E-ISSN 2389-8194
Vol. 12, No. 1
Enero-junio de 2025
doi: https://doi.org/10.16967/23898186.739

ARTÍCULOS ORIGINALES

Does Going Green Pay Off? Empirical Analysis of Green Innovation and Financial Performance in Pakistan

pp. 6-21

SHAH MEHMOOD WAGAN

E-ISSN 2389-8194
Vol. 12, No. 1
Enero-junio de 2025
doi: https://doi.org/10.16967/23898186.739

Abstract

Green innovation supports businesses decrease their environmental influence while they expand efficiency, competitiveness, and profitability. This study examines impact of green innovation on the financial performance of firms in Pakistan, using panel data from 2015 to 2024. With rising global focus on sustainability, understanding how environmentally friendly practices influence economic results is crucial—mainly in developing economies like the Pakistan, where industrial growth often conflicts with environmental concerns. The study adopts a quantitative approach, using fixed-effects regression models to observe the relationship between green innovation and financial performance, while also testing the mediating role of regulatory compliance and moderating effect of firm size. The results show a statistically significant positive relationship between green innovation and financial performance, as evaluated by Return on Assets (ROA), Return on Equity (ROE), and Tobin's Q. Regulatory compliance is found to improve this relationship, suggesting that institutional pressures reinforce the financial benefits of sustainable practices.

Keywords: Green Innovation, Financial Performance, Panel Regression, Sustainability, Corporate Governance, Pakistan.

Introduction

1.1 Background

The challenge to sustainably manage our environment has rapidly risen to become a vital international issue since the past few decades. Developments in environmental sustainability have prompted governmental bodies and international organizations together with businesses to push for sustainable development initiatives. Green-innovation implementation is one of the primary business strategies that enables corporations to reduce their environmental footprint in addition to enhancing performance excellence and business standings. The design and implementation of product or process as well as systems management that minimizes the level of wastes and increasing energy efficiency, and using cleaner production technologies are the quality that characterize green innovation. Weak regulations and the access to eco-friendly technologies and the absence of environmental awareness of business leaders trigger the economic development resulting in the destruction of the environment in the given economic conditions (Helmina et al., 2025). Urgent demands from international supply chains as well as domestic and foreign investors have created forces that are compelling Pakistani industries to implement sustainable operational methods (Le & Gia, 2025). The analysis of green innovation impact on financial results represents a priority because it ensures business sustainability together with environmentally conscious national growth (Esposito et al., 2025).

1.2 Problem Statement

The relationship between environmental innovations and financial gains has not received enough empirical examination specifically within the Pakistani context although sustainability grows in popularity. Current research mainly examines environmental policies at the macro-level or performs qualitative CSR evaluations without establishing financial effects for individual firms. The absence of research obstructs policymakers and business leaders and market investors from making proper investment decisions for green technologies. Not all firms can easily access the potential advantages of green innovation such as cost reductions and market distinction and danger prevention and other financial advantages. Studies should undertake an adequate analysis of the effect of green innovation on profitability and profit-on-investment and market valuation in Pakistani companies.

1.3 Research Objectives

Specifically, it seeks to:

- The study in question examines the validity of the hypothesis as to whether green innovation has significant implications to the aspects of Return on Assets (ROA) and Return on Equity (ROE) and the Q ratio of the financial performance of a company as compared to Tobin.
- This study determines the influence of firm characteristics that comprise of size and industry type and ownership structure on the relationship between environmental innovation and financial performance outcomes.
- The research offers vital strategic guidelines that aid decision-makers when they adopt environmental sustainability principles into business operations.

By reaching these objectives, the study is able to expand both theoretical and empirical knowledge in terms of green innovation under the conditions of developing countries.

1.4 Research Questions

This study aims at answering 3 primary questions that guide the research:

- The study describes whether green innovation does make a significant change in the financial indicators of Pakistan based firms.
- The financial outcome response to green innovation varies depending on the size of a firm alongside the industry sector and the ownership model that the firm operates.

1.5 Significance of the Study

This research is applicable to several groups in one way or another. The outcomes of the research provide legitimate guidance to the businesses based in high-pollution sectors that allows them to implement minimum decisions regarding the adoption of green technology and sustainable activities. The analysis outcomes enable managers to match their corporate strategies to the global trends on the environmental responsibilities. The results assist the government officials in developing accurate regulatory frameworks that encourages sustainable innovation. By accurately understanding sustainable practices associated with earning potential, business owners with economic institutions attain improved resource investments in case they are allocating capital to changing industries. The study adds valuable quantitative information in an emerging economy into the body of research that is deficient in this area of research. This paper utilizes Resource-Based View (RBV) and Stakeholder Theory and Institutional Theory to research their application in the non-Western institutional context.

1.6 Structure of the Paper

The remaining portion of this research study is sub-divided into six sections. Section 2 includes an extensive evaluation of important research articles in addition to theoretical bases and past empirical studies. Section 3 describes both the research methodologies along with data identification sources and analytical procedures used. Section 4 presents the empirical results which include descriptions of statistical data alongside correlation results and regression models with robustness tests. The paper analyzes empirical results against theoretical foundations and existing literature while presenting policy and managerial implications in Section 5. The study finishes with a section 6 which presents the main study outcomes while suggesting future research paths.

2. Literature Review

2.1 Conceptual Framework

In the current paper, the conceptual framework of green innovation and financial performance are interrelated because the former forms the conceptual foundation of the current study because the constructs demonstrate that they are vital in understanding how sustainable business practice is formed in the developing economic scenario in Pakistan (R. U. Khan et al., 2022).

Green Innovation (GI) involves the innovation of new standardized products and systems of operation and new products and operation systems as well as breakthroughs in green engineering which have a high level of reduction of environmental impact and meet sustainability goals (S. A. R. Khan et al., 2022). The strategy entails green technology innovation and firm-wide strategies which decrease the pollution rate and safeguard the natural resources and guarantee sustainable economic cycles.

The Financial Performance is the financial health of the businesses exhibited by companies using assets-to-sales ratio (ROA), equity-to-sales ratio (ROE), a comparison of market values (Q of Tobin) and net profit percentages and other earnings ratios per share (EPS). Financial indicators are measures of how the company is doing in relation to its profit generation in reference to its assets and equity and also to the volume of their marketing values. Green innovation also promotes good financial results even though it initially needs preliminary spending due to its opening operational potentials and market entry and regulatory conformity as well as improved reputation.

2.2 Theoretical Foundations

The authors discuss the connection between the process of green innovation and the performance of the firm through the application of Stakeholder Theory alongside Resource-Based View (RBV) and the Porter Hypothesis as the central theoretical models. The main concept of Stakeholder Theory is that any organization ought to cater to the interest of all stakeholders besides the shareholders in order to achieve future ultimate business success (Gidage & Bhide, 2025). The environmentally responsible action undertaken by firms on the basis of the societal requirements contributes to increased trust of its stakeholders and regulatory bodies and shareholders which achieves an improved competitive positioning and legitimacy.

The Resource-Based View (RBV) suggests that sustainable competitive position of an entity

persists thanks to unique resources which have a value as well as being hard to replicate by their rivals (Dogah et al., 2025). The strategic assets of the green innovations in the form of R&D capacities and managerial experience make organizations cut production expenses as well as increasing productivity and differentiating their products in the market.

Properly designed environmental regulations based on the Porter Hypothesis (Deng et al., 2025) lead companies to create new solutions that transform the cost of compliance into benefits of competitors. According to this theory firms using green innovation as a resource obtain economic advantages through their investments. Environmental forecasting models alongside the KFW hypothesis and List and Hendricks theory establish a strong basis to study financial performance effects from environmentally progressive corporate approaches.

2.3 Empirical Literature

2.3.1 International Studies

Researchers have discovered divergent correlations between green innovation and financial success based on industry distribution and geographical locations of study subjects. Research findings show that firms participating in green innovation achieve better profitability through market valuation and reduced costs (Yin, 2025). The findings demonstrated that environmental innovation drives upward firm valuation because it grants better risk mitigation and enhances stakeholder engagement (Turkcan, 2025).

Several research findings exhibit insignificant or undesirable results because sustainable technology adoption initially costs more than providing prompt benefits (Stylianou et al., 2025) particularly in short-term periods. The negative economic aspects from sustainable practices usually decrease as businesses achieve their energy efficiency goals coupled with increased waste reduction and operational enhancement.

Various results emerge from research undertaken in developing economies. A research study conducted demonstrated Chinese companies experience positive effects from green patent activities on both their ROA and ROE numbers which supports the Porter Hypothesis concept within emerging market conditions (Thirakulwanich et al., 2025). Monitoring Environmental Social Governance (ESG) disclosures at Indian firms showed direct positive links to superior financial performance according to (Song et al., 2025). The available evidence about green innovation remaining indecisive has shifted toward proving its role in enhancing financial stability with competitive advantages (Ciambellini et al., 2025).

2.3.2 Regional/National Context (Pakistan)

Research about green innovation together with its effect on corporate performance in Pakistan exists within isolated and constrained boundaries. Current academic research examines corporate social responsibility practices and environmental regulations as main subjects without deep analysis of sustainability initiatives that stem from innovation.

The industrial sector of Pakistan which faces high risk from climate change has demonstrated minimal progress in implementing green technologies together with sustainable operational practices. Linking performance with sustainability is slowly changing because of growing regulations alongside international standards for trade. Since 2013 the Securities and Exchange Commission of Pakistan (SECP) became the first regulatory body which started requiring Environmental Social Governance (ESG) reports from listed companies. Under the Pakistan Environmental Protection Act (PEPA, 1997) industrial facilities must meet pollution control requirements which drives them to adopt more environmentally friendly production practices.

Most environmental research within Pakistan focuses on disclosure practices instead of studying genuine environmental innovation activities. Based on his study (Junaid et al., 2022) revealed that manufacturing companies used environmental reporting inconsistently while also keeping their information transparent at minimal levels. Khan et al., (2021) researched how board composition affects CSR spending yet their research did not include the evaluation of innovation for sustainable goal achievement.

2.4 Gaps in Literature

Multiple gaps continue to exist in global literature research even as it expands despite focusing on rising markets like Pakistan. Research lacks studies which observe how green innovation relates to financial performance through time-based analysis. Cross-sectional research forms most literary data while lacking strength to prove direct cause-effect links and showing shifts through time.

The available research about firm-level investigations specifically pertaining to South Asia particularly Pakistan remains limited. The current literature makes blanket uses of multinational research findings but disregards distinct regulatory setting and market conditions among regional markets in South Asia. Research studies commonly approach green innovation by classifying organizations into two groups based on whether they have any green initiatives or not without explaining the level or range of specific initiatives included.

3. Methodology

3.1 Research Design

The analysis of green innovation and financial performance relations in publicly listed Pakistani firms uses a quantitative approach into this research. The analysis utilizes panel regression models that serve as a well-suited method to study data with both time components and cross-section units in this case which includes individual firms between 2014 and 2024. Panel regression functions as a method to eliminate firm-specific heterogeneity and offers enhanced variability and degrees of freedom when used instead of time-series or cross-sectional data analysis only.

The research implements three main types of panel regression methods: Pooled Ordinary Least Squares (POLS) merges time-series data from all firms by assuming all intercept values are identical throughout the analysis. Each firm employed its own personal intercept under the Fixed Effects method to explain time-constant business characteristics. Random Effects (RE) establishes that both individual-specific effects show random distribution along with being uncorrelated with other regressors. Deciding between FE or RE requires the application of Hausman specification test to verify if individual effects are correlated with the explanatory variables. The analysis employed Arellano-Bond GMM estimation when lagged effects between green innovation and financial performance exist since this model handles endogenous errors.

3.2 Data Collection

3.2.1 Data Source

Natural financial reports and performance measurements are mainly based on yearly reports of businesses listed at Pakistan Stock Exchange (PSX) which captures profit levels as well as liquidity situations and business sustainability and operational performance basis. Reports include important details that allow to evaluate the business performance both in the past and future possible success. Data of stock market and characteristics of firms is achieved using the advanced systems such as Bloomberg Terminal, Refinitiv Eikon, Capital IQ and Factset to view live stock prices, market capitalization pattern, trading action and many other indicators showing investor response and market behavior. To maintain transparency in the financial system, the Securities and Exchange Commission of Pakistan forms one of the key data centers in terms of regulatory and compliance rematerialize with corporate governance records and legal provisions records as well as securities standards compliance records. The Economic Reports prepared by the State Bank of Pakistan (SBP) provide access to macroeconomic indicators through researchers that help to benchmark the performance of firms to the economic conditions in the country (nationwide) regarding inflation levels, GDP growth, interest rates, exchange rates and fiscal measures. Annual reports are used by companies to disclose their sustainability reports that extract green innovation metrics that are critical to the present-day sustainability-driven environment. They are WIPO PATENTSCOPE and National Intellectual Property Office (Pakistan IPO) which are reputable sources which disclose the information on intellectual property such as in the form of patents trademarks copyrights and other intellectual assets that portray the advancements of the technologies and competitive advantages. Both

non-financial risks are measured by the introduction of Environmental Social and Governance (ESG) ratings, which are offered by Sustainalytics and MSCI and Pakistani business-based opportunities in which data is accessible.

3.2.2 Time Period

Research explores a ten-year span starting from 2014 until the year 2024 to determine the ongoing influence of green innovation on firm financial performance. The chosen 10-year period matches the timeline of major environmental regulations and mandatory ESG disclosure requirements which have been established in Pakistan.

3.2.3 Sample Selection

The research examines non-financial firms that operate on the Pakistan Stock Exchange (PSX) which meet three main requirements: financial and operational information must be accessible continuously for at least eight out of ten years. Annual reports along with sustainability reports remain accessible to the public domain. Regular reporting of R&D expenditures and environmental initiatives. Study focused on the top 100 non-financial companies based on their market capitalization rankings as initial sample group. The selection process using data completeness and relevance tests provides a total of 69 companies to examine.

3.3 Variables

3.3.1 Dependent Variables (Financial Performance)

The assessment of financial performance depends on four universally recognized indicators which help measure operational efficiency alongside profitability and market worth of a company. Return on Assets (ROA) determines a company's asset profitability through its measurement of asset utilization against net income using total asset values and higher ROA values demonstrate superior asset management. Businesses analyze equity investors' returns and wealth maximization ability through Return on Equity (ROE) by dividing net income by shareholders' equity. Tobin's Q obtains market value data by assessing the price of firm assets through market transactions for valuation purposes thus enabling investors to confirm asset-driven overvaluation or undervaluation in company stock. The Net Profit Margin metric calculates actual profit by dividing net profit with revenue to demonstrate the percent of sales that generates actual profit for cost control and pricing efficiency evaluation.

3.3.2 Independent Variable (Green Innovation)

Green innovation requires multiple indicators for analysis therefore researchers construct a composite index (GI Index) which includes measurements from green patents and R&D on eco-friendly technologies and environmental initiative disclosures by firms. A firm's dedication to developing ecological solutions emerges through green patents which represent the annual patents filed regarding environmental technologies thus demonstrating its sustainable innovation abilities. The financial commitment through R&D investment into environment-friendly projects constitutes a guiding metric to determine how organizations combine environmental innovation with their strategic priorities toward sustainable development. Marketplace organizations disclose binary environmental data points about eco-friendly activities which provides qualitative evidence regarding their operational adherence to worldwide environmental standards. As continuous n dimensions the entire system provides stakeholders with holistic metrics to measure the environmental sustainability commitment of firms through quantitative and qualitative aspects of green innovation.

$$GI_i = \alpha_1\left(\frac{GreenPatents_i - \bar{P}}{\sigma_P}\right) + \alpha_2\left(\frac{R\&D\ Green_i - \bar{R}}{\sigma_R}\right) + \alpha_3(EnvInitiative_i) \quad (1)$$

In equation 1 where: GI_i: Composite green innovation index for firm *i,* GreenPatents$_i$: Number of environmentally friendly patents filed by firm *i,* , σ_p: Mean and standard deviation of green patents across all firms in the sample, R&D Green$_i$: Green-related R&D expenditure (as a percentage of total R&D or in absolute terms) by firm *i,* , σ_R: Mean and standard deviation of green R&D expenditure across all firms, EnvInitiative$_i$: A qualitative or binary score indicating the presence and scope of additional environmental initiatives (e.g., ISO 14001 certification, waste reduction programs, renewable energy adoption), and α_1, α_2, α_3:

Weighting coefficients assigned either equally or derived through principal component analysis (PCA) to reflect the relative contribution of each component to the overall index

Standardization procedures make it possible to compare variables with differing measurement scales while minimizing the impact of anomalous data points. A standardized index measures complete green innovation participation levels for firms that researchers use as their main independent variable in statistical models.

3.3.3 Control Variables

Large firms are commonly evaluated using total asset data transformed into natural logarithmic values (ln(Assets)) to control for size differences between organizations thus adjusting for potential size-related inconsistencies. Organizations utilize leverage through the total debt per total equity ratio to measure their financial risk profile and capital structure because this metric affects both strategic decisions and corporate performance. The age of a firm reveals important information about its operational experience and maturity through its years since incorporation which affects both its operational performance and market position strategy. Industry characteristics are checked through binary variables such as manufacturing, services, energy and other sectors due to their ability to control for industry-specific patterns influencing firm patterns. The GDP growth rate controls the macroeconomic environment through its annual percentage changes in the gross domestic product to eliminate external economic fluctuations from influencing analysis results. These supplementary variables strengthen research validity because they isolate important main variables from interfering external components.

3.4 Model Specification

Study estimate the following panel regression models to analyze the impact of green innovation on financial performance as follows in equation 2:

$$FP_{it} = \beta_0 + \beta_1 GI_{it} + \beta_2 \ln(\text{Size})_{it} + \beta_3 Leverage_{it} + \beta_4 Age_i + \gamma_t + \epsilon_{it} \quad (2)$$

Where:

- FP_{it}: Financial performance of firm i in year t
- GI_{it}: Green Innovation Index
- $\ln(\text{Size})_{it}$: Log of total assets
- $Leverage_{it}$: Debt-to-equity ratio
- Age_i: Firm age
- γ_t: Year fixed effects
- ϵ_{it}: Error term

The analysis employs three estimation approaches including Pooled OLS that falls short of controlling firm-specific factors and Fixed Effects and Random Effects which account for those effects. Fixed Effects (FE): Controls for time-invariant firm characteristics. Random Effects (RE) considers all organizational effects as randomly distributed variables which also exhibit no association with model parameters. The Hausman test chooses between Random Effects or Fixed Effects models through hypothesis testing. The researchers employ H0: Random Effects as appropriate and H1: Fixed Effects as the preferred solution. The researcher selects Fixed Effects when the null hypothesis receives rejection. Otherwise, Random Effects is adopted. When lagged effects of green innovation are suspected, the analysis requires estimation through the Arellano-Bond GMM estimator by implementing the model displayed as equation 3:

$$FP_{it} = \beta_0 + \beta_1 FP_{it-1} + \beta_2 GI_{it} + \beta_3 X_{it} + u_{it} \quad (3)$$

Where FP_{it-1} accounts for persistence in financial performance across periods.

3.5 Diagnostic Tests

Different diagnostic tests were implemented to validate the reliability and robustness of the regression models that handled the relationship assessment between green innovation and financial performance. The tests evaluated for existing econometric issues involving multicollinearity, heteroskedasticity and autocorrelation, model misspecification and normality violations. This section explains the individual diagnostic tests alongside their obtained results and their corresponding effects. The research used the Variance Inflation Factor (VIF) to measure all independent variables and control variables.

The VIF value should be below 10 for healthy multicollinearity status.

Table 1: Multicollinearity Test

Variable	VIF Score
Green Innovation	1.89
Regulatory Compliance	1.76
Firm Size	2.11
Industry Type	1.65

The VIF scores presented in Table 1 are less than 10 which proves there is no significant multicollinearity effect among explanatory variables. The coefficients maintain their reliability and stability in this model framework. This analysis made use of both Breusch-Pagan test and the White test. When the null hypothesis fails to hold it indicates heteroskedasticity because homoskedasticity/constant variance describes the situation.

Table 2: Heteroskedasticity Test

Test	Chi-Square Statistic	p-value	Decision
Breusch-Pagan Test	9.35	0.154	Fail to reject H_0
White Test	11.20	0.131	Fail to reject H_0

The results indicate heteroskedasticity is not statistically significant due to p-values surpassing 0.05 in Table 2. The research used robust standard errors to boost inference efficiency even though the results proved no heteroskedasticity. The Durbin-Watson statistic was computed. The value of 2 indicates no autocorrelation although the statistic below 2 points towards positive autocorrelation and values above 2 signify negative autocorrelation.

Table 3: Autocorrelation Test

Model	Durbin-Watson Statistic
ROA Regression Model	1.91
ROE Regression Model	1.89
Tobin's Q Regression Model	1.95

All the Durbin-Watson statistics in Table 3 approach 2 which confirms there is no substantial autocorrelation present in residual values. The results confirm the suitability of applying fixed-effects regression models along with no need for additional adjustments due to serial correlation. The researchers conducted an F-test on the joint significance of squared predicted values appended to the regression model through the Ramsey RESET test.

Table 4: Ramsey RESET Test

Model	F-statistic	p-value	Decision
ROA Regression Model	1.34	0.261	Fail to reject H_0
ROE Regression Model	1.28	0.275	Fail to reject H_0
Tobin's Q Regression Model	1.42	0.237	Fail to reject H_0

The p-values in Table 4 demonstrate that conventional significance levels are not met thus confirming that specification models are correct and eliminate any bias from omitted variables or incorrect functional forms. The analysis revealed results from testing skewness and kurtosis of residuals through the Jarque-Bera test. The results show normal distribution of residuals when p-value increases.

Table 5: Jarque-Bera Test

Model	Jarque-Bera Statistic	p-value	Decision
ROA Regression Model	5.12	0.077	Fail to reject H_0
ROE Regression Model	5.89	0.052	Marginal rejection
Tobin's Q Regression Model	6.01	0.049	Reject H_0

The test results in Table 5 indicate that Tobin's Q deviated from normality compared to ROE according to the Jarque-Bera test. However, the deviations appear small enough for inference to remain unaffected because of the large sample size and fixed effects implementation. Additional diagnostic tests should be employed to verify normality in case acute non-normality emerges in future research using standard errors or robust approaches.

Table 6: Summary of Diagnostic Tests

Diagnostic Test	Assumption Checked	Result	Action Taken
VIF Test	Multicollinearity	No multicollinearity detected	None required
Breusch-Pagan / White Test	Homoskedasticity	Homoskedasticity assumed	Robust standard errors used
Durbin-Watson Test	Autocorrelation	No significant autocorrelation	None required
Ramsey RESET Test	Functional form specification	Correctly specified	None required
Jarque-Bera Test	Normality of residuals	Mild deviation in some models	Consider bootstrapping in future

Diagnostic tests presented in Table 6 verify the regression models used in this investigation follow the required statistical inference conditions. The diagnostic tests validate that the used regression models meet every requirement for valid statistical inference without serious multicollinearity problems and heteroskedasticity along with autocorrelation. In addition, the chosen functional form of the model remains appropriate. The results maintain their validity since the robust estimation approaches tolerate minor deviations from normal distribution. The results concerning how green innovation impacts financial performance prove to be both reliable and robust in nature.

4. Results and Analysis

4.1 Descriptive Statistics

The study period (2015–2024) displayed data statistical patterns through Table 7 for all sample firm variables.

Table 7: Descriptive Statistics

Variable	Mean	Std. Deviation	Min	Max
Green Innovation (GI)	3.78	1.42	0.00	6.95
Return on Assets (ROA)	0.078	0.061	-0.18	0.25
Return on Equity (ROE)	0.122	0.095	-0.30	0.40
Tobin's Q	1.25	0.52	0.42	3.10
Regulatory Compliance	0.68	0.21	0.00	1.00
Firm Size (ln Assets)	12.45	1.85	9.20	16.30
Industry Type	1.45	0.50	1.00	2.00

The descriptive statistics reveal key insights into the variables under study. The scale of Green Innovation (GI) measurement shows a mean value at 3.78 and standard deviation of 1.42 while keeping a distribution between 0.00 to 6.95 across the sample group. Return on Assets (ROA) spans from -0.18 to 0.25 with an average of 0.078 and standard deviation of 0.061. This dispersion indicates assets becoming unprofitable for specific firms. The ROE data shows an average value of 0.122 while displaying high variability (SD = 0.095) due to return distributions from -0.30 to 0.40 in the sample. The average value of Tobin's Q stands at 1.25 with 0.52 standard deviation which demonstrates firms typically generate value yet encounter significant variation between 0.42 to 3.10. Most organizations maintain standard regulatory compliance based on the low standard deviation (SD = 0.21) while the average regulatory performance stands at 0.68. Total asset measurements computed as the natural log produce an average value of 12.45 while showing standard deviation at 1.85 and extending from 9.20 to 16.30

for firm sizes. The statistics indicate Industry Type factors to be distributed as binary or categorized choice between 1.00 and 2.00 with average score of 1.45 at SD = 0.50.

4.2 Correlation Matrix

Table 8 displays all key variable Pearson correlation coefficients which offer insights about bivariate relationships and potential multicollinearity problems. According to the statistical data, it is observed that those organizations, which engage in more green innovation, exhibit better financial and market performance at p < 0.01 level as GI has a positive relationship with ROA (0.32) and TOBQ (0.24) and ROE (0.28). Reinteraction between return on assets and return on equity has been stable with a high statistical relationship of 0.61 (p < 0.01). The correlations of Regulatory Compliance indicators reveal positive correlation with GI (0.19) and ROA (0.22) and ROE (0.18) moderately but significantly which points to some correspondence between the measures of compliance and the performance outcomes. Firm Size exhibits low correlations with other variables whose relationship with the Q of Tobin attains significance at the level of p of 0.05 alongside reaching a range of between 0.06 and 0.21. Most correlations within the research demonstrate moderate strength which indicates meaningful relationships even though very strong coefficients above 0.70 are minimal therefore minimizing multicollinearity issues in the regression analysis.

Table 8: Correlation Matrix

Variables	GI	ROA	ROE	Tobin's Q	RC	FS
Green Innovation (GI)	1.00	—	—	—	—	—
ROA	0.32***	1.00	—	—	—	—
ROE	0.28***	0.61***	1.00	—	—	—
Tobin's Q	0.24***	0.43***	0.39***	1.00	—	—
Regulatory Compliance	0.19*	0.22**	0.18*	0.15	1.00	—
Firm Size	0.13	0.10	0.09	0.21**	0.06	1.00

*** p ‹ 0.01, ** p ‹ 0.05, * p ‹ 0.10

4.3 Regression Results

This equation helps understand how green innovation impacts financial performance and is presented in equation 4:

$$FP_{it} = \beta_0 + \beta_1 GI_{it} + \beta_2 RC_{it} + \beta_3 FS_{it} + \beta_4 IT_{it} + \varepsilon_{it} \qquad (4)$$

Where: FP_{it} = Financial performance of firm *i* in year *t*, GI_{it} = Green innovation index, RC_{it} = Regulatory compliance indicator, FS_{it} = Natural log of total assets (proxy for firm size), IT_{it} = Dummy variable for industry type, and ε_{it} = Error term.

Table 9: Fixed Effects Regression Results

Variables	ROA	ROE	Tobin's Q
Green Innovation	0.014***	0.021***	0.110***
Regulatory Compliance	0.009*	0.012**	0.045*
Firm Size	-0.002	-0.001	0.031***
Industry Type	-0.005	-0.003	0.024
Constant	0.051***	0.078***	0.920***
R-squared (Within)	0.38	0.35	0.41

*** p ‹ 0.01, ** p ‹ 0.05, * p ‹ 0.10

Table 9 contains the fixed effects regression analysis which analyzes green innovation together with other control variables to determine their impact on financial and market performance.

Green Innovation (GI) leads to improved financial metrics and higher market value across all three performance indicators including Return on Assets (ROA = 0.014, p < 0.01), Return on Equity (ROE = 0.021, p < 0.01) and Tobin's Q (0.110, p < 0.01) among surveyed firms. The impact of Regulatory Compliance on ROA at (0.009, p < 0.10) and ROE at (0.012, p < 0.05) reached statistical significance at the 10% level while it demonstrated a stronger effect on Tobin's Q (0.045, p < 0.10). The effects of Firm Size on ROA and ROE are minimal yet statistically irrelevant but this influence results in a substantial positive correlation with Tobin's Q (0.031, p < 0.01). Research findings demonstrate that Industry Type fails to show any meaningful relationship with the evaluated performance measures. Within-individual performance variations are explained by these models at a rate between 35% to 41% according to the obtained R-squared values. These findings support Hypothesis H1. Study analyzed the moderating functions of firm size and industry type through equation 5 by creating interaction terms for the model.

$$FP_{it} = \beta_0 + \beta_1 GI_{it} + \beta_2 FS_{it} + \beta_3 (GI \times FS) FS_{it} + \beta_4 IT_{it} + \varepsilon_{it} \quad (5)$$

Table 10: Moderating effects

Interaction Term	ROA	ROE	Tobin's Q
GI × Firm Size	0.003**	0.004*	0.016***

Table 10 presents a positive and statistically significant effect of GI × Firm Size for both ROA (0.003, p < 0.05) and ROE (0.004, p < 0.10) and Tobin's Q (0.016, p < 0.01) indicating that firm size strengthens the link between green innovation and performance outcomes. The combination of GI and Firm Size demonstrates a positive relationship with performance metrics including ROA (0.003, p < 0.05) and ROE (0.004, p < 0.10) and Tobin's Q (0.016, p < 0.01). Larger firms derive greater benefits from green innovation initiatives regarding profitability and market valuation when compared to smaller counterparts. This supports Hypothesis H3.

4.4 Robustness Checks

4.4.1 Alternative Model Specifications

Research utilizes multiple different functional forms to re-estimate the model for both confirming reliability and stability of detected findings. The alternative measure of market performance uses Market-to-Book ratio instead of Tobin's Q. The model now employs the log of sales growth as a new metric to evaluate firm performance. Lagged green innovation is put into practice through research to establish ways in which the effect of lag implementation influences performance of the organization. The findings are consistently verified by a combination of alternative specifications of main findings that establish that the green innovation vs firm performance relationship is independent of measurement methods as well as model specifications.

4.4.2 Sub-sample Analysis

The article considers the various impacts of green innovation by categorizing organizations into two high-polluting and low-polluting organizations. Cement and chemical industries give rise to strong environmental pollutants whereas those industries that generate less pollution are food processing and textiles. Findings have shown that the performance-enhancing effect of green innovation is more effective in companies which also cause more pollution compared to the ones that produce less pollution. Firms that work in environmentally sensitive sectors gain better financial and market advantages through their adoption of green innovation strategies because they face stronger regulatory forces alongside intense stakeholder oversight and they achieve higher operational efficiency.

Table 11: Sub-sample Analysis

Group	ROA Coefficient	ROE Coefficient	Tobin's Q Coefficient
High-Polluting	0.017***	0.025***	0.130***
Low-Polluting	0.010*	0.015**	0.090***

The Table 11 statistical analysis shows Green Innovation as a positive variable with coefficients at 0.017 for ROA and 0.025 for ROE and 0.130 for Tobin's Q in high-polluting firms at the 1% significance level. Low-polluting firms display mildly positive effects on firm performance but with lower precision as the coefficient results show 0.010 (10% significance), 0.015 (5% significance) and 0.090 (1% significance) respectively for ROA, ROE and Tobin's Q. The effects of green innovation show stronger correlations with profitability and

market performance among companies operating in industries with significant environmental impacts because these sectors experience more regulatory pressure and saving potential along with enhanced reputation from sustainability efforts. The financial performance analysis shows that high-polluting firms receive considerable benefits of green innovation due to them facing heavier regulatory requirements and operational problems that green technologies address professionally.

5. Discussion

5.1 Interpretation of Findings

This research produces sound evidence that supports the fact that green innovation has a good outcome on financial performance of Pakistani companies. The predictions provided by Resource-Based View (RBV) firms indicate that they are capable of establishing a competitive advantage and increase profits through exploiting unique resources and precious assets such as green technologies and sustainability. Companies that make investments in environment-friendly research and development as well as cleaner production strategies generate twofold fortunes of reducing the cost of operation and increasing the operational efficacies that enables them to serve new markets and achieve more financial results.

The results justify the concept of the Stakeholder Theory as consumers as well as investors and regulators are among the stakeholders who compels companies to develop green innovation. The voluntary, open-minded nature of sustainable practices by firms has the benefit of helping them establish better reputations among its stakeholders, as well as raise the trust of its investors that leads to the high values of Q in Tobin. The Institutional Theory has an extra promotion based on the study of the size of firms since larger ones are more sensitive to the adherence to environmental laws and standards of the global supply chain. These companies, with their high financial capabilities and technology and their skilled labor, do a better job of carrying out sustainable strategies than small businesses.

The findings of the research are in line with all past research studies conducted in the developed countries of Europe and North America. The concluding researchers by Ramzan & Ali, (2025) and Ma et al., (2025) found out that environmental regulations lead to novelty growth and the creation of price cut along with market choice known by researchers as Porter Hypothesis. The green innovation engines of Pakistani companies are primarily due to the demand of the trade and global requirements that affect more the textile exporting industry and Western firms are inclined to develop green innovation on the CSR agenda and customer requirements.

5.2 Policy Implications

5.2.1 For Firms

The data gathered in the research shows that companies gain financial wellbeing when they opt with green innovation due to it being a strategic business method. To succeed in local and international markets, organizations must invest in superior environmental research and development and deploy effective technologies and attain green certifications. By applying ESG (Environmental, Social, Governance) indicators in their internal performance measurement systems, businesses are able to measure their development as well as convey value to their stakeholders.

5.2.2 For Government

The implementation of green innovation is highly determined by the policies that are developed by the governmental officials. This paper validates that compliance with regulations is significant in the environmental policy. The government should thus work on increasing its efforts to enforce the existing environmental regulations and offer economic stimulus packages including tax credits and special deals to firms adopting environmentally friendly technology. The reporting standards of environmental sustainability fosters the implementation of sustainable practices by various industries at the small and big business levels. Through encouraging the collaboration between the public and the private entrepreneurs assist small and medium enterprises (SMEs) to acquire knowledge and skills regarding the adoption of green technology options.

5.2.3 For Investors

The ESG factors have emerged as critical criterion that investment evaluation process of the investor should consider. This paper suggests that companies that specialize in green innovation both have better financial performance and informative evidence regarding linkage between ESG integration and portfolio growth. Having a green innovation measure incorporated in the institutional valuation models and risk measures are useful in enabling mutual funds and institutions to see those companies that are doing well but with high-order thinking ability.

5.3 Limitations of the Study

There are certain limits of this study in the form of research. Use of Pakistan Stock Exchange (PSX) data which is publicly listed is the primary source used in this research undermines the potential to insufficiently generalize the results of research to non-listed or privately-sourced companies. Few small and medium enterprises alongside informal businesses remained omitted from analysis because they did not disclose their sustainability data or financial reports. The assessment of green innovation depends on subjective interpretations. Feedback from research relies on R&D expenditure and patent data to measure green initiatives because other initiatives such as waste reduction, recycling and process optimization lack quantifiable measures. There is unknown variables that impact both green innovation output and financial results which limit the effectiveness of the panel regression method. New studies need to conduct qualitative research or distribute surveys for enhancing the existing quantitative insights about firm conduct.

6. Conclusion and Recommendations

6.1 Summary of Key Findings

This research analyzed how green innovation affects financial metrics of Pakistani firms through a quantitative analysis of data from 2015 to 2024. The findings are supported by multiple regression models that are defensible when the factors include the firm size and regulatory compliance and industry type data points among others.

The prevalent indicators of financial performance improvement were predominantly due to three key aspects of green innovation, namely, investments in eco-friendly research and development and the implementation of clean technology as well as the acquisition of environmental certifications. Companies that actively cut power consumption and minimized the amount of waste and increased supply chain sustainability were likely to create cost cuts and enhance operational effectiveness and increase financial markets acceptance. Results of an analysis do not suggest that all types of firms equally benefit because of green innovation. Greater business corporations were found to have more financial benefits in environmental efforts as it seems the scale of the programs adjusted the effectiveness of the programs. Uniqueness of green technologies and other capabilities that bring long-term competitive advantages are unique capabilities in case of the Resource-Based View as witnessed in these findings. Uniqueness of green technologies and other capabilities that bring long-term competitive advantages are unique capabilities in case of the Resource-Based View as witnessed in these findings.

6.2 Practical Recommendations

6.2.1 For Businesses

Companies should have green innovation as a fundamental strategy planning tool rather than use it as an outside activity. Organizations should establish environmental research and development funds and implement power-saving manufacturing systems and sustainable supply chain participation. As part of their sustainable practices companies need to establish Environmental Social Governance (ESG) measuring systems to track their environmental advancements and share clear sustainability information with stockholders and market consumers. The leading firms possessing greater financial capabilities should initialize benchmark processes to facilitate a collective understanding of sustainability practices within their industries.

6.2.2 For Regulators and Policymakers

To encourage green innovation the government must implement supportive measures which combine regulatory requirements with financial benefits and development programs. The enforcement of the environmental standards in the legal framework is a strong incentive that the businesses implement the use of environmentally friendly technology. ESG measurements are to be divulged in publicly traded companies by a mandatory regulation since this increases openness and responsibility of the organization and improves monitoring of sustainability objectives. Medium sized enterprises and small businesses enjoy special subsidies and tax exemption. by availing itself of green financing expertise that mutually mitigate business impediments as well as extend to accessible sustainable projects.

6.2.3 For Researchers and Academia

Green innovation research must develop new processes of examining green innovation variables that go beyond the simple quantification of patents and R&D costs. The organizational difficulties and cultural issues that affect the green decision-making is explained by a combination of qualitative information received on case studies and interviews and survey processes of the managers. The effects of international sustainability movement on Pakistani multinational and local firms carrying out operations in Pakistan must be compared by the qualified research.

6.3 Future Research Directions

Although the current study provides highly significant information on the relationship between green innovation and financial performance in Pakistan, there are multiple ways of furthering this information in future research. To begin with, an extension period of the research beyond 2024 gives an opportunity to researchers to examine the impacts of recent trends including, new climate policies, investments in renewable energy and global supply chain changes and their impacts on the relationships between green innovation and financial performance. The longitudinal studies reflect movement of changes in trends and be able to show tenacity of the observed correlation. Second, the qualitative approaches in the form of semi-structured interviews with managers, policymakers, and industry professionals play a significant role in promoting the perception of the decision-making processes involved in adopting green innovation. Interpretation of interview findings in terms of thematic analysis is one of the ways of revealing the variables, nuances, and patterns that cannot be systematically observed and measured with the help of conventional econometrics. Third, the area of future research is to incorporate in the sample those organizations, including the SMEs and the private sector, which constitute a large portion of the industrial base of Pakistan but are not adequately represented in current databases. Industry surveys by details gathered via questionnaires or building up alliances with trade groups are not just beneficial to the researchers but also allows a more in-depth and more extensive overview of how green innovation was being implemented in the market, on a more aggregate size. Thirdly, a further investigation into the sector-related differences such as the gap between the industry with high rate of pollution and the one with low rate of pollution describes the requirement of a specific action that is even more beneficial to a sustainable development.

References

Ciambellini, G., D'Adamo, I., Gastaldi, M., & Smol, M. (2025). Sustainability and competitiveness: Economic analysis of a photovoltaic plant with storage in an Italian textile company. *Innovation and Green Development*, *4*(2), Article 100209. https://doi.org/10.1016/j.igd.2025.100209

Deng, J., Li, M., Liu, F., & Ding, Y. (2025). Impact of green technology innovation on firm performance: does firm lifecycle stage matter?. *Applied Economics*. https://doi.org/10.1080/00036846.2024.2449215

Dogah, K. E., Wesseh, P. K., & Adomako, S. (2025). Green credit policy, technological innovation, and corporate financial performance: Evidence from the energy industry. *Business Strategy and the Environment*, *34*(1), 1171-1188. https://doi.org/10.1002/bse.4041

Esposito, P., Doronzo, E., Riso, V., & Tufo, M. (2025). Sustainability in Energy Companies Under the Lens of Cultural Pressures: When Do We Talk of Greenwashing?. *Corporate Social Responsibility*

and Environmental Management. https://doi.org/10.1002/csr.3111

Gidage, M., & Bhide, S. (2025). Exploring the nexus between intellectual capital, green innovation, sustainability and financial performance in creative industry MSMEs. *Journal of Enterprising Communities*. https://doi.org/10.1108/JEC-07-2024-0134

Helmina, M. R. A., Yusniar, M. W., & Respati, N. W. (2025). Green development and its impact on financial performance and corporate value in the coal industry. *Multidisciplinary Science Journal*, *7*(5), Article e2025255. https://doi.org/10.31893/multiscience.2025255

Junaid, M., Zhang, Q., & Syed, M. W. (2022). Effects of sustainable supply chain integration on green innovation and firm performance. *Sustainable Production and Consumption*, *30*, 145-157. https://doi.org/10.1016/j.spc.2021.11.031

Khan, K. I., Babar, Z., Sharif, S., Iqbal, S., & Khan, M. I. (2021). Going green? Investigating the role of GSCM practices on firm financial and environmental performance through green innovation. *International Journal of Procurement Management*, *14*(6), 681-701. https://doi.org/10.1504/IJPM.2021.117894

Khan, R. U., Arif, H., Sahar, N. E., Ali, A., & Abbasi, M. A. (2022). The role of financial resources in SMEs' financial and environmental performance; the mediating role of green innovation. *Green Finance*, *4*(1), 36-53. https://doi.org/10.3934/GF.2022002

Khan, S. A. R., Piprani, A. Z., & Yu, Z. (2022). Digital technology and circular economy practices: future of supply chains. *Operations Management Research*, *15*(3-4), 676-688. https://doi.org/10.1007/s12063-021-00247-3

Le, T. T., & Gia, L. L. C. (2025). How Green Innovation and Green Corporate Social Responsibility Transform Green Transformational Leadership Into Sustainable Performance? Evidence From an Emerging Economy. *Corporate Social Responsibility and Environmental Management*, *32*(2), 2527-2541. https://doi.org/10.1002/csr.3077

Ma, Y., Feng, G. F., Yin, Z. J., & Chang, C. P. (2025). ESG disclosures, green innovation, and greenwashing: All for sustainable development?. *Sustainable Development*, *33*(2), 1797-1815. https://doi.org/10.1002/sd.3210

Ramzan, I., & Ali, K. (2025). Going green, growing strong: how climate policy boosts US companies performance. *Climate Policy*, *25*(4), 593-611. https://doi.org/10.1080/14693062.2024.2407832

Song, Z., Jia, Q., & He, Z. (2025). Green credit guidelines and corporate financialization: Evidence from heavily polluting enterprises in China. *Finance Research Letters*, *76*, Article 107040. https://doi.org/10.1016/j.frl.2025.107040

Stylianou, I., Christofi, M., Karasamani, I., & Magidou, M. (2025). Assessing the transition risks of environmental regulation in the United States: Revisiting the Porter hypothesis. *Risk Analysis*. https://doi.org/10.1111/risa.70022

Thirakulwanich, A., Szczepańska-Woszczyna, K., & Kot, S. (2025). Policy Instruments and Green Indicators in the Diffusion of Green Innovation: A Comparative Analysis of Poland and Thailand. *Challenges in Sustainability*, *13*(1), 35-47. https://doi.org/10.56578/cis130103

Turkcan, H. (2025). How to improve financial performance through sustainable manufacturing practices? The roles of green product innovation and digital transformation. *Journal of Manufacturing Technology Management*, *36*(3), 577-596. https://doi.org/10.1108/JMTM-03-2024-0112

Yin, N. (2025). Will Digital Transformation Empower Corporate ESG Performance: Moderated Mediation Analysis through the Prism of Executives' Foreign Experience. *Polish Journal of Environmental Studies*, *34*(4), 3893-3907. https://doi.org/10.15244/pjoes/189714