Journal of Accounting and Finance Review

Journal homepage: https://jafr.comsats.edu.pk/index.php/Home

Driving sustainable performance through eco-conscious behavior: Evidence from PSX 100 firms

Sadeema Nazir[1]*, Muhammad Naveed[1], Muhammad Atif Raza[1], Noor e haram[1]

Accepted January 15, 2026, Published January 22, 2026

Abstract

This paper empirically analyzes how climate risk, in the form of temperature variations, natural hazards, and air quality affect the performance of stock markets in Pakistan, using the PSX-100 index and its financial and non-financial sectors. The study employs a hybrid approach that includes a time-series regression of the aggregate PSX-100 index and two-way fixed effects panel regressions of the firm-level financial and non-financial sector data (2020-2024) with a sustainability index as a moderating variable. The results indicate that climate risks are significantly negatively related to financial stability, which proves the destabilizing impact of environmental degradation on capital markets. More importantly, the sustainability index has a robust positive moderating impact, which alleviates these negative effects and highlights the importance of corporate sustainability practices to economic resilience. The research has certain policy implications since it recommends the establishment of compulsory climate-related financial reporting (in line with the TCFD framework) and the creation of a national sustainability taxonomy to inform the allocation of capital. These implications are crucial to policymakers, regulators, and corporate executives to balance economic planning with sustainability objectives, reduce systemic climate risk and contribute to the achievement of the UN SDGs. This study is one of the earliest to examine the moderating effect of sustainability in the climate-finance nexus in Pakistan and identifies sustainability as an important process of market resilience and provides evidence-based advice on climate-responsive economic policy.

Keywords: Eco-Conscious behavior, Financial Stability, Climate risk, Sustainable Performance.

1. Introduction

Climate change has emerged as a systemic risk to the financial stability of the global system, and the frequency and severity of physical shocks, including heatwaves, storms, and environmental degradation, are creating massive economic destruction and posing a threat to

*Corresponding author: Sadeema Nazir

1 - Bahria University, Islamabad, Pakistan, Email: sadeemanazir@gmail.com

DOI: https://doi.org/*10.26652/jafr/25.02.004*. Journal of Accounting and Finance Review is published by Department of Management Sciences, COMSATS University Islamabad, Pakistan

the value of assets worldwide (Brunetti et al., 2021; World Economic Forum, 2019). The direct financial effect of those shocks is decreased returns on investments and heightened volatility, which explains why financial institutions must consider climate risk as part of their strategic plan to build resilience (Krueger et al., 2020; Biswas & Rahman, 2023). This threat occurs in a very acute form in emerging economies like Pakistan. As one of the most climate-vulnerable nations in the world, Pakistan faces poly-crises whereby climate risks, such as precipitation increase and warming (Khan et al., 2022), and extreme urban air pollution (Mahmood et al., 2024), interact with institutional and infrastructural vulnerabilities. This creates destabilizing feedback loops of ecological shocks and financial instability, but the processes of transmission to capital markets are not well understood, particularly among the different sectors of the economy. The effectiveness of green practices and ESG integration as a stabilizer in frontier markets has not been determined yet, although the theory of green practices and ESG integration as a stabilizer is established (DeMenno et al., 2022).

The paper addresses three literature gaps on climate-finance. First, an empirical gap exists that currently available literature studies climate factors in developed economies, while the transmission of such environmental stresses (i.e., simultaneous heatwaves and pollution) to stock returns and market value in institutionally weak, emerging markets, i.e., Pakistan, is still not studied. Second, there is a sustainability paradox of sustainability indices, where the sustainability indices are believed to mitigate the climate risk in the portfolio, whereas the actual performance of the sustainability indices in reducing the stock price volatility and shareholder value in the frontier markets is not empirically tested. Third, the policy-practice gap whereby the vulnerable countries respond to climate risks, lack evidence-based models of ecological-financial transmission, and thus fail to shield the capital market from systemic risk.

In order to address these gaps, the present research applies a hybrid approach to the empirical research strategy in which time-series regression is employed to analyze the aggregate market and two-way fixed effects panel regression to analyze the sectoral data of firms in the Pakistan Stock Exchange (PSX-100) during the years 2020 to 2024. It evaluates the impact of specific climate risk indices, air quality (Mahmood et al., 2024), natural hazards (He et al., 2022), and temperature anomalies (Wu et al., 2023) on market performance with a sustainability index (Ozili & Iorember, 2023), being an important moderating variable where macroeconomic factors like GDP growth and governance index are controlled.

This study contributes in three ways. Firstly, it provides a pioneering, sector-differentiated empirical research on the transmission of multi-dimensional climate-risks in the capital markets of Pakistan. Second, it offers evidence on the financial materiality of corporate sustainability that proves its strategic shock absorber. Third, it also translates these findings into real policy implementation, suggesting a system of mandatory climate-related financial reporting and a national sustainability taxonomy to make financial regulation consistent with ecological reality and make systems more resilient.

Using the context of high stakes in Pakistan as a basis of the discussion, this paper transfers the discussion of the generic climate advocacy to the discussion of evidence-based financial governance, which can be applied as a model to be followed by other emerging economies undergoing the same poly-crises.

2. Literature Review

The correlation between climatic factors and financial markets has gained great interest after increasing evidence of environmental threats to financial stability. Battiston et al. (2017) showed that climate change presents systematic financial risks via network effects, with 1.4-4.2% of the world's financial assets at risk of losses due to climate change. This analysis was furthered by Hong et al. (2019), who demonstrated that the systematic underpricing of long-term climate risks occurs in markets, and by Bernstein et al. (2019), who presented industry-specific results using real estate markets exposed to sea level rise. Nevertheless, the current literature focuses on individual climate variables as opposed to combined multi-factor methods. Monasterolo (2020) found several ways of transmitting climate risks to financial instability but demanded an extensive empirical study that would integrate physical risks (temperature, natural disasters) with the impact of pollution. This is a methodological weakness that constrains the comprehension of complicated climate-finance interactions.

In addition to the immediate economic expenses of physical damage, the transmission of environmental risks into financial markets has a large behavioral and psychological mode of operation that affects the decision-making of investors. Although the effect of general weather conditions on investor mood and risk-taking has been reported in the literature on finance, the so-called weather effect (Hirshleifer & Shumway, 2003), special weather conditions, such as air pollution, have stronger cognitive and affective effects. The studies reveal that low air quality decreases cognitive ability and has a negative effect, which is converted to a higher risk aversion among the market participants (Zhang et al., 2017). Importantly, other research, such as Levy and Yagis (2011), offers direct empirical support that the declining air quality is associated with reduced stock returns, an indisputable channel of sentiment risk in which pollution affects the market pricing, through its psychological effects on investors. Likewise, natural catastrophes and temperature deviations impact markets both physically and by creating a great deal of uncertainty and panic, which forces investors to reconsider risk premiums and asset allocation. Knowledge of these psychological and behavioral processes is vital in the analysis of how environmental shocks get internalized in the prices of stocks, especially in the emerging markets, where the shocks are common and extreme.

ESG literature has defined sustainability-performance relations as Eccles et al. (2014) reported that high-sustainability companies perform better in periods of economic stress, whereas meta-analysis of 2,000+ studies by Friede et al. (2015) reported positive ESG-financial correlations in 90 percent of studies. Sharfman and Fernando (2008) proved that environmental risk management leads to a decrease in financing cost due to the perceived reduction in risk. Although extensive direct ESG-performance research has been conducted, limited empirical evidence exists on the moderating role of sustainability practices on climate risk effects on financial performance. This is a severe theoretical gap because sustainability can serve as an adjustment mechanism at the time of environmental stress.

The limitation of the literature is geographic concentration in developed markets. Kahn et al. (2019) concluded that temperature rise lowers GDP growth by 0.23 percentage points in developing economies and 0.07 in developed economies, indicating a stronger climate-finance nexus in the former because of low adaptive capacity.

Ziolo (2019) has explored sustainable finance in developing economies, with the environmental issue becoming more significant in capital allocation, but the institutional frameworks are not yet developed. Nevertheless, the climate-finance research is mostly centred on the US/Europe markets, with little evidence on the Asian emerging market. According to Campiglio et al. (2018), financial institutions (indirect portfolio exposure) and non-financial firms (direct operational exposure) had different climate vulnerabilities. The empirical confirmation of these sectoral differences has been scarce, especially in emerging markets where business models and adaptive capacities are not the same as in developed economies.

Air Quality Index (AQI) is an indicator that is used worldwide to convert the levels of air pollution and health risks associated with pollution. It is determined based on the concentrations of the significant pollutants, including PM10, PM2.5, SO_2, NO_2, CO, and O_3, and classifies the quality of the air as a function between the categories of good and hazardous. Air pollution has become an issue of concern in Third World countries, including Pakistan. According to the World Health Organization (WHO), air pollution is described as the impairment of the indoor or outdoor environment with any chemical, physical, or biological substance that alters the natural features of the air. The environmental trajectory of Pakistan is worrying, as far as emissions are concerned. In 2013, the country contributed 0.69 percent of the global CO_2 emissions. According to the International Energy Agency (IEA), the level of carbon dioxide emissions in Pakistan has grown since 1990 by almost two times to over 320.7 million tons in 2013 (Ali et al., 2019). Selden and Song (1994) argue that air pollution is a highly predictive factor in the performance of the financial markets, which destroys economic growth. Some studies have established that poor weather has a significant negative effect on stock trading (Lu and Chou, 2011). An investor's mood condition, known as seasonal affective disorder (SAD), may affect the stock prices and returns. A single study revealed that there is a negative correlation between AQI and stock return, and a stronger correlation in polluted regions. Recent studies in China indicate that there are short-term air quality impacts on the level of trading, with investor sentiment being correlated to the performance of stocks. The low returns, increased volatility, and illiquidity in Chinese markets were caused by high levels of pollution. These were mainly common in the development of stocks, volatility, and distressed stocks. Global warming and carbon dioxide emissions have a negative impact on the gross domestic product (GDP), according to a study carried out in Pakistan (Khurshid, 2022). The report indicates that uncertainty in the climate is detrimental to the economic growth in the country. The analysis results in a research hypothesis:

H1*: The Air Quality Index has a negative effect on financial stability.*

The other significant climate-related problem is the temperature abnormality or non-normal deviation of the long-term trend of average temperature. These abnormalities may cause serious disturbances in the environmental balance, human health, and economic output. The temperature change is usually associated with bigger processes that include climate change, including changes in the distribution of disease and agricultural productivity. Kozarcanin et al. (2019) reported that the world temperature on the surface rose by about 0.2°C per decade throughout the 20th century. According to Anton (2021), weather conditions have now affected almost 70 percent of the economic activity in the world. Further, the Intergovernmental Panel on Climate Change (IPCC, 2021) found that the average temperature on the planet increased

by about 1.09°C from 2011 to 2020 compared to the pre-industrial era of 1850-1990. The extreme impact of temperature anomalies on financial performance is reported by empirical studies. Flori (2021) determined that climate variables such as temperature and rainfall have a direct effect on the financial distress indicators, especially in the commodity markets, and therefore, affect financial stability in general. Huang (2018) also reported that firms in countries with harsh weather conditions record high profit decreases, and increasing volatility of cash flows and profitability. A cross-national study conducted in 93 countries showed that increased temperatures reduce the overall business performance, including operational income and revenues. Pankratz (2023) also adds that heat exposure adds to the operating costs by raising the amount of energy consumed in cooling and necessitating greater compensation to employees to offset health risks posed by working in hot weather. Besides this, temperature variations may decrease the lifespan of assets, increase exposure to credit risks, particularly in insurance sectors and financial institutions (Sun, 2022). Wu et al. (2023) found that temperature deviations had a strong negative relationship with financial stability, with high temperatures strongly correlated with declining financial market stability. This gives rise to a hypothesis:

H2*: Unusual Temperature Variations have a detrimental effect on financial stability.*

Natural risks associated with the destruction of biodiversity and degradation of natural systems jeopardize economic and financial systems. They are presented in two primary types, which are physical risks and transition risks (CISL, 2021). Physical risks involve direct monetary effects such as a reduction in asset prices and an increase in liabilities as a result of natural catastrophes. Floods, droughts, and storms can lead to the destruction of infrastructure, trade disruption, and depreciation of assets. Transition risks, in turn, are associated with regulatory adjustments, market dynamics, and technological advances that are introduced as a result of mitigation and adaptation actions in relation to climate change (Wu & Wan, 2023). The frequency and intensity of natural calamities such as floods, storms, droughts, and heat waves have increased in the past decades due to the acceleration of climate change. According to the Food and Agriculture Organization (FAO, 2021), the agricultural sector bears the brunt of these events, as it is affected by approximately 26 percent of the total damage, especially given that nearly 80 percent of the world's poor depend on agriculture as their source of livelihood.

Carleton et al. (2022) assume that despite the necessity of climate change adaptation measures, low-income countries cannot implement them due to their limited resources or institutional strains. This kind of under-adaptation exposes the financial systems to climate shock. Natural calamities can have a severe impact on the financial sector. According to Batten (2016), there are several transmission mechanisms in which catastrophic weather events have a negative impact on financial stability: physical damage to banking infrastructure, increased investor uncertainty, decreased lending, weakened balance sheets, and drastic declines in asset prices and insurance cover. Chandio (2020) highlights that climate change enhances the prevalence of droughts and floods, which have a serious impact on agricultural productivity in the case of Pakistan. Higher temperatures also contribute to additional stress on water resources and aggravate the threat to the energy and financial sectors. Based on the analysis above, a research hypothesis is developed:

H3*: Natural Hazards have a detrimental effect on financial stability.*

Sustainability is one of the important moderating variables in this study as stipulated by the Brundtland Report (Brundtland, 1987). It is defined as the needs of the present should be met without interfering with the capacity of future generations to meet their needs. Van Marrewijk (2012) then goes further to elaborate on this concept by stating that sustainability is the capacity of a corporation to meet the stakeholder demands of the employees, customers, pressure groups, and communities, and is the capacity to meet the future stakeholder demands. Besides serving short-term requirements, sustainability is also a tool for creating sustainable value, not only on an economic basis but also in terms of its contribution to society. According to Wolf (2013), the evolving marketplace and social demands are altering corporate responsibilities, and business has taken on the role of responsibility and the role of sustainability practices as risk mitigation mechanisms, which has received empirical evidence in the recent literature. Eccles et al. (2014) showed that companies that have good ESG practices are more resilient in times of economic recession, which implies that sustainability acts as an organizational shock absorber. In a meta-analysis of 2,000+ studies, Friede et al. (2015) identified positive ESG-financial relationships in 90 percent of the cases, and higher effects during market volatility periods.

Sharfman and Fernando (2008) presented certain evidence that there is a reduction in the cost of capital to firms due to better environmental risk management that decreases the perceived investment risk. Nevertheless, although much research literature exists to document the direct relationship between ESG-performance, there is a dearth of empirical studies to determine how sustainability practices, in particular, moderate the effects of climate risks on financial performance. This is an essential gap because sustainability can act as an adaptive mechanism that can help firms to sustain performance under environmental stress, especially in climate-sensitive emerging markets. The final reflective analyses that have been performed resulted in the development of an articulated research hypothesis:

H4*: The Sustainability Index moderates the relationship between climate risk and financial stability.*

H4a*: The Sustainability Index moderates the relationship between the Air Quality Index and financial stability.*

H4b*: The Sustainability Index moderates the relationship between Temperature Abnormalities and financial stability.*

H4c*: The Sustainability Index moderates the relationship between Natural Hazards and financial stability.*

The paper has found four essential gaps in the literature review, namely: (1) Methodological: There is limited evidence on the integrated analysis of multiple factors versus individual climate variables; (2) Geographic: There is a bias toward developed markets and limited evidence on the sustainability of climate risks in emerging markets; (3) Theoretical: The sustainability of climate risks has not been sufficiently studied; (4) Sectoral: The financial versus non-financial climate sensitivity has not been studied in emerging markets. The research fills these gaps by investigating integrated climate variables (air quality, temperature anomalies,

natural hazards) under a sustainability moderation effect on financial and non-financial sectors in the emerging market setting of Pakistan by using a 5-year panel analysis.

The theoretical framework developed after the literature review comprised two phases. The initial stage has three independent variables (Air Quality Index, Natural Hazards, and Temperature Abnormalities) and a dependent variable (Financial Stability). The second step is premised on the moderator, the Sustainability Index, and how it moderates the relationship between the independent variables and the dependent variables is examined. The proposed framework incorporated six analytical hypotheses, three direct hypotheses, and three moderator hypotheses based on three independent variables (IVs) that affect the dependent variable (DV) relationship and the Moderator variable relationship, as illustrated in Figure 1.

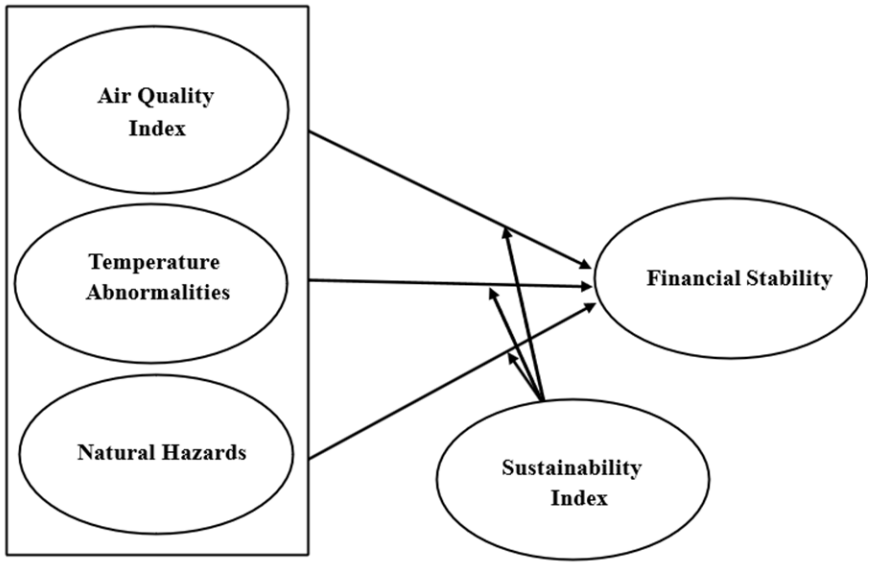

Figure 1: Theoretical Framework
Source: Developed by the Researchers

3. Research Methodology

3.1 Data and Sample Selection

This paper examines the effect of climate risk on financial stability based on a balanced panel sample of Pakistani Stock Exchange (PSX) listed companies. The sample was composed of 20 financial institutions (banks) and 30 non-financial firms purposely sampled out of the PSX-100 index according to market capitalization, level of revenue, and availability of data to represent the core economy in Pakistan. The data frequency is monthly, with the period from 2020 to 2024. It created a balanced panel of 1, 200 observations of the 20 financial firms and 1,800 observations of the 30 non-financial firms, making 3,000 firm-month observations.

3.2 Variable Measurement and Sources

The choice and quantification of variables are based on the existing climate-finance sources (Nieto, 2023; Wu et al., 2023; He et al., 2022). Financial stability is measured as the stock returns of the PSX-100 index and firm-level monthly returns of financial and non-financial firms. The Pakistan Stock Exchange database was used as a source of data. Climate Risk Proxies: Air Quality Index (AQI) is a combined index of both particulate matter (PM2.5,

PM10) and gaseous pollutants (CO, O3), which is provided by the Pakistan Environmental Protection Agency (Pak-EPA) and calculated with the help of the US EPA methodology. Temperature Anomalies (TEMP is the difference (in °C) between the 30-year historical average of the primary area where the firm operates and the current temperature. The sources of data were the Pakistan Meteorological Department. Natural Hazards (NH) is a count variable that indicates the number of times every month floods, droughts, or extreme weather events were reported by the National Disaster Management Authority (NDMA). Sustainability Index (SI): An overall ESG performance measure (0-100) created by content analysis of annual sustainability reports of firms and PSX filings, the moderating variable. Control Variables: GDP Growth Rate is the rate of growth of GDP in quarters of the year, obtained through the Pakistan Bureau of Statistics, and was added to put a check on the macroeconomic factors and Governance Index (GI) is the Worldwide Governance Indicators score on Regulatory Quality, which is part of the World Bank, is added to control the institutional quality.

3.3 Empirical Model and Estimation Technique

In order to test the hypothesized relationships and also consider the various data structures, we use a hybrid empirical approach, where we have separate models of aggregate market analysis and firm-level sectoral analysis.

3.3.1 Aggregate Market Model (PSX -100 Index)

In the general market analysis, the time-series multiple regression model with Ordinary Least Squares (OLS) estimation is used. We use Newey-West heteroskedasticity- and autocorrelation-consistent (HAC) standard errors to make valid inferences in the presence of autocorrelation and heteroskedasticity in financial time series.
The model is specified as:

$$FS_t = \beta_0 + \beta_1 AQI_t + \beta_2 TEMP_t + \beta_3 NH_t + \beta_4 SI_t + \beta_5 AQI_t \times SI_t + \beta_6 TEMP_t \times SI_t + \beta_7 NH_t \times SI_t + \gamma_1 GDP_t + \gamma_2 GI_t + \varepsilon_t \quad (1)$$

Where SI_t represents a market-wide annual sustainability proxy, calculated as the average SI score of all sample firms for the corresponding year.

3.3.2 Sectoral Firm-Level Models

Where SI_t is a market-wide sustainability proxy (annual), which is the average SI score of all sample firms in the given year.

The firm-level model is specified as:

$$FS_{it} = \beta_0 + \beta_1 AQI_t + \beta_2 TEMP_t + \beta_3 NH_t + \beta_4 SI_{it} + \beta_5 AQI_t \times SI_{it} + \beta_6 TEMP_t \times SI_{it} + \beta_7 NH_t \times SI_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \quad (2)$$

Where FS_{it} is the monthly stock return for firm *i* in month *t*. AQI_t, $TEMP_t$, NH_t are the climate risk variables for month *t*. SI_{it} is the firm's Sustainability Index score for the corresponding year. As the index is reported annually, the value is constant for all months within a given calendar year for each firm. The interaction terms ($AQI_t \times SI_{it}$, $TEMP_t \times SI_{it}$, $NH_t \times SI_{it}$) test the moderating hypothesis. α_i represents firm-fixed effects, controlling for all

time-invariant firm characteristics. λ_t represents time-fixed effects (month-year), controlling for common temporal shocks and ε_{it} is the idiosyncratic error term.

The panel models are estimated using the within-estimator with Driscoll-Kraay standard errors, which remain consistent in the presence of cross-sectional dependence, heteroskedasticity, and autocorrelation.

The two-way fixed effects specification is an extreme method of determining relationships in panel data. With firm fixed effects, we were able to incorporate all time-invariant firm characteristics that could be correlated with sustainability performance and financial performance. Economy-wide shocks are absorbed by time fixed effects.

4. Results Analysis and Discussion

This paper has performed a series of tests to diagnose, which include data stationarity testing and descriptive statistics. The descriptive analysis was done to test the measures of central tendency and dispersion. In order to establish the data stationarity, the Augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1979) was employed. The test determined that the variables are stationary. In addition to this, endogeneity problems were also put into consideration, and it was noted that model misspecification due to the correlation of error terms with independent variables can lead to inaccurate estimates.

Table 2. Regression Results

Variables	(1)		(2)		(3)	
	PSX-100 Index		Financial Firms		Non-Financial Firms	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C	0.679	0.853	(151.941)	1.000	(4686)	1.000
AQ	(0.009)	0.078*	(1.372)	0.293	(5.511)	0.938
AQ(SI)	0.000	0.047**	0.039	0.029**	0.164	0.093*
TEMP	20.163	0.319	(737.646)	1.000	(20486)	1.000*
TEMP(SI)	0.528	0.028**	19.580	1.000*	481.653	1.000*
NH	(0.041)	0.065*	176.949	1.000	1784.765	1.000*
NH(SI)	-	-	5.235	1.000*	47.787	1.000*
GDP	(0.006)	0.694	2.576	1.000	44.235	1.000*
GI	0.079	0.004***	8.714	0.190	65.009	0.856
R-squared	0.857		0.198		0.245	
Adjusted R-squared	0.838		0.178		0.194	
Prob(F-statistic)	0.000		0.049**		0.000	

* p < 0.1, ** p < 0.05, *** p < 0.01.

Regression estimates are shown in Table 2 in three columns. Column (1) shows the estimate for the PSX-100 index as a whole, Column (2) shows the estimate for financial sector companies, and Column (3) shows results for non-financial companies. All regressions have the interaction of climate risk indicators and the sustainability index as a moderating variable.

5.1 Discussion of the Results

According to the regression results, the relationship between climate risk and financial performance in Pakistan is subtle, and the aggregate market and individual sectors differ dramatically. The analysis proves that the climate factors are material financial risks, and corporate sustainability practices are a critical moderating mechanism.

The negative and statistically significant coefficient of the Air Quality Index (AQI) on the PSX-100 index shows that the decline in air quality erodes the stability of the market in general. This is consistent with the new market research, including a study in China that showed that air pollution has a negative impact on stock performance, especially in markets where ownership is concentrated, like in Pakistan (He, Zhao, & Zheng, 2023). But at the firm level, the direct impact of air quality is not statistically significant. This deviation indicates that air quality is a systematic, market-wide risk factor within the Pakistani financial industry, in which the effects at the portfolio level are predominant. More importantly, the positive and significant interaction term of AQI(SI) indicates that the negative effect is alleviated by an increase in the Sustainability Index. This observation is highly consistent with the theoretical hypothesis that environmental, social, and governance (ESG) practices should be viewed as a risk management buffer, and the previous studies by Friede et al. (2015) and Eccles et al. (2014) have reported a greater ESG protective impact in times of environmental stress.

The results of temperature anomalies (TEMP) on the aggregate index are negligible, while the negative coefficients of financial and non-financial companies imply the sharp vulnerability of firms to abnormal temperature changes. The sector-specific sensitivity supports the results of Bernstein et al. (2019) and Hong et al. (2019) on the variations in climate exposures. The moderating effect of the sustainability index, TEMP(SI), is positive and significant, which validates the importance of ESG integration in developing operational resilience to physical climate risks, as theorized by Ziolo (2019). The strong firm-level effect, compared to the weak market-level effect, probably represents the extreme range of temperatures in Pakistan that directly affects the operations of firms, whereas the diversified index absorbs the idiosyncratic shocks.

The effect of natural hazards (NH) on the PSX -100 index is strongly negative, which proves their destabilizing systemic shock. The sectoral outcomes indicate non-uniform coefficients, which implies that climate disasters spread risks unevenly throughout the economy. This substantiates the argument by Wu et al. (2023) that climate-related disruptions undermine the stability of the financial system. The results align with the systematic risk theory of Battiston et al. (2017) on an emerging market environment, showing that the exposure and the lack of adaptive capacity in Pakistan increase the financial stability risk of such events, as theorized by Monasterolo (2020).

Concerning control variables, Governance Index (GI) has a positive and significant effect, especially on PSX-100. It strengthens the institutional theory and empirical data that good governance increases financial resilience and is a key to efficient climate risk management (Eccles et al., 2014; Monasterolo, 2020). The association with GDP growth is more intricate, with a negative association at the market level and a positive association at the firm level. This deviation is consistent with Campiglio et al. (2018) finding that fundamentals of firms can be positively associated with growth and macroeconomic volatility and uncertainty priced in by aggregate markets.

Lastly, the PSX-100 model has an exceptionally high explanatory power (R^2= 0.857), which means that the aggregate market returns are largely explained by the combination of the climate and control variables used, which is higher than the explanatory power of similar studies in developed markets (Battiston et al., 2017; Hong et al., 2019). The smaller yet statistically significant R^2 of the financial and non-financial sector models indicates that the transmission of climate risk is systematic in the broad market and idiosyncratic at the firm level, with non-financial firms having a higher direct relationship as they have operational exposure. Overall, the discussion has established that the financial stability of Pakistan is materially dependent on climate risks; these risks have a different effect at the market and firm level, and corporate sustainability practices can moderate their impact and increase resilience.

5. Summary and Conclusion

Climate change is mounting threats to financial stability, but its relationship is not fully explored in the emerging markets. This study fulfilled this gap by considering the effects of climate risk factors, such as degradation of air quality, temperature imbalances, and natural disasters, on financial performance in the corporate environment in Pakistan.

The results are consistent with the existing literature on climate finance and also indicative of new market-specific dynamics. In line with Porter and van der Linde (1995) and other more recent works by Battiston et al. (2017) and Monasterolo (2020), the findings reveal that there are strong negative relationships between climate factors and financial performance. The moderating effect of the sustainability index extends to the theoretical frameworks of Friede et al. (2015), who reported ESG-performance relationships in developed markets. The results reveal that firms that incorporate sustainability models have a higher resilience rate. The heterogeneous effects within the sectors support the findings of Bernstein et al. (2019) and Hong et al. (2019), though the Pakistani setting shows more systematic impacts. The findings have strong implications for the stakeholders. The policymakers should introduce compulsory sustainability disclosures and a sustainability taxonomy in line with international initiatives. Corporate executives must incorporate ESG into their business practices and make sustainability a strategic necessity instead of a voluntary CSR. Financial institutions and regulators should integrate climate risks in lending decisions, and climate-savvy oversight should be developed incorporate environmental factors as part of prudential regulation and stress-testing frameworks. Through these evidence-based suggestions, Pakistan can mitigate climate-finance risks and create economic resilience. The dynamic interdependencies and non-linear effects need to be studied in future research to gain a better insight into the climate-finance mechanisms in developing economies.

This research expands the theoretical background of climate finance, as it empirically proves that the environmental factors, air quality, temperature changes, and natural disasters are not external shocks but the key determinants of financial performance in emerging markets. The results are consistent with the stakeholder theory and the resource-based perspective and indicate that there is a subtle association between climate risk and financial performance in Pakistan, and the relationship varies considerably between the aggregate market and separate sectors. The analysis proves that the climate factors are material financial risks, and corporate sustainability practices are a critical moderating mechanism.

The high model fit (R^2 = 0.857) indicates that the Pakistani stock exchange has systematic sensitivity to the climate variables and thus there is a need to have compulsory climate-related financial disclosure in line with TCFD models for all listed firms. The strong moderating nature of the sustainability practices ensures that companies that integrate ESG structures exhibit quantifiably higher resilience to environmental shocks. The regression findings indicate that climate-finance interconnections are significant, which should be integrated into prudential regimes and stress-testing procedures by the financial regulators, as the difference in the effect of financial and non-financial sectors shows in Table 2. To increase market transparency and direct capital to climate-resilient investments, policymakers should create a national sustainability taxonomy, which may be backed by the empirical confirmation of sustainability as a risk mitigation tool.

Although this study makes great contributions and the results are useful in practice, it is not devoid of limitations, which provide directions to future researchers. Firstly, the study used a small sample due to the lack of time. Future research can extend the time horizon through analysis of long-term data, using more advanced techniques like stress testing, and more detailed sectoral data. Second, the research focused on the PSX-100 index and non-financial and financial sectors in general. Future research can expand on this initiative by investigating the sectoral vulnerabilities, i.e., agricultural, manufacturing, or energy sectors that have the greatest climate shock sensitivity in Pakistan. Finally, a new frontier can explore the integration of artificial intelligence (AI) to identify and remove risks. The research on AI tools application to predict financial risks caused by climate change and support adaptive financial policies might offer new opportunities to enhance economic resilience.

Conflict of Interest: The authors declare no conflict of interest.

References

Addoum, J. M., Ng, D. T., & Ortiz-Bobea, A. (2020). Temperature shocks and establishment sales. *The Review of Financial Studies*, *33*(3), 1331-1366.

Ahmad, N., Scholz, M., AlDhaen, E., Ullah, Z., & Scholz, P. (2021). Improving firm's economic and environmental performance through the sustainable and innovative environment: evidence from an emerging economy. Frontiers in Psychology, 12, 651394.

Albitar, K., Al-Shaer, H., & Liu, Y. S. (2023). Corporate commitment to climate change: The effect of eco-innovation and climate governance. *Research Policy*, 52(2), 104697.

Alexakis, P., Apergis, N., & Xanthakis, E. (1996). Inflation volatility and stock prices: evidence from ARCH effects. *International Advances in Economic Research*, *2*(2), 101-111.

Ali, S., Ying, L., Nazir, A., Ishaq, M., Shah, T., Ilyas, A., ... & Tariq, A. (2019). The effect of climate change on economic growth: Evidence from Pakistan. *Pacific International Journal*, *2*(2), 70-76.

Amel-Zadeh, A., & Serafeim, G. (2018). Why and how investors use ESG information: Evidence from a global survey. *Financial analysts journal*, *74*(3), 87-103.

Anton, S. G. (2021). The impact of temperature increase on firm profitability. Empirical evidence from the European energy and gas sectors. *Applied Energy*, *295*, 117051.

Atz, U., Van Holt, T., Liu, Z. Z., & Bruno, C. C. (2023). Does sustainability generate better financial performance? review, meta-analysis, and propositions. *Journal of Sustainable Finance & Investment*, *13*(1), 802-825.

Batten, S., Sowerbutts, R., & Tanaka, M. (2016). Let's talk about the weather: the impact of climate change on central banks.

Battiston, S., Mandel, A., Monasterolo, I., Schütze, F., & Visentin, G. (2017). A climate stress-test of the financial system. *Nature Climate Change*, *7*(4), 283-288.

Benlemlih, M., & Girerd-Potin, I. (2017). Corporate social responsibility and firm financial risk reduction: On the moderating role of the legal environment. *Journal of Business Finance & Accounting*, *44*(7-8), 1137-1166.

Bernstein, A., Gustafson, M. T., & Lewis, R. (2019). Disaster on the horizon: The price effect of sea level rise. *Journal of Financial Economics*, *134*(2), 253-272.

Biswas, R. R., & Rahman, A. (2023). Adaptation to climate change: A study on regional climate change adaptation policy and practice framework. *Journal of Environmental Management*, *336*, 117666.

Brundtland, G. H. (1987). Our common future world commission on environment and developement.

Brunetti, C., Dennis, B., Gates, D., Hancock, D., Ignell, D., Kiser, E. K., ... & Tabor, N. K. (2021). Climate change and financial stability.

Bu, M., Lin, C. T., & Zhang, B. (2017). Globalization and climate change: new empirical panel data evidence. *Environmental Economics and Sustainability*, 201-220.

Bua, G., Kapp, D., Ramella, F., & Rognone, L. (2024). Transition versus physical climate risk pricing in European financial markets: A text-based approach. *The European Journal of Finance*, *30*(17), 2076-2110.

Campiglio, E., Dafermos, Y., Monnin, P., Ryan-Collins, J., Schotten, G., & Tanaka, M. (2018). Climate change challenges for central banks and financial regulators. *Nature climate change*, *8*(6), 462-468.

Carleton, T., Jina, A., Delgado, M., Greenstone, M., Houser, T., Hsiang, S., ... & Zhang, A. T. (2022). Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits. *The Quarterly Journal of Economics*, *137*(4), 2037-2105.

Chandio, A. A., Jiang, Y., Rehman, A., & Rauf, A. (2020). Short and long-run impacts of climate change on agriculture: an empirical evidence from China. *International Journal of Climate Change Strategies and Management*, *12*(2), 201-221.

Czerny, A., & Letmathe, P. (2024). The productivity paradox in carbon-intensive companies: How eco-innovation affects corporate environmental and financial performance. *Business Strategy and the Environment*, *33*(6), 5900-5919.

Davis, N., & Kutan, A. M. (2003). Inflation and output as predictors of stock returns and volatility: international evidence. *Applied Financial Economics*, *13*(9), 693-700.

Del Guercio, D., Seery, L., & Woidtke, T. (2008). Do boards pay attention when institutional investor activists “just vote no”? *Journal of Financial Economics*, *90*(1), 84-103.

Dell, M., Jones, B. F., & Olken, B. A. (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics*, *4*(3), 66-95.

DeMenno, M. B. (2022). Environmental sustainability and financial stability: can macroprudential stress testing measure and mitigate climate-related systemic financial risk?. *Journal of Banking Regulation*, 1.

Dinh, T. T. H., Nguyen, T. H., & Nguyen, T. P. (2024). Climate-related risks, firm performance and role of risk reserve funds: empirical evidence in Vietnam. *Journal of Sustainable Finance & Investment*, 1-38.

Eccles, R. G., Ioannou, I., & Serafeim, G. (2014). The impact of corporate sustainability on organizational processes and performance. *Management Science*, *60*(11), 2835-2857.

Elsayed, A. H., Naifar, N., & Nasreen, S. (2023). Financial stability and monetary policy reaction: Evidence from the GCC countries. *The Quarterly Review of Economics and Finance*, *87*, 396-405.

Feng, T., Chen, X., Ma, J., Sun, Y., Du, H., Yao, Y., ... & Mi, Z. (2023). Air pollution control or economic development? Empirical evidence from enterprises with production restrictions. *Journal of Environmental Management*, *336*, 117611.

Friede, G., Busch, T., & Bassen, A. (2015). ESG and financial performance: aggregated evidence from more than 2000 empirical studies. *Journal of Sustainable Finance & Investment*, *5*(4), 210-233.

Ginglinger, E., & Moreau, Q. (2023). Climate risk and capital structure. *Management Science*, *69*(12), 7492-7516.

Gong, Y., & Ho, K. C. (2018). Does corporate social responsibility matter for corporate stability? Evidence from China. *Quality & Quantity*, *52*(5), 2291-2319.

Goss, A., & Roberts, G. S. (2011). The impact of corporate social responsibility on the cost of bank loans. *Journal of Banking & Finance*, *35*(7), 1794-1810.

He, Z., Guo, B., Shi, Y., & Zhao, Y. (2022). Natural disasters and CSR: Evidence from China. *Pacific-Basin Finance Journal*, *73*, 101777.

He, Z., Zhao, Y., & Zheng, L. (2023). How does air pollution affect the stock market performance? Evidence from China. *Environmental Science and Pollution Research*, *30*(27), 70636-70648.

Hirshleifer, D., & Shumway, T. (2003). Good day sunshine: Stock returns and the weather. *The Journal of Finance*, *58*(3), 1009-1032.

Hong, H., Li, F. W., & Xu, J. (2019). Climate risks and market efficiency. *Journal of Econometrics*, *208*(1), 265-281.

Hsiang, S., Kopp, R., Jina, A., Rising, J., Delgado, M., Mohan, S., ... & Houser, T. (2017). Estimating economic damage from climate change in the United States. *Science*, *356*(6345), 1362-1369.

Huang, H. H., Kerstein, J., & Wang, C. (2022). The impact of climate risk on firm performance and financing choices: An international comparison. In *Crises and Disruptions in International Business: How Multinational Enterprises Respond to Crises* (pp. 305-349). Cham: Springer International Publishing.

Kahn, M. E., Mohaddes, K., Ng, R. N., Pesaran, M. H., Raissi, M., & Yang, J. C. (2021). Long-term macroeconomic effects of climate change: A cross-country analysis. *Energy Economics*, *104*, 105624.

Khan, F., Ali, S., Mayer, C., Ullah, H., & Muhammad, S. (2022). Climate change and spatio-temporal trend analysis of climate extremes in the homogeneous climatic zones of Pakistan during 1962-2019. *Plos one*, *17*(7), e0271626.

Khurshid, N., Fiaz, A., Khurshid, J., & Ali, K. (2022). Impact of climate change shocks on economic growth: A new insight from non-linear analysis. *Frontiers in Environmental Science*, *10*, 1039128.

Kozarcanin, S., Liu, H., & Andresen, G. B. (2019). 21st century climate change impacts on key properties of a large-scale renewable-based electricity system. *Joule*, *3*(4), 992-1005.

Krueger, P., Sautner, Z., & Starks, L. T. (2020). The importance of climate risks for institutional investors. *The Review of Financial Studies*, *33*(3), 1067-1111.

Kuranchie-Pong, L., Bokpin, G. A., & Andoh, C. (2016). Empirical evidence on disclosure and risk-taking of banks in Ghana. *Journal of Financial Regulation and Compliance*, *24*(2), 197-212.

Levy, T., & Yagil, J. (2011). Air pollution and stock returns in the US. *Journal of Economic Psychology*, *32*(3), 374-383.

Lu, J., & Chou, R. K. (2012). Does the weather have impacts on returns and trading activities in order-driven stock markets? Evidence from China. *Journal of Empirical Finance*, *19*(1), 79-93.

Mahmood, A., Shaheen, W., & Ullah, U. (2024). Breathless Returns: Assessing Air Pollution's Influence on Dividend Yields in Pakistan and the USA. *International Journal of Management Research and Emerging Sciences*, *14*(3).

Martins, A., Branco, M. C., Melo, P. N., & Machado, C. (2022). Sustainability in small and medium-sized enterprises: A systematic literature review and future research agenda. *Sustainability*, 14(11), 6493.

Monasterolo, I. (2020). Climate change and the financial system. *Annual Review of Resource Economics*, *12*(1), 299-320.

Muggah, R. (2019, January). The world's coastal cities are going under. Here's how some are fighting back. In *The World Economic Forum*.

Nieto, M. J. (2019). Banks, climate risk and financial stability. *Journal of Financial Regulation and Compliance*, *27*(2), 243-262.

Ozili, P. K., & Iorember, P. T. (2024). Financial stability and sustainable development. *International Journal of Finance & Economics*, *29*(3), 2620-2646.

Pagnottoni, P., Spelta, A., Flori, A., & Pammolli, F. (2022). Climate change and financial stability: Natural disaster impacts on global stock markets. *Physica A: Statistical Mechanics and Its Applications*, *599*, 127514.

Pankratz, N., Bauer, R., & Derwall, J. (2023). Climate change, firm performance, and investor surprises. *Management Science*, *69*(12), 7352-7398.

Porter, M. E., & Linde, C. V. D. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, *9*(4), 97-118.

Qiu, S. C., Jiang, J., Liu, X., Chen, M. H., & Yuan, X. (2021). Can corporate social responsibility protect firm value during the COVID-19 pandemic? *International Journal of Hospitality Management*, *93*, 102759.

Reddy, D. A., Misra, S., Sindhu, P. J., Premarajan, S., & John, S. (2020). Is Deteriorating Air Quality Impacting Stock Performance in India? Air Quality Index Predicts Stock Performance. *Indian Journal Of Science And Technology*, *13*(02), 103-113.

Saad, M., Taib, H. M., & Bhuiyan, A. B. (2018). Determinants of outreach performance of microfinance institutions in Pakistan. H*ealth*, *9*(15).

Selden, T. M., & Song, D. (1994). Environmental quality and development: is there a Kuznets curve for air pollution emissions? *Journal of Environmental Economics and Management*, *27*(2), 147-162.

Sharfman, M. P., & Fernando, C. S. (2008). Environmental risk management and the cost of capital. *Strategic Management Journal*, *29*(6), 569-592.

Sun, L., Fang, S., Iqbal, S., & Bilal, A. R. (2022). Financial stability role on climate risks, and climate change mitigation: implications for green economic recovery. *Environmental Science and Pollution Research*, *29*(22), 33063-33074.

Svartzman, R., Espagne, E., Julien, G., Paul, H. L., Mathilde, S., Allen, T., ... & Vallier, A. (2021). A'Silent Spring'for the Financial System? Exploring Biodiversity-Related Financial Risks in France.

Torjai, L., Nagy, J., & Bai, A. (2015). Decision hierarchy, competitive priorities and indicators in large-scale 'herbaceous biomass to energy'supply chains. *Biomass and Bioenergy*, *80*, 321-329.

Van Marrewijk, M. (2003). Concepts and definitions of CSR and corporate sustainability: Between agency and communion. *Journal of Business Ethics*, *44*(2), 95-105.

Wolf, J. (2014). The relationship between sustainable supply chain management, stakeholder pressure and corporate sustainability performance. *Journal of Business Ethics*, *119*(3), 317-328.

Wright, H., Huq, S., & Reeves, J. (2022). *Impact of climate change on least developed countries: are the SDGs possible?* International Institute for Environment and Development.

Wu, F., Wang, S. Y., & Zhou, P. (2023). Marginal abatement cost of carbon dioxide emissions: The role of abatement options. *European Journal of Operational Research*, 310(2), 891-901.

Wu, G. S. T., & Wan, W. T. S. (2023). What drives the cross-border spillover of climate transition risks? Evidence from global stock markets. *International Review of Economics & Finance*, *85*, 432-447.

Wu, L., Liu, D., & Lin, T. (2023). The impact of climate change on financial stability. *Sustainability*, *15*(15), 11744.

Zhang, X., Zhang, X., & Chen, X. (2017). Happiness in the air: How does a dirty sky affect mental health and subjective well-being? *Journal of Environmental Economics and Management*, *85*, 81-94.

Ziolo, M., Filipiak, B. Z., Bąk, I., & Cheba, K. (2019). How to design more sustainable financial systems: The roles of environmental, social, and governance factors in the decision-making process. *Sustainability*, *11*(20), 5604.