

DOES CLIMATE RISK AFFECT CORPORATE FINANCIAL PERFORMANCE? EVIDENCE FROM TÜRKİYE

İklim Riski Kurumsal Finansal Performansı Etkiliyor mu? Türkiye'den Kanıtlar

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Abstract

Climate risk affects not only living things and nature but also, increasingly, firms. Therefore, quantifying the impacts of climate risk on firms and analyzing their impact on financial performance constitutes an important area of research. In this context, the objective of this study is to investigate the effects of climate risk on corporate financial performance. The research applies climate risk indices developed by Bua et al. (2024) as a proxy for climate change risk. For the purpose of this study, firm data for the BIST Sustainability 25 Index, listed non-financial companies, consisting of a panel data set between 2005 and 2023, is applied. In pursuit of this goal, the System Generalized Method of Moments (System GMM) was used, as it is considered a suitable estimator of dynamic panel data in measuring climate hazard impacts on financial performance. The results of the study show that both physical risk and transition risk have negative effects on corporate financial performance. This study provides important insights for policymakers and enterprises in terms of climate risk and corporate financial performance.

Keywords:

Financial Performance, Climate Risk, Sustainability.

JEL Codes:

G32, Q54, Q56.

Öz

İklim riski sadece canlıları ve doğayı değil aynı zamanda giderek artan oranda işletmeleri de etkilemektedir. Dolayısıyla iklim riskinin işletmeler üzerindeki etkilerinin nicelleştirilmesi ve finansal performansları üzerindeki etkilerinin analiz edilmesi önemli bir araştırma sahası oluşturmaktadır. Bu bağlamda, bu çalışmanın amacı, iklim riskinin kurumsal finansal performans üzerindeki etkilerini arařtırmaktır. Çalışmada iklim değışikliği risk ölçüsü olarak Bua vd. (2024) tarafından geliştirilmiş iklim risk endeksleri kullanılmaktadır. Arařtırma kapsamında firma verileri olarak ise BIST Sürdürülebilirlik 25 Endeksi'nde yer alan finansal olmayan firmalara ait 2005–2023 dönemini kapsayan panel veri seti kullanılmaktadır. Bu doğrultuda, iklim risklerinin firma performansı üzerindeki etkilerini değerlendirebilmek amacıyla dinamik panel veri analiz tekniklerinden biri olan Sistem Genelleştirilmiş Momentler Yöntemi (System GMM) uygulanmıştır. Çalışma sonuçları hem fiziksel riskin hem de geçiş riskinin kurumsal finansal performans üzerinde olumsuz etkileri olduğunu göstermektedir. Bu çalışma iklim riski ve kurumsal finansal performans açısından politika yapıcılar ve işletmeler için önemli çıkarımlar sunmaktadır.

Anahtar Kelimeler:

Finansal Performans, İklim Riski, Sürdürülebilirlik.

JEL Kodları:

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1. Introduction

NASA (National Aeronautics and Space Administration) states that climate change is a gradual shift in the mean patterns of weather that characterize the local, regional, and global climates of the Earth. Two key conclusions can be drawn from this definition. First, climate change occurs as a consequence of prolonged environmental degradation. Second, the impacts of climate change usually extend over a large region. When examining the potential impacts of climate change over the next five years, it is projected that precipitation patterns will show significant regional variations, Arctic warming will continue to exceed the global average, and temperatures will continue to rise (WMO, 2025). All these imminent climate threats are affecting living beings, companies, institutions, and governments, forcing them to prepare action plans.

Bua et al. (2024) classify risks arising from climate change as physical and transition risks. Physical climate risks arise from the tangible effects of climate change. These include climate events such as floods, forest fires, extreme heat, drought, and coastal flooding. Transition risks, on the other hand, arise from the uncertainty surrounding the transition to a more sustainable, net-zero emissions economy.

According to the Intergovernmental Panel on Climate Change's (IPCC, 2022) climate change report, physical climate risks lead directly to production losses, particularly in sectors such as agriculture, fisheries, and tourism. They also inflict damage on ports and assets of energy companies; heat induces significant labor productivity losses. The International Energy Agency (IEA) net-zero emissions report highlighted that transition risks can trigger immediate carbon price shocks, oil and automobile sector demand shifts, and asset stranding in the form of fossil fuel reserves, coal and pipelines, and thermal power plants.

It is widely accepted that both physical and transition risks possess the potential to significantly affect global macroeconomic and financial channels. A study by the International Monetary Fund (IMF) released in 2023, which is captioned 'Global Economic Impacts of Physical Climate Risks,' supports the framework and also emphasizes that climate risks can contribute to disruption in supply chains, an increase in costs, and the reorientation of global trade flows. The channels indicate that the latter impacts growth and inflation on the macroeconomic front. The Network for Greening the Financial System's (NGFS, 2020) report of 2020 also indicates that climate risks beget systemic risks in the context of bank lending, insurance activities, and investment management. The report also notes the adverse developments associated with these threats, for instance, increased insurance expenditures and having larger fiscal impacts on the finances of the public.

Scanning the IMF paper (Global Economic Impacts of Physical Climate Risks- Lepore and Fernando, 2023), indicates that the effects of climate risk are meaningfully different in nations and industries. For instance, the report highlights that countries with middle incomes, and countries with an agricultural dependence register increased exposure to climate risk. Turkey, which falls into the upper-middle-income country status according to the IMF statistics, can similarly be viewed as recording increased risk.

Turkey is exposed to elevated risk from many natural disasters, such as wildfires, floods, landslides, and droughts, because of its geographical position and economic structure, resulting in short-term economic costs. The World Bank's (2022) report on climate includes Turkey among the nations highly exposed to the impacts of climate change. The physical impacts of climate

change also encompass many challenges for Turkey with significant implications for its agricultural sector, food availability, infrastructure, and overall production.

In evaluating transition risk, it is evident that Turkey is highly exposed to climate-related risks. Its reliance on fossil fuels for most of its power generation exacerbates the risk for "stranded asset" scenarios in the event of a demand shock triggering a need for the imposition of stringent carbon regulation (Gulaydin and Mourshed, 2025). Additionally, over-reliance increases the banking and credit risk in fossil fuel investment. Through the inclusion of factors such as the cost of policies and carbon pricing in transition risk analysis, it becomes clear that Turkey is highly exposed to climate risk at both the macroeconomic and firm levels. It requires the development of new policy proposals that yield tangible outcomes.

The overall analysis demonstrates that the impact of climate change has various economic implications, such as the costs of manufacturing and supply systems. This evidence demonstrates that climate change may influence the operations of companies and their financial results in a limited manner and also generate larger economic hazards. Thus, it is evident that climate risk is also a business financial risk and not solely an environmental risk.

Dividing the analysis of the impact of climate risk on the economy into two will help understanding. Dividing it this way allows us to consider the various sectors and aspects impacted by climate risk at a broad level and a detailed level. Climate change risk impacts several major economic factors (Houari et al., 2025). A few of the most significant factors are economic growth, financial stability, inflation, and energy consumption. The negative effects of climate change risk on energy consumption affect many sectors, particularly the transport sector (Cutcu et al., 2023) and manufacturing. Furthermore, recent research reveals a measurable negative relationship between financial stability, inflation variables, and climate change risk (D'Orazio, 2025; Qi et al., 2025).

Climate risk negatively impacts countries' sovereignty, stock market performance and competitiveness to a certain extent (Barbu et al., 2022). Therefore, climate change risk affects many important macroeconomic variables, including economic growth and competitiveness. Furthermore, research suggests that climate change risk can hinder socioeconomic progress (Huang et al., 2023). However, the impact of companies as microeconomic actors on climate change has received relatively little attention compared to that of macroeconomic factors.

Many studies in the literature examine the impact of climate risk on firm value, the cost of capital, investment decisions, and profitability. Some of these studies focus on the impact of climate change risk on corporate environmental, social and governance (ESG) performance (Wright and Nyberg, 2024; Khalid et al., 2024; Abdulla and Jawad, 2024; Li et al., 2024; Yin et al., 2024; Li and Zha, 2025; Afzali et al., 2025), while others have explored the impact of climate change risk on the green and technological innovation achievements of companies (Zhao and Parhizgari, 2024; He et al., 2024; Habib et al., 2025). Apart from this, studies have also been conducted on other major issues such as firm value and company risk (Lu et al., 2024; Xing et al., 2024; Abd-Elhaleim et al., 2025; Chen and Wang, 2025).

Several studies tested the effect of climate risk on the financial performance of companies (Huang et al., 2018; Sun et al., 2020; Cavlak et al., 2021; Mondal and Bauri, 2022; Zhang et al., 2023; Ozkan et al., 2023; Sun et al., 2023; Dinh et al., 2024; Fazil et al., 2024; Mondal and Bauri, 2024; Thai et al., 2024; Bauri et al., 2025; Khemiri et al., 2025). However, the majority of these

studies focus on companies operating in developed countries. In developing economies, the effects of climate risk may emerge through different channels due to differences in the depth of financial systems, corporate governance structures and regulatory frameworks. Although there are studies on the interaction between high-carbon emission sectors, capital markets, and sustainability policies in energy-intensive, externally dependent economies such as Turkey (Kolsuz and Yeldan, 2017; Kılıç et al., 2018; Kılıç and Kuzey, 2019a; Kılıç and Kuzey, 2019b; Gahramanova and Furtuna, 2023; Öncel and Akbulut, 2024), the impact of climate risk on firm performance has not yet been adequately investigated. This creates a significant empirical gap in the literature. In this context, the main research question can be expressed as follows:

“How and through what channels does climate risk affect corporate profitability in an emerging market environment?”

This study empirically examines the impact of climate change on the financial performance of firms operating in Turkey, addressing this gap. Moreover, it advances the understanding of the impact of climate risk on the performance of corporations through the adoption of an original climate risk scale developed by Bua et al. (2024). The research used panel data collected from corporations listed in the Borsa Istanbul (BIST) Sustainability 25 Index during the years 2005 to 2023. The corporations in question are characterized by clear disclosures concerning their environmental and governance approaches, and hold distinctive institutional capacities to respond to climate risk.

While estimating the impact of climate risk on financial performance, it is necessary to account for dynamic relationships and the presence of potential endogeneity. Profitability in the firm is dependent on past performance and may have a bidirectional relationship with the climate risk indicators. Thus, the System GMM approach proposed by Blundell and Bond (1998) was chosen for estimation. The approach addresses the problem of endogeneity by including the level and the first-difference equation in such a manner that, with instrumental variables, consistent and efficient estimates can be derived. The model may then be used to quantify the impact of climate risk on short- and long-term profitability.

It explores the intersection between corporations' financial performance and climate-associated risk, and makes three novel contributions to the existing scholarship. It is the first empirical analysis of how climate risk impacts the financial results of Turkish companies using the System GMM technique in conjunction with the global risk scale used by Bua et al. (2024). Secondly, the research uses the dynamic panel model in order to accommodate the impact of past profitability and the endogenous variables, and thus allow for more reliable causal inferences concerning the impact of climate risk. Finally, the findings provide evidence to policymakers in the development of sustainable finance policies and the effectiveness of green investment policies in Turkey, offering empirical support in this area.

In order to be able to make these contributions, the second phase of the study shall be carried out in the following steps. A comparison of the latest scholarly publications is provided, and research hypotheses will be presented in the second section. The methodology and data set are explained in the third section. The fourth section of the study reports the research findings and discusses them in the context of earlier research. The conclusions, policy implications, limitations of the study, and avenues for future studies are contained in the final section.

2. Literature Review

Climate change has various direct and indirect effects on living beings, the environment, countries, and financial and non-financial institutions. Therefore, it is critical to analyse these impacts from multiple perspectives, present the findings, and develop policies to address these challenges. The literature offers a wide range of studies examining the economic consequences of climate change through macroeconomic indicators and microeconomic variables at the firm level. However, establishing a theoretical link between macroeconomic and microeconomic levels to explain how climate risk is transmitted would also enhance the internal consistency of the literature. This section therefore, examines the literature in three main areas to provide the basis for research hypotheses: 1) macroeconomic-level impacts, 2) firm-level responses, and 3) implications for financial performance.

2.1. The Impact of Climate Risk at the Macroeconomic Level

Macroeconomic research shows that climate risk affects countries' economic growth, financial stability, and price dynamics. Barbu et al. (2022), for example, define climate risk as a variable affecting countries' sovereignty risk, while Cutcu et al. (2023) point out that climate risk can significantly impact energy consumption. Hu and Borjigin (2024), meanwhile, argue that energy markets are more sensitive to climate risk during periods of economic change.

There are also studies in the literature that empirically examine the impact of climate change risk on financial stability and inflation (D'Orazio, 2025; Qi et al., 2025). In addition to studies indicating that commercial credit use decreases in countries with high climate risk (Islam and Wheatley, 2020), some studies suggest that climate risk can increase demand in certain circumstances (Niu and Li, 2022). In this context, it has been demonstrated that climate risk affects real and financial balances via macro-level cost shocks (e.g., energy supply issues and production disruptions) and uncertainty channels.

2.2. Responses to Climate Change at the Firm Level

The way firms respond to climate change is crucial in transmitting macroeconomic shocks to the microeconomic level. They are reorganizing their risk-taking behaviors in order to address the growing risk of climate change (Chen and Wang, 2025), as well as develop resilience to shocks by controlling their asset-liability structures. Lu et al. (2024) and Li et al. (2024) found that climate change increases credit and liquidity risk, and Jin and Cairang (2025) provided evidence that climate risk contributes to higher price volatility.

Moreover, the association between corporate climate risk and social responsibility (Habib et al., 2025), along with the linkage between climate risk and ESG performance (Yin et al., 2024), is also slowly gaining prominence in research. Companies with strong ESG performance have lower costs of financing and higher market confidence (Abdulla and Jawad, 2024). Moreover, the empirical evidence reveals that the underperforming ESG organizations also significantly depend on short-term debt (Li and Zha, 2025). Overall, the evidence suggests that climate risk provides a transformative effect on the allotments of capital, financing structures, and policies involving the social responsibility of companies.

2.3. Consequences for Financial Performance

The impact of climate risk on financial performance, mediated by investors' perceptions and market conditions, has attracted significant academic attention. Adediran et al. (2024) revealed that green and mature stock markets can act as buffers against climate risk. Conversely, findings by Xing et al. (2024) suggested that the protective role may contribute to enhancing market contagion unintentionally. Furthermore, studies revealed that climate risk significantly impacts investment outcomes of firms (Arian and Naeem, 2025). Conversely, investment in FinTech is viewed as an advanced measure that mitigates the impacts of climate risk on the financial market (Yao and Yang, 2025; Chen and Zhang, 2025).

Most of the firm-level studies document that climate change has a detrimental impact on financial performance (Cavlak et al., 2021; Zhang et al., 2023; Ozkan et al., 2023; Fazil et al., 2024; Dinh et al., 2024; Bauria et al., 2025; Qiu et al., 2025; Khemiri et al., 2025; Khemiri, 2025). Conversely, some research documents positive findings regarding the effects of climate change in some industry lines such as power transmission and agriculture (Sun et al., 2023; Mondal and Bauri, 2024; Thai et al., 2024). These variations indicate that the effect of climate risk is industry- and region-specific.

While macro-level cost shocks impact corporations' cost structures through the channels of energy and production routes, these impacts are reflected in the financial results via capital allocation, financing strategies, and investment decisions at the firm level. The mechanism reveals that climate risk creates financial results through the cost allocation and perception channels. The prior research lacks adequate empirical studies that assess this chain holistically. This study offers an original contribution to the research literature by analyzing, through an original country panel, the effect of climate risk on financial results in the physical and transition risk dimensions. In line with this theoretical framework, the core hypotheses of the research are structured as follows:

H1: Climate risk negatively affects corporate financial performance.

H1a: Physical risk negatively affects corporate financial performance.

H1b: Transition risk negatively affects corporate financial performance.

H2: Climate risk concerns negatively affect financial performance.

H2a: Physical concerns negatively affect corporate financial performance.

H2b: Transition concerns negatively affect corporate financial performance.

3. Data and Methodology

Existing research indicates a potential interaction between climate risk and corporate performance. Within this framework, the persistence of profitability and the mechanisms through which climate risks influence corporate performance demonstrate a dynamic configuration, wherein historical performance informs contemporary results. Usually, the impact of climate risk on business develops over time rather than suddenly; this impact finds expression in financial performance with some delay. Hence, the dynamic panel estimator has also been utilized to account for this time-varying impact and, in the process, eliminate potential endogeneity complications.

3.1. Data

The research aims to measure the effect of global climate risk on the performance of Turkey-centered corporations listed in the BIST Sustainability 25 Index by deploying two different datasets. Compared with existing studies, the current research utilizes climate risk indices prepared by Bua et al. (2024) to set out climate change risk. The risk indices can be categorized into two basic groups: the Transition Risk Index (TRI) and the Physical Risk Index (PRI). Reuters' news articles are considered in the creation of the indices, and the data is continuously updated. When creating the PRI, news articles related to rising sea levels, thawing permafrost, floods, and adaptation measures were taken into account. When determining transition risk, regulatory climate news and news discussing the importance of technological developments in achieving a greener economy were considered. To determine physical risk and transition risk, the Physical and Transition Concern (TRC) series is first created. Therefore, four different time series emerge as measures of climate risk. Four different panel regression models were created using the PRI, TRI, Physical Concern (PHC), and TRC time series to analyze the effects of climate risk on corporate financial performance within the scope of this study. Regarding climate risk, data developed by Bua et al. (2024) and published on the website named "Lavinia Rognone-Library" were used. The same data can also be accessed at <https://www.policyuncertainty.com/>.

The second dataset used in the study consists of ratios derived from companies' financial data, collected via the Finnet database. The company-level data cover the period 2005–2023 for companies included in the BIST Sustainability 25 Index for which complete data is available. Return on Assets (ROA) and Return on Equity (ROE) are used as profitability variables in the study to measure the impact of climate risks on company performance. The ROA variable is used because it allows for the assessment of company profitability independently of capital structure (Penman, 2013) and it is one of the most important ratios for measuring asset utilization efficiency (Gitman and Zutter, 2015). The other profitability variable, ROE, is used because it is a central measure of the value created by the firm for its equity investors (Damodaran, 2012), and plays a critical role in understanding the profitability of resources (Higgins, 2012). Additionally, Chen et al. (2005) found evidence in their study that ROA and ROE are among the strongest indicators in financial performance analysis, particularly in emerging markets. Accordingly, this study, conducted specifically for Turkey, employed ROA and ROE as financial performance determinants.

Control variables are used in the study to reduce confounding effects between variables and increase the explanatory power of the model. Accordingly, Total Assets ($\ln ASSETS$) and Asset Growth (AS_{Growth}) were added to the models as growth variables, Current Ratio (CR) as a liquidity variable, Leverage (LEV) as a leverage variable, Fixed Assets Ratio (FAR) as an asset structure variable, and Turnover of Total Assets (TTA) as an efficiency variable. The abbreviations, explanations, and data sources for the variables used in the analysis are shown in Table 1.

Table 1. Explanations Regarding Variables Used in the Analysis

Dependent variable	Abbreviation	Description	Source
Return on Assets	ROA	Net Income / Total Assets	Finnet
Return on Equity	ROE	Net Income / Shareholders Equity	
Independent variable			
Transition Risk Index	TRI	Variables Related to Climate Risk	L R - Library
Physical Risk Index	PRI		
Transition Concern	TRC		
Physical Concern	PHC		
Control Variables			
Total Assets	lnASSETS	Natural Logarithm of Total Assets	Finnet
Current Ratio	CR	Current Assets / Current Liabilities	
Asset Growth	AS _{Growth}	Asset growth by period	
Leverage	LEV	Total Liabilities / Total Assets	
Fixed Assets Ratio	FAR	Fixed Assets / Total Assets	
Turnover of Total Assets	TTA	Net Sales / Total Assets	

3.2. Methodology

The Generalized Method of Moments is used to estimate parameters in statistical models. There are several advantages to using the GMM estimator for dynamic panel data models. The advantage of the GMM methodology is that it takes into account econometric problems encountered in models with lagged dependent variables, such as unobservable country-specific effects and the endogeneity of independent variables (Mhadhbi, 2014: 48; Ke et al., 2020: 10).

In dynamic panel data analysis, GMM can be applied in different ways based on different assumptions. Arellano and Bond (1991) emphasized that GMM management yields better results than other methods in cases involving normally distributed data, varying variance, and measurement errors, and recommended the Difference-GMM estimation method. Subsequently, the System-GMM method was developed by Arellano and Bover (1995) and Blundell and Bond (1998). System-GMM estimators apply the first difference transformation and utilize the lagged values of the endogenous variables in the first difference equations (Coşkun and Kök, 2011: 79-80; Aytürk and Yanık, 2015: 161). In this context, System GMM provides more reliable and efficient estimates due to its lower variance (Blundell and Bond, 1998:138).

In this study, the Two-Step System GMM model estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) was chosen as the analysis method to examine the relationship between climate risk and firm performance. System-GMM applications become susceptible to potential fragilities in data sets with a small number of units of observation (N) and a large number of time periods (T). In particular, a rapid increase in the number of instrumental variables and small-sample bias can cause the Hansen test to lose its meaning (Arellano and Bond, 1991; Blundell and Bond, 1998; Windmeijer, 2005; Roodman, 2009a; Roodman, 2009b; Bun and Windmeijer, 2010). To prevent such methodological issues and enhance the robustness of the model, various precautions were taken in our analysis. During the analyses, the number of instruments was limited by applying the “collapse” command in Stata. This prevented both the instrument proliferation problem and the model from becoming over-identified. Furthermore, to correct downward-biased deviations, the adjustment proposed by Windmeijer (2005) was applied, thereby estimating unbiased standard errors. The Windmeijer (2005) adjustment was a decisive factor in choosing the Two-Step System-GMM estimator. Furthermore, for robustness checks, the models were also estimated using the Driscoll–Kraay standard error estimator and One-Step

System-GMM. The findings obtained with these methods are presented compared to the Two-Step System-GMM results. The relevant regression model is given in Equation 1.

$$y_{it} = \beta_0 + \beta_1 y_{i,t-1} + \beta_3 X_{it} + \gamma Z_{it} + \eta_i + \lambda_t + \mu_{it} \quad (1)$$

Here; y_{it} : represents the dependent variable (ROA / ROE), $y_{i,t-1}$: It represents a lagged value of the dependent variable, X_{it} : represents the independent variable (TRI/PRI/TRC/PHC), Z_{it} : represents the control variables (lnASSETS / CR / AS_{Growth} / LEV / FAR / TTA), η_i : refers to firm-specific effects that cannot be observed, λ_t : expresses effects specific to unobservable time, μ_{it} : refers to the term error.

The following models were created to measure the relationship between the ROA, the independent variable, and climate risk indicators.

$$\text{Model 1: } ROA_{it} = \beta_0 + \beta_1 ROA_{i,t-1} + \beta_2 TRI_{it} + \beta_3 \ln ASSETS_{it} + \beta_4 CR_{it} + \beta_5 ASGrowth_{it} + \beta_6 LEV_{it} + \beta_7 FAR_{it} + \beta_8 TTA_{it} + \eta_i + \lambda_t + \mu_{it}$$

$$\text{Model 2: } ROA_{it} = \beta_0 + \beta_1 ROA_{i,t-1} + \beta_2 PRI_{it} + \beta_3 \ln ASSETS_{it} + \beta_4 CR_{it} + \beta_5 ASGrowth_{it} + \beta_6 LEV_{it} + \beta_7 FAR_{it} + \beta_8 TTA_{it} + \eta_i + \lambda_t + \mu_{it}$$

$$\text{Model 3: } ROA_{it} = \beta_0 + \beta_1 ROA_{i,t-1} + \beta_2 TRC_{it} + \beta_3 \ln ASSETS_{it} + \beta_4 CR_{it} + \beta_5 ASGrowth_{it} + \beta_6 LEV_{it} + \beta_7 FAR_{it} + \beta_8 TTA_{it} + \eta_i + \lambda_t + \mu_{it}$$

$$\text{Model 4: } ROA_{it} = \beta_0 + \beta_1 ROA_{i,t-1} + \beta_2 PHC_{it} + \beta_3 \ln ASSETS_{it} + \beta_4 CR_{it} + \beta_5 ASGrowth_{it} + \beta_6 LEV_{it} + \beta_7 FAR_{it} + \beta_8 TTA_{it} + \eta_i + \lambda_t + \mu_{it}$$

The following models were created to measure the relationship between ROE, which is another independent variable used in the analysis, and climate risk indicators.

$$\text{Model 1: } ROE_{it} = \beta_0 + \beta_1 ROE_{i,t-1} + \beta_2 TRI_{it} + \beta_3 \ln ASSETS_{it} + \beta_4 CR_{it} + \beta_5 ASGrowth_{it} + \beta_6 LEV_{it} + \beta_7 FAR_{it} + \beta_8 TTA_{it} + \eta_i + \lambda_t + \mu_{it}$$

$$\text{Model 2: } ROE_{it} = \beta_0 + \beta_1 ROE_{i,t-1} + \beta_2 PRI_{it} + \beta_3 \ln ASSETS_{it} + \beta_4 CR_{it} + \beta_5 ASGrowth_{it} + \beta_6 LEV_{it} + \beta_7 FAR_{it} + \beta_8 TTA_{it} + \eta_i + \lambda_t + \mu_{it}$$

$$\text{Model 3: } ROE_{it} = \beta_0 + \beta_1 ROE_{i,t-1} + \beta_2 TRC_{it} + \beta_3 \ln ASSETS_{it} + \beta_4 CR_{it} + \beta_5 ASGrowth_{it} + \beta_6 LEV_{it} + \beta_7 FAR_{it} + \beta_8 TTA_{it} + \eta_i + \lambda_t + \mu_{it}$$

$$\text{Model 4: } ROE_{it} = \beta_0 + \beta_1 ROE_{i,t-1} + \beta_2 PHC_{it} + \beta_3 \ln ASSETS_{it} + \beta_4 CR_{it} + \beta_5 ASGrowth_{it} + \beta_6 LEV_{it} + \beta_7 FAR_{it} + \beta_8 TTA_{it} + \eta_i + \lambda_t + \mu_{it}$$

4. Research Findings

Before presenting the analysis results, this section provides descriptive statistics and correlation values for the dependent and independent variables used in the study. Table 2 shows the mean, median, skewness, kurtosis, maximum, minimum, values, and standard deviation statistics for the variables. According to the descriptive statistics presented in Table 2, the average ROA of the companies is 5.01%, while ROE is 14.22%. The ROA variable ranges from a minimum value of -0.1821 to a maximum value of 0.9451, while the ROE variable ranges from -2.1013 to 6.4515. Furthermore, the skewness for the ROA variable is 4.47, and the kurtosis is 38.76, while the skewness for the ROE variable is 7.11 and the kurtosis is 148.37. Overall, the high skewness and kurtosis values in climate risk and financial variables indicate that there are

significant differences in environmental and financial structures among companies. Additionally, information obtained from descriptive statistics indicates that during the period covered by the data set analysis, companies showed moderate profitability (average ROA of 5%, average ROE of 14%), moderate indebtedness (average LEV of 58%), and a reasonable liquidity ratio (average CR of 1.45).

Table 2. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Median	Max	Skewness	Kurtosis
ROA	1368	0.0501	0.0757	-0.1821	0.0352	0.9451	4.4659	38.7576
ROE	1368	0.1422	0.3054	-2.1013	0.1099	6.4515	7.1100	148.3686
TRI	1368	-0.0047	0.0267	-0.0815	-0.0060	0.1250	1.2553	9.4675
PRI	1368	-0.0066	0.0201	-0.0493	-0.0085	0.0656	0.5490	4.2444
TRC	1368	0.0790	0.0287	0.0314	0.0791	0.2166	1.2509	8.1379
PHC	1368	0.0706	0.0211	0.0248	0.0698	0.1251	0.0559	2.8908
lnASSETS	1368	16.4068	1.6246	13.2781	16.1806	22.1407	0.6255	3.0059
CR	1368	1.4514	0.6211	0.4300	1.3100	5.3200	1.2812	5.7085
AS _{Growth}	1368	0.2911	0.4666	-0.5063	0.1837	6.2677	5.5829	52.8941
LEV	1368	0.5888	0.1836	0.1304	0.6139	0.9990	-0.2468	2.2005
FAR	1368	0.5325	0.1498	0.1375	0.5302	0.8702	-0.0438	2.1902
TTA	1368	1.0829	0.9067	-3.1500	0.8150	7.4600	1.7794	11.4607

Following the descriptive statistics for the variables is followed by Table 3, displaying the correlation matrix associated with these variables. The results of the correlation analysis presented in Table 3 show the associations between the study's variables. There was a positive association between ROE and ROA. The climate risk indicators TRI, PRI, TRC, and PHC revealed strong and positive associations with each other. Associations between climate risk variables and the profitability indicators were weak and mostly negative. When the control variables were tested, positive associations between TTA and AS_{Growth}, and the profitability indicators existed. Conversely, there is a negative association between LEV and ROA, indicating that higher indebtedness can decrease profitability. In general, though the climate risk variables are highly related to each other, their effect on profitability is weak. To prevent potential multicollinearity in the analysis, climate risk indicator variables were incorporated in different models.

Table 3. Correlation Matrix

	ROA	ROE	TRI	PRI	TRC	PHC	lnASSETS	CR	AS _{Growth}	LEV	FAR	TTA
ROA	1.000											
ROE	0.551	1.000										
TRI	-0.009	-0.020	1.000									
PRI	0.000	0.015	0.547	1.000								
TRC	-0.055	-0.036	0.925	0.562	1.000							
PHC	-0.042	-0.015	0.535	0.930	0.629	1.000						
lnASSETS	-0.009	0.131	-0.123	-0.030	-0.141	-0.087	1.000					
CR	0.060	-0.068	-0.012	-0.042	-0.004	-0.027	-0.194	1.000				
AS _{Growth}	0.387	0.249	0.058	0.144	0.053	0.095	0.320	-0.095	1.000			
LEV	-0.256	0.047	-0.045	0.009	-0.051	-0.013	0.404	-0.600	0.102	1.000		
FAR	-0.089	-0.156	-0.047	-0.055	-0.054	-0.055	-0.037	-0.141	-0.003	-0.235	1.000	
TTA	0.278	0.273	0.017	0.021	0.031	0.038	-0.103	-0.181	0.108	0.138	-0.403	1.000

If panel data model endogeneity is left unaddressed, then it's possible that coefficient estimates become inconsistent and biased. Specifically, in financial performance models, it's possible that a number of independent variables exist in a two-way causal relationship with profitability. Consequently, prospective endogeneity consequences have to be controlled in an

effort to confirm model findings. In dynamic models, the lagged value of the dependent variable and firm-level parameters often carry potential endogeneity risk. This is because these parameters can change simultaneously with profitability changes due to firm-level decisions. Therefore, in our models, LEV, AS_{Growth}, and CR have been potentially endogenously estimated. The instrumental variable (IV) approach was used to address endogeneity in the problem. The basic intuition behind this method is to reduce estimation bias by eliminating the correlation between the error term and independent variables. Therefore, the instrumental variables in the form of lagged variable values were taken and estimated via the System-GMM estimator.

After determining the endogenous-exogenous status of the variables, the analysis was performed. Tables 4 and 5 show the Driscoll–Kraay estimates for all models, the one-step System GMM results, and the two-step System GMM results when the dependent variable is ROA.

Table 4. Relationship between Climate Risk and ROA (Model 1 and Model 2)

Dependent Variable ROA	Driscoll–Kraay Estimates		System GMM (One-Step) ¹		System GMM (Two-Step) ²	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
ROA _(t-1)			0.268* (0.139)	0.283** (0.133)	0.287* (0.140)	0.314** (0.126)
TRI	-0.089 (0.062)		-0.184* (0.095)		-0.170** (0.071)	
PRI		-0.185** (0.082)		-0.321* (0.160)		-0.348** (0.165)
lnASSETS	0.011 (0.007)	0.011 (0.006)	0.010* (0.005)	0.009* (0.005)	0.007* (0.004)	0.007* (0.003)
CR	-0.014 (0.013)	-0.015 (0.013)	0.001 (0.010)	0.000 (0.010)	0.009 (0.012)	0.007 (0.011)
AS _{Growth}	0.053*** (0.018)	0.054*** (0.018)	0.048* (0.024)	0.050* (0.025)	0.060*** (0.019)	0.060*** (0.017)
LEV	-0.220*** (0.071)	-0.219*** (0.071)	-0.341** (0.158)	-0.314* (0.152)	-0.287** (0.119)	-0.247** (0.112)
FAR	-0.010 (0.078)	-0.012 (0.077)	-0.505*** (0.128)	-0.516*** (0.126)	-0.472*** (0.153)	-0.487*** (0.132)
TTA	0.025** (0.010)	0.025** (0.010)	0.005 (0.016)	0.004 (0.015)	0.002 (0.016)	0.001 (0.015)
Number of obs.	1368	1368	1350	1350	1350	1350
Num. of instr.			14	14	14	14
R-squared	0.3154	0.3170				
AR1			-2.24 0.025	-2.26 0.024	-2.17 0.030	-2.24 0.025
AR2			0.04 0.967	-0.12 0.904	0.08 0.934	-0.05 0.961
Sargan Test			4.43 0.618	3.25 0.776	4.43 0.618	3.25 0.776
Hansen Test			3.94 0.684	2.82 0.831	3.94 0.684	2.82 0.831
	Hansen test exc. group		2.14	1.53	2.14	1.53
Difference-in-Hansen	Diff. (null H = exogenous)		0.829	0.910	0.829	0.910
			1.80 0.180	1.29 0.255	1.80 0.180	1.29 0.255

Note: Standard errors are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1 level is significant.

¹ Obtained using Stata's "xtabond2" command with the "small onestep robust" option.

² Windmeijer (2005) corrected Two-Step GMM standard errors obtained using the "small twostep robust" option in Stata's "xtabond2" command.

Table 5. Relationship between Climate Risk and ROA (Model 3 and Model 4)

Dependent Variable ROA	Driscoll–Kraay Estimates		System GMM (One-Step) ¹		System GMM (Two-Step) ²	
	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4
ROA _(t-1)			0.279*	0.292**	0.287*	0.305**
			(0.150)	(0.135)	(0.154)	(0.135)
TRC	-0.220**		-0.319**		-0.294***	
	(0.078)		(0.112)		(0.092)	
PHC		-0.282***		-0.398**		-0.408***
		(0.090)		(0.148)		(0.139)
lnASSETS	0.009	0.010	0.007	0.007	0.004	0.005
	(0.007)	(0.006)	(0.005)	(0.005)	(0.003)	(0.003)
CR	-0.015	-0.015	0.000	0.000	0.007	0.006
	(0.013)	(0.013)	(0.009)	(0.010)	(0.011)	(0.010)
AS _{Growth}	0.055***	0.055***	0.045**	0.044*	0.054***	0.052***
	(0.018)	(0.018)	(0.022)	(0.023)	(0.019)	(0.017)
LEV	-0.222***	-0.219***	-0.305*	-0.288*	-0.230*	-0.210*
	(0.071)	(0.071)	(0.174)	(0.157)	(0.116)	(0.109)
FAR	-0.017	-0.015	-0.498***	-0.515***	-0.446***	-0.473***
	(0.079)	(0.076)	(0.120)	(0.121)	(0.144)	(0.126)
TTA	0.025**	0.025**	0.008	0.007	0.004	0.003
	(0.010)	(0.010)	(0.015)	(0.015)	(0.017)	(0.015)
Number of obs.	1368	1368	1350	1350	1350	1350
Num. of instr.			14	14	14	14
R-squared	0.3216	0.3210				
AR1			-2.22	-2.25	-2.06	-2.12
			0.026	0.025	0.039	0.034
AR2			-0.20	-0.34	-0.26	-0.45
			0.845	0.735	0.792	0.650
Sargan Test			2.94	2.48	2.94	2.48
			0.816	0.870	0.816	0.870
Hansen Test			3.48	2.41	3.48	2.41
			0.746	0.879	0.746	0.879
	Hansen test excluding group		3.36	2.18	3.36	2.18
Difference-in-Hansen	Difference (null H = exogenous)		0.645	0.824	0.645	0.824
			0.12	0.23	0.12	0.23
			0.724	0.433	0.724	0.632

Note: Standard errors are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1 level is significant.

¹ Obtained using Stata's “xtabond2” command with the “small onestep robust” option.

² Windmeijer (2005) corrected Two-Step GMM standard errors obtained using the “small twostep robust” option in Stata's “xtabond2” command.

Tables 4 and 5 present models examining the relationship between ROA and climate risk. Models 1 and 2 use TRI and PRI indicators, while models 3 and 4 analyze TRC and PHC variables. Three different estimation methods, Driscoll–Kraay, One-Step System-GMM, and Two-Step System-GMM, were used, and high consistency was observed in terms of the direction and significance of the results.

The findings generally reveal that climate risk indicators negatively affect profitability in all models. According to the Driscoll–Kraay estimation results in Table 4, although the TRI in Model 1 is not statistically significant, the PRI coefficient in Model 2 is -0.185 and statistically significant. This suggests that the vulnerability of companies to physical climate risks adversely

impacts their active profitability. This influence is particularly evident in the GMM estimations. In the One-Step System-GMM models, the TRI coefficient is -0.184 and the PRI coefficient is -0.321, both of which are negative and statistically significant. Conversely, in the Windmeijer-adjusted Two-Step System-GMM estimates, these figures are -0.170 and -0.348, respectively, also demonstrating statistical significance. These statistics go on to depict that climate risk in a systematic and permanent manner negatively impacts the profitability of businesses. Climate risk's negative influence on profitability obliges governments to intervene to promote widespread adoption of disaster-resilient infrastructure and to get businesses to adapt to climate risk.

Likewise, the findings presented in the case of Model 3 and Model 4 in Table 5 indicate that the variables PHC and TRC significantly adversely affect ROA. The Driscoll–Kraay estimates yielded coefficients of -0.220 for TRC and -0.282 for PHC. These coefficients are statistically significant. It emerges that organizations' worries regarding the transition process and actual effects related to climate change have been stressing financial performance. In the One-Step System-GMM models, the coefficients for TRC (-0.319) and PHC (-0.398) are negative and significant. These calculated values were -0.294 and -0.408, respectively, in the Two-Step System-GMM method estimate, with the retention of the original sign and effect significance. These results unambiguously confirm that both transformational risks and regulatory risks related to the climate transition and physical climate threats have a constant and negative impact on operating profitability. Such findings corroborate the prevailing academic discussion (Cavlak et al., 2021; Zhang et al., 2023; Ozkan et al., 2023; Fazil et al., 2024; Dinh et al., 2024; Bauri et al., 2025; Qiu et al., 2025; Khemiri et al., 2025; Khemiri, 2025). It calls for the framing of climate policies in a more stable context and entails the adoption of prudent supporting measures, including tax relief to corporations.

Lagged variables in the models were also used in the current study, knowing that the effects of climate risk could be revealed over time. It then became possible to examine the effect of both current and prior period risks on firm performance. This approach enabled the use of the dynamic structure of the model. In all the models, the coefficient of the lagged dependent variable (ROA_{t-1}) was found to be positive and significant. The implication is the persistence of the measure of profitability ratios of firms, such that the prior period's performance has a positive effect on the current period's profitability.

After observing the control variables, the results show that the AS_{Growth} variable has a positive and highly significant correlation in all the models. This implies that accelerated growth culminates in higher profitability. The LEV variable was negative and significant. It was established that increased debt hampers the financial flexibility of firms and therefore reduces profitability. The FAR variable is considered insignificant in view of the Driscoll–Kraay estimation results, but it registered a negative and significant correlation in both the One-Step System-GMM and Two-Step System-GMM estimations. This indicates that capital-based structures limit profitability. The CR variable is found to be statistically insignificant and is viewed as not contributing to explaining profitability.

Estimates regarding the validity and reliability of the models yield significant results. The validity of the models presented in the form of estimates in Tables 4 and 5 was obtained using AR (2) together with the Hansen and Sargan tests. The model's autocorrelation was tested using the Arellano-Bond (1991) Serial Correlation Test. The absence of second-order serial correlation in this test is crucial for the consistency of the GMM estimator (Farzana et al. 2024: 5). Since the

p-values for the AR (2) parameter are greater than 10% in all models, the null hypothesis that there is no second-order autocorrelation cannot be rejected. Therefore, it indicates that there is short-term continuity in firm performance, but no serial correlation in the model. It also implies that the lagged dependent variable captures the performance dynamics in firms, as well. Examination of the results of the Hansen (1982) test shows that the p-values are higher than 0.05, implying statistical insignificance in all the models. Similarly, the analysis of the Sargan test statistics also indicates p-values higher than 0.05, implying statistical insignificance in all the models. The implication of this is that the instrumental variables used in the analysis are valid, and the null hypothesis that the instruments used in the model are exogenous cannot be rejected. Additionally, the findings of the Difference-in-Hansen test also support the exogeneity assumption of the instrumental variables used in the analysis. This implies that the instrument structure of the model is sufficiently defined and the GMM estimates are valid. Consequently, the assumptions underlying the System GMM hold.

The combined findings across the four analytical models confirm that climate risk has a negative impact on the financial performance of companies. The fact that similar results are obtained under different estimation methods indicates that this effect is not a temporary situation and represents a significant and sustainable source of financial vulnerability for companies. Specifically, the observed coefficients for physical risk are both larger and more statistically significant, indicating that corporations suffer more when they encounter environmental catastrophes like flood and storm damage. Conversely, transition risk negatively impacts profitability due to higher costs, regulatory pressures, and investment mismatches in the course of transitioning to the low-carbon economy. The repeated appearance of similar findings across several estimation procedures fortifies the view that the negative impacts of climate risk on financial performance are inherently structural and lasting in their effect, and thus confirms that climate risk presents an enormous cause of financial vulnerability for corporations.

However, because ROA used as the dependent variable is measured by total assets and is an indicator of performance, it may or may not respond directly and significantly to changes in capital structure. Especially, debt increases may be observed in the ROA to a limited degree, and the impact in some instances may be weak or indirect. Hence, in determining the impact of climate risk on ROA, the structural features of the indicator should be considered, and the findings should be interpreted carefully. This emphasizes the necessity of models that investigate the connection between capital structure and funding conditions, and ROA in more detail. In addition to this, the impacts generated by climate risk must be evaluated in terms of both the present balance sheet composition and future progress. A deterioration of a few percentage points in profitability can impact the investment capacity of companies, long-term growth possibilities, and financial flexibility, particularly in sectors with low profit margins and high competition. This can generate chain impacts on financial stability in the form of heightened risk perceptions in markets, elevated costs of borrowing, and deterioration in firm value. Therefore, such effects are not limited to performance indicators but constitute an issue that must be addressed at a strategic level for the long-term sustainability of firms.

When the findings are evaluated specifically for Turkey, it can be said that the ROA of companies included in the index is vulnerable to climate shocks. In particular, physical asset damages not covered by insurance, and the impact of climate shocks on balance sheets, may become permanent. Turkey's carbon-intensive energy structure increases the negative elasticity of ROA to climate shocks. Furthermore, the findings show that as climate risk is priced in by

lenders in Turkey, financing costs will increase and ROA will decline further. Additionally, credit restrictions on carbon-intensive sectors will increase the risk of negatively affecting ROA. Finally, physical risks such as forest fires and drought are also expected to have adverse effects on the supply chain.

After presenting findings on the effects of climate risks across all assets, an ROE analysis, which also evaluates the effects of climate risks in terms of financial leverage, will yield useful results. In this context, Tables 6 and 7 present the Driscoll–Kraay estimates, One-Step System GMM, and Two-Step System GMM Estimation Results for all models where the dependent variable is ROE.

Table 6. Relationship between Climate Risk and ROE (Model 1 and Model 2)

Dependent Variable ROA	Driscoll–Kraay Estimates		System GMM (One-Step) ¹		System GMM (Two-Step) ²	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
ROE _(t-1)			0.273*** (0.073)	0.257*** (0.076)	0.210** (0.084)	0.208** (0.080)
TRI	-0.255 (0.193)		-0.592** (0.227)		0.808*** (0.288)	
PRI		-0.227 (0.249)		-0.705 (0.461)		-1.073** (0.430)
lnASSETS	0.038** (0.015)	0.039** (0.015)	0.007 (0.019)	0.004 (0.018)	0.018 (0.012)	0.015 (0.010)
CR	-0.034 (0.025)	-0.034 (0.025)	0.038 (0.023)	0.034 (0.024)	0.023 (0.025)	0.015 (0.025)
AS _{Growth}	0.095*** (0.031)	0.095*** (0.032)	0.150* (0.073)	0.168* (0.081)	0.177*** (0.061)	0.195** (0.068)
LEV	-0.245* (0.127)	-0.242* (0.127)	-0.596 (0.481)	-0.614 (0.505)	-0.865* (0.473)	-0.926* (0.465)
FAR	-0.224 (0.191)	-0.220 (0.187)	-0.926* (0.495)	-0.942** (0.474)	- (0.405)	- (0.371)
TTA	0.128** (0.228)	0.128** (0.049)	0.050 (0.058)	0.047 (0.055)	-0.012 (0.044)	-0.011 (0.042)
Number of obs.	1368	1368	1350	1350	1350	1350
Num. of instr.			14	14	14	14
R-squared	0.1463	0.1460				
AR1			-1.28 0.199	-1.25 0.212	-1.35 0.178	-1.30 0.192
AR2			-1.12 0.265	-1.15 0.249	-1.18 0.237	-1.21 0.227
Sargan Test			14.96 0.021	14.90 0.023	14.12 0.015	13.68 0.018
Hansen Test			7.02 0.319	6.59 0.361	4.04 0.544	3.56 0.615
Difference-in-Hansen	Hansen test excluding group		5.90	6.26	3.73	3.16
	Difference (null H = exogenous)		0.316	0.282	0.444	0.531
			1.12	0.33	0.31	0.39
			0.290	0.567	0.578	0.531

Note: Standard errors are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1 level is significant.

¹ Obtained using Stata's "xtabond2" command with the "small onestep robust" option.

² Windmeijer (2005) corrected Two-Step GMM standard errors obtained using the "small twostep robust" option in Stata's "xtabond2" command.

Table 7. Relationship between Climate Risk and ROE (Model 3 and Model 4)

Dependent Variable ROA	Driscoll–Kraay Estimates		System GMM (One-Step) ¹		System GMM (Two-Step) ²	
	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4
ROE _(t-1)			0.279*** (0.072)	0.269*** (0.081)	0.216** (0.090)	0.197** (0.092)
TRC	-0.452** (0.181)		-0.535** (0.248)		-0.726*** (0.243)	
PHC		-0.525** (0.242)		-1.032** (0.414)		-1.358*** (0.425)
lnASSETS	0.037** (0.015)	0.038** (0.015)	0.008 (0.016)	0.003 (0.019)	0.018 (0.013)	0.008 (0.011)
CR	-0.035 (0.025)	-0.035 (0.026)	0.043* (0.024)	0.033 (0.025)	0.026 (0.024)	0.012 (0.026)
AS _{Growth}	0.098*** (0.032)	0.097*** (0.032)	0.137** (0.070)	0.171** (0.077)	0.169*** (0.057)	0.194*** (0.067)
LEV	-0.248* (0.127)	-0.243* (0.127)	-0.502 (0.512)	-0.612 (0.517)	-0.820 (0.498)	-0.931* (0.462)
FAR	-0.235 (0.188)	-0.229 (0.187)	-0.920* (0.503)	-0.987* (0.054)	-1.500*** (0.438)	-1.547*** (0.365)
TTA	0.129** (0.048)	0.129** (0.049)	0.055 (0.055)	0.057 (0.054)	-0.006 (0.050)	-0.004 (0.041)
Number of obs.	1368	1368	1350	1350	1350	1350
Num. of instr.			14	14	14	14
R-squared	0.1475	0.1471				
AR1			-1.24 0.215	-1.19 0.233	-1.27 0.203	-1.22 0.221
AR2			-1.22 0.224	-1.25 0.212	-1.20 0.232	-1.23 0.218
Sargan Test			14.55 0.012	13.53 0.019	14.55 0.012	13.53 0.019
Hansen Test			4.19 0.522	3.49 0.625	4.19 0.522	3.49 0.625
		Hansen test excluding group	3.88	3.08	3.88	3.08
Difference-in-Hansen		Difference (null H = exogenous)	0.423	0.545	0.423	0.545
			0.31	0.41	0.31	0.41
			0.576	0.522	0.576	0.522

Note: Standard errors are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1 level is significant.

¹ Obtained using Stata's "xtabond2" command with the "small onestep robust" option.

² Windmeijer (2005) corrected Two-Step GMM standard errors obtained using the "small twostep robust" option in Stata's "xtabond2" command.

The analysis results presented in Tables 6 and 7 demonstrate the impact of climate risks on ROE. According to the estimates of Model 1 and Model 2 in Table 6, climate risks appear to have a negative effect on ROE. According to the Driscoll–Kraay estimator, the TRI and PRI risk coefficients are not statistically significant. Looking at the System-GMM estimates, in a one-step estimation, the TRI coefficient is -0.592 and statistically significant, but the PRI coefficient is -0.705 and statistically insignificant. For Two-Step Windmeijer adjusted estimates, the coefficient estimates are calculated at values of -0.808 and -1.073 and are statistically significant. These results uncover that transition risks and physical risks put pressure on firms' long-run capital structure. Hence, such measures that facilitate financial assistance to firms in order to improve capital efficiency and bolster the environment of investment in Turkey should be taken.

Looking at the findings of Models 3 and 4 in Table 7, the TRC and PHC coefficients are negative and significant across all the models, indicating that the companies face financial fragility both during the process of transition and under the effect of direct environmental impacts. In the Driscoll–Kraay estimates, TRC is -0.452, and PHC is -0.525, and significant. In the One-Step System-GMM models, the TRC (-0.535) and PHC (-1.032) coefficients are negative and significant. In the Two-Step System-GMM models, the values of the coefficients are -0.726 and -1.358 and are statistically significant. Transition and physical risks of climate change lower the ability of corporations to make good use of their assets in generating profitability. Thus, it's worthwhile to utilize measures such as green financing incentives to minimize the uncertainties that corporations face and ensure equity profitability protection.

The highly significant and large coefficient for the lagged dependent variable ($ROE_{(t-1)}$) indicates continuity in the profitability model of enterprises. This finding indicates that companies that showed higher profitability during the previous periods maintained their performance, and hence the profitability dynamics showed a level of consistency.

In terms of control variables, AS_{Growth} is positive and highly significant in all models, showing that growing firms achieve a higher ROE. LEV is negative and significant, obtained from the Driscoll–Kraay estimates for all models. It is statistically negative and insignificant in the One-Step system GMM, while in the Two-Step system GMM, it is negative and significant only in models 2 and 4. The FAR variable is also negative and generally significant in all estimates except the Driscoll–Kraay estimates; this finding indicates that intensive investment in fixed assets weakens profitability. In contrast, CR is statistically insignificant in all models. While $\ln ASSETS$ is positive and statistically significant according to the Driscoll–Kraay estimates, it is, according to the other two estimators, statistically insignificant in all models.

For the model estimates presented in Table 6 and Table 7, since the p-values for the AR (2) parameter are greater than 10% in all models, the null hypothesis that there is no second-order autocorrelation is accepted. Therefore, there is no sequential autocorrelation problem in the model. The Hansen test results were statistically insignificant in all models and indicated that the instrument variables were valid. However, when we look at the Sargan test results, the p-values were statistically significant in all models. This result contradicts the Hansen test result and weakens the claim that the instrumental variables used are valid. However, a relatively large number of instruments in small samples can create such differences in results. Therefore, despite the significant results in the Sargan test and considering the more robust structure of the Hansen test, it can be said that the instrumental variables used in the models are consistent and valid overall. It increases the reliability of the estimation results and shows that the findings are supported methodologically, thus maintaining their general validity. The findings of the Difference-in-Hansen test also support the assumption of exogeneity of the instrumental variables used.

In general, findings from the four models show that companies' exposure to climate risk significantly reduces ROE. On the other hand, increases in debt levels create a leverage effect on ROE, amplifying the impact of climate risks on profitability and weakening companies' financial resilience. In this context, both forms of transition and physical risks (TRI–PRI and TRC–PHC) exhibiting negative effects reveal that companies are becoming vulnerable both during the transition process and in the face of direct environmental shocks. Furthermore, the findings are consistent with previous studies in the literature (Cavlak et al., 2021; Zhang et al., 2023; Ozkan

et al., 2023; Fazil et al., 2024; Dinh et al., 2024; Bauri et al., 2025; Qiu et al., 2025; Khemiri et al., 2025; Khemiri, 2025).

The permanent and adverse impact of climate risk on ROE could give rise to a number of macro-financial problems in countries such as Turkey, which have limited financial depth and are vulnerable to climate change. First, damage to physical assets caused by climate shocks will lead to capital erosion. Second, high climate risk will increase the risk premium for lenders and raise costs, resulting in lower returns on equity. Finally, the slowdown in capital accumulation due to climate risk may also have negative effects on the growth potential of companies and the economy. When the macro-financial impacts of the results are evaluated for Turkey, it is calculated that climate shocks would deter capital flows, escalate credit risk and collateral obligations, create falls in stock values, and adversely affect corporate transformation capacity by diminishing the funds dedicated to green transformation, because of weak ROE.

If the results are evaluated together, the findings indicate that climate risk has a detrimental impact on profitability-based measures of financial performance such as ROE and ROA. This implies a stronger and longer-lasting strain stemming from the channel of capital profitability. The current scenario also indicates that climate-associated factors can cause long-run damage to the sustainability of finance by perturbing the balance between the return on a firm's equity and its capital structure. The study finds that, just like the studied Turkish corporations, having high operating leverage in conjunction with low equity will further increase the level of financial vulnerability, given the future loss of equity stemming from a greater level of climate risk. Also, the scope of natural disaster insurance in Turkey is very limited, thus making it more likely that physical damage will be computed as a loss of equity. Given the sample companies' ESG integration activities, it is apparent that the problem is even greater for other companies.

5. Conclusion

This investigation analyzed the implications of climate-associated risks on the financial performance of corporations through the lens of dynamic panel data models. The analyses, which employed various estimation techniques (Driscoll–Kraay, One-Step, and Two-Step System-GMM), indicate that both physical and transition-related climate risks exert negative and statistically significant influences on corporate profitability. In this analytical framework, the effects of transition and physical risk indicators on ROA and ROE were assessed, demonstrating that environmental uncertainties present a financial challenge to enterprises. Escalating costs associated with climate change adversely affect corporate profitability. Notably, the negative and statistically significant effects of transition risk and physical risk indicators on both profitability metrics reinforce this observation. Moreover, the significance of lagged ROA and ROE values suggests that corporate profitability possesses a dynamic characteristic, wherein prior performance influences current profitability. Nonetheless, the findings also indicate that this effect diminishes over time. Concerning control variables, aspects such as firm size and asset growth are identified as factors that enhance profitability; conversely, elements like a high debt ratio and a considerable fixed asset ratio obstruct corporate performance. This situation emphasizes that the financial structures and investment strategies of firms can profoundly impact their capacity to endure climate risks.

The study also highlights the necessity for corporations to be proactive when it comes to managing risk from climate change and the role of policymakers in framing environments that

facilitate this. On the firm level, the evidence also advocates for the necessity of corporations to report climate risk accurately, which the regulatory architecture also must support. However, it is also found to be essential to develop policies for corporations based on not just the statements of sustainability but also quantifiable targets and impeccably implementable adaptation options related to the climate. The embedding of such policies by the organizations can go a long way in gaining a competitive advantage in areas where environmental concerns hold intense importance. Since the risk of climate change has the potential to negatively impact the valuation of corporations, it is essential to improve the availability of financial instruments like green bonds, sustainable debt instruments, and carbon markets for corporations to better handle the risk. The development of technical assistance and financial enabling programs, especially for the small and medium-sized organizations with severe debt burden and financial exposure, may be seen as part of the toolbox of policies aimed at improving their resilience in the face of climate-induced risk.

Following an analysis of the findings of the research at the policy-making level, it is apparent that specific sectoral and general instruments need to be applied in order to compensate for the impact of climate change among Turkish businesses. Notably, the immense costs that the energy-intensive industry incurs in transitioning to low-carbon production indicate the specific need for transition support at the policy-making level. In this context, it is imperative to create the financial and reporting infrastructure within a sustainable development process in the entire institutional setting in Turkey with the aim of encouraging active participation in green finance. Application of the policies will not only improve the capacity of companies to respond to climate-related risks but also enhance the resilience of the financial center to disruptions originating in climatic circumstances.

Based on comprehensive assessments and the analysis of Turkey's economic and institutional setting, it is necessary to spur investments to promote climate resilience among companies, as suggested by the findings in this study. In particular, it is necessary to strengthen insurance mechanisms in order to cushion the effects of climate risk on the equity and assets of companies. In addition to this, the shift towards sustainable finance also demands offering low-interest loans to companies displaying negligible carbon footprints. Rewards in the capital markets should be complemented by the provision of subsidies, such as tax breaks, to companies that are respectful of ESG principles. Supervisory and regulatory authorities, such as the Central Bank of the Republic of Turkey (CBRT), the Banking Regulation and Supervision Agency (BRSA), and the Turkish Banks Association (TBB), need to develop a macro-financial oversight framework that incorporates climate risk into their financial evaluations.

The research also identifies a few of its own constraints. Analysis is confined to the companies that are constituents of the BIST Sustainability Index. This restriction reduces the overall sample size. Future research that encompasses companies from various countries and industries will enable us to conduct comparison studies and derive greater policy implications.

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

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There is no potential conflict of interest in this study.

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