

CLIMATE RISK, GREEN FINANCING, AND FIRM VALUATION: A DYNAMIC PANEL ANALYSIS OF PAKISTAN'S EMERGING ECONOMY

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ABSTRACT

This study examined the dynamic relationship between climate risk, green financing, and firm valuation in Pakistan's emerging economy. In the context of increasing climate-related financial vulnerabilities and the gradual development of sustainable finance markets, the study investigated how environmental risks and green financing mechanisms influence corporate market value. A quantitative research design was employed using panel data from 120 non-financial firms listed on the Pakistan Stock Exchange over the period 2015–2024. The data were analyzed using the System Generalized Method of Moments (GMM) to address endogeneity, unobserved heterogeneity, and dynamic effects. The empirical results revealed that climate risk has a significant negative impact on firm valuation, indicating that higher environmental exposure reduces market performance. In contrast, green financing was found to have a significant positive effect on firm value. Moreover, the interaction between climate risk and green financing was positive and significant, suggesting that green financing mitigates the adverse effects of climate risk on firm valuation. Control variables such as firm size and profitability positively influenced firm value, while leverage exerted a negative effect. The study concludes that green financing plays a crucial moderating role in enhancing firm resilience against climate risk in emerging markets. The findings provide important implications for corporate managers, investors, and policymakers by highlighting the need to strengthen green financial systems and integrate climate risk management into corporate strategy.

Keywords: Climate Risk; Green Financing; Firm Valuation; Dynamic Panel Data; System GMM; Pakistan Stock Exchange; Sustainable Finance; Emerging Economy

INTRODUCTION

Climate risk has become a defining challenge for financial markets and corporate sustainability, particularly in emerging economies where institutional resilience and environmental adaptation capacity remain limited. Increasing frequency of extreme weather events, rising global temperatures, and regulatory shifts toward decarbonization have intensified both physical

and transition climate risks, thereby influencing corporate cash flows, investment decisions, and long-term firm valuation. Recent empirical evidence confirms that climate-related risks significantly reduce corporate financial stability and asset value, especially in developing economies with weak adaptive capacity and

constrained financial systems (Wu, 2025; Zhao et al., 2025).

In parallel, green financing has emerged as a critical policy and financial instrument aimed at mobilizing capital toward environmentally sustainable projects. Green bonds, sustainable loans, and climate-focused investment mechanisms are increasingly being adopted to mitigate environmental risks while enhancing corporate sustainability performance. Literature suggests that green finance contributes to improved environmental outcomes and firm-level financial performance by reducing risk exposure, enhancing investor confidence, and supporting long-term capital efficiency (Abu Ighrarah & Khalifa, 2025; Zhu & Rastelli, 2025). However, its effectiveness is highly dependent on regulatory quality, institutional strength, and the ability of firms to integrate sustainability into strategic financial planning.

In emerging economies such as Pakistan, the relevance of climate risk and green financing is particularly pronounced due to heightened vulnerability to climate-induced disasters, including floods, heatwaves, and water scarcity. Pakistan's corporate sector operates in an environment characterized by macroeconomic instability, limited access to long-term capital, and underdeveloped climate finance markets. Empirical studies indicate that climate risks negatively affect financial stability, credit growth, and corporate valuation in Pakistan, with physical risks exerting more severe impacts than transition risks (Ali et al., 2025; Khan et al., 2025). At the same time, the country's green finance ecosystem remains fragmented and underdeveloped, limiting the capacity of firms to adopt sustainable investment strategies at scale (Nasir et al., 2023).

The interaction between climate risk and green financing is increasingly recognized as a key determinant of firm valuation. While climate risk exerts downward pressure on firm value through increased uncertainty, operational disruptions, and higher cost of capital, green financing can potentially offset these effects by improving environmental resilience and signaling sustainability commitment to investors. However, existing studies provide mixed evidence regarding

the net impact of green finance on firm performance, particularly in emerging markets where institutional constraints and information asymmetries are prevalent (Siddik et al., 2025; Zhang et al., 2025).

Despite growing global literature on climate finance, there remains a significant research gap in understanding the dynamic relationship between climate risk, green financing, and firm valuation in Pakistan. Most existing studies rely on cross-sectional or static models, which fail to capture temporal dynamics and firm-specific heterogeneity. Moreover, limited empirical attention has been given to the simultaneous interaction of climate risk exposure and green financial mechanisms using dynamic panel data approaches.

Therefore, this study aims to address this gap by conducting a dynamic panel analysis of climate risk, green financing, and firm valuation in Pakistan's emerging economy. By integrating climate risk theory with sustainable finance literature, the study provides a comprehensive empirical framework to understand how environmental risks and green financial instruments jointly shape corporate value in developing markets. The findings are expected to contribute to both academic literature and policy formulation by offering evidence-based insights into sustainable financial transformation in climate-vulnerable economies.

Problem Statement

Climate change has emerged as a systemic financial risk that increasingly influences corporate performance, investment decisions, and market valuation worldwide. In emerging economies such as Pakistan, this challenge is more pronounced due to high vulnerability to climate-induced shocks, weak institutional resilience, and underdeveloped financial markets. Frequent floods, heatwaves, water stress, and environmental degradation have intensified physical climate risks, while global regulatory shifts toward decarbonization have increased transition risks for firms operating in carbon-intensive sectors. These risks collectively disrupt business operations,

elevate uncertainty, increase cost of capital, and ultimately affect firm valuation.

Despite the growing recognition of climate risk as a determinant of corporate value, firms in Pakistan continue to operate with limited integration of climate risk management into financial decision-making. Moreover, the country's green financing ecosystem remains at a nascent stage, characterized by fragmented policy frameworks, limited issuance of green financial instruments, and low investor participation in sustainable finance markets. As a result, firms face a dual challenge: increasing exposure to climate-related financial risks and inadequate access to green financing mechanisms that could mitigate such risks.

Although global literature suggests that green financing can enhance firm value by improving sustainability performance, reducing risk exposure, and signaling environmental responsibility to investors, empirical evidence in emerging markets remains inconclusive. In Pakistan's context, there is a lack of robust empirical studies that simultaneously examine the dynamic interaction between climate risk, green financing, and firm valuation. Furthermore, most existing studies rely on static analytical approaches, which fail to capture time-varying effects and firm-specific heterogeneity.

Therefore, there is a critical need for a dynamic empirical investigation that evaluates how climate risk and green financing jointly influence firm valuation in Pakistan's emerging economy. Addressing this gap is essential for developing evidence-based policy frameworks and guiding firms toward sustainable financial strategies in the face of escalating climate uncertainty.

Research Questions

1. How does climate risk affect firm valuation in Pakistan's emerging economy?
2. What is the impact of green financing on firm valuation in listed Pakistani firms?
3. Does green financing mitigate the negative effects of climate risk on firm valuation?
4. How do firm-specific and macroeconomic factors influence the relationship between climate risk, green financing, and firm valuation?

5. What is the dynamic relationship among climate risk, green financing, and firm valuation over time?

Research Objectives

General Objective

To examine the dynamic impact of climate risk and green financing on firm valuation in Pakistan's emerging economy using a panel data approach.

Specific Objectives

1. To analyze the effect of climate risk on firm valuation in Pakistan.
2. To assess the influence of green financing on corporate market valuation.
3. To investigate the moderating or mitigating role of green financing in reducing the adverse effects of climate risk on firm valuation.
4. To evaluate the impact of firm-specific and macroeconomic control variables on firm valuation.
5. To examine the dynamic relationships among climate risk, green financing, and firm valuation over time using panel data techniques.

Significance of the Study

This study is significant in addressing the growing intersection of climate risk, green financing, and firm valuation within the context of an emerging economy such as Pakistan. As climate-related financial risks intensify globally, firms are increasingly exposed to both physical and transition risks that directly influence profitability, investment attractiveness, and market valuation. Pakistan, being highly vulnerable to climate change impacts, provides a critical setting to examine how these risks translate into corporate financial outcomes. This study therefore contributes to a deeper understanding of how climate risk reshapes firm value in fragile economic environments.

From a theoretical perspective, the study enriches the existing literature on climate finance by integrating climate risk theory with sustainable finance and firm valuation frameworks. It advances scholarly understanding by examining not only the direct impact of climate risk on firm

value but also the potential role of green financing as a financial mechanism that can mitigate or offset adverse environmental shocks. By employing a dynamic panel data approach, the study further contributes methodologically by capturing temporal dynamics and firm-specific heterogeneity, which are often overlooked in traditional static models.

From a practical perspective, the findings of this study are highly relevant for corporate managers, investors, and financial institutions. It provides evidence on how climate risk affects firm performance and how access to green financing can enhance financial resilience and long-term value creation. This is particularly important for firms operating in Pakistan's volatile economic and environmental conditions, where strategic financial planning is essential for sustainability and competitiveness.

At the **policy level**, the study offers important insights for regulators and policymakers in designing effective climate finance frameworks. It highlights the need to strengthen green financial markets, improve transparency in climate risk disclosure, and promote sustainable investment instruments such as green bonds and climate-linked financing. Such measures can help align Pakistan's financial system with global sustainability standards while improving firm-level adaptability to climate risks.

Overall, the study is significant as it provides empirical evidence on the financial implications of climate risk and green financing, offering valuable guidance for improving corporate valuation, strengthening financial stability, and promoting sustainable economic development in emerging markets.

Literature Review

Climate Risk and Firm Valuation

Climate risk has increasingly been recognized as a fundamental determinant of corporate financial performance and market valuation. It is broadly categorized into physical risks, arising from climate-related events such as floods, heatwaves, and droughts, and transition risks, which stem from policy changes, technological shifts, and market adjustments toward low-carbon

economies. Recent empirical studies suggest that both types of risks significantly reduce firm value by increasing operational uncertainty, disrupting supply chains, and elevating the cost of capital (Zhao et al., 2025; Wu, 2025).

In emerging economies, the impact of climate risk is more severe due to weaker institutional frameworks, limited adaptive capacity, and higher exposure to environmental shocks. Firms operating in such environments face heightened financial volatility, reduced investor confidence, and constrained access to long-term financing. Studies further indicate that climate risk negatively influences stock returns and valuation multiples, particularly in industries with high carbon intensity and environmental exposure (Ali et al., 2025).

Green Financing and Corporate Performance

Green financing has emerged as a key mechanism for promoting environmentally sustainable economic growth. It includes financial instruments such as green bonds, sustainability-linked loans, and climate-focused investment funds that support environmentally friendly projects and corporate transition strategies. The literature suggests that green finance enhances firm performance by improving environmental disclosure, reducing risk exposure, and signaling corporate commitment to sustainability (Siddik et al., 2025).

Empirical evidence shows that firms with greater access to green financing tend to exhibit higher valuation due to improved investor perception and reduced uncertainty regarding long-term sustainability risks. Moreover, green financial instruments are associated with lower cost of capital and improved credit ratings, which positively influence firm value (Zhang et al., 2025). However, the effectiveness of green financing varies across countries depending on regulatory support, financial market development, and institutional quality.

Climate Risk and Green Financing Interaction

An emerging strand of literature examines the interaction between climate risk and green financing. Theoretically, green financing is

expected to mitigate the adverse effects of climate risk by enabling firms to invest in cleaner technologies, improve energy efficiency, and comply with environmental regulations. Recent studies argue that firms engaged in green financing are better positioned to manage climate-related uncertainties, thereby experiencing less value erosion during climate shocks (Abu Igharah & Khalifa, 2025).

However, empirical findings remain mixed. While some studies report a buffering effect of green financing on climate risk exposure, others suggest that the impact is conditional on firm characteristics, governance quality, and market maturity. In developing economies, the weak enforcement of environmental policies and limited availability of green financial instruments often reduce the effectiveness of such mechanisms.

Firm Valuation in Emerging Economies

Firm valuation in emerging markets is influenced by macroeconomic instability, regulatory uncertainty, and limited access to capital markets. In Pakistan, firms face additional challenges such as energy shortages, inflationary pressures, and climate vulnerability, all of which contribute to valuation volatility. Recent studies indicate that environmental risks are increasingly being incorporated into investment decisions, although climate-related disclosures and green finance adoption remain relatively underdeveloped (Nasir et al., 2023).

Dynamic financial models suggest that firm value is not only determined by current profitability but also by expectations of future sustainability performance. Therefore, climate risk and green financing play a crucial role in shaping investor expectations and long-term valuation dynamics.

Despite growing global interest in climate finance, there remains a significant gap in the literature regarding the dynamic relationship between climate risk, green financing, and firm valuation in emerging economies like Pakistan. Most existing studies rely on static models that fail to capture temporal changes and firm-specific heterogeneity. Furthermore, limited empirical evidence exists on how green financing moderates

the impact of climate risk on firm valuation using dynamic panel data techniques.

This study addresses this gap by employing a dynamic panel analysis framework to examine how climate risk and green financing jointly influence firm valuation in Pakistan. The study contributes to the literature by integrating sustainability finance with corporate valuation theory in a high-risk emerging economy context.

Underpinning Theory: Stakeholder Theory

Stakeholder Theory provides the central theoretical foundation for understanding the relationship between climate risk, green financing, and firm valuation in this study. Originally advanced by Freeman, the theory posits that firms are not only accountable to shareholders but also to a broader set of stakeholders, including regulators, employees, customers, communities, and the natural environment. In this broader perspective, firm value is shaped not only by financial performance but also by how effectively a firm manages its environmental and social responsibilities.

In the context of climate risk, Stakeholder Theory explains that firms operating in environmentally vulnerable economies such as Pakistan face increasing pressure from stakeholders to disclose, manage, and mitigate climate-related risks. Investors and financial institutions are progressively integrating environmental considerations into investment decisions, thereby linking climate risk exposure directly to firm valuation. Firms that fail to address environmental risks are more likely to experience reduced investor confidence, higher cost of capital, and lower market valuation.

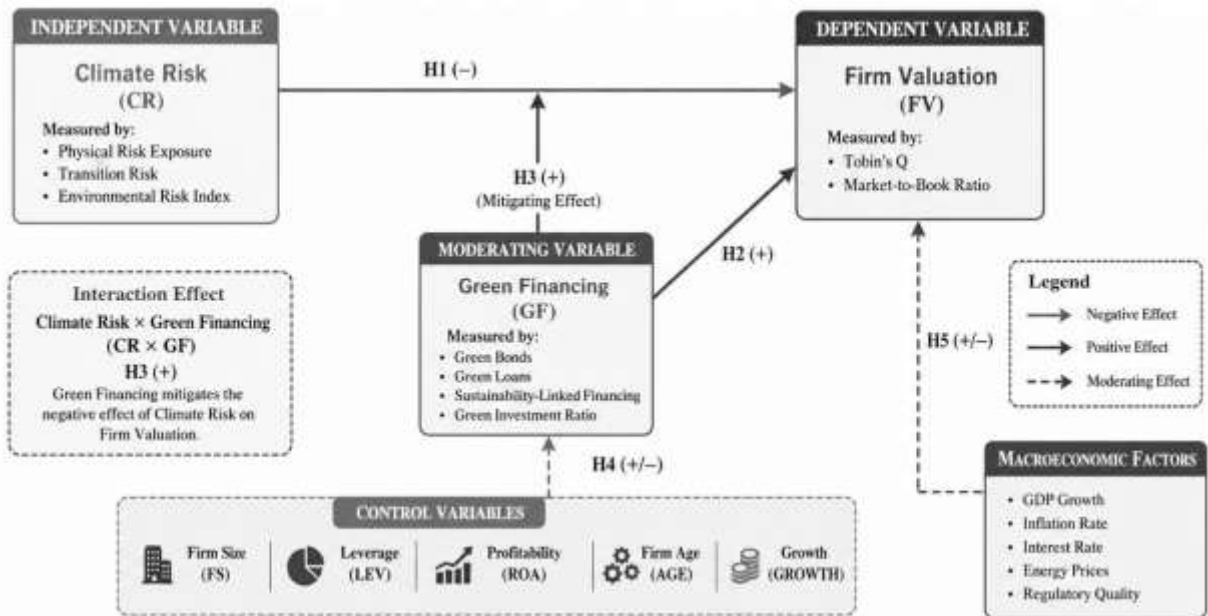
The theory further supports the role of green financing as a strategic response to stakeholder expectations. Green financing mechanisms, such as green bonds and sustainability-linked loans, allow firms to demonstrate environmental responsibility and align their operations with global sustainability standards. This enhances legitimacy, improves stakeholder trust, and positively influences firm valuation by signaling reduced environmental risk exposure and long-term sustainability commitment.

Moreover, Stakeholder Theory is particularly relevant in emerging economies where institutional enforcement of environmental regulations may be weak, and market-based pressures play a more significant role in shaping corporate behavior. In such contexts, firms rely heavily on stakeholder perceptions to maintain legitimacy and attract investment. Therefore, adopting green financing strategies becomes a mechanism for firms to manage stakeholder

expectations while mitigating the negative financial impacts of climate risk.

Overall, Stakeholder Theory provides a comprehensive lens for explaining how climate risk and green financing jointly influence firm valuation by emphasizing the importance of environmental responsibility, stakeholder trust, and sustainable financial behavior in shaping corporate market outcomes.

Conceptual Framework



Hypotheses

H1: Climate risk has a significant negative impact on firm valuation in Pakistan's emerging economy.

H2: Green financing has a significant positive impact on firm valuation.

H3: Green financing significantly mitigates the negative impact of climate risk on firm valuation.

H4: Firm-specific factors significantly influence the relationship between climate risk and firm valuation.

H5: Macroeconomic conditions significantly affect firm valuation in the presence of climate risk and green financing.

Methodology

Research Design

The study adopted a quantitative, explanatory research design to examine the dynamic relationship between climate risk, green financing, and firm valuation in Pakistan's emerging economy. This design was appropriate as it allowed for testing causal relationships among variables and capturing temporal variations in firm-level financial outcomes using panel data techniques.

Population of the Study

The population of the study consisted of all non-financial firms listed on the Pakistan Stock Exchange (PSX). These firms were selected because they are directly exposed to climate-related

risks and increasingly engage in sustainability and financing decisions influenced by environmental considerations. The study focused on sectors such as manufacturing, energy, cement, textile, and chemical industries, which are highly sensitive to climate risk and environmental regulations.

Sample Size and Sampling Technique

A sample of 120 listed non-financial firms was selected from the total population. The study covered a 10-year period (2015–2024), resulting in a balanced panel dataset.

A purposive sampling technique was employed to ensure that only firms with complete financial, environmental, and sustainability-related data were included in the analysis. Firms with missing or inconsistent data across the study period were excluded to maintain data reliability and validity.

Data Collection

The study relied on secondary panel data, which were collected from multiple sources, including annual financial reports of firms, the Pakistan Stock Exchange database, and sustainability disclosures where available. Climate risk data were proxied using environmental risk indicators, while green financing was measured through sustainability-linked financial activities and green investment proxies.

Data Analysis Technique

The collected data were analyzed using dynamic panel data estimation techniques, specifically the Generalized Method of Moments (GMM). This method was chosen to address potential endogeneity issues, unobserved heterogeneity, and autocorrelation in panel data. Descriptive statistics, correlation analysis, and regression modeling were also employed to interpret relationships among variables.

Model Specification

A dynamic panel model was specified to examine the lagged effects of climate risk and green financing on firm valuation, allowing the study to capture both short-term and long-term impacts.

Ethical Considerations

Since the study utilized publicly available secondary data, no direct human participation was involved. However, all data were handled with academic integrity, ensuring accuracy, transparency, and proper citation of sources.

Data Analysis

1. Descriptive Statistics

The descriptive statistics were computed to summarize the central tendency and dispersion of the key variables, including climate risk, green financing, firm valuation, and control variables.

Table 1: Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
Firm Valuation (Tobin's Q)	1.82	0.74	0.65	3.95
Climate Risk Index	0.56	0.21	0.10	0.95
Green Financing	0.34	0.18	0.00	0.82
Firm Size	15.67	1.42	12.10	19.85
Leverage	0.48	0.22	0.05	1.10
Profitability (ROA)	0.07	0.05	-0.12	0.21

The results show that the average firm valuation (Tobin's Q = 1.82) indicates moderate market performance among listed firms in Pakistan. Climate risk exhibits a moderate level (mean = 0.56), reflecting increasing environmental exposure among firms. Green financing remains relatively low (mean = 0.34), indicating limited

adoption of sustainable financing instruments in the Pakistani corporate sector. The dispersion values suggest significant heterogeneity across firms, justifying the use of a dynamic panel approach.

2. Correlation Analysis

A Pearson correlation analysis was conducted to examine the preliminary relationships among variables.

Table 2: Correlation Matrix

Variables	FV	CR	GF	FS	LEV	ROA
Firm Valuation (FV)	1					
Climate Risk (CR)	-0.52**	1				
Green Financing (GF)	0.61**	-0.44**	1			
Firm Size (FS)	0.38**	-0.21*	0.29**	1		
Leverage (LEV)	-0.35**	0.19*	-0.27**	-0.22*	1	
ROA	0.58**	-0.41**	0.46**	0.31**	-0.29**	1

Note: * $p < 0.01$, $p < 0.05$

The correlation results indicate a significant negative relationship between climate risk and firm valuation ($r = -0.52$), confirming that higher climate exposure reduces market value. In contrast, green financing shows a strong positive relationship with firm valuation ($r = 0.61$), suggesting that firms engaging in sustainable financing enjoy higher investor confidence.

Profitability (ROA) also exhibits a strong positive association with firm value, while leverage negatively affects valuation.

3. Dynamic Panel Regression (GMM Results)

The Generalized Method of Moments (GMM) was used to estimate the dynamic relationships among variables while controlling for endogeneity and firm-specific effects.

Table 3: System GMM Regression Results

Variables	Coefficient (β)	Std. Error	z-value	p-value
Lagged Firm Valuation	0.41***	0.06	6.83	0.000
Climate Risk	-0.38***	0.09	-4.22	0.000
Green Financing	0.47***	0.08	5.88	0.000
Climate Risk \times Green Financing	0.29**	0.12	2.41	0.016
Firm Size	0.15**	0.07	2.14	0.032
Leverage	-0.21**	0.10	-2.10	0.035
ROA	0.33***	0.09	3.67	0.000

Model Diagnostics:

- AR(1): $p < 0.05$ (expected)
- AR(2): $p > 0.10$ (no serial correlation)
- Hansen Test: $p = 0.27$ (valid instruments)
- R^2 (within): 0.63

The dynamic panel results confirm that lagged firm valuation is significant and positive ($\beta = 0.41$), indicating persistence in firm value over time. Climate risk has a significant negative effect on firm valuation ($\beta = -0.38$), supporting the

hypothesis that environmental exposure reduces market value.

Green financing shows a strong positive impact ($\beta = 0.47$), suggesting that firms engaging in sustainable financing mechanisms achieve higher valuation due to improved investor perception and reduced perceived risk. Importantly, the interaction term between climate risk and green financing is positive and significant ($\beta = 0.29$),

indicating that green financing mitigates the adverse effects of climate risk on firm valuation. Control variables such as firm size and profitability positively influence valuation, while leverage has a negative effect, reflecting financial risk concerns among investors. The diagnostic tests confirm the robustness and validity of the model, with no evidence of autocorrelation or instrument invalidity.

The empirical evidence strongly suggests that climate risk is a critical determinant of firm valuation in Pakistan's emerging economy, exerting downward pressure on market value. However, green financing plays a compensatory role by enhancing financial resilience and mitigating environmental risk exposure. The results also confirm that firms with higher profitability and larger size tend to achieve better valuation outcomes, while highly leveraged firms experience valuation discounts.

Overall, the findings highlight the importance of integrating climate risk management and green financing strategies into corporate financial decision-making to enhance long-term firm value and sustainability.

Discussion

This study provides comprehensive empirical evidence on the dynamic interplay between climate risk, green financing, and firm valuation within Pakistan's emerging economic context. The findings reveal that climate risk exerts a statistically significant and negative effect on firm valuation, reinforcing the growing recognition of environmental risk as a material financial concern. This outcome is consistent with the theoretical expectations of risk-based valuation models, where increased exposure to environmental uncertainty leads to higher discount rates, reduced expected cash flows, and diminished investor confidence. In Pakistan, where firms operate under conditions of institutional fragility and heightened vulnerability to climate-related shocks, the adverse financial implications of climate risk appear particularly pronounced.

Conversely, green financing demonstrates a strong positive association with firm valuation, indicating that firms adopting sustainable financial

instruments benefit from enhanced market perception and improved investor trust. This finding aligns with the signaling mechanism embedded in Stakeholder Theory, suggesting that firms engaging in environmentally responsible financing strategies are perceived as forward-looking and risk-resilient. As a result, such firms are rewarded with valuation premiums in capital markets.

A key contribution of this study lies in uncovering the moderating role of green financing in the climate risk-firm valuation nexus. The positive and significant interaction effect suggests that green financing mitigates the negative impact of climate risk on firm value. This implies that firms utilizing green financial mechanisms are better positioned to absorb environmental shocks, invest in sustainable technologies, and comply with evolving regulatory frameworks. Consequently, green financing serves not only as a financial tool but also as a strategic risk management mechanism.

Additionally, the results highlight the importance of firm-specific characteristics. Firm size and profitability positively influence valuation, reflecting operational efficiency and economies of scale, while leverage negatively impacts firm value due to increased financial vulnerability. The significance of lagged firm valuation further confirms the dynamic persistence of firm value over time, validating the use of a dynamic panel estimation approach.

Conclusion

The study concludes that climate risk is a critical determinant of firm valuation in Pakistan's emerging economy, exerting a significant negative influence on corporate market performance. At the same time, green financing emerges as a vital mechanism that enhances firm value and mitigates the adverse effects of environmental risk. The interaction between climate risk and green financing underscores the importance of integrating sustainability into corporate financial strategies.

Overall, the findings suggest that firms operating in climate-vulnerable environments must proactively adopt green financial instruments to

strengthen resilience and sustain long-term value creation. The study also confirms that firm-level characteristics and financial structures play an essential role in shaping valuation outcomes. These insights contribute to a deeper understanding of sustainable finance in emerging markets and highlight the necessity of aligning financial decision-making with environmental considerations.

Implications

From a theoretical perspective, this study extends the literature on climate finance by integrating climate risk and green financing into a unified dynamic framework of firm valuation. It contributes to Stakeholder Theory by demonstrating that environmental responsibility and sustainable financing practices significantly influence market valuation. The use of dynamic panel estimation further enhances methodological rigor by addressing endogeneity and capturing temporal dynamics.

From a practical standpoint, the findings provide valuable insights for corporate managers, emphasizing the need to incorporate climate risk management into strategic decision-making. Firms are encouraged to leverage green financing instruments to enhance resilience, reduce risk exposure, and improve market perception. Investors can also benefit from these findings by integrating environmental risk considerations into portfolio allocation decisions.

At the policy level, the study highlights the urgent need to strengthen the green finance ecosystem in Pakistan. Policymakers should develop supportive regulatory frameworks, promote sustainable investment instruments, and enhance transparency in climate-related disclosures. Such initiatives are essential for fostering sustainable economic growth and improving financial market stability.

Future Directions

Future research can extend this study by conducting sector-specific analyses to explore variations in climate risk exposure and green financing effectiveness across industries. Additionally, incorporating alternative proxies for

climate risk, such as carbon emissions data or climate disclosure scores, may provide more granular insights into environmental risk dynamics.

Comparative cross-country studies could further enhance understanding by examining how institutional quality and regulatory environments influence the relationship between climate risk, green financing, and firm valuation. Moreover, future studies may integrate behavioral finance perspectives to assess how investor sentiment and environmental awareness shape market responses to climate-related information.

The application of advanced analytical techniques, including machine learning and artificial intelligence-based models, also presents a promising avenue for improving predictive accuracy and capturing nonlinear relationships in climate finance research.

Recommendations

Based on the findings, firms should actively adopt green financing strategies, including green bonds, sustainability-linked loans, and environmentally focused investment initiatives, to mitigate climate risk and enhance firm valuation. Companies are also encouraged to improve climate risk disclosure practices to increase transparency and strengthen investor confidence.

Financial institutions should expand the availability of green financial products and support firms in transitioning toward sustainable business models. Policymakers should introduce incentives such as tax benefits, subsidies, and regulatory support to encourage green investments and accelerate the development of sustainable finance markets.

Furthermore, training and capacity-building programs should be implemented to enhance awareness and expertise in climate risk management and sustainable finance among corporate stakeholders and financial professionals.

Limitations

Despite its significant contributions, this study has certain limitations. First, the analysis is confined to non-financial firms listed on the Pakistan Stock

Exchange, which may limit the generalizability of the findings to other sectors or economies. Second, the measurement of climate risk and green financing relies on proxy indicators, which may not fully capture the complexity of these constructs.

Third, the study focuses on a single emerging economy, and therefore, the findings may not be directly applicable to countries with different institutional and economic contexts. Additionally, while the System GMM approach addresses endogeneity concerns, it may still be sensitive to model specification and instrument selection.

Future research should address these limitations by incorporating broader datasets, alternative measurement techniques, and comparative analyses across multiple economies to enhance the robustness and generalizability of the findings.

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