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THE IMPACT OF CLIMATE CHANGE ON FINANCIAL PERFORMANCE OF THE ELECTRICITY INDUSTRY: THE CASE OF TÜRKİYE

İklim Değişikliğinin Elektrik Sektörünün Finansal Performansı Üzerindeki Etkileri: Türkiye Örneği

Çağdaş GÜNDÜZ*

Keywords: Securities Markets, Financial Ratios, Climate Change, Electricity Industry

JEL Codes: G10, G32, Q54, L94

Abstract

The world is encountering increasingly frequent and intense extreme weather events, driven by climate change. There is a strong scientific consensus that warns of an existential threat if greenhouse gas (GHG) emissions are not dramatically reduced and global temperatures kept under control soon. In this context, alternative energy technologies have become essential, as they can generate energy without adding to GHG emissions. Türkiye's electricity energy industry, as a core component of the country's economic stability and energy security, plays a major role in adapting to climate change. This study specifically focuses on listed electricity energy firms in Türkiye over the period from 2008 to 2022, investigating how climate change impacts their financial performance using panel data methodology. The empirical findings show that climate change has a significant and positive influence on financial outcomes, suggesting that adapting to climate pressures can benefit the industry financially. As a result, it is essential for the electricity power industry to incorporate climate-related strategies into their corporate agendas. However, technological innovations will mean little without large-scale public action, where local and national governments work together with international organizations and nations.

Anahtar Kelimeler: Menkul Kıymetler Piyasaları, Finansal Oranlar, İklim Değişikliği, Elektrik Endüstrisi

JEL Kodları: G10, G32, Q54, L94

Öz

Dünya, iklim değişikliğinin etkisiyle giderek daha sık ve şiddetli ekstrem hava olaylarıyla karşı karşıya kalmaktadır. Sera gazı emisyonlarının ciddi şekilde azaltılmaması ve küresel sıcaklıkların yakında kontrol altına alınmaması durumunda varoluşsal bir tehdit oluşturacağı konusunda güçlü bir bilimsel fikir birliği vardır. Bu bağlamda, sera gazı emisyonlarına yol açmadan enerji üretebilen alternatif enerji teknolojileri hayati önem kazanmıştır. Türkiye'nin ekonomik istikrarı ve enerji güvenliğinin temel bir unsuru olan elektrik enerjisi sektörü, iklim değişikliğine uyum sağlamada büyük bir rol oynamaktadır. Bu çalışma, 2008-2022 döneminde Türkiye'deki halka açık elektrik enerjisi firmalarına odaklanarak iklim değişikliğinin bu firmaların finansal performansını nasıl etkilediğini panel veri metodolojisi ile incelemektedir. Ampirik bulgular, iklim değişikliğinin finansal sonuçlar üzerinde anlamlı ve olumlu bir etkiye sahip olduğunu, iklim baskılarına uyum sağlamanın sektör için finansal olarak fayda sağlayabileceğini göstermektedir. Sonuç olarak, elektrik enerjisi sektörünün iklimle ilgili stratejileri kurumsal gündemlerine dahil etmesi gereklidir. Ancak, teknolojik yenilikler geniş çaplı bir kamu eylemi olmadan yeterli olmayacaktır; bu noktada yerel ve ulusal hükümetlerin uluslararası kuruluşlar ve diğer ülkelerle iş birliği içinde çalışması önemlidir.

*Asst. Prof. Dr., Pamukkale University, Faculty of Applied Sciences, Capital Market Department, Türkiye, cgunduz@pau.edu.tr (Corresponding Author)

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1. Introduction

Many industries, such as energy, logistics, and aviation, operate under dynamic conditions largely shaped by external developments and stakeholder expectations, both physical and social. Consequently, the business world views climate change as a phenomenon with substantial financial and strategic impacts on its activities.

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2023) states that approximately 3.5 billion people reside in areas that are particularly vulnerable to the impacts of climate change. Climate change leads to massively negative impacts and associated losses for both nature and humans, with these effects being unevenly distributed across various systems, regions, and industries. Economic harm from climate change has been observed specifically in industries vulnerable to climate shifts, such as agriculture, forestry, fishing, energy, and tourism which seriously affects productive activities. Furthermore, the effects of extreme climate risks may consume available economic resources to mitigate it. Looking at the statistics of the last research by the World Economic Forum (WEF, 2024), climate change topics (extreme weather events, natural resource shortages) are selected as the top global risks over a 10-year period. Adaptation efforts stand behind at the intensity of climate change-related events while countries are grappling with the impacts of record-breaking climate change-related issues. If the global community does not commit to more proactive climate change control measures and provide support to poorer nations in managing its effects, world GDP will decrease by 4% in 2050 (S&P Global, 2022).

Every year, 1.3 billion tons of food waste, 300 million tons of plastic waste and 50 million tons of electronic waste are among the main factors causing climate change. Also, this causes a rise in GHG emissions. 60 billion tons of resources transferred to the economy become waste and trigger the climate crisis (DCube Döngüsel Ekonomi Kooperatifi, 2020). On the other hand, the dependence on a constant flow of resources exposes national economies to fluctuating commodity prices and economic shock waves. High volatility in resource price levels increases uncertainty, discourages firms from investing, and increases the cost of protecting against resource-related risks (Ellen MacArthur Foundation, 2016). All of these factors will negatively impact economic growth, leading to economic losses that could reach nearly $8 trillion by 2050 (Qing et al., 2024).

The global electricity power system is influenced too much by climate change because it is highly sensitive and vulnerable to climate change effects (Vafadarnikjoo et al., 2022). The design, generation, demand, and allocation of electricity energy supply become more crucial due to climate change influences on this system (Perera et al., 2020). Some key climate change events impact various parts of the world. Extreme weather events such as Hurricane Katrina in the U.S. and Typhoon Haiyan in the Philippines, extreme heat in big cities like New Delhi and Paris, droughts in regions like sub-Saharan Africa, California, wildfires in places like Australia and the Amazon rainforest, climate-induced migration in places like Bangladesh and parts of Africa will also change conditions of demand, generation, and allocation of energy assets.

In terms of Türkiye, extreme climate change events are putting raising pressure on her infrastructure, ecosystems, and economy. For instance, coastal cities like Istanbul, Izmir, and Antalya are at risk of flooding due to rising sea levels. More frequent and severe heatwaves in Istanbul, Ankara, and İzmir lead to energy demands for cooling. Çukurova, Konya, and Söke plains, Southeastern Anatolia, and other agricultural parts of Türkiye have been facing prolonged droughts impacting agricultural productivity. In recent years, forest fires that occurred in regions in the southern and western parts of the country have been causing economic and environmental damage. All of these events have been putting strain on energy production and significant disruptions in the power system. According to the World Bank (2022) geographical, climatic, and socioeconomic conditions in Türkiye make the country highly vulnerable to the effects of climate change hazards. They highlight the need for enhanced resilience and reliability in Türkiye's power system, indicating that the adaptation of the energy market to climate change still requires large public and private investments.

Besides, apart from physical risks including heatwaves, droughts, forest fires, and floods, there are also transitional climate change risks. Transitional risks can affect the market. The electricity power industry has significant potential for reducing emissions and is one of the key points for struggling against climate change. According to the Republic of Türkiye Ministry of Energy and Natural Resources (2024) data, nearly 60% of Türkiye's electricity generation will be obtained from renewable energy sources in 2023. The promotion of low-carbon policies has been causing the growth of renewable energy generation. Moreover, these policies will drive up production costs in carbon-intensive industries, then temporarily lower the market competitiveness of these firms. When looking at statistics, emissions related to the energy industry have the largest share with 72% among other industries according to the Turkish Statistical Institute (2024) in 2022. To survive into the green transition, non-renewable industries must boost technological innovation investment and enhance the efficiency of energy system (Sun et al., 2023).

Climate change and reducing its effects are on the agenda of many countries. Obviously, in order to solve this problem, it is necessary to invest in clean and renewable energy sources (Gençyürek and Ekinci, 2021). When the cost of such an investment is considered, unfortunately, it leaves a question mark in minds about how eager developed countries are to make these investments in struggling against climate change or how sincere they are in reducing the use of coal and fossil fuels.

Previous research (Durmuşkaya, 2016; Heyes et al., 2016; Pagnottoni et al., 2022; Dang et al., 2023) about the effects of climate change performance on financial performance has massively focused on the macro level, such as examining the physical impacts of hotter temperatures, air pollution, and natural disasters. Studies (Huang and Song, 2006; Dhaliwal et al., 2011) about the financial performance of the electricity industry have primarily concentrated on factors like corporate capital management, capital structure, and social responsibility. However, as an external factor, climate change performance role has received less attention. In this context, this paper centers on publicly listed electricity firms in Türkiye from 2008 to 2022, exploring the impact of climate change performance on their financial performance through panel data analysis. Accordingly, the potential contributions of this paper encompass three key aspects. Firstly, the paper examines how climate change performance affects the publicly listed electricity power firms' financial performance in Türkiye's securities market. Secondly, this study systematically analyzes the positive and negative impacts of climate change performance on corporate financial performance using both firm-level and country-level data. Finally, it develops a methodology including a range of climate performance data, containing GHG emissions, renewable energy, energy use and climate policy, to analyze their composed impacts on electricity power firms' operations.

The introduction part of the paper is followed by a review of the relevant literature. Third section clarifies the data and the methodology. Section four presents the empirical findings and discussions; and the final section is the conclusion part including policy recommendations.

2. Literature Review

Many studies in the field of finance show that climate change can directly and indirectly affect the financial health of both climate-sensitive industries, like energy, agriculture mining, forestry, fishing, and non-climate-sensitive industries (for instance; service and insurance) (Liu et al., 2020). These effects can cause various changes. Studies have shown that exposure to climate change risks leads to serious economic, social, and physical losses (Campiglio et al., 2018; Pagnottoni et al., 2022).

Climate change impacts on specific industries, such as the energy industry, have garnered widespread attention. Electricity generation is widely recognized as sensitive to climate change risks due to its reliance on temperature variations and weather conditions. (Sun et al., 2023). These kinds of events can disrupt the operations of electric power firms by damaging infrastructure, reducing efficiency, and increasing operational expenses resulting in potential revenue losses. Consequently, climate change events are expected to negatively affect the financial performance of electricity power firms. Some scholars have searched the link between climate change events and the financial performance of electricity energy firms in terms of multiple perspectives, including corporate social responsibility, environmental regulation, corporate capital structure, capital management, electricity supply, and demand. Few studies have been focused on financial performance. Heyes et al. (2016), compared daily data from the S&P 500 with air quality readings from U.S. Environmental Protection Agency (EPA) sensors near Wall Street. They found a correlation between high air pollution and lower stock values, with each standard deviation decrease in air quality leading to a 12% drop in stock returns. In other words, over 100 trading days, S&P 500 performance was 15% worse on the 25th most polluted day compared to the 75th cleanest day. They also observed this effect when analyzing data from the New York Stock Exchange and Nasdaq. Fan et al. (2019), examined the sensitivity of electricity demand to climate change events by panel data method for 22 years. The paper finds that climate change conditions positively impact per capita electricity demand. As climate change intensifies in the future, electricity demand is expected to rise, particularly to accommodate the increasing need for cooling. Without the implementation of effective climate policies, more energy will be consumed to manage this growing cooling demand. To Van Ruijven et al. (2019), future energy demand is projected to rise due to climate change, with the increase ranging from 11% to 58% by 2050, depending on the severity of warming and socioeconomic scenarios. The greatest increases in energy demand are expected in tropical regions and parts of the USA, Europe, and China, while socioeconomic factors will strongly influence the extent of this impact, particularly for low-income populations. Li et al. (2016), focus on electric power generation expansion planning while considering the uncertainties of climate change. They develop a preliminary model using data from various sources and define discrete climate scenarios to optimize planning decisions under uncertainty. Two optimization models, one minimizing total expected cost and the other minimizing maximum regret, are proposed to find robust solutions that work across all climate scenarios, helping policymakers avoid the risks of relying on a single forecast. Yu et al. (2020), examine optimal investment strategies for Chinese power enterprises in light of the nationwide carbon emissions trading market. Their study suggests that, while short-term investments in clean technology should be prioritized over large-scale green energy installations to improve profits and manage carbon emissions, long-term investments in green energy will help mitigate the rising costs of carbon trading.

In this study, climate change impacts on the electricity energy industry are mostly from both macro and corporate levels to explore the effect of changes in macro and corporate policies on the operation of electricity energy firms. A study exploring the impact of air pollution on stock returns at Borsa İstanbul (BIST) during the period from February 1, 2007 to July 20, 2016 shows that air pollution significantly and negatively affects BIST Services Index returns, while it has a delayed effect on the returns of BIST-100, BIST Industrial, and BIST Financial Indices (Eyüboğlu and Eyüboğlu, 2018). Güngör and Küçün (2019), discuss the trading volume and trading size in BIST 100 Index and weather conditions between February 2011 and September 2015. The findings show that there is a significant difference between the averages of trading volume and trading size in terms of weather conditions in the classification as sunny, cloudy, rainy and snowy.

Hong et al. (2019), explore climate change impacts, particularly rising global temperatures and increasing drought risks, on food stock prices. Researchers analyzed publicly traded food companies' data from 31 countries. Then, they ranked data based on long-term drought trends via the Palmer Drought Severity Index. They explored that countries with worsening drought trends tend to experience lower growth in profit and poorer stock returns. This suggests that stock prices are not fully accounting for the risks posed by climate change, leading to predictable underperformance in countries more vulnerable to drought. The mining industry is highly exposed to climate change risks, which impact corporate financial performance both directly and indirectly. An analysis of China's 75 listed mining firms from 1995 to 2017 shows that climate risks affect financial outcomes, with varying sensitivity based on resource types. To mitigate these risks, mining firms should adopt low-carbon strategies, and increase transparency in emissions reporting to strengthen brand value and long-term competitiveness (Sun et al., 2020). Another study analyzes the impact of temperature changes on Chinese-listed manufacturing companies, finding that higher temperatures decrease financial performance importantly, while other seasons have no notable effect. Extreme temperatures, both below -12°C and above 27°C, negatively affect corporate financial outcomes, primarily by reducing labor productivity and increasing adaptation costs (He et al., 2021). Pagnottoni et al. (2022) conducted a statistical analysis of how natural disasters and global climate change affect international stock markets. Using an event study methodology, the study examines the impact of various disasters (meteorological, biological, geophysical, climatological, hydrological) in 104 countries on 27 stock market indexes between 2001 and 2019. The results reveal that stock market reactions vary by disaster type and location, with climatological and biological events causing the most significant market responses, particularly in Europe. The study also develops a hedging strategy to explore investment opportunities related to natural disaster risk mitigation. Sun et al. (2023) searched climate change risk impact on the financial performance of Chinese electricity energy firms and find a significant and positive correlation. While rainfall and drought indices improve financial performance, cryogenic freezing disasters negatively affect it by causing regional power system breakdowns. To them, in order to enhance adaptability, power firms should integrate climate risks into their management frameworks, and optimize energy sources, and governments should support this transition with green financial tools.

3. Research Methodology

3.1. Variable Selection

Evaluating the performance of firms correctly is crucial when making investment decisions in the financial world. There are many indicators used for evaluation. To show climate change performance impacts on financial health, this paper consults the existing literature to select Tobin's Q (Lo and Sheu, 2007; Ziegler, 2012), earnings per share (EPS) (Sun et al., 2023), and return on assets (ROA) (Vena et al., 2020; Sun et al., 2020) as corporate financial performance indicators. These indicators play a guiding role to evaluate the financial health of firms in the literature. Among these, EPS and ROA are solely derived from the firm's financial data and may not completely capture the long-term performance.

While both EPS and ROA are important financial metrics that help an investor to understand the firm's overall financial health, Tobin's Q reflects the market value of a firm (Lindenberg and Ross, 1981; Chung and Pruitt, 1994; He et al., 2021). The market value of a firm is actually influenced by its current financial position, which aligns with the information reflected in metrics like EPS and ROA (Sami and Zhou, 2004). Moreover, the market value of a firm signifies the present value of its anticipated future profits, reflecting not only its future profitability but also adjustments for risk (Brealey et al., 2007; Rabier, 2017). Since it can provide more comprehensive information about financial condition, this paper chooses Tobin's Q as another measure of corporate financial performance.

To test the impacts of climate change performance on the financial performance of Türkiye's listed electric power firms, Climate Change Performance (CCP) is selected as the independent variable. Considering that climatic factors are linked to climate change and play a significant role in influencing the output of firms, the study combines these factors such as renewable energy, GHG emissions, climate policy, and energy use under a single heading as CCP in the research model.

The financial health of firms may also be affected by other different indicators. According to existing research, the study uses two kinds of control variables. The first kind of control variable is the micro-level corporate financial indicators. The second one is macro-level control variables. Therefore, the study refers to He et al. (2021) and Sun et al. (2023) for controlling the micro-level variables such as firm size (SIZE), internal rate of return (IRR), asset-liability ratio (LEV), fixed asset ratio (FIX), and macro-level variables such as per capita GDP (LnPGDP), foreign investments (INV) in the research model.

3.2. Data Source

The study focuses on publicly listed electricity power firms from the "Electricity, Gas and Water" industry on the BIST stock market between 2008 and 2022 as the research subjects. Financial data at the firm level is sourced from their financial statements, while macroeconomic data is obtained from the International Monetary Fund (2023) database.

The data on climate change performance in the paper is from the annual Climate Change Performance Index (Burck et al., 2022). Index data covers four categories defining the overall score, which collects GHG emissions, renewable energy, energy use, and climate policy data.

This study gathers financial data of firms from their financials. After removing missing data and outliers, the final dataset consists of 31 firms and 465 observations. To remove the impact of outliers for the firm-level data, the paper eliminates samples that have a large number of missing observations. A description of all variables is shown in Table 1 below.

Table 1. Definitions of Variables

Type	Name	Code	Description
Dependent Variables	Earnings Per Share	EPS	Net Profit/Capitalization
	Return on Assets	ROA	Net Profit/Average Total Assets
	Tobin's Q	Tobin's Q	(Total Debts+Market Value)/Total Assets
Independent Variable	Climate Change Performance	CCP	The yearly indices of four climatic factors which are weighted average
Micro-Level Control Variables	Firm Size	SIZE	Asset growth rate
	Internal Rate of Return	IRR	Growth in operating income
	Asset-liability Ratio	LEV	Liabilities/Total Assets
	Fixed Asset Ratio	FIX	Fixed Assets/Total Assets
Macro-Level Control Variables	Per Capita GDP	Ln PGDP	Logarithm of (GDP/Population)
	Foreign Investments	INV	Percent of GDP

3.3. Model Setting

In this study, CCP is used as the independent variable, while financial performance, measured by EPS, ROA, and Tobin's Q, serves as the dependent variable for analyzing the correlation between climate change performance and financial performance by establishing a panel data model. Since the analysis involved time series (T) data for a large number of firms, panel data analysis, which combines cross-sectional (N) and time series analyses, was chosen as the econometric method in the study. In this method, it is generally observed that the number of cross-sectional units exceeds the number of time periods, leading to a situation where N>T (Tatoğlu, 2016). The study constructs the following models by referring to Chen and Yang (2019):

$$EPS_{it} = \alpha_0 + \alpha_1 CCP_{it} + \alpha_2 Control_{it} + u_i + \vartheta_i + \varepsilon_{it} \quad (1)$$

$$ROA_{it} = \beta_0 + \beta_1 CCP_{it} + \beta_2 Control_{it} + u_i + \vartheta_i + \varepsilon_{it} \quad (2)$$

$$TobinQ_{it} = \gamma_0 + \gamma_1 CCP_{it} + \gamma_2 Control_{it} + u_i + \vartheta_i + \varepsilon_{it} \quad (3)$$

where EPS_{it}, ROA_{it} and $TobinQ_{it}$ represent the corporate financial performance of firm *i* in year *t*. $Control_{it}$ denotes the control variable for firm *i* in year *t*, encompassing micro-level characteristics and macro-level factors. To avoid excluding non-time-varying unobservable factors and to avoid biased estimates resulting from time trends, the study controls the time-invariant firm fixed effects (u_i) and the year fixed effects (ϑ_i). ε_{it} is an error term. Additionally, to address issues of heteroscedasticity and autocorrelation, the study employs firm-level clustered robust standard errors.

At the start of the analyses, this study applies the F-test and the Hausman test to choose between the classical, fixed-effects, and random-effects models. Then, a series of specification tests are conducted to examine the potential presence of issues frequently encountered in panel regression models, such as heteroskedasticity, autocorrelation, and cross-sectional dependency. The paper executes Breusch-Pagan (1980) / Cook-Weisberg (1983), Levene (1960), Brown and Forsythe (1974) tests for heteroskedasticity in the estimated models, then it applies the Durbin Watson (DW) test of Bhargava et al. (1982), the Locally Best Invariant (LBI) test of Baltagi-Wu

(1999) and Wooldridge (2002) tests for autocorrelation. However, since the dataset used in the paper is unbalanced, cross-sectional dependency tests could not be conducted. The results of the heteroskedasticity and autocorrelation tests are presented in Table 2. The study used Stata 14 in order to estimate the panel data model.

4. Empirical Findings and Discussion

In panel data models, the validity of the classical model, in other words, the presence of unit and/or time effects, can be determined using the F-test. It is generally examined whether the data varies across units in this test. If the data does not differ across units, the classical model is deemed appropriate. In the F-test, the hypothesis ($H_0: \mu_i = 0$) that all unit effects are equal to zero is tested. Therefore, F-test was first conducted to make a choice between the classical model and the fixed-effects/random-effects model in the study. Then the Hausman test was used to make a decision between the fixed-effects model and the random-effects model. Table 2 reports the regression results.

Table 2. Regression Results of Climate Change Performance on EPS, ROA and Tobin's Q

		EPS (1)	ROA (2)	Tobin's Q (3)
F-test	Prob > F	0.0035	0.5141/0.2939	0.0000
LM Test	Prob>chi2	0.0028	-	-
Hausman Test	Prob>chi2	0.7867	-	0.0216
Heteroskedasticity	W0	0.0000	-	0.0000
	W50	0.0445	-	0.0000
	W10	0.000	-	0.0000
	Breusch-Pagan / Cook-Weisberg	-	0.0001	-
Autocorrelation Tests	DW	1.3555	-	1.0387
	LBI	1.9943	-	1.6461
	Wooldridge	-	0.0005	-

Note: Significance at the 5% confidence level.

Based on the results presented in Table 2, the null hypothesis (H_0) that all unit effects are equal to zero is rejected for models (1) and (3), indicating the presence of unit effects. Therefore, the classical model is not suitable for these models. For model (2), however, the null hypothesis (H_0) that unit and time effects are equal to zero cannot be rejected, indicating that these effects are insignificant. F-test statistics are calculated at 0.5141 for unit effects and 0.2939 for time effects which means the classical estimator is appropriate for only this model. Breusch-Pagan (1980), developed the Lagrange Multiplier (LM) test, based on the residuals of the classical model, to test the suitability of the classical model against the random effects model (Tatoğlu, 2016). In this test, the hypothesis ($H_0: \sigma_\mu^2 = 0$) that the variance of the random unit effects is zero is tested. In this test statistic, if the null hypothesis (H_0) is rejected, it is concluded that the classical model is not suitable. Baltagi and Li (1990) extended the Breusch-Pagan test for unbalanced panels. Based on all the test results, the null hypothesis (H_0) is rejected. The variance of the unit effects is different from zero, meaning the presence of unit effects is accepted. Therefore, it is concluded that the classical estimator is not convenient for model (1). In other words, the baseline regression utilizes the random-effects model.

As a result of the tests, if unit and/or time effects are found to be present, it is necessary to determine whether these effects are fixed or random. In the study, the Hausman test was used to decide between these estimators. The Hausman test, used to test the null hypothesis "the random effects model is appropriate" against the fixed effects model, provides the following values based on the results 0.7867 for model (1) and 0.0216 for model (3). As a result of the tests, for model 1, since the null hypothesis was accepted, it is concluded that the random effects estimator is valid. For model 3, since the null hypothesis was rejected, it is concluded that the fixed effects estimator is valid. Thus, the first model was estimated using the random effects estimator, while the third model was estimated using the fixed effects estimator.

To test for heteroskedasticity, this study applied the Levene (1960) and Brown and Forsythe (1974) tests (W0, W50, and W10) for models (1) and (3), Breusch-Pagan (1980) / Cook-Weisberg (1983) tests for model (2). The null hypothesis (H0), which states "the variances of the units are equal" is rejected for the research models, indicating that there is heteroskedasticity in these models.

According to the findings in Table 2, since the LBI and DW test statistics are less than 2, it can be understood that there is autocorrelation in the models (1) and (3). For model (2), the paper applied Wooldridge (2002) test and decided that there is autocorrelation.

Multicollinearity refers to the situation where two or more predictor variables exhibit a high degree of linear relationship with each other. Even if no pair of variables has an exceptionally high correlation, it is still possible for a linear relationship to exist among three or more variables. This phenomenon is called multicollinearity. It occurs when the explanatory variables influence not only the dependent variable but also each other. The degree of this effect can reduce the predictive power of the explanatory variables in the model. A better way to assess multicollinearity is by calculating the variance inflation factor (VIF). In practice, there is typically a small degree of linearity among the predictors. As a general rule, while VIF value above 5 suggests problematic multicollinearity, above 10 suggests highly problematic multicollinearity (Roso et al., 2005; James et al., 2013). To test for multicollinearity in the paper, VIF values are calculated and presented in Table 3.

Table 3. VIF Values

Variable	EPS (1)	ROA (2)	Tobin's Q (3)
CCP	1.88	1.81	1.81
SIZE	1.33	1.31	1.30
IRR	1.14	1.10	1.10
LEV	1.25	1.21	1.19
FIX	1.18	1.12	1.10
LnPGDP	3.64	2.92	2.97
INV	4.19	3.22	3.28

As can be seen from Table 3, VIF values are within acceptable limits. Therefore, it is decided that there is no multicollinearity in the models. Since autocorrelation and heteroskedasticity were detected in the research models, they were re-estimated using the robust Huber (1967), Eicker (1967), and White (1980) estimator.

To determine whether climate change performance is important for the financial performance of listed electricity energy firms, the models in Equations (1), (2), and (3) were re-estimated using robust estimators. The estimation results are presented in Table 4.

Table 4. Robustness Regression Results

Variable	EPS (1)	ROA (2)	Tobin’s Q (3)
CCP	0.1446008**	0.4242471**	0.1502995***
SIZE	0.0125847**	0.0292484**	0.0029345
IRR	-0.0001309	0.0017238***	-0.0000384
LEV	-0.0483871**	-0.2615851***	0.0331027*
FIX	-0.0343392*	-0.227367***	-0.0108851
LnPGDP	5.500521***	20.95785**	3.702598***
INV	-0.0637677	-0.6244762*	0.0557311

Note: *, **, *** represent significant at 10%, 5%, 1% confidence level.

Table 4 summarizes the regression results of CCP on EPS, ROA, and Tobin’s Q of listed firms in the electricity market in Türkiye’s securities market. The impact of CCP on the financial performance of listed electricity energy firms is significantly positively correlated. In other words, CCP has positive impacts on the financial performance of listed firms this study is searching for. These impacts can be argued in some ways. Initially, climate change risk encourages electric power firms to invest in restructuring energy efficiency and renewable energy thereby gaining long-term competitive advantage and reducing cost. Secondly, most electric power firms are actively trying to improve their environmental brand image. They are adapting to take steps towards environmental sustainability policies. At the same time, information is being received from corporate ads, news, and media indicating that the government supports firms in managing the negative impacts of climate change on stakeholders. Thirdly, firms can face with new business opportunities by managing rightly their climate change policies. Today, people are talking too much about sustainability, carbon trading, green finance, and renewable energy. These projects can create financial opportunities for firms to strengthen their long-term financial performance. Of course, there are also some negative climate change impacts on financial performance. For instance, natural disasters brought on by climate change (floods, droughts, storms, etc.) can damage firms’ physical assets, production processes, and supply chains. This means that production losses and unexpected costs in terms of firms. Also, adapting to sustainability issues like climate change policies requires significant capital expenditures. Firms have to invest in high amounts to reduce carbon emissions and switch to climate-friendly technologies. This also points out financial burdens in the short term especially. Considered together, the results indicate that the advantages outweigh the drawbacks, although natural disasters and financial challenges arising from climate change events could have some negative impact on the electricity energy industry.

SIZE is positively correlated with EPS and ROA. It is known that adapting to climate change-related issues is costly. The larger a firm’s asset, the more budget it can allocate to such issues. When they expand their assets, they will focus not only on short-term survival or profit but also on pursuing sustainable growth, thereby enhancing their profitability. Another positive correlation is observed between the IRR and ROA of listed firms. Typically, the growth rate of operating income indicates the extent of business expansion and the pace of development acceleration. Thus, the larger this indicator, the greater the rise in profitability. LEV is negatively correlated with EPS and ROA and positively correlated with Tobin's Q. If a firm's debt levels increase relative to its assets, its profitability tends to decrease. The increase in this ratio means the firm is relying on more debts to finance its operations, this can limit liquidity and put pressure on operational efficiency. Since, with a higher LEV, more of the firm's earnings will be directed to the payment of interest. Thus, the firm cannot invest in new projects. These issues can lead to decrease in profitability, result in lower EPS and ROA. On the other hand, it is seen that LEV is positively correlated with Tobin's Q. As it is told before, Tobin's Q reflects both market value and long-term performance. If a firm prefers debt to fund expansion or invest in new opportunities and investors believe that these investments will have positive sights on future profit, then Tobin's Q drives up. Since interest payments are tax-deductible, the firm get a chance to enhance tax efficiency which can drive up its market value. It is seen from Table 4 that FIX is negatively correlated with EPS and ROA. Results show that when a firm holds more of long-term investments, its profitability tends to decrease. Fixed assets such as property, plant, and equipment have lower liquidity and cannot generate cash immediately. While most of the firm's assets are tied up in long-term investments this may reduce overall asset efficiency. ROA measures how effectively a company utilizes its assets to generate profit so lower efficiency in assets may negatively impact ROA. Also, fixed assets are subject to depreciation. The more fixed assets a firm owns, the higher depreciation expenses rise, net income falls. Thus, it is directly reducing overall profitability and the income available to shareholders which directly impacts EPS. The results state that the effect of macroeconomic conditions (LnPGDP and INV) on firm performance is mixed. According to the empirical findings, while LnPGDP is positively correlated with firm performance at all confidence levels, INV is negatively correlated with firm performance at a 10% confidence level.

5. Conclusion and Policy Implications

This paper confirms the correlation between climate change performance and the listed electricity firm's performance on BIST by setting a panel data model for empirical analysis. The study covers the years between 2008 and 2022. The findings of this paper are consistent with recent studies such as Sun et al. (2023), Hong et al. (2019) and Heyes et al. (2016) highlighting these matters. For example, Sun et al. (2023), investigate the impact of climate change risks on the financial performance of Chinese electricity energy firms and report a significant positive correlation. Moreover, Hong et al. (2019), discover that countries facing worsening climate change events often experience slower profit growth and weaker stock returns. Heyes et al. (2016), found a correlation between extreme climate change events and financial performance too. Clearly, findings show that firms need to fully account for the risks posed by climate change and reflect them in financial conditions.

The empirical findings based on panel data model show that CCP positively impacts the firm performance which is measured by EPS, ROA and Tobin's Q of electricity power firms. The positive sign of the coefficient indicates that higher (lower) CCP in a firm's activities improves (worsens) performance. As firms invest more in CCP issues, they get better financial results, which positively affects their performance. Therefore, electric power industry must take into account the effects of climate change risks and set varied strategic responses for such kind of risks. The findings of this paper offer policy recommendations for a large number of stakeholders such as the environment, investors, regulatory institutions, governments, and others.

Firstly, electricity energy firms should consider climate change investments together with their own resources. This means that using a single energy production source can create inefficiency due to the negative effects of climate change. Therefore, existing facilities should be optimized according to the conditions that climate change risks may create. So, when a firm decides to make an infrastructure investment and design future production activities, it should notice to the trend of climate change risks.

Second, firms should optimize their production processes according to climate change conditions in their local areas. These crucial efforts help firms adapt to changing climate patterns. By analyzing climate change performance, firms can improve their clean energy projects. Additionally, they can set up relevant departments related to climate change-related issues and then integrate these departments into their risk management system. Moreover, these departments should issue various green instruments to get cheap funds from investors, to build a good reputation and brand value in the market.

Third, listed firms should actively complete low-carbon emission and energy use responsibilities, shifting to renewable energy responsibilities in order to avoid high fines from the legal authorities. These authorities should encourage the development of GHG emissions, renewable energy, energy use and climate policy for firms to obtain financial support.

Fourth, the more investors are enthusiastic about green instruments, the more firms consider climate change. For this reason, governments, and legal institutions should encourage market-driven reforms in the industry and improve electric power firm's ability to adapt to climate change. Hence, these initiatives will accelerate industry firms to take advantage of supportive policies and spend more on clean energy investments.

Finally, when awareness of climate change is embraced by all segments of society, it will also have positive effects on the environment. Reduced fossil fuel consumption, and investing more in green strategies will lead to less environmental pollution and a healthier life.

Industries, from industrial facilities to our homes, from transportation to healthcare directly depends on energy. A reliable and sustainable energy supply is a milestone of modern life. As in almost all emerging markets, electric power firms in Türkiye are one of the most important institutions to reduce energy dependency. Energy independence reduces a country's vulnerability to energy shocks. It supports economic development and social well-being. Therefore, a healthy structure of the industry is of great importance for the welfare of the economy. As a result, it can be said that governments and electric power firms in Türkiye should take into account climate change-related issues and the impact of these issues on overall performance. Since the majority of electric power firms in Türkiye are not publicly listed, the sample size in this paper is limited and need to be expanded. Future research can focus on addressing this limitation.

Declaration of Research and Publication Ethics
This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement
I am a single author of this paper. My contribution is 100%.

Declaration of Researcher's Conflict of Interest
There is no potential conflict of interest in this study.

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