect of the CSR committee. *Journal of Cleaner Production*, 225, 554–562. doi:[10.1016/j.jclepro.2019.03.337](https://doi.org/10.1016/j.jclepro.2019.03.337).
- Glass, C., Cook, A., & Ingersoll, A. R. (2016). Do women leaders promote sustainability? Analysing the effect of corporate governance composition on environmental performance. *Business Strategy and the Environment*, 25(7), 495–511. doi: [10.1002/bse.1879](https://doi.org/10.1002/bse.1879).
- Global Carbon Budget (2023). Population based on various sources 2023. OurWorldInData.org/co2-and-greenhouse-gas-emissions
- Gonenc, H., & Krasnikova, A. (2022). Corporate governance, carbon disclosure, and climate performance. *Journal of Cleaner Production*, 331, 129923.
- Gonzalez, M., Guzman, A., Pablo, E., & Trujillo, M. A. (2019). Is board turnover driven by performance in family firms?. *Research in International Business and Finance*, 48(1), 169–186. doi: [10.1016/j.ribaf.2018.12.002](https://doi.org/10.1016/j.ribaf.2018.12.002).
- Goud, N. N. (2022). Corporate governance: Does it matter management of carbon emission performance? An empirical analyses of Indian companies. *Journal of Cleaner Production*, 379, 134485. doi: [10.1016/j.jclepro.2022.134485](https://doi.org/10.1016/j.jclepro.2022.134485).
- Grabsch, C., Jones, M. J., & Solomon, J. (2010). Accounting for biodiversity in crisis: A European perspective. Working paper presented at the financial reporting & business communication conference, Bristol.
- Haji, A. A., & Ghazali, N. A. M. (2013). A longitudinal examination of intellectual capital disclosure and corporate governance attributes in Malaysia. *Asian Review of Accounting*, 21(1), 27–52.
- Haque, F. (2017). The effects of board characteristics and sustainable compensation policy on carbon performance of UK firms. *The British Accounting Review*, 49(3), 347–364. doi: [10.1016/j.bar.2017.01.001](https://doi.org/10.1016/j.bar.2017.01.001).
- Hategan, C. D., Sirghi, N., Curea-Pitorac, R. I., & Hategan, V. P. (2018). Doing well of doing good: The relationship between corporate social responsibility and profit in Romanian companies. *Sustainability (Switzerland)*, 10(4), 1041–1064. doi: [10.3390/su10041041](https://doi.org/10.3390/su10041041).
- IPCC (2021). *Climate change 2021: The physical science basis*. Cambridge University Press.
- Khairunnisa, A., Astuti, C. D., & Hussein, M. A. (2024). The influence of board diversity and environmental committees on carbon emission disclosure in Southeast Asian corporations. *Journal of Green Economy and Low-Carbon Development*, 3(1), 26–35. doi: [10.56577/jgelcd030103](https://doi.org/10.56577/jgelcd030103).
- Khanna, T., & Palepu, K. (2000). The future of business groups in emerging markets: Long-run evidence from Chile. *Academic of Management Journal*, 43(3), 268–285. doi: [10.2307/1556395](https://doi.org/10.2307/1556395).
- Konadu, R., Ahinful, G. S., Boakye, D. J., & Elbardan, H. (2022). Board gender diversity, environmental innovation and corporate carbon emissions. *Technological Forecasting and Social Change*, 174, 121279. doi: [10.1016/j.techfore.2021.121279](https://doi.org/10.1016/j.techfore.2021.121279).

- Konrad, A. M., Kramer, V., & Erkut, S. (2008). Critical mass: The impact of three or more women on corporate boards. *Organizational Dynamics*, 37(2), 145–164.
- Kumari, D., Shashwat, S., Verma, P. K., & Giri, A. K. (2025). Examining the nexus between carbon dioxide emissions, economic growth, fossil fuel energy use, urbanization and renewable energy towards achieving environmental sustainability in India. *International Journal of Energy Sector Management*, 19(3), 731–746. doi: [10.1108/ijesm-05-2024-0007](https://doi.org/10.1108/ijesm-05-2024-0007).
- Kyaw, K., Treepongkaruna, S., & Jiraporn, P. (2022). Board gender diversity and environmental emissions. *Business Strategy and the Environment*, 31(7), 2871–2881. doi: [10.1002/bse.3052](https://doi.org/10.1002/bse.3052).
- Le, H. T. P., Pham, T. N., Tran, T. N. D., Dang, H. G., & Duong, K. D. (2024). Financial constraints and bankruptcy risks of listed firms in Vietnam: Does firm size matter?. *Sage Open*, 1(4), 1–14. doi: [10.1177/21582440241305156](https://doi.org/10.1177/21582440241305156).
- Likitapiwat, T., & Treepongkaruna, S. (2023). Staggered board, social capital and sustainability. *Corporate Social Responsibility and Environmental Management*, 30(3), 1524–1533. doi: [10.1002/csr.2435](https://doi.org/10.1002/csr.2435).
- Lipton, M., & Lorsch, J. W. (1992). A modest proposal for improved corporate governance. *The Business Lawyer*, 48(1), 59–77.
- Lu, J., & Wang, J. (2021). Corporate governance, law, culture, environmental performance and CSR disclosure: A global perspective. *Journal of International Financial Market, Institutions and Money*, 70(2), 125–140. doi: [10.1016/j.intfin.2020.101264](https://doi.org/10.1016/j.intfin.2020.101264).
- Luo, L., Tang, Q., Fan, H., & Ayers, J. (2023). Corporate carbon assurance and the quality of carbon disclosure. *Accounting and Finance*, 63(4), 657–690. doi: [10.1111/acfi.13060](https://doi.org/10.1111/acfi.13060).
- Luu, Q. T., Nguyen, H. T. T., Tran, T. N. D., & Ho, T. T. (2026). Financial constraints and corporate bankruptcy risks in China: The buffer role of cash holdings. *PLoS One*, 21(1), e0341114. doi: [10.1371/journal.pone.0341114](https://doi.org/10.1371/journal.pone.0341114).
- Maneenop, S., Padungsaksawasdi, C., & Treepongkaruna, S. (2023). Co-opted board, environmental, social and governance. *Business Strategy and the Environment*, 1–12. doi: [10.1002/bse.3540](https://doi.org/10.1002/bse.3540).
- Mansour, M., Abu-Allan, A. J., Alshdaifat, S. M., E’leimat, D. A., & Saleh, M. W. A. (2025). Board effectiveness and carbon emission disclosure: Evidence from ASEAN countries. *Discover Sustainability*, 6(1), 604. doi: [10.1007/s43621-025-01405-4](https://doi.org/10.1007/s43621-025-01405-4).
- Maroun, W. (2019). Does external assurance contribute to higher quality integrated reports?. *Journal of Accounting and Public Policy*, 38(4), 106–120. doi: [10.1016/j.jaccpubpol.2019.06.002](https://doi.org/10.1016/j.jaccpubpol.2019.06.002).
- Miah, M. D., Hasan, R., & Usman, M. (2021). Carbon emissions and firm performance: Evidence from financial and non-financial firms from selected emerging economies. *Sustainability*, 13(23), 13281. doi: [10.3390/su132313281](https://doi.org/10.3390/su132313281).
- Nuber, C., & Velte, P. (2021). Board gender diversity and carbon emissions: European evidence on curvilinear relationship and critical mass. *Business Strategy and the Environment*, 30(4), 1958–1992. doi: [10.1002/bse.2727](https://doi.org/10.1002/bse.2727).
- Orozco, L. A., Vargas, J., & Galindo-Dorado, R. (2018). Trends on the relationship between board size and financial and reputational corporate performance: The Colombian case. *European Journal of Management and Business Economics*, 27(1), 183–197. doi: [10.1108/ejmb-02-2018-0029](https://doi.org/10.1108/ejmb-02-2018-0029).
- Oyewo, B. (2023). Corporate governance and carbon emissions performance: International evidence on curvilinear relationships. *Journal of Environmental Management*, 334, 117474. doi: [10.1016/j.jenvman.2023.117474](https://doi.org/10.1016/j.jenvman.2023.117474).
- Rjiba, H., & Thavaharan, T. (2022). Female representation on boards and carbon emissions: International evidence. *Finance Research Letters*, 49, 103079. doi: [10.1016/j.frl.2022.103079](https://doi.org/10.1016/j.frl.2022.103079).
- Subramaniam, N., Akbar, S., Situ, H., Ji, S., & Parikh, N. (2023). Sustainable development goal reporting: Contrasting affects of institutional and organizational factors. *Journal of Cleaner Production*, 411, 137339. doi: [10.1016/j.jclepro.2023.137339](https://doi.org/10.1016/j.jclepro.2023.137339).

- Suttipun, M. (2021). The influence of board composition on environmental, social and governance (ESG) disclosure of Thai listed companies. *International Journal of Disclosure and Governance*, 18(4), 391–402. doi: [10.1057/s41310-021-00120-6](https://doi.org/10.1057/s41310-021-00120-6).
- Suttipun, M. (2022). Eternal auditors and KAMs reporting in alternative capital market of Thailand. *Meditari Accountancy Research*, 30(1), 74–93. doi: [10.1108/medar-04-2020-0850](https://doi.org/10.1108/medar-04-2020-0850).
- Suttipun, M. (2026). The first step of mandatory environmental, social and governance (ESG) reporting in Thailand and its effect on market reaction. *Journal of Environmental Accounting and Management*, 14(1), 13–24. doi: [10.5890/jeam.2026.03.002](https://doi.org/10.5890/jeam.2026.03.002).
- Suttipun, M., & Yordudom, T. (2022). Impact of environmental, social and governance disclosures on market reaction: An evidence of Top50 companies listed from Thailand. *Journal of Financial Reporting and Accounting*, 20(3/4), 753–767. doi: [10.1108/jfra-12-2020-0377](https://doi.org/10.1108/jfra-12-2020-0377).
- Suttipun, M., Phuensane, P., & Kijkasiwat, P. (2026). Co-opted board and carbon emissions in Thailand. *Journal of Disclosure and Governance*, 23(1), 212–223. doi: [10.1057/s41310-025-00286-3](https://doi.org/10.1057/s41310-025-00286-3).
- Tang, Q., & Demeritt, D. (2018). Climate change disclosure and corporate governance. *Accounting, Auditing and Accountability Journal*, 31(3), 880–905.
- Thanthanongsakkun, S., Treepongkaruna, S., & Jiraporn, P. (2022). Carbon emissions, corporate governance, and staggered boards. *Business Strategy and the Environment*, 32(1), 767–780.
- Tingbani, I., Chithambo, L., Tauringana, V., & Papanikolaou, N. (2020). Board gender diversity, environmental committee and greenhouse gas voluntary disclosures. *Business Strategy and the Environment*, 29(6), 2194–2210.
- Treepongkaruna, S., & Suttipun, M. (2022). The impact of environmental, social and governance (ESG) reporting on corporate profitability: Evidence from Thailand. *Journal of Financial Reporting and Accounting*. doi: [10.1108/JFRA-09-2023-0555](https://doi.org/10.1108/JFRA-09-2023-0555).
- The Stock Exchange of Thailand (SET) (2022). Listed companies of the stock Exchange of Thailand (SET). Available from: www.setsustainability.com
- Tian, Z., Gao, Y., Wu, J., Tang, Y., Liu, G., & Yun, J. (2025). Quantitative analysis and carbon reduction strategies based on spatiotemporal electricity carbon emission factors. *International Journal of Sustainable Energy Planning and Management*, 46(1), 41–57. doi: [10.54337/ijsepm.9789](https://doi.org/10.54337/ijsepm.9789).
- Yoon, B., Lee, J., & Byun, R. (2018). Does ESG performance enhance firm value: evidence from Korea. *Sustainability*, 10(10), 3635–3652.
- Zhang, D., Zhang, Z., Ji, Q., Lucey, B., & Liu, J. (2021). Board characteristics, external governance and the use of renewable energy: International evidence. *Journal of International Financial Market, Institutions and Moaney*, 72, 101317. doi:[10.1016/j.intfin.2021.101317](https://doi.org/10.1016/j.intfin.2021.101317).

Further reading

- Adams, R. B., & Ragunathan, V. (2015). Lehman sisters. FIRN Research Paper.
- Barber, B., & Odean, T. (2001). Boys will be boys: Gender, overconfidence, and common stock investment. *The Quarterly Journal of Economics*, 116(1), 261–292. doi: [10.1162/003355301556400](https://doi.org/10.1162/003355301556400).
- Charles, A., & Redor, E. (2014). Female are from Venus; males are from Mars: But do the financial markets know it?. *Economics Bulletin*, 34(1), 589–604.
- Chen, S., Ni, X., & Tong, J. Y. (2016). Gender diversity in the boardroom and risk management: A case of R&D investment. *Journal of Business Ethics*, 136, 599–621.
- Cucari, N., Esposito de Falco, S., & Orlando, B. (2018). Diversity of board of directors and environmental social governance: Evidence from Italian listed companies. *Corporate Social Responsibility and Environmental Management*, 25(1), 250–266. doi: [10.1002/csr.1452](https://doi.org/10.1002/csr.1452).
- Erhardt, N., Werbel, J., & Shrader, C. (2003). Board of director diversity and firm financial performance. *Corporate Governance*, 11(2), 102–111. doi: [10.1111/1467-8683.00011](https://doi.org/10.1111/1467-8683.00011).

- Garcia, A. S., Mendes-Da-Silva, W., & Orsato, R. J. (2017). Sensitive industries produce better ESG performance: Evidence from emerging markets. *Journal of Cleaner Production*, 150(1), 135–147. doi: [10.1016/j.jclepro.2017.02.180](https://doi.org/10.1016/j.jclepro.2017.02.180).
- Huang, J., & Kisgen, D. J. (2013). Gender and corporate finance: Are male executives overconfident relative to female executives?. *Journal of Financial Economics*, 108(3), 822–839. doi: [10.1016/j.jfineco.2012.12.005](https://doi.org/10.1016/j.jfineco.2012.12.005).
- Jain, T., & Jamali, D. (2016). Looking inside the black box: The effect of corporate governance on corporate social responsibility. *Corporate Governance: An International Review*, 24(3), 253–273. doi: [10.1111/corg.12154](https://doi.org/10.1111/corg.12154).
- Jensen, M. (1993). The modern industrial revolution, exit and the failure of internal control systems. *Journal of Finance*, 48(3), 831–880. doi: [10.1111/j.1540-6261.1993.tb04022.x](https://doi.org/10.1111/j.1540-6261.1993.tb04022.x).
- Krishnan, G. V., & Parsons, L. M. (2008). Getting to the bottom line: An exploration of gender and earnings quality. *Journal of Business Ethics*, 78(1/2), 65–76. doi: [10.1007/s10551-006-9314-z](https://doi.org/10.1007/s10551-006-9314-z).
- Nalikka, A. (2009). Impact of gender diversity on voluntary disclosure in annual reports. *Accounting and Taxation*, 1(1), 101–113.
- Ongsakul, V., Jaroenjitrakam, A., Treepongkaruna, S., & Jiraporn, P. (2022). Does board gender diversity reduce CEO luck. *Accounting and Finance*, 62(1), 243–260.
- Sila, V., Gonzalez, A., & Hagendorff, J. (2016). Women on board: Does boardroom gender diversity affect firm risk?. *Journal of Corporate Finance*, 36(1), 26–53. doi: [10.1016/j.jcorpfin.2015.10.003](https://doi.org/10.1016/j.jcorpfin.2015.10.003).
- Srinidhi, B., Gul, F. A., & Tsui, J. (2011). Female directors and earnings quality. *Contemporary Accounting Research*, 28(5), 1610–1644.

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