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The Impact of Carbon Emissions on Firms' Financial Performance: An Application in BIST Sustainability Index

Karbon Emisyonlarının Firmaların Finansal Performansına Etkisi: BIST Sürdürülebilirlik Endeksinde Bir Uygulama

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ABSTRACT

The purpose of this study is to examine the carbon emission data of the firms listed in the Borsa Istanbul Sustainability Index in Turkey and analyze the relationship between carbon emissions and the financial performance of these firms. In this research, annual data for 31 firms listed in the Borsa Istanbul Sustainability Index for the period 2017–2020 were used. The relationship between the financial performance indicators of the firms and their carbon emissions was analyzed using a random effects panel data model. The dependent variables identified were return on assets and return on equity as measures of financial performance, while carbon emissions were considered as the independent variable, along with control variables such as firm size, leverage ratio, firm growth, and firm value. The research findings indicate that carbon emissions have a negative impact on both return on assets and return on equity.

JEL Codes: C23, M41, Q56

Keywords: BIST Sustainability Index, carbon emission, financial performance, panel data analysis, sustainability reporting

ÖZ

Bu çalışmanın amacı, Türkiye'de Borsa İstanbul Sürdürülebilirlik Endeksi'nde listelenen firmaların karbon emisyon verilerini incelemek ve bu firmaların finansal performansı ile karbon emisyonları arasındaki ilişkiyi analiz etmektir. Bu araştırmada, 2017–2020 dönemi için Borsa İstanbul Sürdürülebilirlik Endeksi'nde yer alan 31 firmanın yıllık verileri kullanılmıştır. Firmaların finansal performans göstergeleri ile karbon emisyonları arasındaki ilişki rassal etkiler panel veri modeli kullanılarak analiz edilmiştir. Finansal performansın ölçütleri olarak varlık getirisi ve özkaynak getirisi belirlenirken, bağımsız değişken olarak karbon emisyonları yanında firma büyüklüğü, kaldıraç oranı, firma büyümesi ve firma değeri gibi kontrol değişkenleri de ele alınmıştır. Araştırma bulguları, karbon emisyonlarının hem varlık getirisi hem de özkaynak getirisi üzerinde olumsuz bir etkisi olduğunu göstermektedir.

JEL Kodları: C23, M41, Q56

Anahtar Kelimeler: BIST Sürdürülebilirlik Endeksi, karbon emisyonu, finansal performans, panel veri analizi, sürdürülebilirlik raporlaması

Introduction

Due to the excessive increase in the world population and the consequent rise in human needs, the damage to the environment is continuously increasing. Lately, challenges such as the destruction of natural habitats, overexploitation of natural resources, and the increase in pollution caused by hazardous carbon elements have led both countries and global firms to adopt new policies. Such policies have become a fundamental principle, critical for implementing specific activities at both macro and microeconomic levels, leading to the adoption of sustainable development (Ganda & Milondzo, 2018, p. 1). Global warming and climate change have emerged as significant challenges for sustainable development. Many governments are taking steps to reduce greenhouse gas emissions through national policies that include emission trading programs, voluntary initiatives, carbon or energy taxes, and regulations and standards related to energy efficiency and emissions (The Greenhouse Gas Protocol, 2004, p. 3). If actions are not taken to mitigate and stabilize this situation, increasing carbon emissions will lead to social, economic, and environmental adverse impacts globally and in Turkey.

According to the Intergovernmental Panel on Climate Change (IPCC) report in 2021, Turkey accounted for 1% of global emissions, ranking 16th in the world, by emitting 530 million tons of carbon dioxide equivalent in 2020. When examining emission sources in Turkey, 24.1% accounts for the electricity sector, 21.2% for manufacturing, 15.8% for transportation, 13.8% for buildings, 11.1% for waste, and 9.3% for agriculture. The remaining portion is attributed to the maritime, oil, and natural gas sectors (Kaya, 2021).

Various policy methods, including emission trading systems, emission standards, carbon taxes, and energy taxes, are being implemented to reduce carbon emissions (Şencan, 2021, p. 50). To achieve comprehensive participation and feasibility of these policies, several processes have been established worldwide. One of the significant processes is the Kyoto Protocol, signed in 1997 and enforced in 2005, aiming to control greenhouse gas emissions globally (United Nations Climate Change, 2020, p. 12). The Paris Agreement, developed in 2016 to combat climate change and accepted by many countries, aims to keep global warming well below 1.5°C in the long term (United Nations Climate Change, 2020, p. 25). The implementation of the mentioned methods and compliance with these agreements play a crucial role in cost-effectiveness. Their feasibility and impact on firm performance are considered as one of the most important points (Şencan, 2021, p. 50).

Considering high carbon emission levels, studies on the relationship between emissions and corporate financial performance are of vital importance for evaluating both social and firm behavior aspects. As a result, in order to achieve long-term success in a competitive business environment and prepare for future national or regional climate policies, firms need to understand and manage emission risks.

Research shows that the use of nonrenewable energy sources contributes to increased carbon emissions and, therefore, has global-scale financial, social, and environmental impacts (Chen et al., 2019; Doğan & Öztürk, 2017; Doğan & Turkekul, 2016; Jebli & Ben Youssef, 2015; Zafar et al., 2019). There are differing views on the direction of the relationship between practices designed to reduce carbon emissions and financial performance (Ganda & Milondzo, 2018; Narayan & Sharma, 2015; Yang & Zhang, 2017). One group of researchers argues that reducing carbon emissions, or green investment activities, will cause financial losses (Ganda & Milondzo, 2018, p. 10), while some researchers claim that it enhances firm profitability (Narayan & Sharma, 2015, p. 84). Another view suggests that expenses incurred to reduce carbon emissions may initially reduce profitability but will lead to increased profitability in the later stages (Yang & Zhang, 2017, p. 1421).

The relationship between financial and environmental performance is a growing research area, and this study focuses on this topic. The lack of consensus in the literature on this issue can be attributed to several factors. Compliance with environmental regulations may impose additional costs on businesses. As a result, achieving shareholders' wealth maximization goal may not be possible due to these additional costs. However, it can be argued that a business that can effectively control pollution can also effectively control other production costs, leading to higher return rates.

In this study, the impact of carbon emissions on the financial performance of firms operating in Turkey and listed in the Borsa Istanbul Sustainability Index is examined. BIST Sustainability Index was created by Turkey's main stock exchange, Borsa Istanbul (BIST), to promote sustainable and socially responsible business practices among Turkish companies. Companies included in this index are generally evaluated according to various sustainability criteria, such as environmental performance (such as energy efficiency and emissions reduction), social responsibility (including labor practices and community participation) and governance (transparency and board structure). In this case, this index was preferred because it encourages businesses to act more environmentally friendly and socially responsible in their activities and to provide more transparent and realistic information about carbon emissions. The aim of the study is to investigate the effect of emission levels of firms emitting carbon on their financial performance. Therefore, the theoretical framework related to the topic is first presented, and the literature on carbon emissions and firm financial performance is reviewed. The study then proceeds to discuss the research methodology and the findings of the study.

Institutional Theory

Institutional theory is a way of thinking about the relationship between organizational structures and the social processes these structures develop (Dillard et al., 2004, p. 508). Institutional theory focuses on the dense and more enduring issues of a social framework. It considers the procedures in which models, regulations, values, and norms become legitimate criteria for institutional social behavior (Scott, 2004, pp. 408–414). Institutional theory examines organizational forms and explains the reasons for having homogeneous characteristics or forms in organizations within the same organizational field. DiMaggio and Powell (1983) define the organizational field as a recognized domain of institutional life consisting of organizations collectively. This field includes key suppliers, resource and product consumers, regulatory bodies, and other organizations producing similar services or products.

Institutional theory views organizations as operating within a social framework composed of norms, values, and accepted assumptions about what constitutes appropriate or acceptable economic behavior (Carpenter & Feroz, 2001, p. 565). When an organizational field is structured, various forces emerge within the society and lead the organizations in this field to become more similar to each other (DiMaggio & Powell, 1983, p. 147). The core of institutional theory, explaining the relationship between the social environment and the organization, is based on organizations' perspectives on changing norms, values, and social trends, and their processes of adapting to these changes (Rodrigues & Craig, 2007, p. 742).

Organizational forces are seen as regulatory mechanisms over an individual's interests, goals, and desires, shaping action scenarios; such forces can also lead to continuous adoption or transformation of a particular course of action. In this context, a vital component of the social environment affects how institutions are organized, which organizations possess regulatory, normative, and cognitive structures and activities that provide stability and meaning for social behavior (Ganda & Milondzo, 2018, pp. 2–3). At the forefront of these activities are the impacts on the environment. Producing environmentally friendly products and services has become an area of increasing importance to consumers due to the growing interest in environmental issues in society (Sözüer, 2011, p. 51). Accordingly, businesses aim to minimize their environmental impact, seek solutions to mitigate damages, and disseminate green practices, thereby guiding their stakeholders towards sustainability (Emgin & Türk, 2004, p. 8). Consequently, external pressures from relevant parties prompt firms to adopt behaviors that address such demands.

Corporate pressures consist of economic, legal, and customer pressures. The impact of globalization has increased competition, leading businesses to focus on profitability and cost reduction (economic pressures), the rise of legal environmental obligations (legal pressures), and the increased expectations and desires of customers (customer pressures), all of which have driven firms to emphasize green practices (Srivastava & Srivastava, 2006, pp. 524–525). As a result, institutional theory is a theory that explains how and why organizations are influenced by their environments and examines stakeholder groups that exert various pressures on businesses. In today's rapidly changing and transforming world, organizations' ability to adapt to their environment is essential for their survival and competitiveness. To ensure their long-term existence, businesses must achieve environmental compliance and take the necessary steps (Apaydın, 2009, p. 19).

Literature Review

According to the International Local Governments Greenhouse Gas Emissions Analysis Protocol (IEAP), carbon emissions are classified into three categories: scope 1, scope 2, and scope 3. Scope 1 emissions are direct emissions resulting from sources owned and controlled by the firm. In other words, these emissions are released into the atmosphere as a direct result of a series of activities at the firm level. Scope 2 emissions are indirect emissions resulting from the production of energy purchased from a public utility provider. In other words, it includes all emissions released into the atmosphere from purchased electricity, steam, heat, and cooling consumption. Scope 3 emissions include emissions from a firm's activities, other than those specified in Scope 2, both upstream and downstream (Greenhouse Gas Protocol (GHG Protocol) Scope 2 Guidance, 2015, p. 3).

The reduction of carbon emissions is considered an activity that businesses should engage in, and such a practice not only serves profit-making purposes but also provides additional benefits. In this context, businesses are expected to participate in activities that reduce negative impacts on the natural environment, protect it, and promote recycling (Ganda & Milonfzo, 2018, p. 4). In research examining the relationship between carbon emissions and a firm's financial performance, there are different views both globally and in Turkey. When the literature in Turkey is examined, it has been determined that there are limited studies focusing on the relationship between carbon emissions and financial performance. In this context, some studies in the literature have indicated a negative relationship between carbon emissions and financial performance, while others have found evidence supporting a positive relationship. Yet, some studies emphasize that there is no significant relationship between carbon emissions and financial performance. Some argue that carbon emission reduction may not have an immediate impact on firms' profitability in the short term but will positively affect firm profitability in the long term (Bragdon & Marlin, 1972; Ghisetti & Rennings, 2014; Gore, 1992; Porter, 1991; Spicer, 1978; Yang & Zhang, 2017). In this context, a summary of research regarding the impact of carbon emissions on firms' financial performance is presented below. According to one perspective, environmental management, production efficiency, innovation, and emission reduction improvements can enhance economic performance (Gore, 1992; Porter, 1991; Spicer, 1978; Bragdon & Marlin, 1972). Carbon emissions can negatively impact a company's financial performance. Güneysu and Atasel (2022) investigated the impact of carbon emissions on the financial performance of nonfinancial firms listed on the BIST100 Index during the period 2014–2021 using panel regression models. In this context, the relationship between firms' total carbon emissions and financial performance indicators (return on assets, return on equity, Tobin's Q, net profit margin, and earnings per share) was examined. The findings indicate a significant and negative relationship between carbon emissions and return on assets and earnings per share, while no significant relationship was observed with other financial performance indicators. Ganda and Milondzo (2018) examine the impact of carbon emissions (scope 1, scope 2, and scope 1 and scope 2) on the financial performance indicators of 63 South African Carbon Disclosure Project (CDP) firms for the 2015 fiscal year, including return on equity (ROE), return on investment (ROI), and net profit margin (ROS). The research findings provide strong evidence of a negative relationship between carbon emissions and corporate financial performance. Hayami et al. (2014) demonstrate that firms producing less waste tend to have higher corporate financial performance. Cucchiella et al. (2017) argue on emission control in an Italian firm that implementing advanced emission control and environmental management systems encourages a firm's profitability to increase through a combination of increased demand and productivity. Based on the data from 941 US manufacturing firms that are publicly traded, Lucas and Noordewier (2016) show that environmental management practices and pollution control initiatives in dirty and nonproactive industries have a positive marginal effect on firm financial performance. The study suggests that this effect is even more significant in dirty sectors than in clean and proactive corporate environments. Misani and Pogutz (2015) find in their study, where they use return on equity, return on sales, and return on assets as dependent variables, that there is a moderate relationship between firms' financial performance and carbon performance, and improved environmental processes reduce carbon emissions and strengthen financial performance.

Another viewpoint is that energy conservation and emission reduction increase environmental costs and lower profit margins (Gingrich, 1995; Walley & Whitehead, 1994). This indicates a positive relationship between carbon emissions and firm profitability. Wang et al. (2016) found in their study that activities designed to reduce carbon emissions negatively impact the financial performance of firms in developing economies, posing a threat to their long-term survival. Mao et al. (2017) investigated 12 Chinese firms operating in the transportation, machinery, and electronics sectors and found that low carbon emissions improved the firm's environmental performance but had a negative effect on its financial performance. Rokhmawati et al. (2015) examined Indonesian firms and observed that carbon emissions had a positive relationship with active profitability, indicating that reducing emissions may not always improve financial performance.

On the other hand, there is an opposing view that suggests there is no significant relationship between environmental management, energy conservation, and firm profitability (Fogler & Nutt, 1975; Salahuddin et al., 2016; Yu et al., 2016). Salahuddin et al. (2016) used data from OECD countries for the period 1991–2012 to predict the short and long-term effects of internet use and economic growth on carbon dioxide (CO2) emissions. The research results showed that economic growth had no significant short or long-term effect on carbon emissions. Yu et al. (2016) studied U.S. S&P 500 firms for the period 2012–2013 and found no significant relationship between emission reduction investments, emission savings, monetary savings, direct emissions, indirect emissions, research and development expenses, total assets, sales, net income, and the number of employees.

Another perspective suggests that improved environmental regulations may not have an immediate impact on business profitability, but they can positively affect long-term profitability (Ghisetti & Rennings, 2014; Yang & Zhang, 2017). Yang and Zhang (2017) analyzed the relationship between low carbon emissions and corporate profitability. They found that in the early stages, Research and development (R&D) costs led to decreased profitability. However, in the long run, reduced carbon emissions resulted in increased profitability. Broadstock et al. (2018) tested the relationship between firm performance and emission levels. They used return on equity and Tobin's *Q* ratio as firm performance indicators. The research results revealed a nonlinear relationship, where performance initially increased and then decreased with emission levels. Iwata and Okada (2011) examined the relationship between environmental performance and financial performance of manufacturing companies in Japan during the period of 2004–2008. The results of the research indicate that waste emissions had no impact on financial performance, but greenhouse gas reduction positively influenced long-term financial performance.

Research Methodology

In this study, panel data analysis was employed to determine the relationship between carbon emissions and financial performance of companies listed on the BIST Sustainability Index. Panel data analysis is a statistical method that allows us to both construct and test time-series and cross-sectional data. It combines the time-series and cross-sectional dimensions to provide more consistent information and controls for individual heterogeneity, recognizing that individuals, firms, or countries are heterogeneous (Baltagi, 2001, p. 1). In this context, models where both fixed and slope parameters are constant across cross-sectional and time units are referred to as pooled panel data models and are defined as follows (Yerdelen Tatoğlu, 2016, pp. 37–42).

$$Y_{it} = \alpha_0 + \sum_{k=1}^{K} \alpha_k X_{kit} + e_{it}$$

Both one-way and two-way panel data models are structured in two ways: fixed effects and random effects models. In the random effects model, error variances can vary across groups and time, while the slope coefficient remains constant (Baltagi, 2001, pp. 14–39).

Random one-way effect model is shown here.

$$Y_{it} = \alpha_i + \beta X_{it} + e_{it}$$

$$\alpha_i = \bar{\alpha} + \mu_i$$

$$u_{it} = \mu_i + e_{it}$$

Random two-way effect model is shown here.

$$Y_{it} = \alpha_0 + \beta X_{it} + e_{it}$$

One-way and two-way panel data models have been developed for panel data analysis to account for the effects of time and units. To achieve this, the likelihood ratio (LR) test is conducted to predict whether the model will be one-way or two-way based on the impact of time and cross section effects. After determining unit and time effects, the Lagrange multiplier (LM) test and LR test developed by Breusch and Pagan (1980) are performed to compare the pooled regression model with the random effects model. The Hausman Test (Hausman, 1978) is used to determine whether the fixed effects model or the random effects model is suitable for the research analysis in this study. In the Hausman test, the null hypothesis suggests that the random effects model is the appropriate model, while the alternative hypothesis proposes that the fixed effects model is the appropriate model for the analysis.

In this study, the appropriate model was determined using the *F*-test, Breusch–Pagan LM test, LR test, score test, and Hausman test.

The objective of this study is to analyze the impact of carbon emissions on financial performance. Based on the literature review, the following research hypothesis has been developed for this study:

H_0: Carbon emission intensity has no effect on the financial performance of the firm.

In the study, carbon emissions are used as independent variables. Additionally, four control variables are identified, which include the natural logarithm of total assets as a measure of firm size, the leverage ratio indicating how the firm's assets are financed, the sales growth rate indicating firm growth, and the firm's value. By considering the dependent variables, independent variables, and control variables, the main model for a firm is presented as follows:

Financial Performance $i,t = \alpha_{\mathbf{i,t}}$ + β1Carbon Emissions i,t + β2Firm Size i,t + β3Leverage i,t + β4Growth i,t + β5Firm Value i,t + $\varepsilon_{i,t}$

α : intercept

t : time-specific effect (t=1, ... T);

i : cross section-specific effect (i=1, ... N);

$\varepsilon_{i,t}$: error term effect.

The panel regression models established to determine the relationship between financial performance indicators and carbon emissions are presented here.

Model 1: $AK_{it} = \alpha_{it} + \beta_1 l\mathrm{LNCO2}_{it} + \beta_2 \mathrm{LNTA}_{it} + \beta_3 \mathrm{LEV}_{it} + \beta_4 \mathrm{G}_{it} + \beta_5 \mathrm{LNFV}_{it} + \varepsilon_{it}$

Model 2: 𝑂𝑆𝐾;$_{it} = \alpha_{it} + \beta_1 l\mathrm{LNCO2}_{it} + \beta_2 \mathrm{LNTA}_{it} + \beta_3 \mathrm{LEV}_{it} + \beta_4 \mathrm{G}_{it} + \beta_5 \mathrm{LNFV}_{it} + \varepsilon_{it}$

Methods

In this study, the relationship between carbon emissions and financial performance is examined. Therefore, how carbon intensity affects financial performance indicators (return on assets and return on equity) will be investigated. The research hypothesis will be analyzed using the panel data analysis method. In this context, the study will use carbon emissions data from the sustainability reports of 31 firms listed in the BIST Sustainability Index for the years 2017–2020, along with the financial performance indicators, return on assets, and return on equity, for the same firms. The data related to carbon emissions were obtained from companies' Sustainability and Integrated (Operational) Reports. Data for other variables were collected from the Public Disclosure Platform (KAP) and the Finnet Database. Therefore, this study does not require ethical approval due to its scope. The variables used in the study, their types, and abbreviations are shown in Table 1.

Table 1.
Variables Used and Type of Variables

Variables	Variable Name	Formulas
Dependent variables		
Return on assets	ROA	Net income/total assets
Return on equity	ROE	Net income/shareholders' equity
Independent variables		
Carbon emission	LNCO2	Logarithm of carbon emission (tons of CO_2)
Control variables		
Firm size	LNTA	Logarithm of total assets
Firm leverage	LEV	Total debt/total equity
Growth	G	(net sales − previous year net sales)/previous year net sales × 100
Firm value	LNFV	Logarithm of firm value

In this study, two financial performance indicators, namely the asset profitability ratio and the equity profitability ratio, are used as dependent variables. Profitability ratios are one of the most important financial indicators that measure a firm's financial success. The asset profitability ratio shows how efficient the firm's assets are in generating profits. It measures the efficiency of the firm's assets in generating profits during a specific period. This ratio is calculated by dividing the net profit by the net assets of the firm (Karaca & Kanışlı, 2015, pp. 35–36). A high asset profitability ratio is desirable for firms as it indicates effective utilization of all assets in generating profits (Yükçü & Atağan, 2010, p. 29).

Equity represents the monetary value of the rights of the founders, partners, and shareholders in the firm's tangible and intangible assets. The equity profitability ratio measures how much profit the firm generates with its equity and indicates its efficiency in generating profits. This ratio shows the percentage of profit earned per unit of equity contributed by the shareholders (Eren & Karasioğlu, 2012, p. 174; Konuralp, 2005, p. 129). The equity profitability ratio indicates how effectively the investment made by the shareholders in the firm is utilized and represents the profitability achieved through equity.

Results

In this section, the results of the research are presented. Table 2 shows the correlation coefficients between the variables.

According to Table 2, which shows the correlation between variables, it is observed that the asset profitability is negatively correlated with carbon emissions, firm size, and leverage ratio, but positively correlated with firm growth and firm value. On the other hand, equity profitability is negatively correlated with carbon emissions and leverage ratio, while it is positively correlated with firm size, firm growth, and firm value.

In panel data analysis, variables include both time and unit dimensions. It is determined that the model needs to be estimated as either one-way or two-way according to time and unit effects (Hsiao, 2005, p. 1). For this purpose, a LR test is conducted using the maximum likelihood method. According to the calculated test statistics at a 1% significance level, it has been interpreted that there is a two-way effect. The null hypothesis for the two-way effect test is that there is no unit or time effect in the model. Since the value of the test statistic for the two-way effect is 50.58529 at a 1% significance level, the null hypothesis is rejected, indicating that there is a two-way effect.

Subsequently, based on the findings of the two-way effect, the presence of unit and time effects has been tested separately. For the cross section effect analysis, the null hypothesis is that the standard error of the horizontal cross section is equal to zero (Evci & Şak, 2018, p. 212). According to the analysis results, since the value of the test statistic is 50.58529, the null hypothesis is rejected at a 1% significance level. This indicates that there is a unit effect in the panel data model.

For model 1, the presence of a time effect has also been examined, and the test statistic does not reject the null hypothesis, indicating that there is no time effect. To determine the appropriate model in the study, *F*-test, Breusch–Pagan LM test, LR test,

Table 2.
Correlation Coefficients Between Variables

	ROA	ROE	LNCO2	LNTA	LEV	G	LNFV
ROA (1)	1						
ROE (2)	0.6598	1					
LNCO2 (3)	−0.2194	−0.1198	1				
LNTA (4)	−0.0224	0.0475	0.6068	1			
LEV (5)	−0.5129	−0.4531	−0.0608	−0.1134	1		
G (6)	0.1727	0.0683	0.0504	0.0386	0.1012	1	
LNFV (7)	0.0869	0.0212	0.5010	0.8129	−0.0472	0.0697	1

Note: Numbers in parentheses, 1 = Return on assets; 2 = Return on equity; 3 = Carbon emission; 4 = Firm size; 5 = Firm leverage; 6 = Growth; 7 = Firm value.

Table 3.
Determining the Model to be used for Model 1

Test	Test Statistic	p	Result
F-test	7.27	.000	The classic model is not suitable.
Breusch–Pagan LM test	60.57	.000	The classic model is not suitable.
LR test	50.59	.000	The classic model is not suitable.
Score test	635.47	.000	The classic model is not suitable.
Hausman test	8.83	.115	The random effects model is suitable.
	Binary	**Unit**	**Time**
χ^2 test	50.58529	50.58529	0
p	.000	.000	1.000

Table 4.
Model 1 Random Effect Model Results

	Coefficient	Standard Error	p
LNCO2 (1)	−0.6234462	0.329481	.058*
LNTA (2)	−2.651313	1.261311	.036**
LEV (3)	−0.2477487	0.030396	.000***
G (4)	0.0414499	0.010105	.000***
LNFV (5)	3.663902	1.137132	.001***
Constant	5.982196	14.88474	.688

Note: Numbers in parentheses, 1 = Carbon emission; 2 = Firm size; 3 = Firm leverage; 4 = Growth; 5 = Firm value.
*Significant at 10% level. **Significant at 5% level. ***Significant at 1% level.

score test, and Hausman test have been applied. The results are presented in Table 3.

According to the F-test results for model 1 in Table 3, the H_0 hypothesis, which states that all unit effects are equal to zero, was rejected because $p < .01$ in the created model. This means that the fixed effects model is preferred. According to the results of the F-test, the classical model is found to be inappropriate. The Breusch–Pagan LM test and LR test results used to determine whether the classical model or the random effects model is more appropriate are shown in Table 3. Lagrange multiplier test statistical values for model 1 in Table 3 are 60.57, and the probability values of the model (p) <.01, the H_0 hypothesis is rejected. This means that the random effects model is preferred over classical models. Likelihood ratio test statistical values for model 1 in Table 3 are 50.59, and the probability values of the model (p) <.01, the H_0 hypothesis is rejected. This means that the random effects model is preferred over classical models. Based on the results of the Hausman test, which is used to choose between the fixed effects and random effects models, the Hausman test statistical value was determined as 8.83 for model 1 and p of the model was >.05, the H_0 hypothesis was accepted. This means that the random effects model is preferred to the fixed effects model. Therefore, the random effects model is chosen as the more suitable model for the analysis.

In Table 4, the results of the analysis conducted with the random effects model are presented. The model 1 results, with return on assets as the dependent variable, show a negative relationship between carbon emissions and return on assets. According to the estimation results presented in Table 4, it was found that LNCO2, LNTA, and LEV have a negative effect on ROA. An increase of 1 unit in LNCO2, LNTA, and LEV would induce a decrease of 0.6234462, −2.651313, and 0.2477487 on ROA, respectively. On the other hand, G and LNFV have a positive effect on the ROA. An increase of 1 unit in G and LNFV would induce an increase of 0.0414499 and 3.663902, respectively.

In Table 5, the results of testing assumptions are presented. The presence of heteroscedasticity (varying variance) was examined using Levene, Brown, and Forsythe's test, and it was found that there is a problem of varying variance. The values of Levene, Brown, and Forysthe test results applied in model 1 were determined as W0 1.60088441 and $p = .045$; W50 0.48310469 and $p = .987$; and W10 1.60088441 and $p = .045$, respectively. According to the findings obtained from the test statistics of Levene, Brown, and Forsythe (W0, W50, and W10), the H_0 hypothesis established that the variance of the units is equal to zero was rejected since the Leyene W0 $p < .05$, and the Brown W50 $p > .05$. The H_0 hypothesis could not be rejected and since the Forysthe W10 $p < .05$, the H_0 hypothesis, which was established as the variance of the units is equal to zero, was rejected. This means that according to the Levene W0 and Forysthe W10 test results in model 2, H_0 was rejected at the 5% significance level, indicating a heteroscedasticity problem in model 1. The presence of autocorrelation was tested using Bhargava, Franzini, and Narendranathan's Durbin–Watson test, and the result being less than 2 indicates the presence of autocorrelation. The Pesaran CD test was used to examine the correlation between units, and the results show that there is correlation between units at 5% and 10%.

Due to the presence of varying variance, autocorrelation, and correlation between units, the robust random effects panel data model was used to obtain consistent estimates. The results of the robust estimation for model 1 can be seen in Table 6.

According to the robust estimation results presented in Table 6, it is found that carbon emissions, firm size, and leverage ratio are negatively related to return on assets. An increase in carbon emissions, firm size, and leverage ratio would lead to respective decreases of 0.6234462, 2.651313, and 0.2477487 in return on assets. These results indicate a connection between carbon emissions and financial performance indicators, suggesting that environmental factors have an impact on firm profitability.

Table 5.
Identifying Deviations from the Model 1 Assumption

Test	Test Statistic	p	Result
Levene, Brown, and Forsythe test	W0 = 1.60088441 W50 = 0.48310469 W10 = 1.60088441	.045 .987 .045	There is varying variance
Bhargava, Franzini, and Narendranathan DW test	1.74520311		There is autocorrelation
Pesaran CD test	2.169	.0301	There is correlation between units

Table 6.
Model 1 Resistive Forecast Results

	Coefficient	Standard Error	*p*
LNCO2 (1)	−0.6234462	0.204078	.055*
LNTA (2)	−2.651313	0.929909	.065*
LEV (3)	−0.2477487	0.026176	.003***
G (4)	0.0414499	0.026176	.211
LNFV (5)	3.663902	1.69184	.119
Constant	5.982196	13.73866	.693

Note: Numbers in parentheses, 1 = Carbon emission; 2 = Firm size; 3 = Firm leverage; 4 = Growth; 5 = Firm value.
*Significant at 10% level. ***Significant at 1% level.

In the panel data analysis, variables include both time and cross section size. According to time and cross section effects, it is determined that the model should be predicted to be one way or two ways. For this purpose, the LR test has performed with the maximum likelihood method for model 2 with return on equity as the dependent variable, and the findings are given in Table 7. For the two-way effects test, the null hypothesis is formed no cross section and time effects in the model. Because the value of the test statistic for the two-way effect is 4.770557 at 10% significance level, the null hypothesis is rejected. This result shows that it is a two-way effect. Then, the presence of the cross section and time effects was tested separately with the movement from the findings that it was a two-way effect. The null hypothesis for cross section effect analysis is that the standard error of cross section is equal to zero. According to the analysis results, the null hypothesis is rejected at 5% significance level since the value of the test statistic is 4.770557. In this case, there is a cross section effect in the panel data model. The existence of time effect was also examined, and the test statistic was calculated as 0 at 1% significance level. According to this result, the null hypothesis cannot be rejected at the 1% significance level with no time effects.

For model 2, various tests were conducted to determine the appropriate model, including the *F*-test, Breusch–Pagan LM test, LR test, Score test, and Hausman test. According to the *F*-test results for model 2 in Table 7, the H_0 hypothesis, which states that all unit effects are equal to zero, was rejected because $p < .01$ in the created model. This means that the fixed effects model is preferred over the classic model is not suitable. The Breusch–Pagan LM test and LR test results used to determine whether the classical model or the random effects model is more appropriate are shown in Table 7. Lagrange multiplier test statistical values for model 2 in Table 7 are 5.38, and the *p* of the model was <.05, the H_0 hypothesis is rejected. This means that the random effects model is preferred over the classical models. Likelihood ratio test statistical values for model 2 in Table 3 are 4.77, and the $p < .05$, the H_0 hypothesis is rejected. This means that the random effects model is preferred over the classical models. Based on the results of the Hausman test, which is used to choose between the fixed effects and random effects models, the Hausman test statistical value was determined as 4.97 for model 2 and *p* of the model was >.05, the H_0 hypothesis was accepted. This means that the random effects model is preferred to the fixed effects model. Therefore, the random effects model is chosen as the more suitable model for the analysis. According to the results of these tests, it was found that the random effects model is more suitable for the data. The results of the tests are presented in Table 8.

Table 7.
Determining the Model to be used for Model 2

Test	Test Statistic	*p*	Result
F-test	2.02	.006	The classic model is not suitable.
Breusch–Pagan LM test	5.38	.010	The classic model is not suitable.
LR test	4.77	.010	The classic model is not suitable.
Score test	13.19	.000	The classic model is not suitable.
Hausman test	4.97	.419	The random effects model is suitable.
	Binary	Unit	Time
χ^2 test	4.770557	4.770557	0
p	0.092	0.014	1.000

In Table 8, the results of the analysis conducted with the random effects model are presented. The model 2 results, with return on equity as the dependent variable, show a negative relationship between carbon emissions and return on equity. According to the estimation results presented in Table 8, it was found that LNCO2 and LEV have a negative effect on ROE. An increase of 1 unit in LNCO2 and LEV would induce a decrease of 5.922428, and 6.177099 on ROE, respectively. On the other hand, LNTV, LEV and G have no effect on the ROE Table 9.

In model 2, the presence of heteroscedasticity was examined using Levene, Brown, and Forsythe tests, while the presence of autocorrelation was tested using Bhargava, Franzini, and Narendranathan's Durbin–Watson test. Additionally, the presence of cross-sectional dependence was tested using the Pesaran CD test. The results of these tests indicate the existence of heteroscedasticity, autocorrelation, and cross-sectional dependence in the model. Therefore, the robust random effects panel data model, which provides consistent estimates in the presence of heteroscedasticity, autocorrelation, and cross-sectional dependence, was used to obtain the results (as shown in Table 10).

According to the robust estimation results presented in Table 10, it is observed that carbon emissions, leverage and growth have a negative effect on return on equity. Specifically, a 1-unit increase in carbon emissions, leverage ratio, and net sales growth will lead to a decrease of 5.922428, 1.552437, and 0.1920624, respectively, in the return on equity. This indicates that higher carbon emissions and leverage, as well as faster net sales growth, negatively impact the firm's equity profitability. These findings suggest that

Table 8.
Model 2 Random Effect Model Results

	Coefficient	Standard Error	*p*
LNCO2 (1)	−5.922428	3.220576	0.066*
LNTA (2)	12.95129	13.00808	0.319
LEV (3)	−1.552437	0.307635	0.000***
G (4)	0.1920624	0.140915	0.173
LNFV (5)	−6.177099	11.92232	0.604
Constant	20.8745	129.8304	0.872

Note: Numbers in parentheses, 1 = Carbon emission; 2 = Firm size; 3 = Firm leverage; 4 = Growth; 5 = Firm value.
*Significant at 10% level. ***Significant at 1% level.

Table 9.
Identifying Deviations from Model 2 Assumptions

Test	Test Statistic	p	Result
Levene, Brown, and Forsythe test	W0 = 1.60088441 W50 = 0.48310469 W10 = 1.60088441	.045 .987 .045	There is varying variance
Bhargava, Franzini, and Narendranathan DW test	1.5543288		There is autocorrelation
Pesaran CD test	2.136	.0327	There is correlation between units

Table 10.
Model 2 Resistive Forecast Results

	Coefficient	Standard Error	p
LNCO2[1]	−5.922428	0.940559	0.008**
LNTA[2]	12.95129	10.49123	0.305
LEV[3]	−1.552437	0.107939	0.001***
G[4]	0.1920624	0.050129	0.031**
LNFV[5]	−6.177099	10.30384	0.591
Constant	20.8745	29.97604	0.536

Note: Numbers in parentheses, 1 = Carbon emission; 2 = Firm size; 3 = Firm leverage; 4 = Growth; 5 = Firm value.
**Significant at 5% level. ***Significant at 1% level.

firms with lower carbon emissions and leverage, as well as steady net sales growth, tend to have higher return on equity.

Discussion and Conclusion

In developing countries like Turkey, the performance of firms plays a crucial role in the economic development of the country. To survive in competitive markets, firms should not only focus on financial profitability but also aim to create value in environmental, social, and economic aspects. In this context, this study investigates the impact of carbon emissions on firm financial performance. Content analysis method is used to collect annual carbon emission data for 31 firms listed on the Borsa İstanbul Sustainability Index from 2017 to 2020. Financial data is obtained from the Finnet Financial Analysis program. Panel data analysis method is used to analyze the data.

As dependent variables, financial performance indicators such as return on assets and return on equity ratios are used in the study. According to the results of model 1, where return on assets is used as the dependent variable, carbon emissions negatively affect return on assets. An increase in carbon emissions leads to a decrease in return on assets. Among the control variables, firm size and leverage ratio variables have significant results for model 1. Therefore, it can be said that these variables enhance the explanatory power of the model. According to the results of model 2, where return on equity is used as the dependent variable, carbon emissions negatively affect return on equity. An increase in carbon emissions leads to a decrease in equity profitability. Among the control variables, the leverage ratio and net sales growth variables have significant results for model 2. Again, these variables enhance the explanatory power of the model.

This study demonstrates that an increase in carbon emissions negatively impacts the financial performance of firms. This finding is consistent with the studies by Misani and Pogutz (2015) and Ganda and Milonzo (2018). The research results indicate that policymakers need to strengthen existing programs designed to reduce carbon emissions. Additionally, policymakers should ensure the direct and indirect implementation of stringent technical criteria and rules for reducing corporate emissions. Policymakers should also create long-term incentives to encourage firms to adopt efficient green technologies and environmentally compatible processes and systems that reduce the impact of climate change. Green technologies used to reduce carbon emissions are often excessively expensive for many firms, especially in developing economies like Turkey. Therefore, providing incentives and cost-effectiveness in their adoption is essential. If a more substantial development in low-carbon or zero-carbon environments is desired, some programs may need to be mandatorily implemented at the national level.

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Genişletilmiş Özet

Uluslararası Yerel Yönetimler Sera Gazı Salımlarının Analizi Protokolü (IEAP) karbon emisyonlarını Kapsam 1, Kapsam 2 ve Kapsam 3 olmak üzere üç kategoriye ayırmaktadır: Kapsam 1: Doğrudan emisyonları temsil eder ve firmaya ait veya kontrol edilen kaynaklardan kaynaklanır. Fabrika tesislerinden veya firmaya ait araçların egzozundan salınan emisyonlar Kapsam 1'e örnek olarak verilebilir. Kapsam 2: Dolaylı emisyonları temsil eder ve firmanın faaliyetleri için enerji sağlayan dış kaynaklardan kaynaklanır. Firmanın elektrik tüketiminin neden olduğu enerji üretimi kaynaklı emisyonlar Kapsam 2'ye örnek olarak verilebilir. Kapsam 3: Firmanın faaliyetleri ile ilişkili diğer emisyonları içerir. Bu kapsam altında, firmanın tedarik zinciri, ürünlerin ömrü boyunca kullanımı, atıkların yönetimi gibi endirekt etkilere yol açan emisyonlar yer alır.

Bu çalışmada, Türkiye'de faaliyet gösteren ve Borsa İstanbul Sürdürülebilirlik Endeksinde yer alan firmaların finansal performansları üzerindeki karbon emisyonlarının etkisi araştırılmaktadır. Çalışmada, BIST Sürdürülebilirlik Endeksinde listelenen 31 firmanın 2017–2020 yılları arasında sürdürülebilirlik raporlarında yer verdikleri karbon emisyonları ile aynı firmaların finansal performans göstergeleri olarak kabul edilen aktif kârlılık ve özsermaye kârlılığı değişkenleri kullanılmıştır. Çalışmada aşağıdaki araştırma hipotezi geliştirilmiştir:

H0: Karbon emisyon yoğunluğunun, firmanın finansal performansı üzerinde bir etkisi yoktur.

Çalışmada bağımsız değişken olarak karbon salınımı kullanılmış, dört adet kontrol değişkeni belirlenmiştir. Bu kontrol değişkenleri, toplam aktiflerin doğal logaritması ile ölçülen firma büyüklüğü, firma varlıklarının hangi kaynaklarla finanse edildiğini gösteren kaldıraç oranı, net satışlar büyüme oranı ile ölçülen firma büyümesi ve firma değeridir. Bağımlı değişkenlerin, bağımsız değişkenlerin ve kontrol değişkenlerinin tam olarak dikkate alınmasıyla, bir firma için ana model şu şekildedir:

Finansal Performans i,t= αi,t+ β1Karbon Emisyonları i,t+β2Firma Büyüklüğü i,t+β3Kaldıraç i,t+β4Büyüme i,t+β5Firma Değeri i,t+ε i,t

Aktif kârlılığın bağımlı değişken olarak kullanıldığı model 1 sonuçlarına göre, karbon emisyonları aktif kârlılığı negatif olarak etkilemiştir. Karbon emisyonlarındaki artış ise aktif kârlılığı azaltmaktadır. Kontrol değişkenleri olarak kullanılan değişkenlerden firma büyüklüğünde ve kaldıraç oranı değişkenleri model 1 için anlamlı sonuçlar vermiştir. Dolayısıyla bu değişkenlerin modelin açıklama gücünü artırdığı söylenebilir.

Özsermaye kârlılığının bağımlı değişken olarak kullanıldığı model 2 sonuçlarına göre, karbon emisyonları karbon emisyonlarının finansal performans göstergesi olarak kullanılan özsermaye kârlılık oranını negatif olarak etkilediği sonucuna ulaşılmıştır. Karbon emisyonlarındaki artış özsermaye kârlılığını azaltmaktadır. Kontrol değişkenleri olarak kullanılan değişkenlerden kaldıraç oranında ve net satışlar büyümesi değişkenleri model 2 için anlamlı sonuçlar vermiştir. Dolayısıyla bu değişkenlerin modelin açıklama gücünü artırdığı söylenebilir.

Analiz sonuçlarına göre, karbon emisyonlarının aktif kârlılık ve özsermaye kârlılığı üzerinde olumsuz bir etkisi olduğu tespit edilmiştir. Ayrıca, firma büyüklüğü ve kaldıraç oranının aktif kârlılık üzerinde negatif etkisi, net satış büyümesi ve firma değerinin ise pozitif etkisi olduğu belirlenmiştir. Bununla birlikte, rassal etkili panel veri analizi kullanılarak yapılan testler, modelin uygun olduğunu göstermiştir. Ancak, modelde değişen varyans, otokorelasyon ve birimler arası korelasyon gibi varsayımlardan sapmalar olduğu tespit edilmiştir. Bu sapmaların dikkate alınarak dirençli tahminlerle analiz sonuçları elde edilmiştir. Bu çalışma firmaların karbon emisyonlarındaki artışın finansal performansı negatif olarak etkilediğini göstermektedir. Bu sonuç, Misani ve Pogutz (2015) ile Ganda ve Milonzo (2018) çalışmalarıyla benzerlik göstermektedir.

Sonuç olarak, karbon emisyonlarının firmaların finansal performansı üzerinde olumsuz bir etkisi olduğu ve çevresel performansın artırılmasının finansal performansı güçlendirebileceği sonucuna ulaşılmıştır. Bu bulgular, firmaların çevresel yönetim stratejilerinin finansal performanslarını iyileştirmek için etkili olabileceğini göstermektedir. Ancak, değişen endüstri ve ekonomik koşulların da etkisi dikkate alınarak çevre dostu politikaların uygulanması değerlendirilmelidir.

Araştırma sonuçları, politika yapıcıların karbon emisyonlarını azaltmak için tasarlanmış mevcut programları güçlendirmeleri gerektiğini ortaya koymaktadır. Ek olarak, politika yapıcılar, kurumsal operasyonların karbon emisyonunun azaltılmasına yönelik katı ve sağlam teknik ölçütlerin ve kuralların doğrudan ve dolaylı düzeyde uygulanmasını sağlamalıdır. Politika yapıcılar, firmaları verimli yeşil teknolojileri benimsemeye ve iklim değişikliğinin etkilerini azaltan çevreyle uyumlu süreçler ve sistemler edinmeye teşvik edecek uzun vadeli teşvikler de oluşturmalıdır.