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Abstract: This paper investigated the effects of carbon emissions and board gender diversity on firm performance using quantile regression. This approach explores the heterogeneity of the effect of carbon emissions on the performance of firms and overcomes some of the drawbacks of OLS regression. This research aimed to identify whether carbon emissions significantly impact firm performance using accounting- and market-based performance measures and how this impact varies according to a company's size. Another objective was to determine how females on a board of directors could impact such a relationship. The data used were a sample of 1382 companies in emerging markets from 2008 to 2021. The findings show that carbon emissions negatively affect small-size companies consisting of both high-performing and low-performing companies; however, as the size of the companies increases, the effect of carbon emissions becomes positive regardless of whether they are high- or low-performing companies. The presence of females on a board has a minimally significant negative effect on a firm's performance, irrespective of whether it is conditioned on size. This research contributes to the literature on the impact of carbon emissions on company performance, both conditional and unconditional on size. Furthermore, the results show that the relationship between carbon emissions and performance depends on size, as revealed using the novel econometrics model developed in this study. This study also shows the importance of the presence of females on a board of directors.

Keywords: carbon emissions; gender diversity; financial performance; quantile regression; emerging markets

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1. Introduction

In recent years, there has been a worldwide surge of interest in research topics related to responsibility and corporate ethics [1,2], particularly those concerning the environment. Accordingly, corporate environmental management measures to what extent companies combine both economic and environmental antecedents in their operations, which might affect companies' performance and the environment [3,4]. Sustainable development is an investment and economic strategy for firms that aim to meet the current and future demands of generations [5]. Sustainable development prevails by enabling each generation to use the remaining resources to achieve improved levels of living [6,7]. Consequently, companies with sustainability objectives have a competitive edge [8]. A corporation has a competitive edge if it can generate more marginal economic value than its competitors. One of the characteristics that distinguishes a corporation is its proclivity to conserve and safeguard the environment.

Companies are concerned about the consumption and usage of water, energy, and biodiversity regarding environmental challenges, particularly climate change [9,10]. Thus, climate change has gained strategic prominence, where carbon performance is one of the most pertinent and non-financial types of information gathered by stakeholders [11].

Climate change and carbon management are becoming crucial components of business corporate sustainability, which is subject to pressure from regulators and stakeholders [12,13]. Consequently, global action has been endorsed by the Kyoto Protocol, which has urged many countries to positively respond to initiatives supported by national and industrial schemes; therefore, greenhouse gas (GHG) reduction has become a top focus for many countries.

GHGs must be lessened to reduce global warming risks, which exerts worldwide pressure on countries with high carbon emissions, such as the US, Japan, China, and Korea [14–17]. It has been debated whether measuring carbon emissions is worthwhile, as some opponents believe carbon emissions are constrained by increasing the financial burden and costs [3,18,19]. Conversely, leading corporations, such as Panasonic, have given more attention to green and sustainable management. They are seeking a reduction in energy consumption, where reduced carbon emissions are a top priority that realize financial gains and maintain environmental sustainability [20–22]. Similarly, corporations can maximize new business prospects and boost long-term investment while monetizing carbon risks, realizing superior environmental and financial performance, and gaining a more competitive edge [23–26]. Companies could gain an advantage over their competitors by expanding their existing sustainability initiatives into areas that are fundamental to their business models, which encourages companies to make more investments to mitigate carbon emissions, thus improving their image, which leads to more profits in the long term. Although carbon emission reduction will help to mitigate climate change, it is unclear how this will impact business operations [19,27,28].

Despite the intense research over the past 25 years, the relationship between a firm's environmental and financial performances remains a subject of interest and debate. The results of studies on the association between corporate environmental performance and corporate financial performance are mixed [23,29,30]. Some argue that environmentally responsible companies are challenged by increased costs and financial incumbrance, which decreases profits and their overall corporate value [31]. However, it has been argued that positive financial gains from voluntary efforts can improve environmental performance [32]. Similarly, companies can enhance their economic performance by pursuing more environmental opportunities [33,34]. Stakeholder theory has been used to highlight differences in firm performance concerning environmental challenges. More involvement in corporate social responsibility activities increases customer trust, which means companies that release lower carbon emissions are seen more favorably by customers and thus have higher performance. This reveals that, following the stakeholder theory, carbon emissions might be negatively associated with firm performance.

The objective of this study was to empirically test the relationship between carbon emissions and firm performance using a sample consisting of 1382 companies. These companies belong to emerging markets in 25 countries and provided information on their carbon emissions from 2008 to 2021. The sample consists of 19199 firm-year observations. Methodologically, the variation in carbon performance is a proxy for CO_2 equivalent emissions. The data used to represent carbon emissions were obtained from DataStream. A company's performance included accounting-based performance (ROA and ROE) and market-based performance (Tobin's Q and MTBV).

Much of the literature on carbon performance is inconsistent and has research gaps. This study contributes to the literature in various ways. First, this study addresses the lack of a comprehensive understanding of the practical aspects of carbon performance, governance systems, and financial implications for emerging nations at the company level. This study used a new methodology to mitigate the heterogeneity of the results by using a sample of the MSCI emerging market index. Second, unlike other studies, this study exploited a novel econometrics model, quantile regression. This quantile regression technique provides a more complete picture of the underlying relationship between the explained variable and the regressors than linear regression. Third, this study scrutinized the relationship between gender diversity and financial performance by distinguishing

between executive and non-executive female board members. Fourth, an interaction relationship was identified between carbon emissions and executive gender diversity and their impacts on financial performance. Furthermore, this study demonstrated another interaction between carbon emissions and non-executive female board members and their effects on financial performance.

Our study shows that carbon emissions negatively affect small-size companies of both high- and low-performing firms; however, as the size of companies increases, the effect of carbon emissions on performance becomes negative, regardless of whether the companies are high- or low-performing. The presence of females on boards has a minimally significant negative effect on firms' performance, both conditional and unconditional on size.

The remainder of this paper is organized as follows: The theoretical background and hypotheses development are explained in Section 2. The data and techniques are described in Section 3. Sections 4 and 5 present the empirical findings, and Section 6 provides the conclusions and recommendations for this study.

2. Theoretical Background and Hypotheses Development

Companies are concerned about the consumption and usage of water, energy, and biodiversity regarding environmental challenges, particularly climate change [9,10,35]. Thus, climate change has gained strategic prominence, where carbon performance is one of the most pertinent and non-financial pieces of information gathered by stakeholders [11]. Climate change and carbon management are becoming crucial components of business corporate sustainability, which is subject to pressure from regulators and stakeholders [12,13]. This has led to the world action endorsed by the Kyoto Protocol, urging many countries to positively respond to initiatives supported by national and industrial schemes. Therefore, greenhouse gas (GHG) reduction has become a top priority for many countries.

The impact of carbon emissions on a company's financial performance is ambiguous because climate change is a complex system, and the understanding and analysis of its repercussions are insufficient [36,37]. Previous studies have tested the association between corporate environmental performance and profit- or market-based performance [29,38–40], obtaining mixed results, with some finding a partially or completely negative association between environmental performance and financial performance [41,42], while others posit a positive relationship [43–46] or show no significant relationship between environmental and financial performance [47]. Despite the abundance of research in the field, more solid information is needed before we can confirm this link [29,39]. This paper utilized a novel methodology to scrutinize the association between carbon emissions and financial performance [48].

The stakeholder theory has been used to demonstrate the variances in a company's performance regarding environmental issues [49]. Stakeholders tend to retain relationships with firms that better meet their expectations. For instance, customers' trust is enhanced by increased incorporation into corporate social responsibility activities [50,51]; responsible customers pay premium prices for sustainable products [52]; companies that are more cautious regarding the environment and society are more favorable to their employees [38]; responsible firms may have less legislative and financial pressures [53]; and financial investors are more attracted to sustainable companies [54]. Based on the stakeholder theory, diverse environmental problems affect financial performance differently, thus leading to mixed results. Accordingly, this study exploited a single environmental outcome: carbon emissions [55]. The resource-based view theory posits that firms have heterogeneous mobile resources across their companies, and these resources guide the strategic choices of those companies. Moreover, this theory determines a company's competitive edge by linking its internal resources with its profits. This study also employed this theory since board diversity is a valuable resource to a company that can impact its environmental actions and strategies, which enable the company to have a higher marginal economic value than its competitors [56]. Thus, this resource can be considered a sustainable competitive advantage to firms that leads to better performance in the short term [57]. Previous studies

have used this theory to demonstrate that unique resources enable companies to exploit environmental strategies that provide competitive advantages [32,58].

Although recent contributions to the literature have started to clarify the effect of carbon emissions on financial performance, the research is still relatively undeveloped compared with other outcomes or environmental performance in general [24,55,59,60]. Many academics have challenged the prevalent linearity assumption in their studies on the association between environmental and financial performance [61–63]. Regarding carbon emissions, previous studies on Japanese industrial companies demonstrated a U-shaped relationship [46,59,64]. However, these studies did not consider the interactions between financial performance and female inclusion on boards and carbon emissions or the interactions between financial performance and board size and carbon emissions.

Carbon emissions and global warming have recently risen to the top of the corporate environmental performance agenda. Since the Kyoto Protocol's implementation in February 2005, several nations and many firms have made initiatives to reduce GHG emissions to improve their environmental performance. Therefore, creating corporate environmental plans to execute carbon emissions reduction may be crucial for a company's carbon emissions performance and financial performance [24,65]. This discussion has generated a debate over whether pollution is a resource waste and whether eliminating pollution may boost productivity by reusing these lost resources [66]. Consequently, considerable academic attention has been directed toward testing the association between carbon emissions and financial performance. According to research conducted on 362 companies between 2003 and 2010, the market consistently penalizes businesses with poor environmental performance more than those with strong performance. Furthermore, a company's performance is not limited by international environmental agreements [67]. According to a study conducted on Indian companies covering the period from 2013 to 2019, carbon emissions adversely impact both accounting- and marketing-based financial performance. Moreover, environmentally sensitive firms are more exposed to the negative effects of carbon emissions than non-sensitive companies [68]. Similarly, another study conducted on 2323 US firms from 2007 to 2016 showed that companies with higher carbon emissions have lower performance [69], while a different study conducted on 89 international companies between 2006 and 2009 revealed a positive association between carbon emissions and return on equity (ROE) but no relationship with return on assets (ROA) [70].

Another study demonstrated that a carbon emissions reduction increases a firm's competitiveness, and thus its competitive advantage [10,71]. Similarly, a positive relationship between a firm's financial performance and carbon emissions was revealed in [72]. Meanwhile, another study found no unanimity between emissions reduction and financial performance, based on a study of the S&P 500 between 1989 and 1992 [44]. Furthermore, an adverse relationship between the quality of coal emissions and corporate performance was shown in [55,73].

However, whether corporations in sensitive industry areas can become socially responsible remains unanswered. Sensitive economic sectors, which include insightful industries, such as tobacco, gambling, alcohol, and adult entertainment, are frequently marked by societal taboos, moral conflicts, and political pressure [74]. The impact of board characteristics on firms' performance in sensitive and non-sensitive industries in a sample of companies in India (the National Stock Exchange of India (NSE) 500) from 2015 to 2020 was investigated, claiming that board independence, board gender diversity, and CEO duality have no significant impact on the environmental performance of both sensitive and non-sensitive industries [75]. Another study conducted in BRICS countries covering the period from 2010 to 2012, which analyzed ESG performance in sensitive industries, showed that companies in sensitive industries present superior environmental performance [76]. Furthermore, it is claimed that carbon-efficient companies demonstrate superior performance. Consequently, firms tend to disclose higher carbon emissions if these firms are more sensitive to carbon pollution in their operations [77]. (Environmentally sensitive industries include the basic materials, energy, industrial, and utilities sectors; socially sensitive industries include the

consumer discretionary, consumer staples, financial, and telecommunications sectors; and non-sensitive industries include the real estate, technology, and healthcare sectors.)

Based on the foregoing, the following hypotheses were developed.

H1. *Carbon emissions have a negative unconditional effect on firm performance and a positive effect conditional on firm size.*

The majority of the earlier research on gender diversity was economics-related, exploring the potential linkages between the presence of females on boards of directors and financial performance [78]. Such studies yielded mixed results, e.g., a Norwegian study found that the mandatory quotas of 40% female representation on boards led to an adverse relationship between gender diversity and financial performance [79,80]. Similarly, mandatory gender board quotas in another Norwegian firm led to reduced short-term profits [78]. On the contrary, another study advocated for balance on a board by demonstrating a positive association between gender diversity and financial performance in a sample of Spanish firms [78]. Other studies showed a positive association between women directors on boards and ecological and societal performance [40] as well as environmental performance [81]. Another study showed that female board representation positively impacts sustainability performance, demonstrating that companies with female board members have superior sustainability performance [82].

Based on the above, the following hypotheses were developed.

H2a. *Executive females on boards have a negative effect on firm performance, and this effect remains the same regardless of a firm's size.*

H2b. *Non-executive females on boards have a positive effect on firm performance, and this effect remains the same regardless of a firm's size.*

3. Data and Methodology

3.1. Sample and Data Collection

This study comprised a sample of 1382 companies listed in the MSCI Emerging Markets Index covering a period of 14 years (2008–2021) with a total of 19,199 firm-year observations. There is little literature on the relationship between carbon emissions and firm performance in developing and emerging markets rather than in developed countries; thus, this study selected the MSCI Emerging Markets Index, which included 25 emerging companies. The sample incorporated countries in America (Brazil, Chili, Colombia, Mexico, and Peru); Europe (the Czech Republic, Greece, Hungary, Poland, Russia, and Turkey); the Middle East and Africa (Egypt, South Africa, Qatar, Saudi Arabia, and the United Arab Emirates); and Asia (China, Hong Kong, India, Indonesia, Korea, Malaysia, Pakistan, the Philippines, Taiwan, and Thailand).

The sample was categorized into 11 industries according to the DataStream Industry Classification, which encompasses basic materials, consumer discretionary, consumer staples, energy, finance, healthcare, industry, real estate, technology, telecommunications, and utilities. Furthermore, the sample firms were additionally classified as operating in environmentally sensitive industries, which included basic materials, energy, industry, and utilities; socially sensitive industries, which included consumer discretionary, consumer staples, finance, and telecommunications; and non-sensitive industries, which included healthcare, real estate, and technology. Steel, cement, and chemicals are the top three emitting industries and among the most difficult to decarbonize due to technical factors, such as the need for very high heat and processing carbon dioxide emissions, as well as economic factors, such as low profit margins, capital intensity, a long asset life, and trade exposure.

We constructed our data by combining and matching several databases. Carbon performance was measured using CO_2 equivalent emissions as a sub-index of the emissions index collected from Refinitiv (Thomson Reuters). In addition, we collected and gathered

all firm performance and firm-specific variables from Thomson Reuters DataStream. Finally, all data related to board structure were collected from the BoardEx database.

3.2. Measurement of Variables

Table 1 shows the measured variables used in this study. Panel (A) represents the dependent variables, which consist of accounting-based performance (ROA and ROE) and market-based performance (Tobin's Q and MTBV). Panel (B) represents the independent variables, which include three groups: carbon performance, board composition, and firm-specific determinants. The first group denotes one of the independent variables as sustainability performance, depicted in CO_2 equivalent emissions. The second group consists of board size, board independence, executive females on the board, non-executive females on the board, and CEO duality. The third group includes firm-specific determinants, namely, firm size and leverage.

Table 1. Measurement of variables.

Panel A: Dependent Variables			
Firm Performance Variables			
Variables	**Definition**	**Measurement**	**Source**
ROA	Return on Asset	Percent	Datastream
ROE	Return on Equity	Percent	Datastream
Tobin's Q	Market-based Performance	Percent	Datastream
MTBV	Market to Book Value	Percent	Datastream
Panel B: Independent variables			
Carbon performance variable			
CO_2		CO_2 equivalent emission	Datastream
Board composition variables			
BSize	Board size	Number of board members	BoardEX
F-ED	Executive Females on the Board	Number of executive females on the board	BoardEX
F-NED	Non-Executive Females on the Board	Number of non-executive females on the board	BoardEX
BInd	Board Independence	Number of independent directors on the board/total board size	BoardEX
CEODualty	CEO Duality	If CEO serves as the chairman of the board = 1; if not = 0	BoardEX
Firm specific determinants			
FSize	Firm Size	Natural Log of Total Assets	Datastream
Lev	Leverage	Total debt/Total assets	Datastream

4. Methodology

In our methodology, we use the quantile regression approach to model the effect of green policy on firm returns in different quantiles. The linear regression technique provides the average effect of the independent variables on the dependent variable. Using the average may hide important features of the underlying relationship, as the explanatory variables may have different effects in different parts of the distribution of the explained variable. Quantile regression provides a more complete picture of the underlying relationship between the explanatory variable and the regressors. The technique is flexible and rich in that it can cover the heterogeneity of the effect of a given explanatory variable for the bottom 10% of firms with low performance versus the top 10% of firms with high performance versus median-performance firms.

The quantile regression model, introduced in [83], can be written as:

$$y_i = \beta'_\alpha X_i + \varepsilon_{\alpha,i} \quad (1)$$

where y is a continuous dependent variable, X is the vector of explanatory variables, β is the vector of parameters, and ε is the error term. We define the conditional α quantile of y given the set of covariates X as $Q(\alpha)$ using

$$Qy/X\,(\alpha) = \beta'_\alpha X_i \quad (2)$$

where α is a proportion (probability) between zero and one.

The α conditional quantile solves the following problem:

$$\min_{\beta_\alpha} \frac{1}{n} \sum_{i=1}^{n} \rho_\alpha(\varepsilon_{\alpha,i}) \quad (3)$$

where ρ_α is the check function and is given using

$$\rho_\alpha(\varepsilon_{\alpha,i}) = \begin{cases} (\alpha-1)\varepsilon_{\alpha,i} & if\ \varepsilon_{\alpha,i} < 0 \\ \alpha\varepsilon_{\alpha,i} & Otherwise \end{cases}$$

Equation (3) becomes

$$\min_{\beta_\alpha} \frac{1}{n} \left[\sum_{i=1,\varepsilon_{i,\alpha}>0}^{n} \alpha|\varepsilon_{\alpha,i}| + \sum_{i=1,\varepsilon_{i,\alpha}<0}^{n} (1-\alpha)|\varepsilon_{\alpha,i}| \right]$$
$$= \min_{\beta_\alpha} \frac{1}{n} \left[\sum_{i=1,\varepsilon_{i,\alpha}>0}^{n} \alpha|y_i - \beta'_\alpha X_i| + \sum_{i=1,\varepsilon_{i,\alpha}<0}^{n} (1-\alpha)|y_i - \beta'_\alpha X_i| \right]$$

In addition, it can be rewritten as

$$\min_{\beta_\alpha} \frac{1}{n} \left[\sum_{i=1}^{n} \alpha(y_i - \beta'_\alpha X_i)(1 - I_{y_i < \beta'_\alpha X_i}) + \sum_{i=1}^{n} (1-\alpha)(y_i - \beta'_\alpha X_i) I_{y_i < \beta'_\alpha X_i} \right]$$

where $I_{y_i < \beta'_\alpha X_i}$ is an indicator function equal to one if $y_i < \beta'_\alpha X_i$ and is zero otherwise.

The entire conditional distribution of y is covered by increasing α continuously from 0 to 1 [84,85] (for a survey on quantile regression, see Buchinsky (1998) [52] and Koenker and Hallock (2001) [83], as well as the Special Issue of *Empirical Economics* (Vol. 26 (3), 2001)). The minimization problem can be solved as a linear programming problem [86] using quantile regression to study the relationship between innovation and market value.

5. Descriptive Statistics

All variables' descriptive statistics are shown in Table 2. The descriptive analysis includes the minimum, maximum, and mean as measures of central tendency, and, finally, the standard deviation as a measure of dispersion. As the table shows, the mean for carbon emissions is 5.974, the median is 0.393, and the standard deviation is 21.39. The executive females have a mean and standard deviation of 0.05 and 0.125, respectively. However, the non-executive females have a mean of 0.131 and a standard deviation of 0.134. The mean and standard deviation for the board size are 11.11 and 3.29, respectively. Moreover, the means are 0.122 and 0.281 for CEO duality and board independence, while their standard deviations are 0.11 and 0.152.

Table 2. Descriptive Statistics.

	Mean	Median	Maximum	Minimum	Std. Dev.
ROA	7.0872	5.73	63.98	−52.45	7.501
ROE	13.3866	13.4300	150.2400	−1444.4700	38.9096
Tobin's Q	0.0014	0.0007	0.0307	0.0000	0.0021
MTBV	2.9308	1.8400	122.7100	−4.2200	4.7351
CO_2	5.9742	0.3932	255.1613	0.0000	21.3897
Lev	0.2282	0.2110	0.8938	0.0000	0.1646
size	16.2762	16.1736	21.0876	12.1476	1.4236
F-ED	0.0510	0.0000	0.6670	0.0000	0.1248
F-NED	0.1307	0.1110	0.7500	0.0000	0.1338
Bsize	11.1051	11.0000	24.0000	3.0000	3.2898
CEOduality	0.0121	0.0000	1.0000	0.0000	0.1093
Bind	0.2806	0.2500	0.8750	0.0455	0.1521

6. Results

Table 3 (Panels A–D) shows the estimated quantile models of factors affecting firms' performance, as measured using the ROA (Panel A), ROE (Panel B), Tobin's Q (Panel C), and MTBV (Panel D). All these models are significant at a 1% level according to the likelihood ratio test. The obtained results reveal that CO_2 emissions have a negative effect across all performance measures, which is consistent with previous studies [41,69]. However, this effect reverts as the size of the firm increases, which is revealed by the interaction effect coefficient ($CO_2 \times$ Size). We also noticed that as the performance increases, the effect of CO_2 becomes stronger. For example, the unconditional marginal effect changes from −0.0819 for the bottom 10% of firms (low-performing) to −0.4270 for the top 10% of firms (high-performing), as shown in columns 2 and 6 of Panel A in Table 3. This result is consistent across all performance measures (columns 2 and 6 of Panel B–D in Table 3). The size effect offsets this negative effect that is highlighted in Figure 1. The graph presents the marginal effect of CO_2 emissions conditional on size. The table shows that as the size increases, the CO_2 emissions increase the performance. In other words, carbon emissions have a negative effect for small-size high- and low-performing companies; however, as the size of companies increases, the effect of carbon emissions on performance becomes negative regardless of whether the companies are high- or low-performing. For high-performing companies, as size increases, carbon emissions and performance increase. This could be because the companies produce more, and their performance increases regardless of the carbon emissions released. These companies are not concerned with the environment as long as they are making profits. Moreover, they are willing to pay taxes or fines for carbon emissions rather than make investments to reduce carbon emissions.

Table 3. Quantile regression.

Panel A: ROA					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	11.1806 ***	30.7601 ***	43.6740 ***	55.3616 ***	63.7192 ***
CO_2	−0.0819	−0.2847	−0.4976 ***	−0.6501 ***	−0.4270 ***
$CO_2 \times$ Size	0.0057	0.017	0.0295 ***	0.0390 ***	0.0254 ***
Leverage	−2.8730 ***	−3.7423 ***	−5.2598 ***	−9.6495 ***	−16.8862 ***
size	−0.5896 ***	−1.6759 ***	−2.2721 ***	−2.7292 ***	−2.8428 ***
F-ED	−0.6219	−0.8982	−2.3647 ***	−3.9943 ***	−2.2206
F-NED	0.5957	0.1384	0.9353	2.4234 *	6.4056 ***
BSize	0.0138	0.0582 **	0.0448	−0.0154	−0.0603
CEOduality	−2.0904	−0.5787	0.1156	0.6612	2.6092 *
BInd	1.1436	2.3243 ***	1.7594 ***	3.3126 ***	0.8207
$CO_2 \times$ F-ED	0.0242	0.0225	0.0232	0.0089	−0.0186
$CO_2 \times$ F-NED	−0.0213	−0.0212	−0.017	−0.1252 **	−0.0999

Table 3. *Cont.*

Panel B: ROE					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	1.829	24.2707 ***	40.8281 ***	73.1981 ***	96.5910 ***
CO_2	−0.5838 *	−0.8899 **	−1.2130 ***	−0.9649 *	−0.8083 ***
CO_2 × Size	0.0335 *	0.0509 **	0.0688 ***	0.0552 *	0.0454 ***
Leverage	−23.1555 ***	−14.9695 ***	−10.2500 ***	−9.3570 ***	−16.6178 ***
size	0.2959	−0.9412 ***	−1.7213 ***	−3.1305 ***	−3.9668 ***
F-ED	0.3185	−1.4816	−0.3586	3.6384	12.3801 **
F-NED	−3.9866	2.2281	2.2967	2.7072	7.8174
BSize	0.1135	0.1804 **	0.2386 ***	0.0899	−0.0421
CEOduality	−6.7239	−0.8306	2.0292	4.2725	48.9577 ***
BInd	0.0386	1.9475	2.8582 **	−1.4437	−4.3790 *
CO_2 × F-ED	0.1156	0.0228	0.0128	−0.0992 **	−0.2155 ***
CO_2 × F-NED	0.1191	0.0078	−0.0089	−0.0865	−0.0413
Panel C: Tobin's Q (MV/TA)					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	0.0032 ***	0.0055 ***	0.0086 ***	0.0120 ***	0.0163 ***
$CO_2 \times 10^{-6}$	−26.900	−53.6 ***	−113 ***	−177 ***	−156 ***
CO_2 × Size $\times 10^{-6}$	1.6300	3.21 ***	6.73 ***	10.4 ***	9.03 ***
Leverage	−0.0004 ***	−0.0008 ***	−0.0016 ***	−0.0027 ***	−0.0041 ***
size	−0.0002 ***	−0.0003 ***	−0.0004 ***	−0.0006 ***	−0.0008 ***
F-EDs	−0.0002 **	−0.0002 **	−0.0002	−0.0007 ***	−0.0004
F-NED	0.0002 **	0.0004 ***	0.0004 **	0.0010 ***	0.0012 **
Bsize $\times 10^{-6}$	4.000 *	2.000	−4	−0.0.0	268
CEOduality $\times 10^{-6}$	2	0	−252	487 **	1876 **
Bind $\times 10^{-6}$	1.0 **	7	−3.0 **	−172	−665 *
CO_2 × F-ED $\times 10^{-6}$	2.0 *	4.0 *	1	6.0 **	0.1
CO_2 × F-NED $\times 10^{-6}$	−7.0 ***	−12 ***	−17 **	−22 **	−10.0000
Panel D: MTBV					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	3.9450 ***	7.1444 ***	12.8069 ***	20.1209 ***	26.3970 ***
CO_2	−0.0797 **	−0.1382 ***	−0.2456 ***	−0.2611 ***	−0.2080 ***
CO_2 × Size	0.0044 **	0.0078 ***	0.0139 ***	0.0151 ***	0.0119 ***
Leverage	−0.7861 ***	−1.0806 ***	−1.1289 ***	−2.4824 ***	−3.4910 ***
size	−0.1733 ***	−0.3374 ***	−0.6313 ***	−0.9777 ***	−1.2470 ***
F-ED	−0.3238	−0.3875	−0.0866	0.5937	1.2934
F-NED	0.0638	0.7178 ***	1.2827 ***	1.8512 ***	2.9350 ***
BSize	0.0059	0.011	0.0234 **	0.0059	−0.0209
CEOduality	0.0787	−0.102	0.2593	1.2729 ***	12.7029 ***
BInd	−0.4555 ***	−0.7864 ***	−1.2923 ***	−1.3140 ***	−1.8296 ***
CO_2 × F-ED	0.0014	0.0091	0.0052	−0.0203 **	−0.0248 ***
CO_2 × F-NED	0.005	−0.0133 **	−0.0260 *	−0.0235	−0.0182

Note: *** means statistically significant at 1%, ** means statistically significant at 5%, and * means statistically significant at 10%.

Table 3 shows that CO_2 emissions have a weak effect on financial performance conditional on gender. However, the results of the interactions between CO_2 emissions and executive and non-executive females on boards are mixed across quantiles and different performance measures. More precisely, Figure 2 exhibits a negative effect of CO_2 on ROE as accounting-based performance and MTBV as market-based performance for 25% and 10% of performing firms conditional on executive female board members. Meanwhile, Figure 3 highlights the mixed effect of CO_2 on firm performance conditional on non-executive female board members. For example, CO_2 has no effect on ROE conditional on non-executive female board members at any significance level in all quantiles. In contrast, the effect on Tobin's Q is significant at a 5% level except for the top 10% of firms with high performance.

We conclude that the existence of females on boards generates conflicting results vis-á-vis the effect of CO_2 emissions on financial performance.

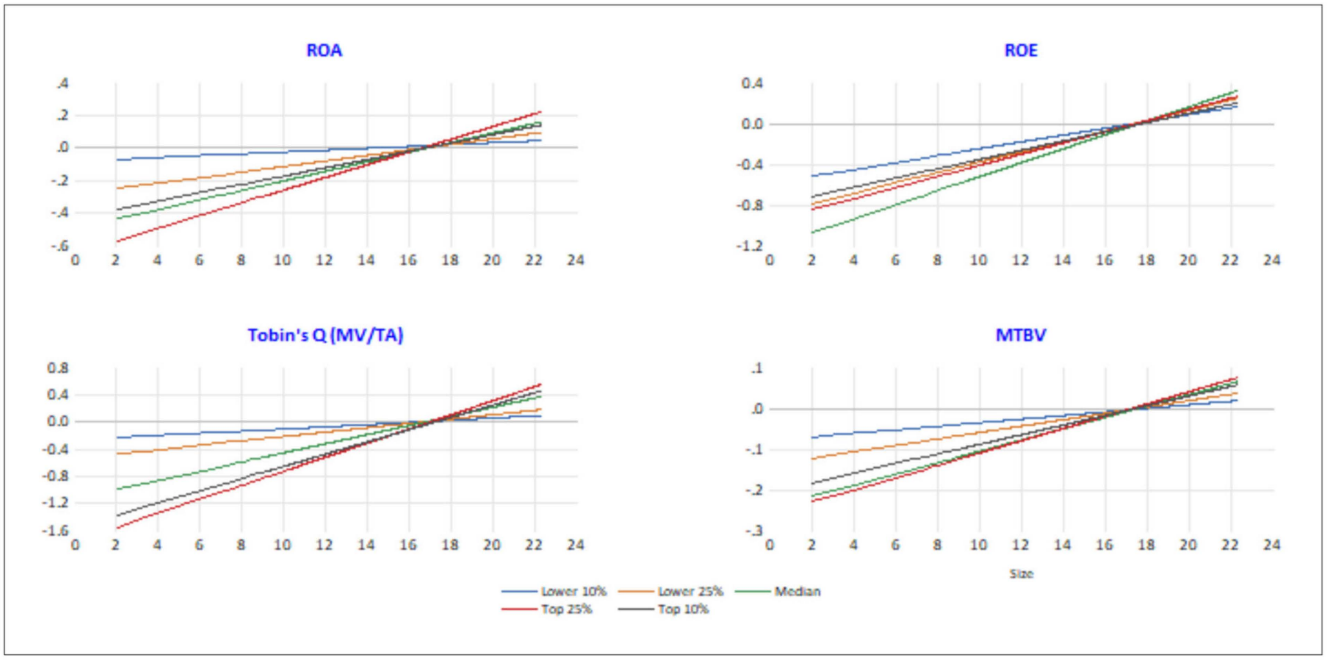

Figure 1. CO_2 emission effect conditional on size.

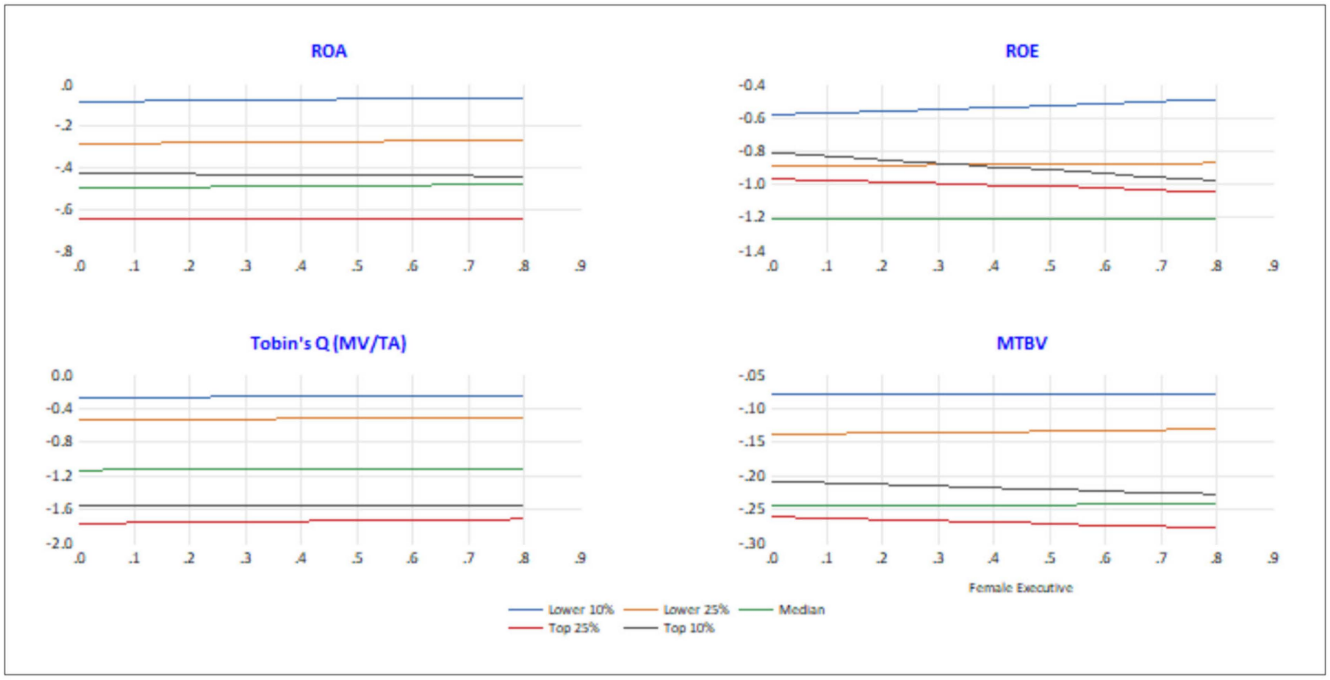

Figure 2. CO_2 emission effect conditional on gender: female executive.

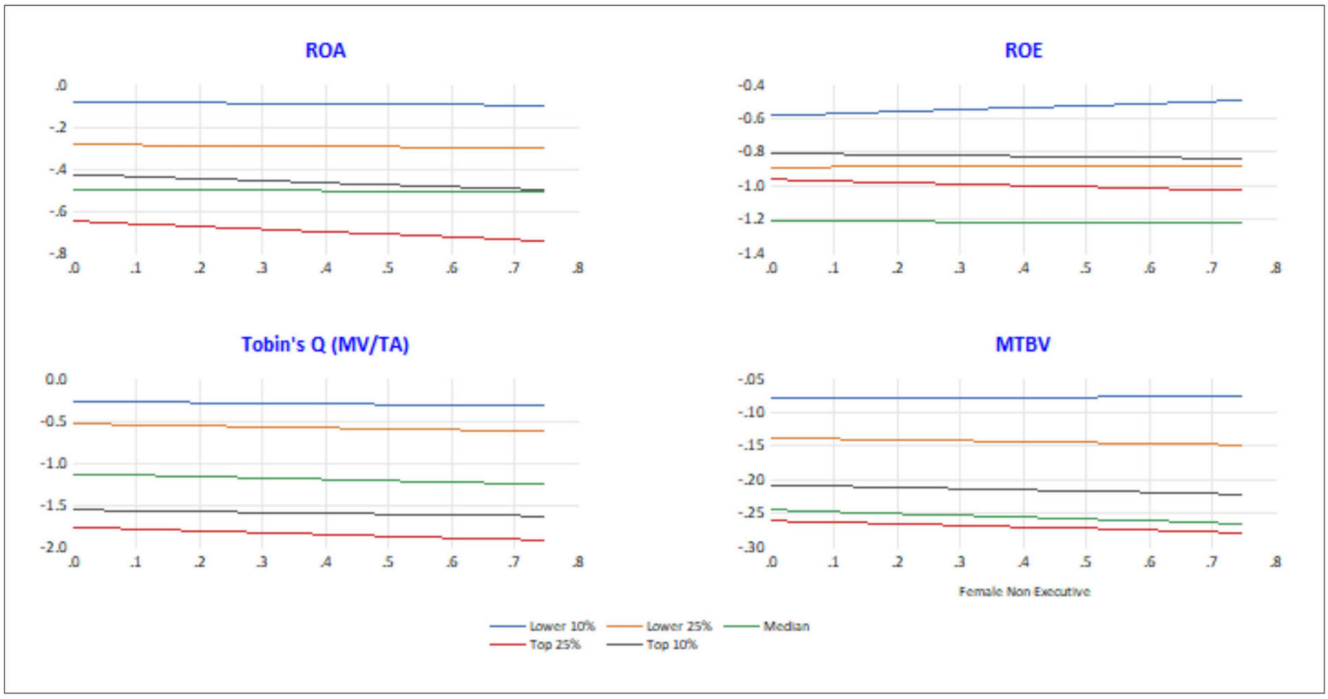

Figure 3. CO_2 emission effect conditional on gender: female non-executive.

7. Further Analysis

This study examined the association between carbon emissions and financial performance in various quantiles conditional on size in different environmental, socially sensitive, and non-sensitive industries. Tables 4–6 list the coefficients of the quantile regression analysis and results. In the case of environmentally sensitive industries, the impact of carbon emissions on ROA is significant for the top 25% of performing companies, while ROE is significant in all quantiles except for the lower 10% of performing companies, as per Tobin's Q, which is significant in all quantiles except for the lower 25% of performing companies, and for MTBV, all quantiles are significant except for the lower 10% and 25% of performing companies. This reveals that carbon emissions have an insignificant impact on the performance of smaller companies compared with larger companies. These results are further illustrated in Figure 4, which shows that there is a positive relationship between carbon emissions and financial performance in larger companies, while there is an adverse relationship between carbon emissions and financial performance in small- and medium-sized companies. The quantile regression results for socially intensive industries are shown in Table 5, where the relationship between carbon emissions and ROA is significant in all quantiles except the lowest and highest 10% of performing companies. However, carbon emissions have an insignificant association with ROE in all quantiles. Similarly, MTBV is insignificant in all quantiles except for the medium-performing companies. These results are further depicted in Figure 5, which demonstrates that carbon emissions do not affect all quantiles' performance in socially sensitive industries. In Table 6, the results of the quantile regression for non-sensitive industries are shown. The results indicate that carbon emissions are significantly associated with ROA in all quantiles except the highest 10% and 25% of performing companies. Meanwhile, the association between carbon emissions and ROE is insignificant except for the lower 25% of performing companies, and the relationships of Tobin's Q and MTBV with carbon emissions are significant in all quantiles. Figure 6 clarifies that in non-sensitive industries, carbon emissions have a lower impact on the financial performance of top-performing companies than on lower-performing companies.

Table 4. Quantile regression (environmentally sensitive).

Panel A: ROA					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	3.7903	19.3478 ***	27.5620 ***	40.1113 ***	53.9878 ***
CO_2	0.0487	−0.1725	−0.1042	−0.3611 *	−0.171
CO_2 × Size	−0.002	0.0104	0.0068	0.0215 *	0.0105
Leverage	−2.2893	−5.3936 ***	−6.8536 ***	−10.2707 ***	−13.0734 ***
size	−0.2409	−1.0053 ***	−1.3457 ***	−1.7786 ***	−2.3333 ***
F-ED	−0.8559	−4.4292 *	−2.5112 *	−5.8624 ***	−4.2144
F-NED	−2.402	0.3611	2.8366 **	2.7365 *	4.6757
BSize	0.1176	0.1054	0.1395 ***	0.0333	−0.0857
CEOduality	−2.9802	0.325	−0.1357	−2.1832	38.7911 ***
BInd	2.8111	3.8239 ***	1.9650 **	0.6716	0.7899
CO_2 × F-ED	0.022	0.0423	0.0136	0.0471	−0.0023
CO_2 × F-NED	−0.0038	−0.0106	−0.0540 *	−0.0744	−0.0917
Panel B: ROE					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	−5.2689	24.8116 **	41.1307 ***	53.5075 ***	107.2048 ***
CO_2	0.0891	−0.8608 **	−0.8355 ***	−0.9920 **	−1.3700 ***
CO_2 × Size	−0.0039	0.0496 **	0.0479 ***	0.0569 **	0.0796 ***
Leverage	−25.3726 ***	−11.7381 ***	−7.6792 ***	−4.9573 *	−12.8394 ***
size	0.3213	−1.3052 **	−2.0123 ***	−2.3050 ***	−5.0437 ***
F-ED	−7.5978	−12.1092 ***	−10.6656 ***	−12.9063 ***	−3.5147
F-NED	−1.6892	−1.1095	0.2014	2.4737	14.9081 *
BSize	0.2209	0.3248	0.3790 ***	0.1275	0.0978
CEOduality	−3.6733	0.4328	2.0966	9.4474 **	114.3006 ***
BInd	14.5736 **	9.9971 ***	7.7541 ***	5.7070 **	2.2
CO_2 × F-ED	0.1982	0.1275 *	0.0659	0.0829	−0.0743
CO_2 × F-NED	−0.1277	0.0435	−0.0418	−0.0912	−0.2295 *

Note: *** means statistically significant at 1%, ** means statistically significant at 5%, and * means statistically significant at 10%.

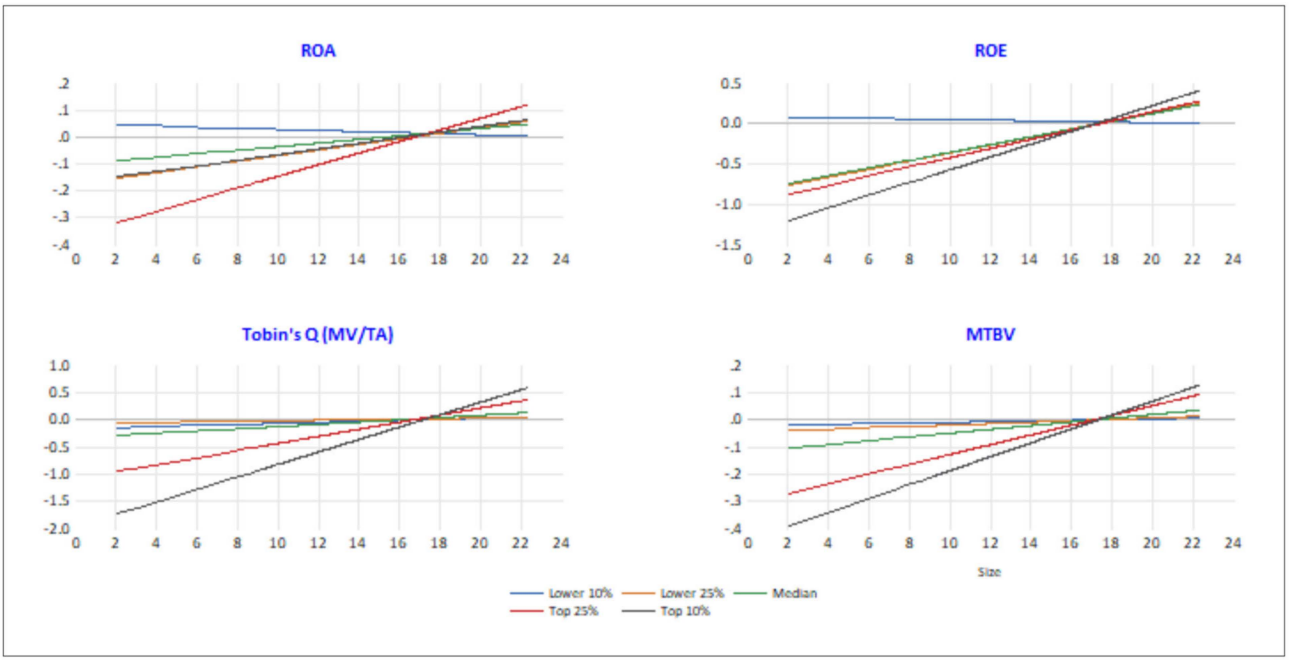

Figure 4. CO_2 emission effect conditional on size (environmentally sensitive).

Table 5. Quantile regression (socially sensitive).

Panel A: ROA					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	28.0732 ***	40.0116 ***	51.9418 ***	67.8889 ***	78.3941 ***
CO_2	−1.7965	−3.9367 ***	−8.0574 ***	−9.1248 ***	−3.7887
CO_2 × Size	0.1092	0.2188 ***	0.4666 ***	0.5255 ***	0.2154
Leverage	−6.0076	−3.8683 ***	−5.2835 ***	−9.9726 ***	−12.7000 ***
size	−1.4706 ***	−2.1215 ***	−2.6459 ***	−3.4531 ***	−3.7762 ***
F-ED	0.9315	2.9590 ***	1.6030 *	−0.2841	−3.2226 *
F-NED	−0.4928	−1.0561	−1.9364	−5.1201 ***	−0.5604
BSize	−0.0288	−0.0176	−0.0623	0.0367	−0.0903
CEOduality	−0.1749	−0.1884	0.1682	0.2539	0.8686
BInd	−0.6722	−0.9325	−0.4546	2.5441 *	1.3753
CO_2 × F-ED	−0.4419	−2.6526 ***	−4.8522 ***	−4.4858 ***	−2.324
CO_2 × F-NED	0.2212	3.0226 ***	4.7246 ***	5.5166 ***	2.2715
Panel B: ROE					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	24.4218 ***	43.6655 ***	74.3366 ***	93.4204 ***	114.4945 ***
CO_2	0.4986	−1.2957	1.6144	−2.7989	2.6414
CO_2 × Size	−0.0025	0.0139	−0.1452	0.1196	−0.1639
Leverage	−27.1158 ***	−13.6954 ***	−10.8069 ***	−7.7240 ***	−5.4171
size	−0.6909 *	−1.8368 ***	−3.2706 ***	−4.1508 ***	−5.0233 ***
F-ED	2.8114	5.2274 *	9.2356 ***	5.6184 **	10.2766 *
F-NED	2.979	2.8902	2.0507	−0.4333	16.5541 *
BSize	−0.1115	0.0219	−0.0915	0.0159	−0.1548
CEOduality	−0.5599	−0.3851	−0.1454	1.7208	48.2899 ***
BInd	−10.9254 **	−5.6962	−5.3355 *	−3.8149	−6.5717
CO_2 × F-ED	1.2776	−2.1758	−0.6644	−2.4558	−0.1985
CO_2 × F-NED	−2.2329	5.3092 ***	2.6121	4.3868	−1.5412
Panel C: Tobin's Q (MV/TA)					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	0.0047 ***	0.0072 ***	0.0095 ***	0.0139 ***	0.0198 ***
CO_2	−0.0001	−0.0002 **	−0.0007	−0.0013 ***	−0.0004
CO_2 x Size	0	0.0000 *	0	0.0001 ***	0
Leverage	−0.0004 ***	−0.0007 ***	−0.0014 ***	−0.0022 ***	−0.0033 ***
size	−0.0003 ***	−0.0004 ***	−0.0005 ***	−0.0007 ***	−0.0009 ***
F-ED	0	0	0	−0.0003	−0.0004
F-NED	0.0001	0.0001	0.0002	0.0002	−0.0007
BSize	0	0	0	−0.0000 *	−0.0001 ***
CEOduality	0	−0.0001	−0.0001	0.0002	0.0019 **
BInd	−0.0001	−0.0003 **	−0.0002	−0.0002	−0.0003
CO_2 × F-ED	−0.0001 **	−0.0002 ***	−0.0005 **	−0.0007 ***	−0.0004
CO_2 × F-NED	0.0002 **	0.0003 ***	0.0005 ***	0.0010 ***	0.0008
Panel D: MTBV					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	8.1539 ***	10.8873 ***	18.6653 ***	25.1119 ***	36.1468 ***
CO_2	0.511	−0.6905	−2.0579 ***	−1.2947	−1.7536
CO_2 × Size	−0.036	0.0358	0.1150 ***	0.0676	0.0807
Leverage	−1.0206 ***	−0.5692 **	−1.7470 ***	−3.1418 ***	−3.0198 ***
size	−0.3950 ***	−0.5405 ***	−0.9229 ***	−1.1958 ***	−1.6948 ***
F-ED	−0.1405	0.6096	1.4485 ***	1.6009 *	3.0691
F-NED	0.5426	1.2678 ***	0.8576	0.1979	0.0886
BSize	0.0094	0.0133	0.0004	−0.034	−0.1002 ***
CEOduality	0.0152	−0.2524	−0.2771	1.1689	12.7845 ***
BInd	−1.4224 ***	−1.6818 ***	−1.7178 ***	−1.5699 **	−1.8195 **
CO_2 × F-ED	−0.0091	−0.6738 ***	−1.5409 ***	−0.9522	−1.5641
CO_2 × F-NED	0.2096	0.7468 ***	1.5287 ***	1.2705	2.4973

Note: *** means statistically significant at 1%, ** means statistically significant at 5%, and * means statistically significant at 10%.

Table 6. Quantile regression (non-sensitive).

Panel A: ROA					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	9.4371	21.2610 ***	34.1383 ***	29.7324 ***	26.4003 **
CO_2	−9.5412 ***	−6.2718 ***	−4.8143 **	−1.6334	4.152
CO_2 × Size	0.5476 ***	0.3730 ***	0.2822 **	0.098	−0.2115
Leverage	1.0021	−1.0449	−13.9587 ***	−25.6635 ***	−35.8137 ***
size	−0.5653	−1.2073 ***	−1.5645 ***	−0.9502 **	−0.2148
F-ED	−2.0352	1.3728	−3.3923	1.2816	15.5406 **
F-NED	5.6524 **	3.4905	3.4322	7.6734 **	7.9826
BSize	0.1502	0.1986	0.1624	0.4263 **	0.4285 *
CEOduality	−116.3199 ***	−118.3996 ***	−0.4452	0.0161	−2.92
BInd	−0.6593	0.9638	−1.2251	−7.0519 **	−14.9565 ***
CO_2 × F-ED	3.5133	−0.1165	1.0936	−3.0999	−9.4665 *
CO_2 × F-NED	−2.3566 ***	−1.8676 **	−0.4818	0.5391	−1.5509
Panel B: ROE					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	−5.4729	12.008	8.0484	16.7388 **	44.1489 **
CO_2	−5.6144	−11.2122 **	−4.9872	−4.4692	−0.8345
CO_2 × Size	0.319	0.6110 **	0.2275	0.2105	−0.0037
Leverage	−31.3597 ***	−14.3261	−26.7314 ***	−31.4993 ***	−50.7418 ***
size	0.3792	−0.0774	0.871	0.4899	−0.3717
F-ED	3.2156	−1.9254	−12.4808	7.7328	4.4107
F-NED	1.1907	0.2087	−1.6803	4.9774	7.0525
BSize	0.1885	0.2422	0.0155	0.2769	0.0198
CEOduality	−554.8664 ***	−560.2661 ***	2.4103	6.5371	2.7115
BInd	10.5944	−3.3028	−0.6295	−4.244	−0.9495
CO_2 × F-ED	20.3624 ***	10.3468 *	21.5253	29.4666	18.1995
CO_2 × F-NED	−1.4051	−2.024	1.7617	0.4698	−0.8896
Panel C: Tobin's Q (MV/TA)					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	0.0033 ***	0.0063 ***	0.0088 ***	0.0118 ***	0.0087 **
CO_2	−0.0005 ***	−0.0008 ***	−0.0008 ***	−0.0010 ***	−0.0008 **
CO_2 × Size	0.0000 ***	0.0000 ***	0.0000 ***	0.0001 ***	0.0000 *
Leverage	−0.0005	−0.0008 **	−0.0032 ***	−0.0055 ***	−0.0062 ***
size	−0.0002 ***	−0.0003 ***	−0.0004 ***	−0.0005 ***	−0.0003
F-ED	0.0005	0.0010 *	−0.0001	−0.0015 *	−0.0019
F-NED	0.0002	0.0006	0.0020 ***	0.0014 **	0.0029
BSize	0	0	0	0	0.0001 ***
CEOduality	0.0004	0.0004	−0.0002	0.0004	−0.0006
BInd	0	0	−0.0003	−0.0010 *	−0.0021
CO_2 × F-ED	0	0	0.0003	0.0014	0.0073
CO_2 × F-NED	−0.0001	−0.0002	−0.0002	0.0005 **	0.0001
Panel D: MTBV					
	Quantile 10%	Quantile 25%	Quantile 50%	Quantile 75%	Quantile 90%
C	5.1438 ***	9.6092 ***	10.9605 ***	16.7205 ***	20.0400 ***
CO_2	−1.2859 ***	−1.4000 ***	−1.5177 ***	−1.7929 ***	−2.3673 ***
CO_2 × Size	0.0717 ***	0.0794 ***	0.0820 ***	0.0948 ***	0.1216 ***
Leverage	−0.0802	−0.7307	−3.0187 ***	−4.0929 ***	−5.8868 ***
size	−0.2476 **	−0.4861 ***	−0.4841 ***	−0.7196 ***	−0.8206 ***
F-ED	−0.6908	0.4896	−0.1404	1.4443	−0.7331
F-NED	0.439	0.4177	1.4009	2.6997 **	5.3273 **
BSize	−0.0219	−0.0291	0.0163	−0.0467	−0.0197
CEOduality	1.6733 ***	1.9150 ***	1.4639 **	1.2172	0.6804
BInd	0.0853	−0.0338	−1.1803 *	−1.7492 ***	−2.9295 **
CO_2 × F-ED	1.6578 **	1.2243	1.2785	2.9244	2.6512
CO_2 × F-NED	−0.1484	−0.1538	−0.3004	0.5542 *	0.1654

Note: *** means statistically significant at 1%, ** means statistically significant at 5%, and * means statistically significant at 10%.

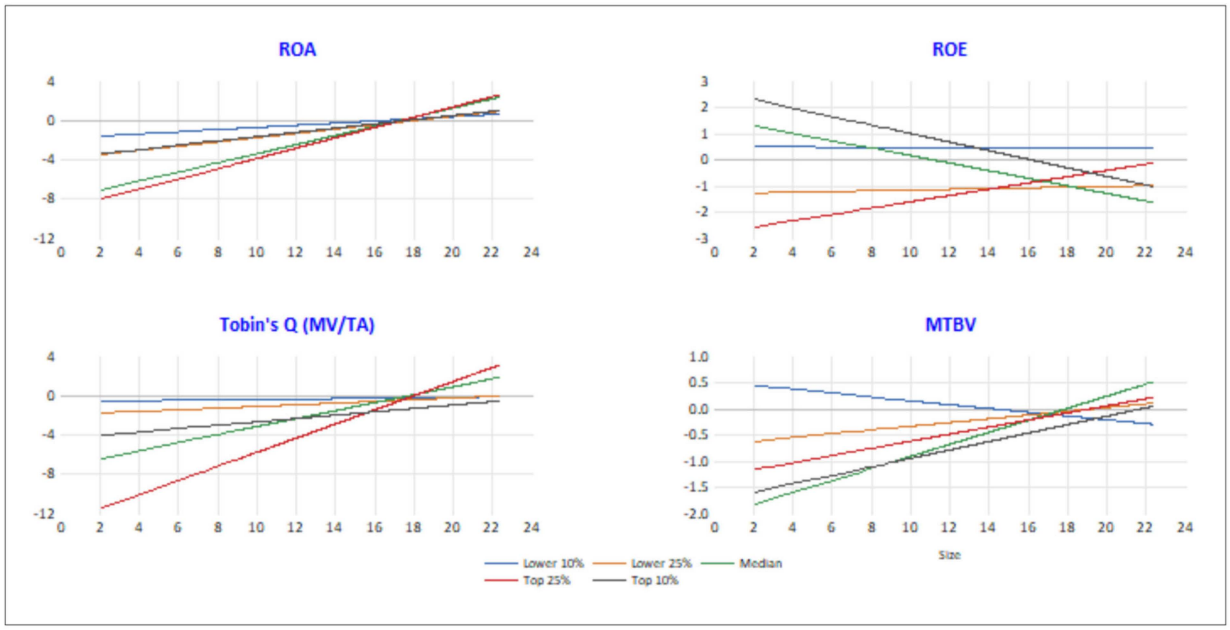

Figure 5. CO_2 emission effect conditional on size (socially sensitive).

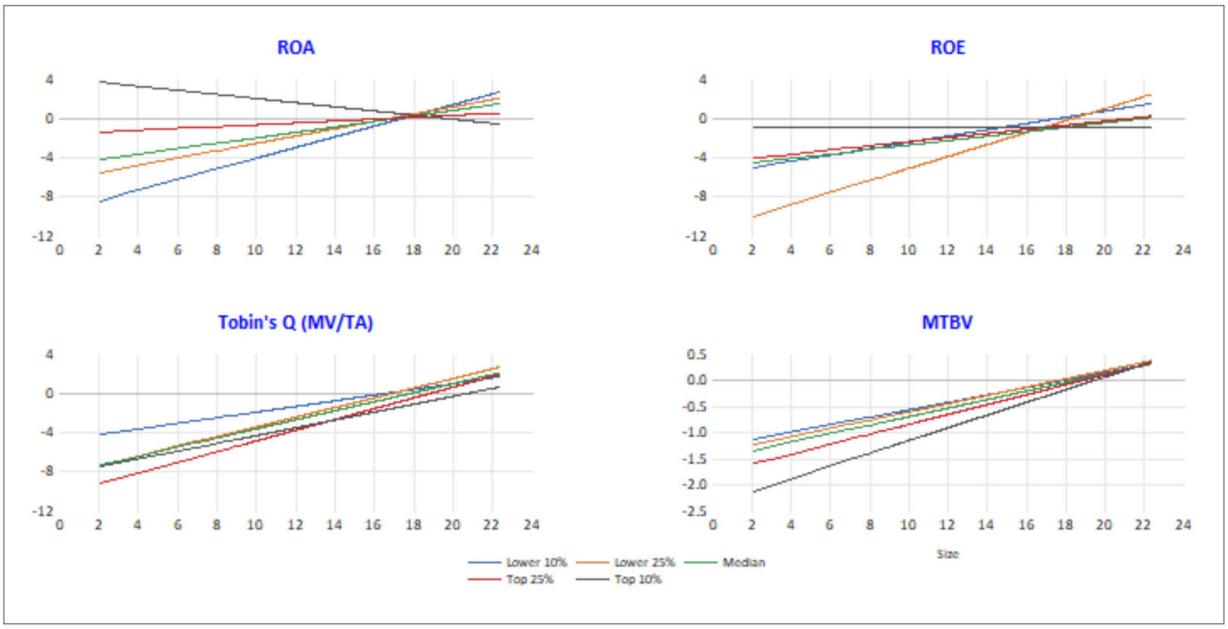

Figure 6. CO_2 emission effect conditional on size (non-sensitive).

As shown in the previous tables and Figures 4–6, our study found that gender diversity significantly impacts socially sensitive industries, such as consumer discretionary, consumer staples, finance, and telecommunications. As for environmentally sensitive industries, gender diversity significantly impacts top-performing companies. The results show the importance of the presence of females on company boards and, more specifically, in socially sensitive industries.

8. Conclusions

Many companies have taken environmental action to lessen the effects of climate change, where resources are allocated to environmental projects, which, in turn, enhances a firm's reputation and attracts more investors. Due to increased environmental production costs or acquiring a competitive advantage over other firms, these environmental policies

impact the financial performance of companies, boosting performance and enhancing their economic worth while achieving sustainability.

An imperative debate about the impact of carbon emissions on financial performance has recently arisen. Therefore, this study examined this relationship in various quantiles. Moreover, this study examined the interactions between carbon emissions and size and companies' financial performance as well as the interactions between carbon emissions and gender diversity and financial performance. Further analysis was conducted incorporating the sensitivity of industries to scrutinize these relationships in different quantiles of operating companies.

The majority of earlier studies that have examined the relationship between carbon emissions and financial performance employed traditional linear regression. However, in this paper, the quantile regression model was utilized to examine the impact of carbon emissions on accounting-based and marketing-based performance in a sample of 1382 companies listed in the MSCI Emerging Markets Index covering a period of 14 years (2008–2021), with a total of 19,199 firm-year observations at various company operation levels.

The empirical results show disparities between different operating levels. For small-size companies, there is an adverse relationship between carbon emissions and financial performance, whereas for larger-size companies, carbon emissions have a positive association with financial performance. As per the interaction impact of gender diversity on financial performance, this study revealed that there is no additional impact on financial performance, which reveals no heterogeneity conditional on gender. For a deeper analysis, it was shown that in larger companies in environmentally sensitive industries, there is a negative association between carbon emissions and financial performance. In non-sensitive industries, high-performing companies' financial performance is not affected by carbon emissions, while lower-operating companies' financial performance is more affected by carbon emissions.

These findings have significant implications for policymakers, managers, and investors. First, policymakers should consider adaptation to climate change and take mitigation actions to respond accordingly by implementing sound climate change policies. Climate change adaptation and mitigation policies necessitate the development and deployment of technology as well as funding. Government policymakers must design financial incentive schemes and incorporate effective guidance into their budgets to conduct effective climate change policies. Second, managers should address climate change concerns involving both technological development and financial commitment for businesses and corporate decision-makers. Although incorporating environmental sustainability into corporate decision making frequently imposes additional costs and constraints on manufacturing and production, such integration also opens up new business opportunities that, if properly exploited, can lead to improved financial and environmental performance. As for investors, firms with high carbon emissions are assigned worse credit ratings, indicating a higher risk of default. As a result, investors are expected to take the necessary measures before investing in such companies. Furthermore, when carbon emissions rise, companies' market value and profitability decrease. Therefore, investors should consider a company's carbon footprint while making investment decisions.

Theoretically, this study contributes to the literature on carbon emissions, global warming, and financial performance. The findings of this study add to those of other earlier studies surrounding the disagreement over how variations in carbon emissions affect financial performance. To demonstrate the differences between various operating quantiles, the quantile regression model was employed, which gave a clearer, more thorough picture of how the explanatory variables and the dependent variable interact. Although quantile regression is increasingly being employed in economics, finance, and other fields, it has recently been used in accounting studies, more specifically, in testing the relationship between carbon emissions and financial performance. Moreover, sensitivity analysis was undertaken to examine the impact of carbon emissions on financial performance conditional on firm size.

This paper has some limitations, such as the study sample consisting of just emerging companies rather than developed ones. Furthermore, this study focused solely on gender diversity as a board diversity variable, ignoring other variables, such as age, education, and nationality. Future research could conduct comparison studies between developed and developing countries, whereby the results will contribute to the body of knowledge in the field of sustainability. Moreover, other studies could consider other board diversity components, such as education, age, and nationality, to obtain an in-depth assessment of the association between carbon emissions and board diversity.

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